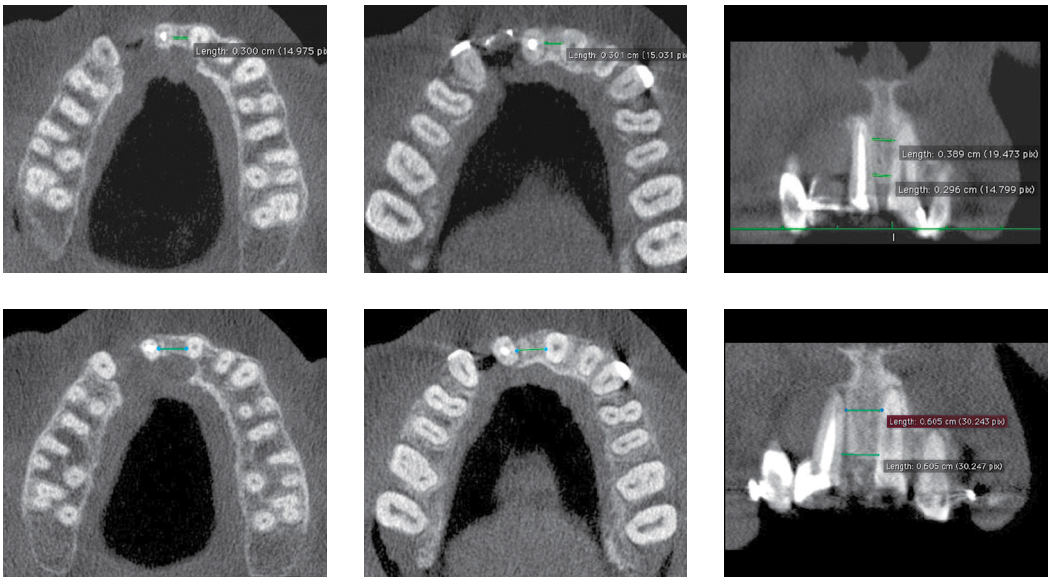
ISSN 2176-9451

Dental Press Journal of ORTHODONTICS

Volume 18, Number 5, Sept / Oct 2013



Official Journal of the Brazilian Association of Orthodontics and Facial Orthopedics

Official Journal of the Brazilian Board of Orthodontics

ABOR
ASSOCIAÇÃO BRASILEIRA DE ORTODONTIA E ORTOPEDIA FACIAL

BBO
BOARD BRASILEIRO DE ORTODONTIA E ORTOPEDIA FACIAL

DentalPress PUBLISHING

Dental Press Journal of
ORTHODONTICS

Volume 18, Number 5, September / October 2013

Official Journal of the Brazilian Association of Orthodontics and Facial Orthopedics
Official Journal of the Brazilian Board of Orthodontics

Dental Press J Orthod. 2013 September/October;18(5):1-178

ISSN 2176-9451

Indexing:

since 2013

since 1999

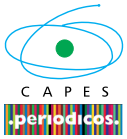
since 2011

since 1998

since 1998

since 2008

since 2005



since 2008

since 1998

since 2002

since 2008

since 2009

Dental Press Journal of Orthodontics
v. 1, n. 1 (set./out. 1996) - . -- Maringá : Dental Press International,
1996 -

Bimonthly
ISSN 2176-9451

1. Orthodontic - Journal. I. Dental Press International.

CDD 617.643005

EDITOR-IN-CHIEF

David Normando UFPA - PA - Brazil

ASSOCIATE EDITOR

Telma Martins de Araujo UFBA - BA - Brazil

ASSISTANT EDITORS

Daniela Gamba Garib HRAC/FOB/USP - SP - Brazil
Fernanda Angelieri USP - SP - Brazil
Flávia Artese UERJ - RJ - Brazil
Ildeu Andrade PUC - MG - Brazil
Matheus Melo Pithon UESB - BA - Brazil

ASSISTANT EDITOR - ABOR SUPERIOR BOARD

Luciane Macedo de Menezes PUCRS – Brazil

PUBLISHER

Laurindo Z. Furquim UEM - PR - Brazil

EDITORIAL SCIENTIFIC BOARD

Adilson Luiz Ramos UEM - PR - Brazil
Danilo Furquim Siqueira USC - SP - Brazil
Jorge Faber UnB - DF - Brazil
Maria F. Martins-Ortiz ACOPEM - SP - Brazil

EDITORIAL REVIEW BOARD

Orthodontics

A-Bakr M Rabie Hong Kong University - China
Adriana de Alcântara Cury-Saramago UFF - RJ - Brazil
Aldrieli Regina Ambrósio SOEPAR - PR - Brazil
Alex Luiz Pozzobon Pereira UFMA - MA - Brazil
Alexandre Trindade Motta UFF - RJ - Brazil
Ana Carla R. Nahás Scocate UNICID - SP - Brazil
Ana Maria Bolognese UFRJ - RJ - Brazil
Andre Wilson Machado UFBA - BA - Brazil
Anne Luise Scabell de Almeida UERJ - RJ - Brazil
Anne-Marie Bolen University of Washington - USA
Antônio C. O. Ruellas UFRJ - RJ - Brazil
Armando Yukio Saga ABO - PR - Brazil
Arno Locks UFSC - SC - Brazil
Ary dos Santos-Pinto FOAR/UNESP - SP - Brazil
Björn U. Zachrisson University of Oslo - Norway
Bruno D'Aurea Furquim Priv. practice - PR - Brazil
Camila Alessandra Pazzini UFMG - MG - Brazil
Camilo Aquino Melgaço UNINCOR - MG - Brazil
Carla D'Agostini Derech UFSC - SC - Brazil
Carlos A. Estevanel Tavares ABO - RS - Brazil
Carlos Flores-Mir University of Alberta - Canada
Carlos Martins Coelho UFMA - MA - Brazil
Cauby Maia Chaves Junior UFC - CE - Brazil
Célia Regina Maio Pinzan Vercelino UNICEUMA - MA - Brazil
Clarice Nishio Université de Montréal - Canada
Cristiane Canavarro UERJ - RJ - Brazil
Daniel Jogaib Fernandes UERJ - RJ - Brazil
David Sarver University of North Carolina - USA
Eduardo C. Almada Santos FOA/UNESP - SP - Brazil
Eduardo Franzotti Sant'Anna UFRJ - RJ - Brazil
Eduardo Silveira Ferreira UFRGS - RS - Brazil
Emanuel Braga Rego UFBA - BA - Brazil
Enio Tonani Mazzieiro PUC/MG - MG - Brazil
Eustáquio Araújo Saint Louis University - USA
Eyas Abuhijleh Ajman University - United Arab Emirates
Fabrício Pinelli Valarelli UNINGÁ - PR - Brazil
Fernando César Torres UNICID - SP - Brazil
Glaucio Serra Guimarães UFF - RJ - Brazil
Guilherme Janson FOB/USP - SP - Brazil
Gustavo Hauber Gameiro UFRGS - RS - Brazil
Hans Ulrik Paulsen Karolinska Institute - Sweden
Helio Scavone Júnior UNICID - SP - Brazil
Henri Menezes Kobayashi UNICID - SP - Brazil
Hiroshi Maruo PUC/PR - PR - Brazil
Hugo Cesar P. M. Caracas UNB - DF - Brazil
James A. McNamara University of Michigan - USA
James Vaden University of Tennessee - USA
Jesús Fernández Sánchez Universidad Europea de Madrid - Spain
Jonas Capelli Junior UERJ - RJ - Brazil
Jonh S. Casko University of Iowa
Jorge Luis Castillo Universidad Peruana Cayetano Heredia - Lima/Peru
José Antônio Bósio Marquette University - Milwaukee - USA
José Augusto Mendes Miguel UERJ - RJ - Brazil
José Fernando Castanha Henriques FOB/USP - SP - Brazil
José Nelson Mucha UFF - RJ - Brazil
José Rino Neto FOUSP – SP – Brazil
José Valladares Neto UFG - GO - Brazil
José Vinicius B. Maciel PUC/PR - PR - Brazil
Julia Cristina de Andrade Vitral Priv. practice - SP - Brazil
Júlia Harfin Universidad Maimónides - Buenos Aires - Argentina
Júlio de Araújo Gurgel UNICEUMA - MA - Brazil
Karina Maria S. de Freitas UNINGÁ - PR - Brazil
Larry White AAO - Dallas - USA
Leandro Silva Marques UFVJM - MG - Brazil
Leniana Santos Neves UFVJM - MG - Brazil
Leopoldino Capelozza Filho HRAC/USP - SP - Brazil
Liliana Ávila Maltagliati USC - SP - Brazil
Lucia Cevidanes University of Michigan - USA
Luciane M. de Menezes PUC/RS - RS - Brazil
Luís Antônio de Arruda Aidar UNISANTA - SP - Brazil
Luiz Filiphe Canuto FOB/USP - SP - Brazil
Luiz G. Gandini Jr. FOAR/UNESP - SP - Brazil
Luiz Sérgio Carreiro UEL - PR - Brazil
Marcelo Reis Fraga UFJF - MG - Brazil
Márcio Rodrigues de Almeida UNOPAR - PR - Brazil
Marco Antônio de O. Almeida UERJ - RJ - Brazil
Marco Rosa University of Insubria - Italy
Marcos Alan V. Bittencourt UFBA - BA - Brazil
Marcos Augusto Lenza UFG - GO - Brazil
Margareth Maria Gomes de Souza UFRJ - RJ - Brazil
Maria Cristina Thomé Pacheco UFES - ES - Brazil
Maria Fernanda Martins-Ortiz Copem - Brazil
Maria Perpétua Mota Freitas ULBRA - RS - Brazil
Marinho Del Santo Jr. Priv. practice - SP - Brazil
Maristela S. Inoue Arai Tokyo Medical and Dental University - Japan
Mônica T. de Souza Araújo UFRJ - RJ - Brazil
Orlando M. Tanaka PUC/PR - PR - Brazil
Oswaldo V. Vilella UFF - RJ - Brazil
Patrícia Medeiros Berto Priv. practice - DF - Brazil
Patricia Valeria Milanezi Alves Priv. practice - RS - Brazil
Paul Mjor University of Alberta – Canadá

Paula Vanessa P. Oltramari-Navarro	UNOPAR - PR - Brazil
Pedro Paulo Gondim	UFPE - PE - Brazil
Renata C. F. R. de Castro	USC - SP - Brazil
Renata Rodrigues de Almeida-Pedrin	USC - SP - Brazil
Renato Parsekian Martins	FOAr-UNESP - SP - Brazil
Ricardo Machado Cruz	UNIP - DF - Brazil
Ricardo Moresca	UFPR - PR - Brazil
Robert W. Farinazzo Vitral	UFJF - MG - Brazil
Roberto Hideo Shimizu	Priv. practice - PR - Brazil
Roberto Justus	Universidad Tecnológica de México - Mexico
Rodrigo César Santiago	UFJF - MG - Brazil
Rodrigo Hermont Cançado	UNINGÁ - PR - Brazil
Rogério Lacerda dos Santos	UFCG - PB - Brazil
Sávio R. Lemos Prado	UFPA - PA - Brazil
Sylvia Frazier-Bowers	University of North Carolina - USA
Tarcila Triviño	UMESP - SP - Brazil
Vladimir Leon Salazar	University of Minnesota - USA
Weber José da Silva Ursi	FOSJC/UNESP - SP - Brazil
Won Moon	UCLA - USA

Oral Biology and Pathology

Alberto Consolaro	FOB/USP - SP - Brazil
Christie Ramos Andrade Leite-Panissi	FORP/USP - Brazil
Edvaldo Antonio R. Rosa	PUC/PR - PR - Brazil
Victor Elias Arana-Chavez	USP - SP - Brazil

Biochemical and Cariology

Marília Afonso Rabelo Buzalaf	FOB/USP - SP - Brazil
Soraya Coelho Leal	UnB - DF - Brazil

Orthognathic Surgery

Eduardo Sant'Ana	FOB/USP - SP - Brazil
Laudimar Alves de Oliveira	UNIP - DF - Brazil
Liogi Iwaki Filho	UEM - PR - Brazil
Waldemar Daudt Polido	Priv. practice - RS - Brazil

Restorative Dentistry

Maria Fidela L. Navarro	FOB/USP - SP - Brazil

TMJ Disorder

José Luiz Villaça Avoglio	CTA - SP - Brazil
Paulo César Conti	FOB/USP - SP - Brazil

Epidemiology

Isabela Almeida Pordeus	UFMG - MG - Brazil
Saul Martins Paiva	UFMG - MG - Brazil

Speech Therapy

Esther M. G. Bianchini	CEFAC-FCMSC - SP - Brazil

Implant Dentistry

Carlos E. Francischone	FOB/USP - SP - Brazil

Dentofacial Orthopedics

Kurt Faltin Jr.	UNIP - SP - Brazil

Periodontics

Adriana C. P. Sant'Ana	FOB/USP – SP – Brazil
Maurício G. Araújo	UEM – PR – Brazil
Mário Taba Jr.	FORP/USP – SP – Brazil

Prothesis

Marco Antonio Bottino	UNESP/SJC - SP - Brazil
Sidney Kina	Priv. practice - PR - Brazil

Radiology

Rejane Faria Ribeiro-Rotta	UFG - GO - Brazil

Dental Press Journal of Orthodontics
(ISSN 2176-9451) continues the **Revista Dental Press de Ortodontia e Ortopedia Facial** (ISSN 1415-5419).

Dental Press Journal of Orthodontics
(ISSN 2176-9451) is a bimonthly publication of Dental Press International
Av. Dr. Luiz Teixeira Mendes, 2.712 - Zona 5 - ZIP code: 87.015-001
Maringá / PR, Brazil - Phone: (55 044) 3031-9818
www.dentalpress.com.br - artigos@dentalpress.com.br.

DIRECTOR: Teresa Rodrigues D'Aurea Furquim - EDITORIAL DIRECTOR: Bruno D'Aurea Furquim - MARKETING DIRECTOR: Fernando Marson - EDITORIAL PRODUCER: Júnior Bianco - DESKTOP PUBLISHING: Bruno Boeing de Souza - Gildásio Oliveira Reis Júnior - ARTICLES SUBMISSION: Simone Lima Lopes Rafael - REVIEW/COPYDESK: - Adna Miranda - Ronis Furquim Siqueira - Wesley Nazeazeno - JOURNALISM: Yara Borges Marchini - DATABASE: Cléber Augusto Rafael - INTERNET: Fernando Truculo Evangelista - COURSES AND EVENTS: Ana Claudia da Silva - COMMERCIAL DEPARTMENT: Roseneide Martins Garcia - LIBRARY/NORMALIZATION: Simone Lima Lopes Rafael - DISPATCH: Diego Matheus Moraes dos Santos - FINANCIAL DEPARTMENT: Cléber Augusto Rafael - Lucyane Plonkóski Nogueira - Roseli Martins - SECRETARY: Rosane Albino Rosana G. Silva.

DPJO

Dental Press Journal of Orthodontics

Official Publication of the

Brazilian Association of Orthodontics and Facial Orthopedics

Volume 18 . Number 5 . September-October 2013

Sections

Editorial

1

From embryo to maturity

David Normando

Orthodontics Highlights

2

Highlights on orthodontics literature

Matheus Melo Pithon

Orthodontic Insight

4

Clarifications, guidelines and questions about the dental bleaching "associated" with orthodontic treatment

Alberto Consolaro, Renata Bianco Consolaro, Leda Francischone

Evidence-based Orthodontics

11

Evidence-based Orthodontics: Has it something to do with your patient?

Fernanda Angelieri

Interview

14

An interview with Adilson Luiz Ramos

BBO Case Report

140

Compensatory orthodontic treatment of Angle Class II malocclusion with posterior open bite

José Newton Torres

Special Article

147

Finishing procedures in Orthodontics: dental dimensions and proportions (microesthetics)

Roberto Carlos Bodart Brandão, Larissa Bustamente Capucho Brandão

Articles

32

Assessment of pain experience in adults and children after bracket bonding and initial archwire insertion

Marcio José da Silva Campos, Marcelo Reis Fraga, Nádia Rezende Barbosa Raposo, Ana Paula Ferreira, Robert Willer Farinazzo Vitral

38

Class II malocclusion treatment with the Herbst appliance in patients after the growth peak

José Carlos de Castro Alvares, Rodrigo Hermont Cançado, Fabrício Pinelli Valarelli, Karina Maria Salvatore de Freitas, Christian Zamberlan Angheben

46

Effects of mandibular protraction appliance associated to fixed appliance in adults

Bruno D'Aurea Furquim, José Fernando Castanha Henriques, Guilherme Janson, Danilo Furquim Siqueira, Laurindo Zanco Furquim

53

Cephalometric evaluation of the predictability of bimaxillary surgical-orthodontic treatment outcomes in long face pattern patients: A retrospective study

Carla Maria Melleiro Gimenez, Francisco Antonio Bertoz, Marisa Aparecida Cabrini Gabrielli, Oswaldo Magro Filho, Idelmo Garcia, Valfrido Antonio Pereira Filho

DPJO

Dental Press Journal of Orthodontics

Official Publication of the

Brazilian Association of Orthodontics and Facial Orthopedics

Volume 18 . Number 5 . September-October 2013

59
Factors related to orthodontic treatment time in adult patients
Ana Camila Esteves de Oliveira Melo, Lilianne Oliveira Thiers Carneiro, Luana Farias Pontes, Rodolpho Lobão Cecim, José Nazareno Rufino de Mattos, David Normando

64
Effects of chin advancement surgery in hyoid bone and tongue positions and in the dimension of the oropharynx
Milena Barreto de Arruda Cabral, André Carlos de Freitas, Telma Martins de Araújo, Nilson Pena, Rivail Almeida Brandão Filho

70
Auditory characteristics of individuals with temporomandibular dysfunctions and dentofacial deformities
Tatiane Totta, Giselda Santiago, Eduardo Sanches Gonçales, Sandra de Oliveira Saes, Giédre Berretin-Felix

78
Is there correlation between alveolar and systemic bone density?
Paula Cabrini Scheibel, Adilson Luiz Ramos, Lilian Cristina Vessoni Iwaki

84
Horizontal and vertical maxillary osteotomy stability, in cleft lip and palate patients, using allogeneic bone graft
Kelston Ulbricht Gomes, Wilson Denis Benato Martins, Marina de Oliveira Ribas

91
Comparison of the changes of alveolar bone thickness in maxillary incisor area in extraction and non-extraction cases: Computerized tomography evaluation
Paulo Roberto Barroso Picanço, Fabricio Pinelli Valarelli, Rodrigo Hermont Cançado, Karina Maria Salvatore de Freitas, Gracemia Vasconcelos Picanço

99
Translation and cross-cultural adaptation of an instrument designed for the assessment of quality of life in orthognatic patients
Adriana Monteiro de Araújo, José Augusto Mendes Miguel, Eveline Coutinho Baldoto Gava, Branca Heloisa de Oliveira

107
Evaluation of life quality of patients submitted to orthognathic surgery
Ana Catarina Alves e Silva, Roberta Almeida Silveira Carvalho, Thiago de Santana Santos, Nelson Studart Rocha, Ana Cláudia Amorim Gomes, Emanuel Dias de Oliveira e Silva

115
Evaluation of the vertical alterations of the upper second molars after the alignment and leveling phase using the MBT technique
Alael Barreiro Fernandes de Paiva Lino, Julio Wilson Vigorito

121
Influence of treatment including second molars on final and postretention molar angulation
Luiz Filiphe Gonçalves Canuto, Karina Maria Salvatores de Freitas, Marcos Roberto de Freitas, Rodrigo Hermont Cançado

128
Intra-articular injections with corticosteroids and sodium hyaluronate for treating temporomandibular joint disorders: A systematic review
Eduardo Machado, Daniel Bonotto, Paulo Afonso Cunali

134
Therapeutic exercises for the control of temporomandibular disorders
Alberto da Rocha Moraes, Monique Lalue Sanches, Eduardo Cotecchia Ribeiro, Antonio Sérgio Guimarães

175
Information for authors

From embryo to maturity

"Time and destiny have had a lifetime relationship, they are a bond, a pair." (Nilson Chaves)

In this issue, *Dental Press Journal of Orthodontics* (DPJO) celebrates 18 years of a meaningful existence. We are able to salute our readers with the deep conviction that we have come this far because we took strategically planned paths which could not be described on the 180 pages that comprise the theme of this volume: "Orthodontic treatment in adults."

When we celebrate dates, especially those that complete a cycle, we tend to relive the past and devise plans for the future. For a periodical that began its embryogenesis with the publication of translated articles, publishing original articles would already be a significant change. A rapid progress that makes us recall a new-born baby who ceases to express his desires by means of facial expressions — which are simulated by mothers and grandmothers — and begins saying his first words, emphasizing his first wishes by his own appropriate words.

The steps are firm and the run is inexorable for those who dream about flying even higher. At the age of 10, DPJO was indexed on SciELO[1] (a very renowned bibliographic database) which allowed us to become part of a select group of journals that are qualified according to the Brazilian Coordination for Improvement of Higher Education Personnel (CAPES). In fact, we are still the only Brazilian dental journal to be recognized with this merit. We would like to take the opportunity to express our desire for company.

On the verge of adolescence, at the age of 13, we stepped into computerization, gaining its organizational benefits. Articles begin to be submitted exclusively online,[2] which facilitates for authors, reviewers, editors and other staff members. At the peak of our growth, the number of submissions now bursts and the young periodical learns how to say no: the solicitous child now welcomes the adolescent who rejects things more than accepts them — a true adolescence. The expression of his needs is underlined by a high frequency of rejections, which arouses undesirable trouble. However, such trouble is extremely necessary for the adolescent to mature and focus on the objectives set since his intrauterine phase.

Growth takes a different turn when the scientific articles previously published in the language of Camões begin to be published in the universal language of science — the language of Shakespeare, who was contemporary with Camões.[3] And that was an inherent change for those who wish to spread the magnitude of Brazilian Orthodontics to a larger number of ears and eyes. We did not change our language, we simply had to express ourselves in another one. DPJO, consolidated by its importance within clinical Orthodontics, has kept and shall keep a mirror of its publications in Brazilian Portuguese. It is all about thanking for the credibility given to us by those who believed in our potentiality when we were still scared of the uncertainties and fears of childhood.

Our speech is consolidated in two different languages — among stumbles that are common to effusive adolescent learners. Legs and arms are extended due to a physiological need to sustain a hebiatric skeleton. These extensions reach institutions that share similar purposes: to raise Brazilian Orthodontics to its incontestable prominent position. At the age of 17, Dental Press Journal of Orthodontics became the official publication in charge of disclosing news about the Brazilian Dental Association (ABOR)[4] and the Brazilian Board of Orthodontics and Dentofacial Orthopedics. In 2013, it began to publish the abstracts of studies presented during the Meeting of the Brazilian Group of Professors of Orthodontics and Pediatric Dentistry — a major achievement that contributes to improving the postgraduate scientific production in Brazil.

In 2012, on the verge of turning 18 years old, articles' citations, which were already going through a process of development, duplicated. In 2013, we gained the recognition of the most important international database on health sciences (PubMed),[5] which shall significantly increase the scientific impact of this periodical. These last achievements reveal the dawn of maturity. Now, that we are able to follow our own path in a swifter manner, it becomes necessary to reassess our plans. For the next year, our aims include duplicating our scientific impact and improving our CAPES evaluation criteria. Additionally, we aim at reducing the time between submission and publication. However, we understand that our aims are only the reflection of a work strongly connected to the conviction that we have been able to achieve maturity at the age of 18 because the eyes of those who read these last words believed in the brave view of those who gave birth to this periodical. Yes, we do have a father and a mother.

David Normando – editor-in-chief
(davidnormando@hotmail.com)

REFERENCES

1. Ramos AL. Conquista. Rev Dental Press Ortod Ortop Facial. 2006;11(1):1.
2. Faber J. Colóquio editorial. Rev Dental Press Ortod Ortop Facial. 2007;12(4):1.
3. Faber J. Adversities stimulating advances. Dental Press J Orthod. 2010;15(1):1.
4. Normando D. The following years. Dental Press J Orthod. 2013;18(1):1.
5. Normando D. MEDLINE: international recognition of Brazilian orthodontic science development. Dental Press J Orthod. 2013;18(4):1.

© 2013 Dental Press Journal of Orthodontics

Matheus Melo Pithon*

RAPID AND SLOW EXPANSION ARE EFFECTIVE PROTOCOLS IN MAXILLARY EXPANSION

Since its introduction, in 1860 by Angel, and reintroduction by Haas, in 1965, maxillary expansion became popular among orthodontists throughout the world. Maxillary expansion provides many orthopedic and orthodontic benefits to the patient, including: Maxillary harmony with other facial bones, space in the dental arch for accommodation of teeth, etc. However, despite their widespread acceptance and use, questions remain about the most effective method of activating the expander to promote the best results. To elucidate these questions, Chinese researchers[1] developed a systematic literature review with the aim of comparing the effectiveness of fast and slow maxillary expansion. The results showed that the slow expansion is effective in expanding the maxilla, and the rapid is effective in expanding both the upper and lower dental arches. The authors note, however, that with the slow expansion it is possible to obtain further expansion in the molar area of the maxilla. The data found in this study are of great clinical importance, since, from its knowledge, orthodontists can choose the protocol that best fits their patients, not based on personal preferences, but on scientific evidence.

STRIPPING CAN PROMOTE TRANSIENT BACTEREMIA IN ORTHODONTIC PATIENTS

The discovery of the presence of tooth size discrepancy by Bolton, in 1958, undoubtedly favored a better finishing of orthodontically treated cases. If present, Bolton discrepancy should be eliminated, either through increments (in the teeth with dental volume deficiency) or stripping on teeth with mesiodistal excess. When the choice is the stripping, there are several methods and tools available. One fact is that the bleeding is always present in this procedure, either for the proximity with the gingival tissue (often hyperplastic, by lack of proper hygiene) or carelessness of the orthodontist, cutting the gingiva with burs or sandpaper. But this simple procedure would be able to cause damage to patients, with respect to transient bacteremia? Seeking an answer to this question, Turks and Saudis researchers[2] developed a clinical study that evaluated the presence of transient bacteremia before and after completion of stripping in anterior teeth. The results were, in a way, alarming. Although no differences were observed (under the statistical point of view) between the blood samples before and after stripping, one of the 30 evaluated patients had transient bacteremia, with *Streptococcus sanguis*. Because of this isolated case, the authors stress the need to evaluate each case individually, preventing the onset of more serious systemic problems, such as bacterial endocarditis.

USE OF PROBIOTICS REDUCE THE LEVEL OF STREPTOCOCCUS MUTANS IN ORTHODONTIC PATIENTS

As we all know, orthodontic treatment requires a lot of complicity between patient and orthodontist. For a good resolution of the treatment, collaboration from the patient is necessary, with respect to the frequency on appointments, use of assistive devices and maintenance of proper oral hygiene. The presence of orthodontic appliances with brackets, wires, rubber bands, among others, favors the bacterial accumulation and cause dental caries. Bacteria, especially *Streptococcus mutans*, develop fast in the presence of orthodontic appliances. Getting to the end of treatment with teeth well positioned and without the presence of dental caries is the desire of every orthodontist. But, how to achieve these results without relying this much on the patient? In the search for alternatives for bacterial control of patients using fixed appliances, Indian researchers[3] developed a randomized controlled clinical trial

Submitted: August 19, 2013 - **Revised and accepted**: August 26, 2013

*Professor, Southwest Bahia University (UESB), Bahia, Brazil. MSc and PhD in Orthodontics, Federal University of Rio de Janeiro, (UFRJ). Diplomate of the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO).

How to cite this section: Pithon MM. Orthodontics highlights. Dental Press J Orthod. 2013 Sept-Oct;18(5):2-3.

Contact address: Matheus Melo Pithon
E-mail: matheuspithon@gmail.com

© 2013 Dental Press Journal of Orthodontics

which evaluated the effect of probiotics in reducing systemic and topical *Streptococcus mutans* in patients with fixed orthodontic appliances. The results demonstrated that the systemic use of probiotics, as yogurt and probiotic toothpaste, significantly reduces the level of *S. mutans* in plaque around orthodontic brackets. The authors conclude this study stressing the importance of conducting long-term studies to verify the real advantages of these new methods of controlling dental caries.

TOOTH AGENESIS CAUSE IMPACT ON QUALITY OF LIFE FOR CHILDREN

It is not new the importance of teeth in the esthetics of a person. A harmonious smile plays an important role so that a good relationship of physical and facial beauty can be established. The absence of teeth compromises, with no doubt, this harmony. It is known that, in contemporary society, much attention has been paid to esthetics. But what would be the impact of missing teeth in the quality of life of affected individuals? In seeking an answer to these questions, English[4] researchers developed a study that assessed the psychosocial impact of tooth agenesis in children, besides investigating the possible influence of gender, socioeconomic status, severity of agenesis and number of teeth involved, in the quality of life of these individuals. The authors concluded with the completion of this study, that tooth agenesis have significant impact on quality of life for children, impacting them functionally, emotionally and socially. These results reaffirm the role of orthodontists not only for esthetics, but in a larger context.

RAPID MAXILLARY EXPANSION PROMOTES INCREASE IN THE NASAL AIR FLOW VOLUME

Every day, Orthodontics turns to treat the individual as a whole. The occlusion, which was the main focus in the past, shares space with other aspects nowadays. The interrelationship of orthodontics with other fields of medicine has never been this usual. It is not uncommon, today, a patient being referred by an otolaryngologist, seeking to fix their respiratory problem. You might wonder, but how could I, being an orthodontist, improve the patient's breathing? Would not the otolaryngologist be responsible for this? It is already known that procedures performed by orthodontists can promote improvements in the respiratory status of our patients. Procedures such as maxillary expansion have been associated with these improvements. But would there be scientific proof for these attributes? In pursuit of these verifications, Turkish and American[5] researchers have developed a clinical study evaluating the effects of rapid maxillary expansion in the upper airway. The results showed that the rapid expansion of the maxilla creates a significant increase in nasal airspace, but this treatment did not significantly increase the oropharyngeal air volume (Fig 1). The results come to reinforce the importance of the orthodontist in the multidisciplinary treatment of patients with respiratory deficiency.

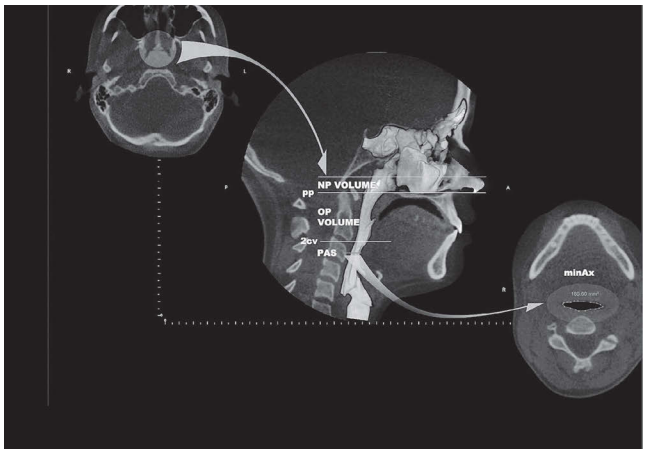


Figure 1 - Upper and lower limits of the oropharyngeal and nasal airway volume (NP), posterior airway space (PAS) and minAx (area of greatest narrowing at the base of the tongue). The circle on the left illustrates the last axial section before fusion of the nasal septum with the posterior pharyngeal wall. In the central image, the top line represents the axial section mentioned in the sagittal view (upper border of the NP). In the lower picture on the right, the area represents the PAS in axial view (pp = line through the palatal plane, 2cv = line passing (anterior-inferior) over the second cervical vertebra and parallel to pp). (Source: El, Palomo[5], 2013).

REFERENCES

1. Zhou Y, Long H, Ye N, Xue J, Yang X, Liao L, et al. The effectiveness of non-surgical maxillary expansion: a meta-analysis. Eur J Orthod. 2013 Jul 4. [Epub ahead of print].
2. Yagci A, Uysal T, Demirsoy KK, Percin D. Relationship between odontogenic bacteremia and orthodontic stripping. Am J Orthod Dentofacial Orthop. 2013;144(1):73-7.
3. Jose JE, Padmanabhan S, Chitharanjan AB. Systemic consumption of probiotic curd and use of probiotic toothpaste to reduce Streptococcus mutans in plaque around orthodontic brackets. Am J Orthod Dentofacial Orthop. 2013;144(1):67-72.
4. Kotecha S, Turner PJ, Dietrich T, Dhopatkar A. The impact of tooth agenesis on oral health-related quality of life in children. J Orthod. 2013;40(2):122-9.
5. El H, Palomo JM. Three-dimensional evaluation of upper airway following rapid maxillary expansion. Angle Orthod. 2013 Jul 18. [Epub ahead of print].

© 2013 Dental Press Journal of Orthodontics

Clarifications, guidelines and questions about the dental bleaching "associated" with orthodontic treatment

Alberto Consolaro[1], Renata Bianco Consolaro[2], Leda Francischone[3]

With regard to the best moment for carrying out or recommending dental bleaching to orthodontic patients, some explanations and orientations are given in order to answers the following questions: 1) Why orthodontic treatment completion is considered the best opportunity for carrying out the procedure? 2) Why dental bleaching should not be performed immediately before orthodontic treatment? 3) If that would be possible at any special case, what would that be? 4) Why dental bleaching should not be performed during orthodontic treatment? 5) If that would be possible at any special case, what would that be? This article highlights why it is essential to protect both the mucosa and the cervical region, regardless of the moment when dental bleaching is performed, whether associated with orthodontic treatment or not. The "how", "why" and "if" of whether or not it is convenient to perform dental bleaching before orthodontic treatment are still a matter of clinical suggestion, as it is a procedure that is under analysis, empirical knowledge waiting for scientific proof or disproof! Although tooth enamel has adamantine fluid flowing within it, providing a specific metabolism that is peculiar to its own and which could scientifically explain and base the option of carrying out teeth whitening before and during orthodontic treatment, we must still be very careful.

Keywords: Teeth whitening. Dental bleaching. Orthodontic treatment.

There was a time, before the 80s, when the orthodontist would perform tooth movement as well as malocclusion and esthetic correction only in young patients with all teeth, without prosthesis or implants, with completely healthy teeth and gingiva.

In addition to responding to functional and esthetic needs of patients of all ages and with different oral and systemic health conditions, the orthodontist has currently supported and helped with other types of oral rehabilitation treatments which vary in complexity.

During orthodontic planning, even before treatment onset, when patient's expectations and projections are still being surveyed, patients tend to question the clinician about when and how is the best moment for dental bleaching. White healthy teeth are an individual as well as a social need.

[1] Head Professor, FOB-USP. Professor of the Post-Graduation Course, FORP-USP.
[2] Professor, Adamantinenses Integrated Schools (FAI). PhD in Pathology, FOB-USP.
[3] PhD in Oral Pathology, College of Dentistry — Bauru/USP.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

How to cite this article: Consolaro A, Consolaro RB, Francischone L. Clarifications, guidelines and questions about the dental bleaching "associated" with orthodontic treatment. Dental Press J Orthod. 2013 Sept-Oct;18(5):4-10.

Submitted: July 04, 2013
Revised and accepted: July 10, 2013

Contact address: Alberto Consolaro
E-mail: consolaro@uol.com.br

© 2013 Dental Press Journal of Orthodontics

Generally, in clinical practice, dental bleaching must be performed prior to restorative and rehabilitative treatments, since such procedures are carried out on the basis of the color obtained from the bleaching technique. Teeth and lost spaces will be restored in harmony with all components of the future smile.

In Orthodontics, however, dental bleaching must be performed after the orthodontic appliance has been removed, except for specific cases with particular purposes.

Based on orthodontic treatment patterns, this article discusses the precautions, explanations and orientations related to the best moment for carrying out dental bleaching, as described in a previously published article[9].

After such discussion, we will explain about the basis on which companies and clinicians have recommended or indicated dental bleaching for patients undergoing orthodontic treatment.

WHY DENTAL BLEACHING SHOULD BE PERFORMED AFTER ORTHODONTIC TREATMENT?

After orthodontic treatment finishes, all crown surfaces are positioned, properly exposed and ready to uniformly receive the bleaching agent. Nevertheless, the initial results will not necessarily be uniform as some teeth may require additional application. This is due to the fact that not all teeth have the same color, just like the whole dental structure, especially the enamel, does not have the same volume, thickness and level of mineralization for all its elements.

In some cases, after the orthodontic appliance has been removed, the surfaces below the brackets may be irregular with regard to surface and color, and have resin fragments adhered to the enamel. These surfaces need to be evened with restorative abrasive procedures or remineralized in order to have uniform color and surface.

Moreover, after orthodontic appliances have been removed, some adjustments must be made to the oral environment. Focal and occasional gingivitis must be reversed and the dental plaque properly controlled. After two to four weeks, these adjustments may lead to an oral environment that is ideal for a more efficient and uniform dental bleaching. Dental plaque, calculus and resin fragments hinder the action of the bleaching agent on the enamel surface. Gingivitis weakens the gingiva in cases in which the bleaching agent accidently reaches its structure.

WHY DENTAL BLEACHING SHOULD NOT BE PERFORMED BEFORE ORTHODONTIC TREATMENT? OR IT SHOULD? WHEN?

In orthodontic treatment, teeth may be intruded or extruded, exposing areas previously covered by gingiva in case of malpositioned or unerupted teeth, a common situation for the maxillary canines. Should the procedure be carried out before orthodontic treatment, the areas covered by gingiva or touching other teeth will not receive the bleaching agent as the other areas will. Such areas are exposed after orthodontic treatment and may end up having a different color.

Bleaching agents are hydrogen peroxide-based acid solutions that act over the teeth.[2,6] They act over the enamel surface causing it to be more porous. Simultaneously or soon after bracket placement, an acid attack is required in order to allow the resin to adhere to the enamel when it is being placed on the dental crown, in which case the enamel below these surfaces may be structurally weakened. When brackets are removed, enamel splinters may be detached, harming its surface.

Resin restorations may present increased infiltrations due to the hydrogen peroxide demineralization action and infiltrating capacity. Thus, it would not be different between resin and bracket on the enamel surface, causing it to easily detach. Similarly, dental plaque bacterial acids tend to accumulate and remain active, causing white spot lesions underneath the brackets, especially if the patient is not careful with his own oral hygiene.

Exposed crown area, where the enamel is more porous, is more subject to stronger dental plaques due to greater mechanical retention caused by brackets and other orthodontic devices.

But, is it possible? When? The appearance of teeth may be generally improved at the first sessions of dental bleaching due to the cleaning efficacy of hydrogen peroxide which penetrates into the smallest recesses such as lamellas, splits or natural depressions and irregularities of the enamel. The pigments in these irregularities will be promptly removed at the first sessions of dental bleaching.

© 2013 Dental Press Journal of Orthodontics

Such an improvement may be motivating for the patient to withstand a long orthodontic treatment. However, it is worth noting that, for this purpose, the bleaching procedure must be brief and with a very specific aim. In addition, its application must be well controlled by a qualified professional.

Another reason for having dental bleaching performed before orthodontic treatment may be of professional nature, especially if we consider that the appearance often predominates over candidates' theoretical or philosophical content. In the case of photographic models and other professionals who depend on their image and exposure, white clean teeth are required. The same happens when the patient attends job interviews or other selection processes related to job or artistic opportunities.

WHY DENTAL BLEACHING SHOULD NOT BE PERFORMED DURING ORTHODONTIC TREATMENT? OR IT SHOULD? WHEN?

Pores and perikymata exposure on the enamel surface will not happen in a controlled and uniform way in the areas below the brackets, even if infiltration between the fixing resin and the dental crown is possible. Moreover, no studies have been carried out to investigate how the enamel and its respective structures as well as the physiology of areas below the fixed brackets act when subjected to bleaching agents.

The areas covered by gingiva or touching other teeth will not receive the bleaching agent as the other areas will. The risk of stains and irregularities in color and surface after brackets removal is high, and the cost-benefit relationship is not worthy in normal cases.

Resin restorations may increase infiltrations by hydrogen peroxide demineralization action and infiltrating capacity. Thus, it would not be different between resin and bracket on the enamel surface, causing it to easily detach. Dental plaque bacterial acids tend to accumulate and remain active, causing white-spot lesions underneath the brackets, especially if the patient is not careful with his own oral hygiene. Exposed crown area, where the enamel is more porous, is more subject to stronger dental plaques due to greater mechanical retention caused by brackets and other orthodontic devices.

But, is it possible? When? In specific cases, it may be necessary to improve the appearance of pigmented irregularities between the brackets, teeth and appliances, because since the first sessions of dental bleaching, the appearance of teeth may be generally improved due to the cleaning efficacy of hydrogen peroxide which penetrates into the smallest recesses such as lamellas, cracks or natural depressions and irregularities of the enamel.

A cleaner aspect of the orthodontic appliance may be a motivating factor for the patient to withstand a long orthodontic treatment. However, it is worth noting that, for this purpose, the bleaching procedure must be brief and with a very specific aim. When the purpose is to effectively bleach teeth with fixed brackets, it should be highlighted that the risk of stains and irregularities in color and surface after bracket removal is high.

Additionally, the bleached enamel may be weaker in structure. In normal cases, surface enamel is eventually removed when brackets are removed. However, it is unknown whether or not this situation increases in cases of bleached enamel.

Another reason for having dental bleaching performed during or before orthodontic treatment may be of professional nature, especially if we consider that appearance often predominates over candidates' intellectual and emotional content.

In the case of photographic models and other professionals who depend on their image and exposure, white clean teeth are required. The same happens when the patient attends job interviews or other selection processes related to job or artistic opportunities. The use of appliances alone may not affect the aspect employers expect from candidates, however, should they have healthy teeth, without dental plaque or pigmentation that give them an unpleasant appearance at smiling, they will not be restrained from being hired.

MUCOSA AND CERVICAL REGION PROTECTION: ALWAYS, REGARDLESS OF THE MOMENT!

Dental bleaching requires qualified professionals who are capable of performing the procedure on the patient. Protection of the oral mucosa and the cervical region of teeth is among the abilities the professional must have.[1,2,4,5-8] The cervical enamel is thin, with beveled thickness which irregularly and

© 2013 Dental Press Journal of Orthodontics

structurally relates itself to the cementum that covers the root. Along the cementoenamel junction, all permanent or deciduous teeth exhibit areas or gaps with dentin exposed to the oral environment.[4-7]

Exposure of dentin windows to the oral environment occurs when the cementoenamel junction "migrates" or is displaced from the gingival connective tissue to the groove due to migration or continuous and compensatory dental eruption mechanism of abrasion in the incisal edges and occlusal aspects.

When exposed to bleaching agents, the areas of dentin exposure and the dental tubules are widened.[6] These effects result in excessive and uncomfortable increase in dental sensibility after bleaching, which may result in unbearable discomfort for a few patients. Thus, protecting the cervical region which receives the bleaching agent during the procedure is essential. From a clinical point of view, the most efficient and practical form to do so is by means of resin protective cervical barriers,[4] however, other options may be used to protect the cervical region. Rubber sheets, for instance, which are used in restorative procedures and not widely used nowadays.

In addition to protecting the cementoenamel junction, the resin protective cervical barrier also protects the gingival mucosa against hydrogen peroxide-based bleaching agents.[2,4] Many researches reveal that hydrogen peroxide may promote chemical carcinogenesis of mucosa, including the oral mucosa.[1,8] Promoters of chemical carcinogenesis are those products that maximize the mutagenic effect of other agents and for this reason are considered carcinogenesis initiators. They are largely present in the mouth in the form of tobacco, herbicide, pesticide, alcohol, virus and many other substances.[1,8]

The resin cervical barrier protects the oral mucosa from receiving hydrogen peroxide provided that before it is removed, the dentist uses a specific type of suction tube to suck the gel or bleaching substance. It is advisable to cut the outer part of the disposable tip so that it becomes more efficient to suck the smallest portions of hydrogen peroxide present in the small recesses between the resin barrier and the tooth.[4]

The suction tube, or its disposable active part, that sucks saliva cannot be the same one that removes the bleaching agent as it will be contaminated by hydrogen peroxide and, thus, contaminate the oral mucosa. If the tube is not carefully used, there is no point in using the resin cervical barrier, which must be taken off only after all hydrogen peroxide has been removed. Should there be hydrogen peroxide left in the patient's mouth, he will swallow it and the substance will affect his gastrointestinal mucosa with the same potential carcinogenic effects.

HOW CAN WE UNDERSTAND THAT BLEACHING AGENTS POSSIBLY ACT ON THE ENAMEL SURFACE BELOW THE BRACKETS?

Some standard procedures are based on clinical observation that is, in general, a result of a venturesome procedure carried out on the basis of previous clinical processes employed in similar cases, aiming at broadening the horizons of clinical practice. After knowing about these "indications and results", researchers and scholars analyze the biological applicability and feasibility of procedures. How can we explain about the basis on which companies and clinicians have "recommended" or "indicated" dental bleaching for patients undergoing orthodontic treatment?

First, we need to understand the enamel as a living tissue. Tooth enamel is alive,[3] although it is commonly thought to be an inactive and amorphous tissue. Once the enamel is produced by the ameloblasts, it is formed by the rods, truly twisted and laterally connected beams. In cross section, the enamel rods are geometrically compared to a keyhole. Among the rods, there is an interrod sheath. Each rod is made up of millions of hexagonal crystals that may be compared to bricks or stones (Fig 1) among which the "adamantine fluid" flows.

In addition to taking part in the hydration process of each crystal, the adamantine fluid brings and takes ions from the enamel surface as well as from other parts of it. Due to the flow of adamantine fluid, the ions are incorporated into the enamel surface and may achieve its deepest parts, as it happens with the topic use of fluoride. This ion exchange allows enamel remineralization in the white spots caused by caries after external dental bleaching. At tooth eruption, the proportion of minerals between the deepest and surface enamel layers is similar, however, once it is exposed to the oral environment, the enamel surface becomes more mineralized and richer in fluoride.[1]

© 2013 Dental Press Journal of Orthodontics

The wavy enamel surface, or perikymata surface, exhibits development pores (Fig 1), millions and true depressions that represent the marks left by the ameloblast Tomes' process when the last layer of ameloblasts is deposited. Fluids and ions enter through the surface pores, renewing the crystals. However, these pores also allow that other substances, including undesirable ones, enter the inner parts of the enamel.

When bacterial as well as other acids enter the enamel via pores and adamantine fluid, they promote demineralization of crystals, dissolving them as an ice cube melts inside a glass, reducing its structure and altering its form. The intercrystal space will increase in size, therefore, increasing enamel porosity, allowing even more undesirable agents, such as bacterial acids and pigments, to enter. Many of these products or agents may reach the dentin or even the dental pulp. At this stage, in enamel decay still in the form of white spots, there are subtle and subclinical localized pulp alterations.[1]

The enamel is alive! When leveling, cutting, removing, smoothing, bleaching and chemically changing the enamel, one aspect must be borne in mind: we are working with a living tissue. Similarly to the care given to the dentin, and even more, to the pulp, one must be careful when working with the enamel.[1]

When external dental bleaching is finished, the enamel surface pores are more open; resin bonding is weaker; orthodontic appliances are more prone to detaching; and the splits more open. Should acids be applied to the enamel for technical purposes, it must be done only if necessary. Demineralized enamel areas exposed to the oral environment are more prone to incorporating pigments and allowing toxic products and acids to enter, thus, promoting alterations in color and increased sensibility in the affected tooth.

Similarly, one must be selective and demanding when indicating or recommending cosmetic products, dentifrices, antiseptics, eating habits and special care related to the teeth, since these aspects influence enamel porosity, composition and structure as well as the dentin and the pulp. The flow of adamantine fluid among the enamel crystals connects the dental surface with the dentinal fluid. What we do to the enamel reflects on the dentin and, in smaller proportions, on the dental pulp. This is due to the fact that not only tooth color depends on the dentin, but also because there is a specific flow within these tissues.[1]

Women, who are careful about their jewels, wash them with seawater, handling, caring and keeping their pearls at special places because they strongly believe that the pearls are alive! They do not expose their pearls to perfume; neither allow them to rub against other surfaces. They want to prevent their pearls from dying and, as a consequence, losing their brightness, vigor and fascination.[1]

Hydrogen peroxide is highly penetrative in enamel; perhaps, it is the most penetrative chemical substance in dental structures. Should it be applied on enamel nearby, to which a bracket is adhered, hydrogen peroxide may reach the enamel subsurface and, thus, bleach the area of enamel that is covered by the bracket (Figs 1 and 2).

However, we must be careful, since we do not know how the hydrogen peroxide flows through the adamantine fluid: Does it flow uniformly? The bleached surface would become irregular, would it not? What is the speed of the bleaching agent diffusibility? Would hydrogen peroxide extend to lateral areas when applied on a surface? Wouldn't the bleaching procedures performed on enamel below the bracket weaken it and cause splinters to be broken off the enamel when brackets are removed?

Why are these questions in this article? This "Insight" sections aim at suggesting, highlighting and instigating new researches that prove or disprove theories, confirming hypothesis and producing scientific knowledge on the basis of concrete data and evidence! The "how", "why" and "if" of whether or not it is convenient to perform dental bleaching before orthodontic treatment are still a matter of clinical suggestion, as it is a procedure that is under analysis, empirical knowledge waiting for scientific proof or disproof!

FINAL CONSIDERATIONS

The best moment to recommend dental bleaching associated with orthodontic treatment coincides with treatment finishing because that is when all dental surfaces are uniformly exposed. What had to be extruded, intruded or leveled, had already been.

It may be considered an option, not a rule, in some special cases, in which situation the patient's lifestyle must be taken into account. Some precau-

© 2013 Dental Press Journal of Orthodontics

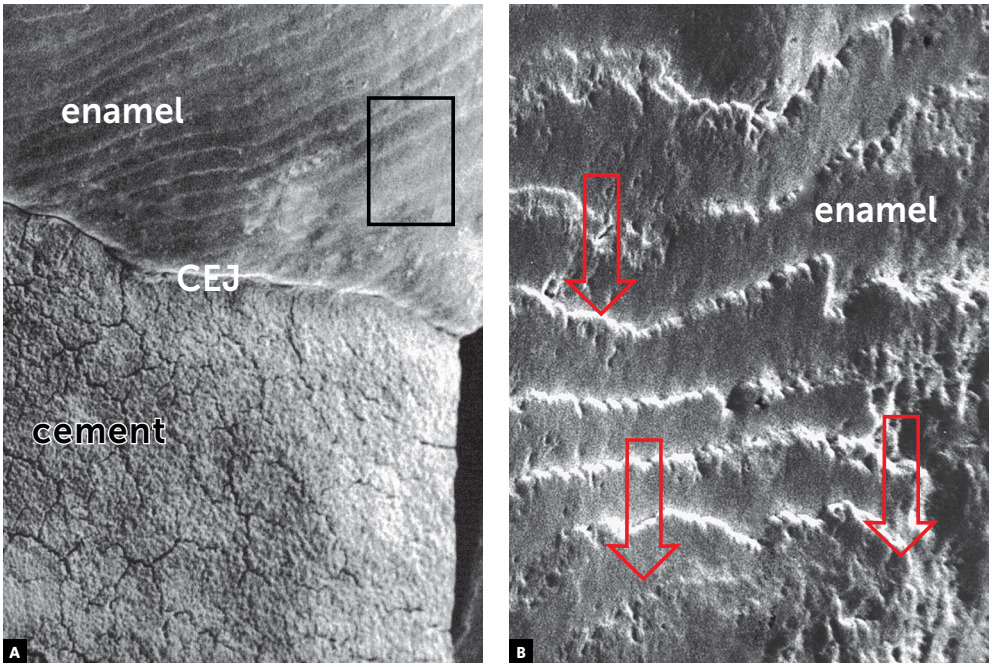


Figure 1 - Morphological aspects of human enamel surface in scanning electron microscopy: with perikymata, or wavy, and very porous. The cementoenamel junction (CEJ) is also observed. (SEM: 100x in **A** and 500x in **B**).

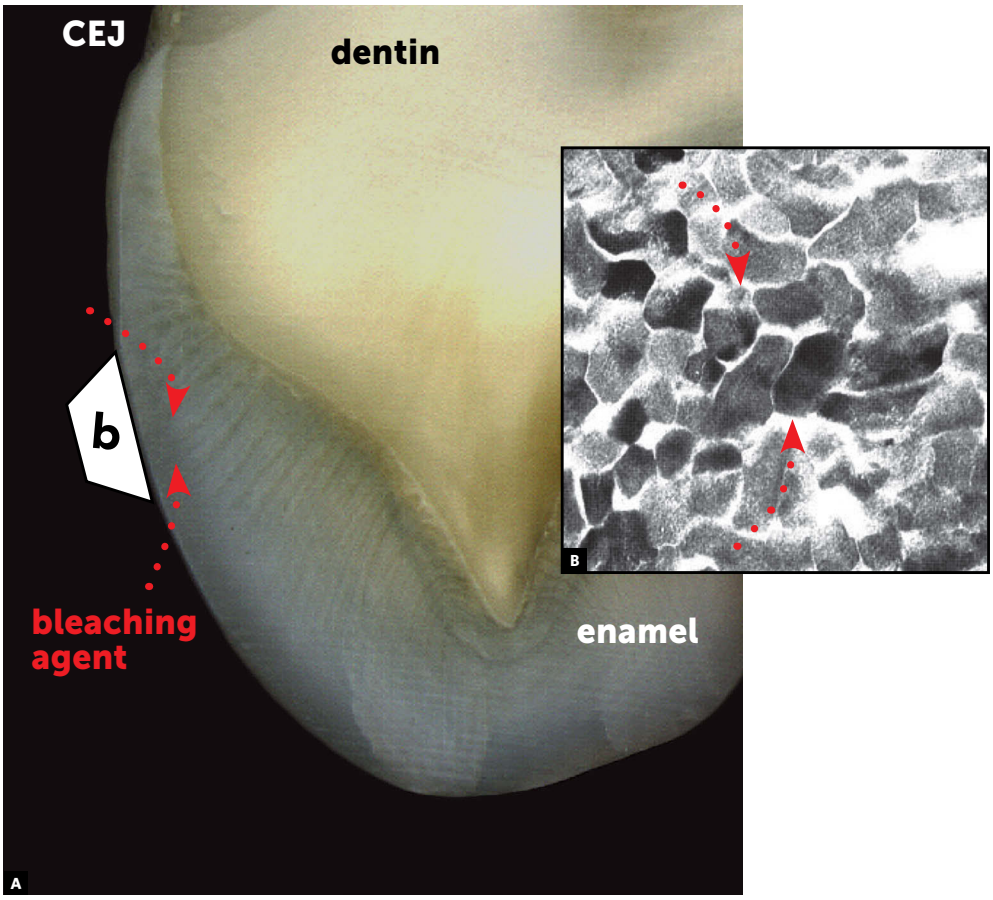


Figure 2 - **A**) Cross section of a human tooth. Morphological aspects of enamel surface and its relationship with the dentin and the cementum. (CEJ = cementoenamel junction). **B**) Transmission electron microscopy reveals the enamel crystals and the spaces where the adamantine fluid flows (arrows), which may carry the dental bleaching agent.

© 2013 Dental Press Journal of Orthodontics

tions and exceptions must be clarified when dental bleaching is exceptionally associated with orthodontic treatment before the latter is finished.

Frequent bracket detachment, white spots, loss of enamel color uniformity after orthodontic appliance is removed, retention of bacterial plaque and potential detachment of surface parts during brackets removal are among the consequences of dental bleaching associated with orthodontic treatment, due to the fact that bleaching agents promote enamel demineralization. Associating dental bleaching with orthodontic treatment is an exception that requires a lot of care and scientific knowledge. Additionally, it is of paramount importance that the patient knows about its potential risks.

It is worth noting that dental bleaching should always be performed by a qualified professional properly trained to act directly on the patient, always protecting the tooth cervical region as well as the oral mucosa with mechanical barriers — among which the resin barrier is the most widely used — in order to prevent the hydrogen peroxide from reaching the cementoenamel junction and its action on the oral mucosa.

The "how", "why" and "if" of whether or not it is convenient to perform dental bleaching before orthodontic treatment are still a matter of clinical suggestion, as it is a procedure that is under analysis, empirical knowledge waiting for scientific proof or disproof. Adamantine fluid flow in the dental enamel, with its own specific metabolism, may be the scientific basis to explain and justify the application of dental bleaching before and during orthodontic treatment. However, we must be very careful and wait for tests, results and evidences!

REFERENCES

1. Camargo WR. Análise do potencial carcinogênico de dentifrício com peróxido de hidrogênio e de agente clareador dentário. Avaliações clínico-macroscópica e microscópica em hamsters em modelo de carcinogênese bucal DMBA-induzida [tese]. Bauru (SP): Universidade de São Paulo; 1999.
2. Consolaro A. Reabsorções dentárias nas especialidades clínicas. 3ª ed. Maringá: Dental Press; 2012.
3. Consolaro A. Há vida no esmalte: metabolismo e circulação própria. Rev Dental Press Estét. 2004;1(1):123-7.
4. Francischone LA, Consolaro A. Clareação dentária externa: importância e tipos de proteção da junção amelocementária. Rev Clín Ortod Dental Press. 2005;4(5):88-98.
5. Francischone LA, Consolaro A. Morphology of the cement-enamel junction of primary teeth. J Dent Child. 2008;75(3):252-9.
6. Esberard R, Esberard RR, Esberard RM, Consolaro A, Pameijer CH. Effect of bleaching on the cemento-enamel junction. Am J Dent. 2007;20(4):245-9.
7. Neuvald L, Consolaro A. Cemento-enamel junction: microscopic analysis and external cervical resorption. J Endod. 2000;26(9):503-8.
8. Pieroli DA. Avaliação do potencial carcinogênico dos agentes clareadores dentais [dissertação]. Bauru (SP): Universidade de São Paulo; 1997.
9. Consolaro A, Consolaro RB, Francischone L. Clareação dentária e o tratamento ortodôntico: esclarecimentos e orientações. Rev Clín Ortod Dental Press. 2013 ago-set;12(4):114-9.

© 2013 Dental Press Journal of Orthodontics

Evidence-based Orthodontics: Has it something to do with your patient?

Fernanda Angelieri*

This section will be led in order to provide the clinician with support for comprehension and critical analysis of scientific articles, with elucidation of the main types of scientific studies, specific methodology and statistical analysis for clinical practice based in scientific evidence. The objective is to approximate clinician and science, easing the comprehension of the intricate scientific methods.

The scientific and technological innovation observed in the last decades in Orthodontics is undeniable. Obviously, we, orthodontists, want to offer the latest and most efficient treatment to our patients. However, how should our patients be submitted to these innovations? In other words, how should the orthodontist securely change the clinical conduct adopting new appliances, techniques or materials?

In recently published research, American orthodontists claimed to modify the treatment of their patients based, primarily, on the opinion of an expert, followed by consultation of published clinical cases, advice from colleagues and literature reviews, respectively. However, would it be wise to change the treatment of a patient based on the opinion of an expert?

In order to scientifically answer the clinical issues in Health, the concept of clinical practice based in scientific evidence initially appeared in Medicine, in the 90s.[2] It consists in the search and applicability of the best and most current scientific evidence, in order to contribute on the decision making about the care in Health.[3,4]

Nowadays, facing the substantial offer of information, the process of search and identification of the best and most reliable scientific results, capable to guide the evidence-based clinical practice, comprises both hierarchy of scientific articles and the adequate interpretation of these results.

According to the hierarchy of scientific evidence, the systematic reviews and meta-analyses are found at the highest level of scientific evidence (Fig 1). Differently from the traditional literature reviews, in which the choice of scientific articles depended fundamentally on the authors, on systematic reviews the selection of scientific articles uses a rigorous scientific methodology, that must be understandable and reproducible.[3] Moreover, a detailed analysis of the quality of the studies must be done, as well as an exhaustive search of all selected articles, according to strict inclusion and exclusion criteria, emphasizing the importance of the insertion of randomized clinical trials. When the results of these scientific studies selected on a systematic review can be grouped and statistically analyzed, this is a meta-analysis. Thus, the meta-analysis increases the general size of the sample and the power of the statistical tests, allowing better precision on the evaluation of the treatment effects.

How to cite this article: Angelieri, F. Evidence-based Orthodontics: Has it something to do with your patient? Dental Press J Orthod. 2013 Sept-Oct;18(5):11-3.

Submitted: July 29, 2013 - **Revised and accepted**: September 17, 2013.

* Associated Professor of the Methodist University of São Paulo.

Contact address:
Universidade Metodista de São Paulo - Secretaria da Faculdade da Saúde
Rua do Sacramento, 230 - Bairro Rudge Ramos
CEP: 09.640-000 - São Bernardo do Campo – SP, Brazil
E-mail: fernandaang@yahoo.com.br

© 2013 Dental Press Journal of Orthodontics

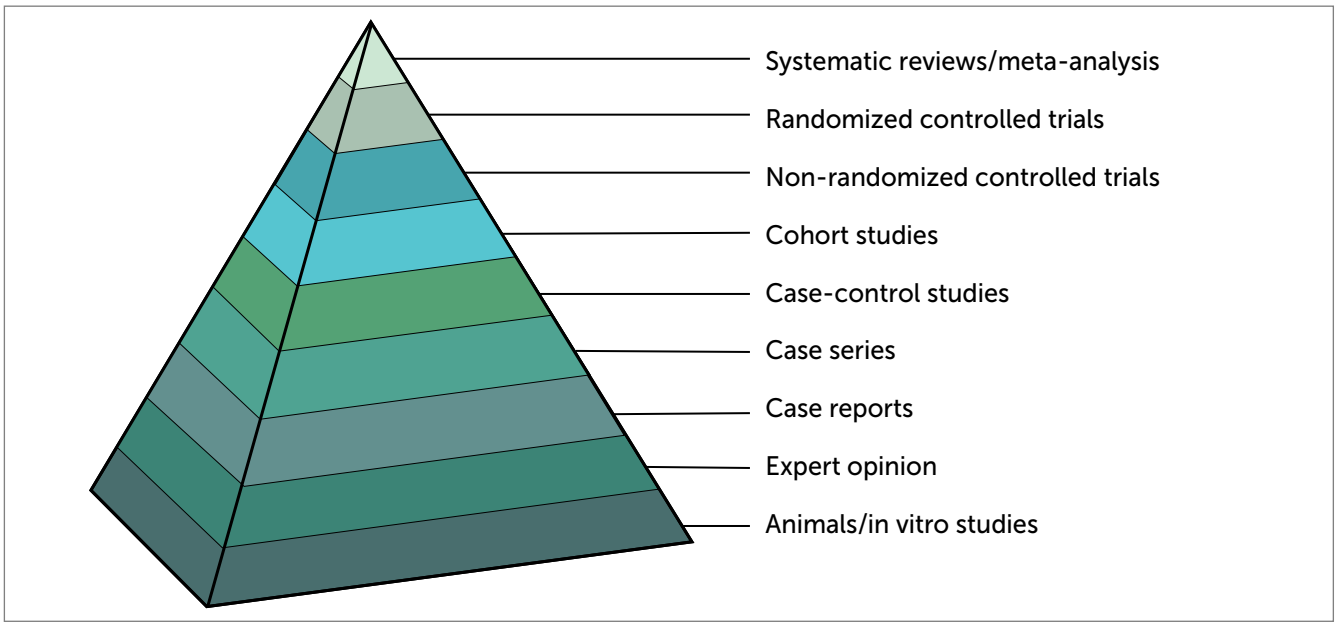


Figure 1 - Levels of scientific evidence in evidence-based Dentistry.

Additionally to the recent publication of several systematic reviews and meta-analysis in scientific orthodontic journals, there are non-profit scientific organizations designated to the production and distribution of systematic reviews in Health, such as The Cochrane Collaboration. These systematic reviews/meta-analysis can be obtained by accessing http://www.cochrane.org, in the Oral Health section.

The RCTs are considered the "gold standard" in therapeutic clinical studies. The randomization implies in random selection of individuals to compose the treatment and control groups, in addition to the random distribution of biases in the studied groups.[3] Biases consist in any variable that may affect the study results. The more biases in the study,the smaller is the scientific value. However, many times, ethical and logistics issues involved in the selection and composition of the treated group and control group prevent the randomization of clinical trials. Despite the lower scientific value, the non-randomized trials provide important results on the evaluation of therapeutic issues in Health.

In a lower grade in the hierarchy of scientific evidence are the cohort studies. Generally, the cohort study refers to the natural history of a disease, to its prognosis or etiology.[4] In this way, a group of individuals is observed over time and a certain risk factor will be evaluated in relation to its evolution and influence on the pathology's natural course. For example, a study evaluating the incidence of temporomandibular disorders (TMD) in individuals subjected to stress (risk factor) and not stressed, with initial absence of signs and symptoms of TMD.

The case-control studies consist in the comparison between two samples. One will present the analyzed pathology or characteristic and the other will not.[3] The correlation studies are considered case-control — for example, associating or not the lower inferior crowding with the presence or absence of lower third molars.

The case series — and, more specifically, the case reports — only demonstrate the ability of a single professional in treating one or more patients. Thus, this type of study not always reflects the reality of the use of a certain therapy when treating a patient randomly selected,[3] considering the great amount of uncontrolled variables present.

Although deeply settled in orthodontic environment, the opinion of an expert assumes one of the lowest levels of scientific evidence. This is due to the highly subjective[3] character implicit in the opinion, which generally includes the clinical experience of that professional, the acquired knowledge and

© 2013 Dental Press Journal of Orthodontics

personal and psychological experiences. However, we must remember that Orthodontics was built around great experts such as Angle, Tweed and Ricketts. Therefore, the opinion of an expert must be considered, but will only be valid as scientific evidence if proved by clinical trials, preferably randomized.

Despite the importance of studies in animals and *in vitro*, for certain topics of Orthodontics — such as, respectively, the evaluation of cytotoxicity and mutagenicity of materials used in Orthodontics or histological studies of orthodontic movement —, these studies comprise the lowest level of scientific evidence for clinical practice. This is due to the fact that they do not refer directly to the clinical reality.[4]

Due to the great amount and diversity of scientific studies, it is worth emphasizing that the intention of organizing them hierarchically aims at obtaining fast and efficient clinical response based in scientific evidence, by means of consultation of systematic reviews/meta-analysis. However, despite the recent publication of several systematic reviews on The Cochrane Collaboration and, specially, on scientific orthodontic journals, numerous clinical issues are still not totally answered by the systematic reviews/meta-analysis.[5]

Given this current panorama, it is extremely important to search for all these types of studies on the main available databases, as: MEDLINE (publicly available at www.pubmed.org), LILACS (Latino American and Caribbean literature in Health sciences, available at http://lilacs.bvsalud.org/), SciELO (Scientific Electronic Library Online, available at www.scielo.br) and Portal Capes (available at www.periodicos.capes.gov.br). In addition, not only the identification of the type of study assumes emphasized relevance, but also the adequate interpretation of methodological quality of scientific articles. In the era of evidence-based clinical practice, it is extremely important that orthodontists have a greater understanding about the complex research design and statistical analysis to effectively treat their patients in the new millennium.[6]

REFERENCES

1. Madhavji A, Araujo EA, Kim KB, Buschang PH. Attitudes, awareness, and barriers toward evidence-based in orthodontics. Am J Orthod Dentofacial Orthop. 2011;140(3):309-16.
2. Sackett D, Rosenberg W, Gray J, Haynes R, Richardson W. Evidence-based Medicine: what it is and what it isn't. Br Med J. 1996;312(7023):71-2.
3. Ruiz M. Evidence-based orthodontics or the paradigm shift. Int Orthod. 2011;9(1):1-19
4. Mariano MTS, Januzzi E, Grossmann E. Ortodontia baseada em evidência científica: incorporando ciência na prática clínica. Rev Dental Press Ortod Ortop Facial. 2009;14(3):107-13.
5. Delière M, Yan-Vergnes W, Hamel O, Marchal-Sixou C, Vergnes J. Cochrane systematic reviews in orthodontics. Int Orthod. 2010;8(3):278-92.
6. Law SV, Chudasama D, Rinchuse D. Evidence-based orthodontics. Angle Orthod. 2010;80(5):952-6.

© 2013 Dental Press Journal of Orthodontics

An interview with

Adilson Luiz Ramos

» Graduated in Dentistry, School of Dentistry - Bauru / University of São Paulo (USP) (1998).
» Resident in Orthodontics at the Hospital for Rehabilitation of Craniofacial Anomalies/ University of São Paulo (USP) (1989-1992).
» MSc in Orthodontics, College of Dentistry of Bauru/USP (1995).
» PhD in Dentistry (Orthodontics) College of Dentistry of Araraquara / State University of São Paulo (UNESP) (2001).
» Associate Professor at the State University of Maringá (UEM).
» Former Coordinator of the Post-Graduation program in Integrated Dentistry at the State University of Maringá (UEM), from 2008 to 2011.
» Former editor of Dental Press Journal of Orthodontics, from 2003 to 2006.

A long-standing friend. Twenty years ago, we started the Orthodontics program at the State University of Maringá, and I am still surprised by his huge cultural background, his ability to deal with problems and his endless concerns to avoid hurting people's feelings. Our students say that he knows everything from Quantum Physics to Statistics, from Microbiology to Physiology, from Bossa Nova to iPhones and iPads.

He was the editor of Dental Press Journal of Orthodontics between 2003 and 2006, and during this period, the periodical was indexed in SciELO, Scientific Electronic Library Online (FAPESP— Research Support Foundation of the State of São Paulo). We will be eternally thankful for his dedication which was essential to consolidate the periodical in an international scenario. He is a perfectionist orthodontist who has got a huge number of adult patients under multidisciplinary treatment. A researcher who carefully designs his works and advises his students. A professor who is greatly admired by his students and colleagues. A reference for any professor working at our institution. A passionate husband and a father who is absolutely dedicated to his two beautiful daughters. A friend for a lifetime.

Laurindo Furquim

How to cite this interview: Ramos AL. Interview. Dental Press J Orthod. 2013 Sept-Oct;18(5):14-31.
Submitted: July 10, 2013 - **Revised and accepted:** August 20, 2013

» Patients displayed in this interview previously approved the use of their facial and intraoral photographs.

© 2013 Dental Press Journal of Orthodontics

1. As a former editor of the Dental Press Journal of Orthodontics between 2003 and 2006, you were largely responsible for leveraging the high technical and scientific level of this journal, causing it to become one of the most important publications in the Orthodontics field. How do you currently perceive the DPJO and what is your opinion about the scientific quality of the articles published by Brazilian authors, inside and outside the country? (Marcio Almeida)

After you sent your question, we received great news about DPJO being indexed in MEDLINE. It would be quite rude, but I know that this piece of news would be enough to indirectly answer your question. Being indexed in MEDLINE means that DPJO currently fulfills the basic qualifications of an international journal! It is time to celebrate and everyone involved in the DPJO "process", including you as peer-reviewer and author of the journal, as well as readers, news designers, authors, reviewers, editors-in-chief and the entire staff of Dental Press led by Mr. Laurindo and Mrs. Teresa, deserves the glory of this achievement which is unique for the Brazilian orthodontists community. It has been 18 years of an ongoing course. Every editor-in-chief gave one step ahead towards quality standards, culminating in this new achievement. Between 2003 and 2006, we gave our contribution by means of indexing the journal in SciELO — which, at that time, meant national Qualis A, according to CAPES(Coordination for the Improvement of Higher Education Personnel) standards. Such process continued going towards qualification, inevitably influencing the quality of the articles and improving researchers' education. Thus, the process of accurately peer-reviewing well-designed researches has resulted in a "natural selection" in which the limited space available for a great demand caused readers to be reached by the best researches, only. To tell you the truth, this is a quite traumatic, but inevitable process. As in any human-dependable procedure, the process is influenced by different reviewers, which justifies fluctuation in article acceptance — what certainly may be unfair. But, that also happens to the best journals in the world. We know how unpleasant it is to have an article declined. At first, we get "angry" with the reviewers and/or with the editor, and feel they have been unfair to us. However, we end up converting it into an opportunity of growth. We have the chance to mature even more! After all, I am sure that we endeavor to carry out researches which are more focused on design (with new questions and without any gaps leading to negative point of view), since we want to see our works being published in notable journals such as the DPJO and other internationally qualified ones. Thus, after experiencing both sides for many years (as author, reader, reviewer and editor) I can clearly notice a significant increase in quality of Brazilian articles published inside and outside the country.

2. Taking into account that the smile is one of the main patterns through which patients evaluate the job performed by the orthodontist, what are the main finishing details that should be carefully looked at by the dentist? (Marcos Janson)

I believe that images mean more than words in this case. I would like to refer to the seven images comprising Figure 1 which are typically considered for frontal smile analysis.[16] It is important to highlight that, in general, the conditions required for an ideal smile take up slight deviations which can't be noticed by our limited human perception. Answers regarding questions 3, 4 and 5 supplement this answer.

3. Based on your previously published researches and your extensive clinical experience of smile esthetics during maxillary incisor retraction, how do you devise a proper plan for space closure in cases treated by means of dental extraction? Which important elements should the orthodontist consider in order to obtain excellent facial esthetics by the end of the treatment? (Marcio Almeida)

With regard to esthetic issues in extraction cases, the orthodontist should pay closer attention to the final position of maxillary incisors he intends to achieve after retraction, in which case the three planes of space must be considered. I believe this is the key to attain successful esthetics in any case, and not only in extraction cases. As you have clearly stated, extractions require special care regarding space closure, since that is what will establish labial profile and smile presentation[1] results. I always remind my students that "profile is affected by retraction, not extraction", in other words, it doesn't matter how space was obtained, the profile changes in accordance with what has been done to the incisors. Thus, in cases with severe lack of space, significant retraction won't be possible; therefore, the profile won't change.

In the anteroposterior plane, anchorage is planned

© 2013 Dental Press Journal of Orthodontics

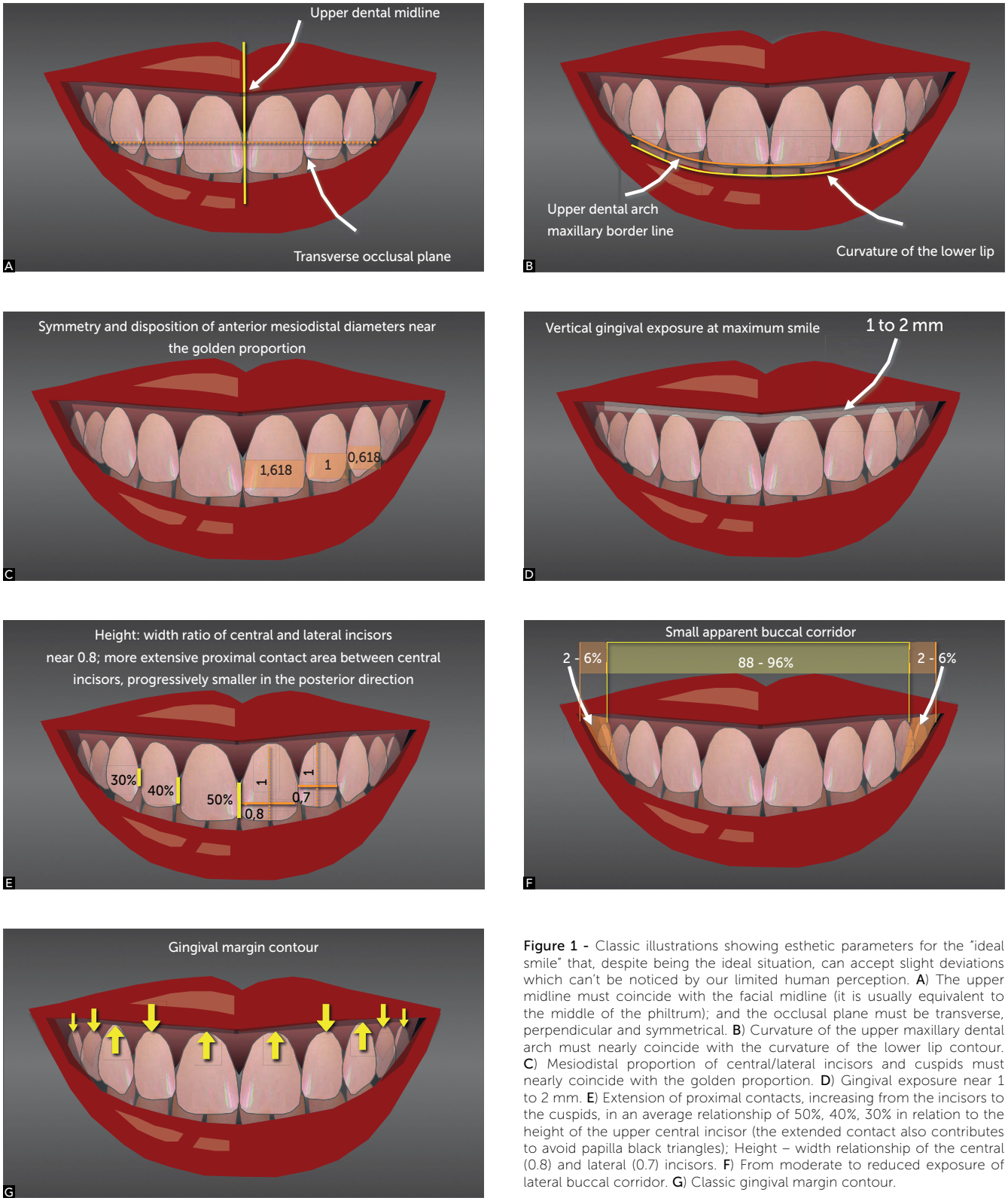


Figure 1 - Classic illustrations showing esthetic parameters for the "ideal smile" that, despite being the ideal situation, can accept slight deviations which can't be noticed by our limited human perception. **A**) The upper midline must coincide with the facial midline (it is usually equivalent to the middle of the philtrum); and the occlusal plane must be transverse, perpendicular and symmetrical. **B**) Curvature of the upper maxillary dental arch must nearly coincide with the curvature of the lower lip contour. **C**) Mesiodistal proportion of central/lateral incisors and cuspids must nearly coincide with the golden proportion. **D**) Gingival exposure near 1 to 2 mm. **E**) Extension of proximal contacts, increasing from the incisors to the cuspids, in an average relationship of 50%, 40%, 30% in relation to the height of the upper central incisor (the extended contact also contributes to avoid papilla black triangles); Height – width relationship of the central (0.8) and lateral (0.7) incisors. **F**) From moderate to reduced exposure of lateral buccal corridor. **G**) Classic gingival margin contour.

© 2013 Dental Press Journal of Orthodontics

according to the level of crowding, incisor inclination (protrusion) and the need of molar relation correction. The specialization course embraces such concepts which are practiced by means of dental VTO and cephalometric analyses. In short, we understand that the more crowding, protrusion and/or need of Class II correction, the more posterior anchorage we will need in order to retract the incisors. However, with the use of skeletal anchorage (mini-implants or mini-plates), this issue is no longer considered as a relevant technical, collaboration problem. On the other hand, despite being possible, complete retraction of the incisors occupying the spaces created by extraction will not result in satisfactory esthetical profile and smile. I agree with Andrews' statement (given during his speech at the 7th Dental Press International Congress, held in 2012) claiming that the best anteroposterior position of the maxillary incisors is the one which coincides with the vertical Glabellar line (LVV-Gb). In general, that allows the UL3 to be positioned 5 mm ahead of the true vertical line, resulting in a harmonious upper lip.[2] With this objective in mind, we need to anticipate the final position of the incisors and the impact they have on the lip. According to one of our researches published in the *Angle Orthodontist*[15] in 2005,every millimeter of incisors retraction (when analyzing the cervical point instead of the incisal point, only), will cause the lip to move 0.7 mm backwards. Therefore, with a 5 mm incisors retraction, we may expect 3.5 mm of upper lip retraction. It is worth noting that we are talking about the cervical point (which is more predictable for this correlation) and not about the incisal point (Fig 2) because in incisor retraction, in which inclination is controlled and fulcrum is located close to the apex, a 7 mm movement in the incisal region may represent 2 mm in the cervical region, thus, causing the lip to retract 1.4 mm (70% of correspondence to this point). And, in translatory movement, for instance (in cases which incisors do not present buccal inclination and need root torque control), a greater proportional impact is expected on lip profile.

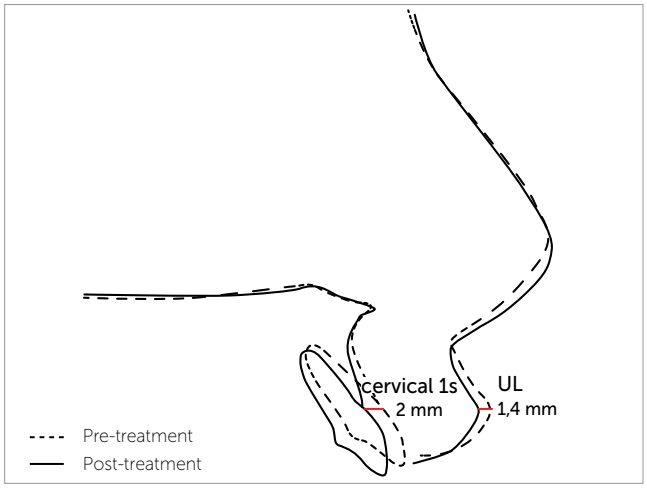


Figure 2 - The impact of upper lip movement caused by retraction of the upper incisors is strongly correlated with the cervical region of the upper incisors and corresponds to a mean retrusion of 1.4 mm for every 2 mm of retraction at this point (nearly 70% of correspondence for this point). The incisal point presents weaker correlation with lip movement.[15]

In the vertical plane, it is essential that we establish how much incisor exposure the patient needs when smiling. When incisors are retracted with controlled inclination (fulcrum of apex movement) there will be relative extrusion. In other words, even if the apex doesn't extrude, incisal exposure will increase. In addition to relative extrusion, real extrusion of anterior teeth may occur depending on the mechanics used. Therefore, we must consider the amount of overbite as well as the extrusion occurring during the closure phase. In that case, the use of *cantilevers* or overlay intrusion arches, with or without mini-implants, for example, may be able to control that.[1] In an esthetically pleasing smile, exposure between 2 and 4 mm at rest and 10 and 12 mm on maximum smiling is expected (considering a medium height of 10 mm for the central incisors, with 0 to 2 mm of gingival exposure (Fig 1D).[16] Maxillary incisor exposure is sometimes welcome and necessary to achieve appropriate smile line and exposure (See questions 2, 4 and 5), in which case lower intrusion performed with *cantilevers* and overlay arches may be necessary to promote upper extrusion.

In the transverse plane, we classically managed the position of the upper midline in relation to the facial midline, the occlusal plane lateral inclination and the transverse arch dimension. Although the aim was to even the midline with the facial midline, many researches have stated that slight deviations (between 2 and 3 mm) pass unnoticed and have little influence over smile esthetics.[9,12] In fact, deviations are tolerated in many aspects of an ideal smile.[9,12,21] The occlusal plane must be perpendicular to the facial midline (Fig 1A), and this is an unanimous point with regard to esthetics,

© 2013 Dental Press Journal of Orthodontics

since it is perceived not only by the lay public, but by professionals as well.[9,16] During retraction (especially if mini-implants have been placed at different heights on each side), we need to pay closer attention to the height of the hooks in order to avoid inclination of the anterior transverse occlusal plane. With regard to transverse arch dimension, especially in four extraction cases, it may have some influence over the appearance of the buccal corridor after space closure. However, torque correction as well as good arch diagram, expansion and coordination are able to circumvent that. It is worth noting that well-performed premolar extractions followed by appropriate mechanics and incisor position control does not have any deleterious effects on smile or profile. On the contrary, if they have been recommended, in general, they are necessary to achieve esthetic objectives.

4. Based on your scientific, professional and teaching experience, which clinical recommendations would you give regarding bracket bonding on upper anterior teeth, with the aim of maximizing smile esthetics? (Daniela Garib)

Strategically and carefully bonding the brackets is essential to achieve satisfactory occlusal results and an esthetic smile. With regard to the smile arch or the smile line, the orthodontist should pay closer attention when placing the brackets in order to favor a symmetric lower lip smile line. Most of the times, this will automatically occur, since in usual cuspid-to-cuspid bonding the brackets are further from the incisal than from the posterior segment. Thus, bracket height ("x") is greater in the anterior area when using both the center of the crown and placement guide tools "x" as reference (Fig 3). However, this rationale may be disregarded when facing a case of deep overbite, in which case, in the attempt to favor vertical correction, brackets are incisally placed. In this case, upper incisor intrusion (relative or complete) may influence the final esthetic result. In addition to the smile line, occlusal plane inclination plays an essential role in smile appearance. Mesial occlusal plane inclination is usually between 5° and 8° in relation to the ground (or perpendicular to LVV). This will allow gingival exposure in the permanent first molar region to be slightly less than gingival exposure in the central incisor region. Should this plane be at 0°, molar exposure tends to be greater than incisor exposure, and should it be at 8°, it tends to be less than incisor exposure, which isn't usually esthetic. This variation depends on each patient's facial pattern and lip elevation (commissures *versus* anterior tubercle) and must be adjusted individually. A smile in which both tubercle and commissures equally raise seems to be more esthetic. Skeletal anchorage and association with orthognathic surgery are usually necessary to achieve these aims.

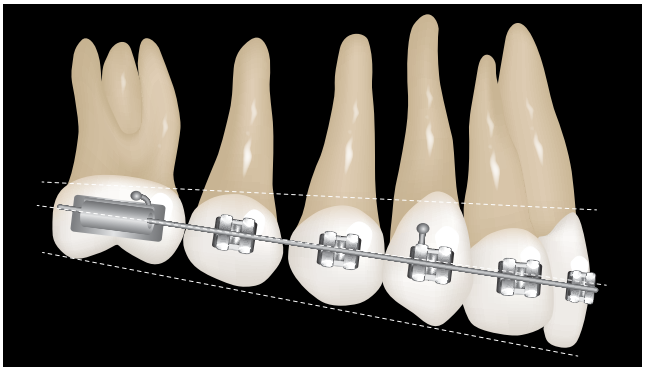


Figure 3 - The bracket bonding height ("x") follows a line that progressively increases from posterior to anterior, which favors a greater exposure of the upper incisors at smile, in addition to correct inclination of the occlusal plane.

I would like to take the opportunity to express my respect and gratitude to all your colleagues and professors from the University of São Paulo, School of Dentistry - Bauru (FOB/USP) to whom I owe my graduate, as well as my Masters degree, especially Professors Guilherme Janson, Marcos Roberto de Freitas, Fernando Castanha Henriques, Renato Rodrigues de Almeida, Arnaldo Pizan and Décio Rodrigues Martins (*in memoriam*).

5. In one of your editorials published in the Dental Press Journal of Orthodontics, you pointed out that beauty and self-image appreciation have influenced Orthodontics. You have stood out from the crowd for your studies on the smile and the impact that extractions have on facial profile. Thus, I would like to know which parameters you consider important for facial and smile esthetics which can promote our patients' better self-esteem, and how can we achieve them in our treatments? (Ary dos Santos-Pinto)

With regard to smile esthetics, I have focused on the effects of aging and on potential strategies we can employ to minimize its impacts. Thus, in addition to the basic criteria considered for a harmonious smile, which I have previously mentioned, strategies concerning deep

© 2013 Dental Press Journal of Orthodontics

overbite correction and mandibular crowding are of particular interest, since these occlusal alterations increase with aging. You have expressly mentioned such points in the Clinical Tip (*Dica Clínica)* section of the Dental Press Clinical Journal of Orthodontics (*Revista Clínica de Ortodontia Dental Press)*.[18,19] In brachyfacial or mesofacial patients, usually adults, upper incisor exposure is already small. Therefore, from an esthetic point of view, it is better to intrude the lower incisors or extrude the posterior teeth (or both) in order to achieve vertical correction. This will allow maintenance or increase in upper incisors exposure, which results in a more jovial smile. As for dolichofacial patients, the decision must be determined in accordance with vertical exposure, in which case the upper incisors and/or the lower ones may be intruded, when necessary (however, posterior extrusion is contraindicated). Despite extractions, we must deal with the vertical role the incisors play in the smile as well as in the anteroposterior direction, as previously mentioned in question 1. Figures 4 to 7 show a case in which deep overbite was corrected by means of lower incisor intrusion associated with extrusion of posterior teeth, aided by a TMA cantilever and an occlusal splint, which allows appropriate incisor exposure and anterior arch curvature to be preserved. Additionally, it has been proven that transverse dimension decreases with aging, which also makes us think about including recovery of posterior tipping in treatment planning, thus, assuring better posterior exposure when smiling. In general, the esthetic conditions shown in Figure 1 must be the aim of any orthodontic treatment in order to minimize the effects of aging.

Figure 4 - Initial photographs presenting the anterior region of the smile arc in accordance with the lower lip contour, as well as good vertical exposure. Occlusal aspect demonstrating accentuated overbite in a case with agenesis of four premolars.

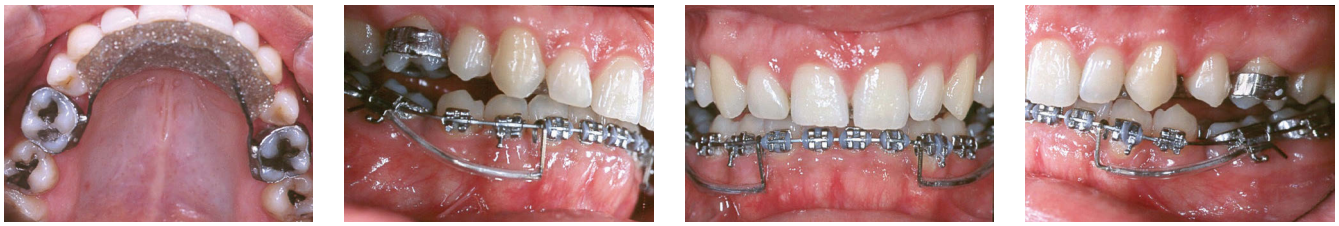


Figure 5 - For overbite correction, an anterior fixed bite plate was used during three months, followed by a removable plate (used at night for 6 months), which facilitated extrusion of the posterior segment and intrusion of the lower anterior teeth performed with two TMA cantilevers combined with a Niti 0.018" x 0.025" wire.

Figure 6 - Partial correction, demonstrating vertical control (anterior superior brackets were avoided at an early stage due to trauma identified at treatment onset, which favored the strategy used for vertical correction, focused on the mandibular incisors and lower posterior extrusion.).

Figure 7 - Smile at the end of treatment demonstrating a preserved contour, exposure of upper anterior teeth and intraoral aspects after orthodontic correction.

© 2013 Dental Press Journal of Orthodontics

6. On analyzing one of your research lines, we have noticed an increasing interest in using fluoride and fluoride-varnish releasing sealants to inhibit or interrupt demineralization affecting patient's tooth enamel underlying the orthodontic brackets. I would like you to comment on the *in vivo* clinical effectiveness of such products which you have been studying along with Dr. S. Jay Bowman, one of the greatest names in world Orthodontics. What should we expect from a near future? What are the most recent evidences concerning remineralization of white spots on the enamel after orthodontic treatment? (Marcio Almeida and Daniela Garib)

I am glad you have mentioned Dr. Jay Bowman's name. I thank him because we started on this line of research after he went to the 1st Dental Press International Congress, held in the city of Maringá, in 2001, during which he instigated us to research about the effects of fluoride varnish. From that point onwards, we developed many *in vitro, in situ* and *in vivo* researches with fluoride materials, aiming at lessening the negative effects of demineralization caused during the use of fixed appliances.[5-8,13,20] Good oral hygiene is still the best way to avoid decalcification, however, due to the fact that many patients have difficulties in keeping it during the whole orthodontic treatment, 50% of them end up presenting some degree of demineralization.

Most patients may have these minor lesions remineralized after orthodontic treatment has finished; however, cases in which they remain are still very common and may not only evolve into cavity, but also affect esthetics. For this reason, it is reasonable to take some supplementary measures which do not depend on the patient, only. If applied every three months, fluoride-varnish at 5% (Duraflat®, Duraflor®, among others) has demonstrated a reduction of 40 to 50% on demineralization, lessening its severity and avoiding its lesion. Fluoride sealants (Opal-Seal®, UltraSeal®) have proved to be similarly effective in *in vitro* studies; however, they may leave some microscopic surfaces or cracks uncovered, allowing demineralization of the enamel to occur.[8] Furthermore, it is hard to imagine that surfaces such as the proximal areas will be completely covered. Resin sealants do not release fluoride; therefore, they do not present the advantages of the material they are made of (glass ionomer cement, varnish, solutions, gel). However, reduction in viscosity of new products, such as the ICON® which is considered as infiltrating, allows treatment of white spots and results in relative color stability.[11] Furthermore, still regarding preventive issues, some researches have also demonstrated reduction of 40 to 50% with products containing CPP-ACP (casein phosphopeptide - amorphous calcium phosphate). I have recently tutored a Masters degree student whose thesis shows promising preventive and remineralizing effects, except for the *in situ* study carried out with Dessensibilize Nano-P® (FGM). It is a compound made of nanometric calcium phosphate (in the form of hydroxyapatite), sodium fluoride (9000 ppm) and potassium nitrate. It is recommended to be applied once a week in the first month, with monthly reapplications, if necessary. In addition to these materials, resin glass ionomer cement, used for bonding brackets (FujiOrtho® and similar ones), may reduce prevalence of white spots from 40 to 50 %[14]. However, the great incidence of bracket falling off when resin glass ionomer cement is used may be considered as an operational problem. In a near future, I believe that these materials will be improved (both the adhesives and the regular-application ones) so that they can be used especially for higher risk cases, thus, eliminating the side effects caused by orthodontic treatment.

7. What do you suggest younger patients do, especially those with poor oral hygiene, in order to prevent decalcification of enamel during orthodontic treatment? And what would be the most appropriate treatment after calcification has already occurred? (Marcos Janson)

Usually, orthodontic patients receive instructions on oral hygiene before bracket bonding, besides being motivated at every section. However, although they know that the best thing to do is to have good oral hygiene, we observe that patients have difficulty in systematically keeping it during orthodontic treatment. Therefore, in the most serious cases, I apply fluoride-varnish (Duraphat®) every three months, which is considered a simple method. The procedure includes prophylaxis (only the gross plaque needs to be removed), relative isolation (with oral retractor), drying and varnish applied with a *microbrush,* especially in gingival and proximal surfaces. Afterwards, the retractor is removed and the varnish layer is left to coagulate by saliva, which turns out to be light-yellow (Fig 8). Patients are advised not to brush their teeth within the next 12 hours.

In addition to varnish, I occasionally use glass ionomer cement reinforced by resin (Fuji Ortho® LC) for bracket

© 2013 Dental Press Journal of Orthodontics

bonding in cases presenting white spots before orthodontic treatment onset. In addition, glass ionomer cement is used to cement the bands. It has the potentiality of protecting the proximal surfaces to where it is applied.[14] Despite all the care, white spots may occur. Therefore, some clinical measures may be taken in order to treat or minimize the effect of those lesions, as follows:

1) Monitor the lesions by means of implementing prophylaxis and monitoring oral hygiene, supplementing it with low concentration fluoride (0.05%) applied on a daily basis. Occasionally, associate it with dental bleaching procedures in order to mask fluorosis.
2) Remineralizing agents, such as the CPP-ACP (Mi-Paste®) and Desensibilize® Nano-P, applied once a week during the first month and once a month afterwards.
3) Microabrasion (pumice + phosphoric acid at 37%, 20 sec) followed by fluoride gel at 1% (1 min).
4) Infiltrant resins (ICON®) and resin fluoride sealants (Pro-Seal®, Ultraseal®).

The sequence presented above may vary according to lesion severity and esthetic effect. Thus, in less severe cases, the procedure must be more conservative, as in options 1 and 2. Should these options fail, 3 and 4 must be carried out. Recently, low-viscosity infiltrant resins have proved to be clinically effective to treat such lesions, with an optic effect that is similar to a healthy enamel.[11]

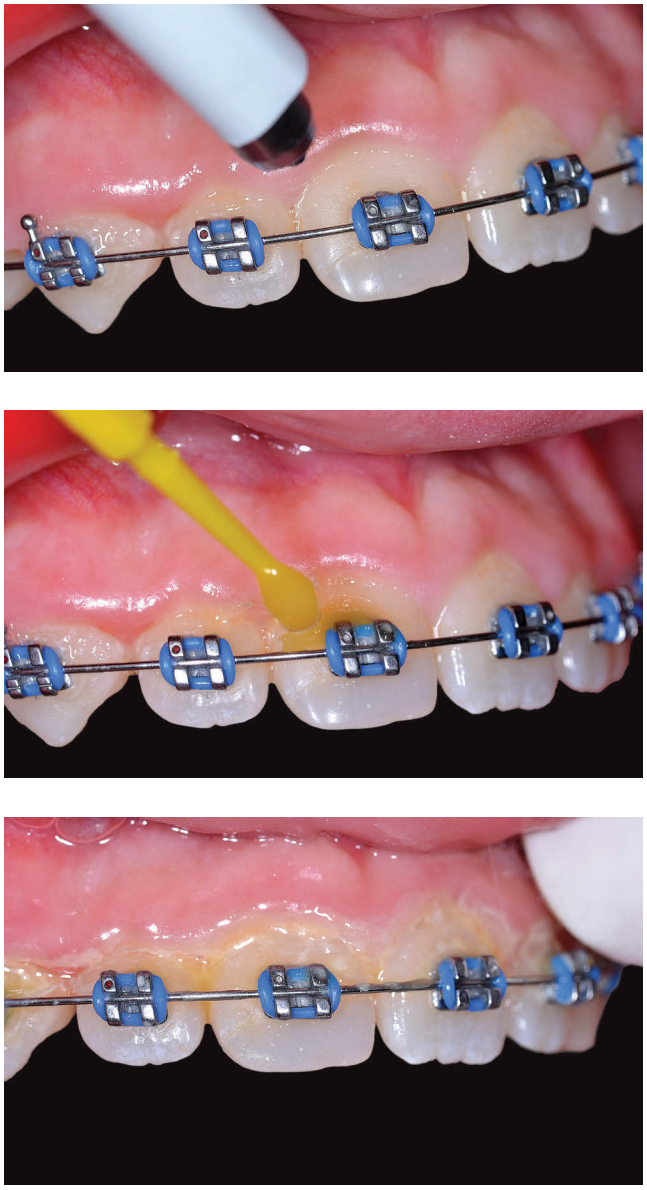


Figure 8 - Topical fluoride varnish application must be carried out every three months and consists of a simple procedure involving biofilm removal (prophylaxis), drying, varnish application and coagulation by saliva. The final aspect is light yellow. Tooth brushing should be avoided within the first 12 hours.

8. Do you believe that there has been a decrease in demineralization of enamel during orthodontic treatment in association with an increase in the number of patients with fluorosis and who are cavity-free? What would you recommend regarding the application of fluoride varnish in cases of demineralization of enamel around the orthodontic bracket, one of the themes of your line of research? (Ary dos Santos-Pinto)

Although the most recent researches have pointed out that demineralization of enamel is frequent during orthodontic treatment, in fact, we have noticed that it has decreased in the last 10 or 15 years of our clinical practice. Frequent use of glass ionomer cement for banding, motivation for brushing (with fluoride toothpastes) and supplementation with topical fluoride may explain the decrease in white spots lesions. However, this issue is still a problem! There are still patients who do not cooperate with hygiene. As you have highlighted, some younger patients come to us cavity-free, but with associated fluorosis or not with enamel hypoplasia. Patients presenting different characteristics intrinsic to the enamel may also suffer from superficial or subsuperficial demineralization during treatment, due to difficulty in removing dental plaque, as we have already discussed in questions 6 and 7 in which we mentioned the varnish application protocol. Figure 9 shows an ordinary case of a patient with hypoplastic spots and subsuperficial lesions worsened after orthodontic treatment.

© 2013 Dental Press Journal of Orthodontics

9. Could you comment on the effects the segmented arch technique had on your education as an orthodontist, when you went for the PhD degree at State University of São Paulo (UNESP) in Araraquara? Which aspects of the technique have you frequently used in your clinical activity and what do you consider to be important when teaching this treatment philosophy?
(Ary dos Santos-Pinto)

Being exposed to the concepts of the segmented arch technique was, undoubtedly, a privilege for my education. Orthodontic mechanics is no longer mysterious once the segmented arch concept has been understood. Although conventional cases have been mainly treated with the Straight-Wire technique, I apply the segmented arch for molar uprighting (Figs 10 to 13), anterior intrusion, root correction loop, *cantilevers* to pull unerupted teeth and geometries for the palatal bar and the lingual arch. These techniques greatly facilitate the evolution of treatment, avoiding undesired side effects on adjacent teeth. Understanding the segmented arch mechanics also enables us to clearly see the effects of forces applied in cases of skeletal anchorage. I am certain that segmented arch concepts must be included in orthodontic education. I would like to publicly thank you and other illustrious professors who were part of my education during the PhD course taken in Araraquara: Tatsuko Sakima, Maurício Sakima, Dirceu Raveli, Luiz Gandini, João Gonçalves, Joel Martins (*in memoriam*).

10. During your orthodontic education, as a trainee, you performed treatment in cleft lip and palate patients with craniofacial anomalies. How did this experience influence the procedures and conducts you have employed during your professional life in patients with no anomalies?
(Daniela Garib)

I worked at the Hospital for Rehabilitation of Craniofacial Anomalies/USP between 1989 and 1992. Hundreds of words would be necessary to express how much it influenced my education. Let me mention a few. In the orthodontic field, I had the pleasure to count with Professors Omar Gabriel da Silva Filho, Leopoldino Capelloza Filho, Reinaldo Mazzotini, Terumi Okada and other colleagues from the Orthodontics Sector, as my first and greatest professors. What I learned there went beyond my orthodontic practice with cleft patients and/or those with anomalies. I also have to mention the opportunity I had to be in touch with Dr. Luiz Alberto de Souza Freitas (Uncle Gastão) who I also would like to thank for his advice, leadership and friendship. I can say that not only the professional experience I acquired there, but also the human conduct I was exposed to have strongly influenced my education. At the Hospital for Rehabilitation of Craniofacial Anomalies/USP, I witnessed a unique dedication of those who were involved with patients (experts, technicians and staff members of different areas and levels). And this is essential to have a successful clinic or institution. Professional integration and team work are key to success as well. At that hospital, I began to understand how necessary that was and started to develop real interdisciplinary plans. Perhaps, one of the greatest lessons I have learnt was about respecting patients' ambitions (their chief complaint) and limitations. Even though we intend to make changes and corrections in order to achieve perfection, we have to admit that Genetics is often implacable in limiting our interventions. And the latter are routinely practiced in any clinic!

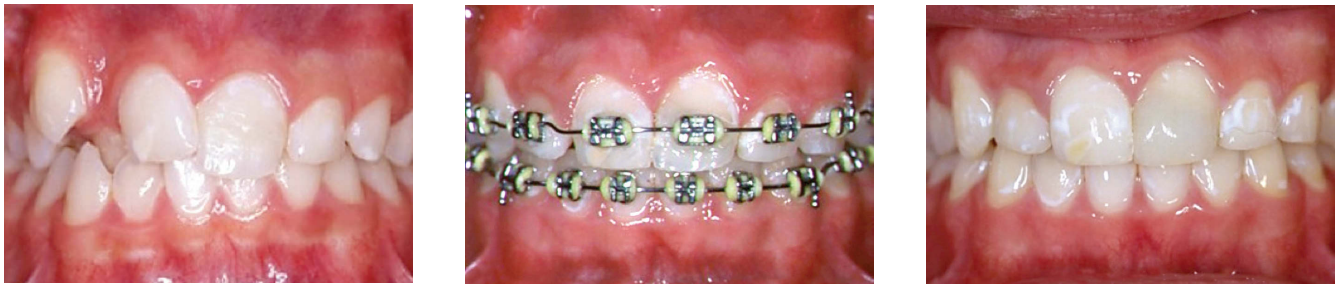


Figure 9 - Trans and post-treatment initial aspect of a patient with enamel hypoplastic spots and white spots worsened after orthodontic treatment.

© 2013 Dental Press Journal of Orthodontics

Figure 10 - Class III malocclusion, with loss of mandibular first molars and accentuated mesial angulation of second molars towards the space, in addition to absence of #12 and root damage of #22.

Figure 11 - The use of a statistically undetermined system, with a TMA wire connected to the cross tube in the anterior region, allowed controlled second molars uprighting, which resulted in movement of the anterior block favoring the use of Class II elastics associated with mechanics of upper posterior segment mesialization.

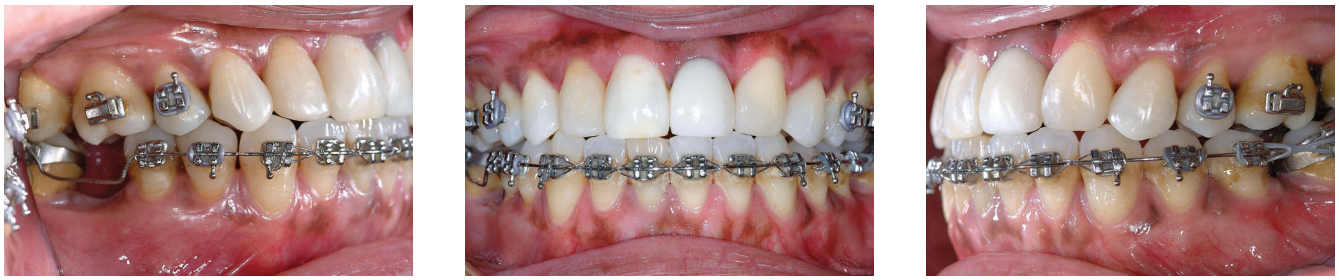


Figure 12 - Occlusal aspect after molar uprighting. Implant space, prosthesis in the #46 ("third pre-molar") and space closure in the #36 region were kept. The upper fixed appliance was partially removed in order to allow restoration/reshaping of upper anterior teeth. The canines were placed in the position of the upper lateral incisors. Orthodontic treatment was immediately resumed.

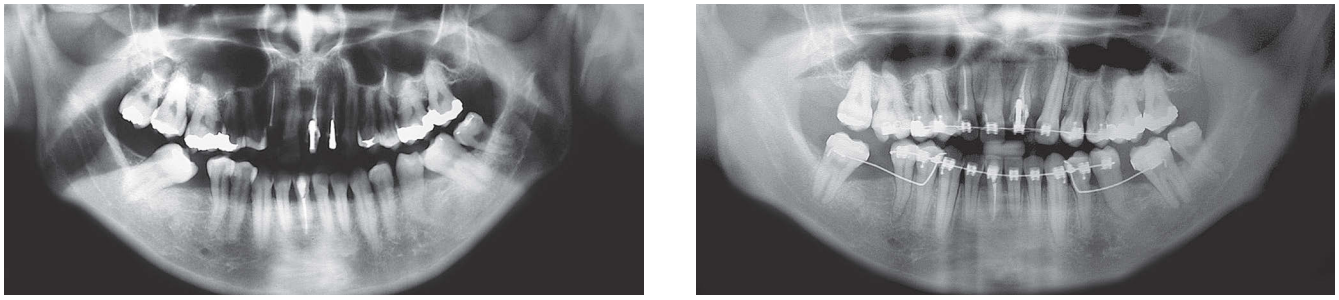


Figure 13 - Panoramic images taken before and after molar uprighting carried out by means of segmented mechanics.

© 2013 Dental Press Journal of Orthodontics

11. Many adults have sought orthodontic treatment, especially in Implantology and Orthodontics. For this reason, these patients' bone condition has become a relevant aspect for treatment planning and therapy. I know you have developed some researches in this area. Therefore, I would like to know more information about this subject and how we can apply them in our daily practice. (Ary dos Santos-Pinto)

As orthodontists, we have actively participated in rehabilitation plannings which must be carried out in an integrated manner before any specialty begins their own intervention. Thus, my colleagues from the Prosthesis, Periodontology, Cosmetic Dentistry, Surgery and Implantology fields and I have helped with the decision making process concerning the attachment of prosthetic components (over implants or not), extractions, ridge points that can be improved, space distribution and possibilities of vertically handling occlusions, among others. Many issues regarding rehabilitation have become a thing of the past, for instance, angulated abutments which used to be solved by means of abrasion on dental structures or making angulated nuclei. Uprighting as well as obtaining better spaces can be easily performed by Orthodontics. Increasing the vertical dimension of occlusion as well as intrusion of posterior and anterior teeth are some other possibilities that allow new prosthetic-restoration plannings. These possibilities have been improved with skeletal anchorage and allow more accurate predictability. I also would like to highlight both vertical and horizontal tooth movements performed to recover the alveolar bone, which facilitate our job.[10] The vertical movements, which have been performed for a long time, are, for example, root extrusion to recover biological distances and extrusion, which may be followed by extraction for leveling the alveolar ridge. Movements performed on the edentulous ridge, however, are no longer considered as a model, although further studies prove to be necessary to understand the maintenance after insertion of retracted teeth or predictability of alveolar dimensions caused by movement. We have recently advised some researchers who developed a study showing that there is an average loss of 1.5 mm in the adjacent crest due to movement. However, the overall bone gain is clinically relevant not only in the buccolingual direction, but also in the alveolar height, thus being superior to such little crest loss.[17] Thus, the contribution given by Orthodontics has been decisive to reduce the need of grafts (or its area) and, more advantageously, the predictability of the ridge height where the implant will be placed. Figures 14 to 28 show some of these situations.

12. Based on the development of the Digital Age in Orthodontics (3D analysis, dental casts, CBCT), the paradigm shift in orthodontic diagnosis with emphasis on the face, reappearance of lingual Orthodontics and self-bonding brackets, skeletal anchorage, removable aligners as well as surgical and non-surgical resources for speeding up tooth movement, what do you expect for Orthodontics in the next few years? (Marcio Almeida)

I believe we can say that this is a self-answering question. The great innovations you mention have taken the orthodontic practice to a higher degree of predictability and esthetics, which has been more and more accepted by our patients. The increasing demand of adult patients for orthodontic treatment stimulates innovations in many respects and integration among areas enables the achievement of satisfactory results. I believe that among the trends you have mentioned, the non-surgical resources performed to speed up tooth movement (the use of local medication, for example) and a more comfortable and practical appliance design may cause treatment to be even more accepted by patients in the next few years. If we think how popular the use of mini-implants has become to facilitate mechanics, and if we ponder patients' high acceptability with regard to Botox injection for transitory esthetical effects (used in Dermatology and cosmetic procedures) we can see that local mediators injected in areas of tooth movement may become feasible options to speed up or hinder movement, in addition to contribute to tissue regeneration in damaged areas, increasingly interacting with other specialties. So many innovations, which will always occur, have consolidated the idea that in addition to excellent specialty education, we need to count on a continuos update regarding the new technologies, thus offering even better options to our patients. This makes orthodontic practice even more exciting!

© 2013 Dental Press Journal of Orthodontics

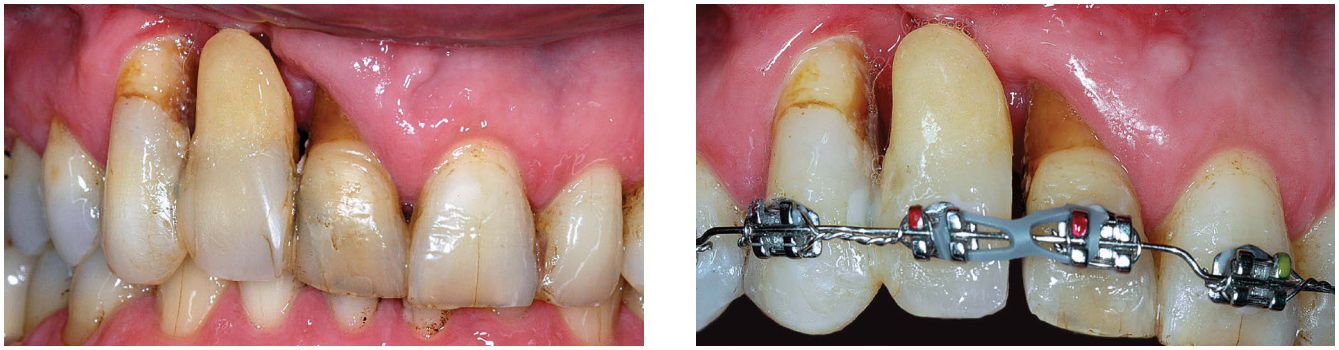


Figure 14 - Initial photographs of a case with accentuated bone loss in the #12, with a history of three unsuccessful graft attempts. Smoking and lesion extension may have contributed to such lack of success.

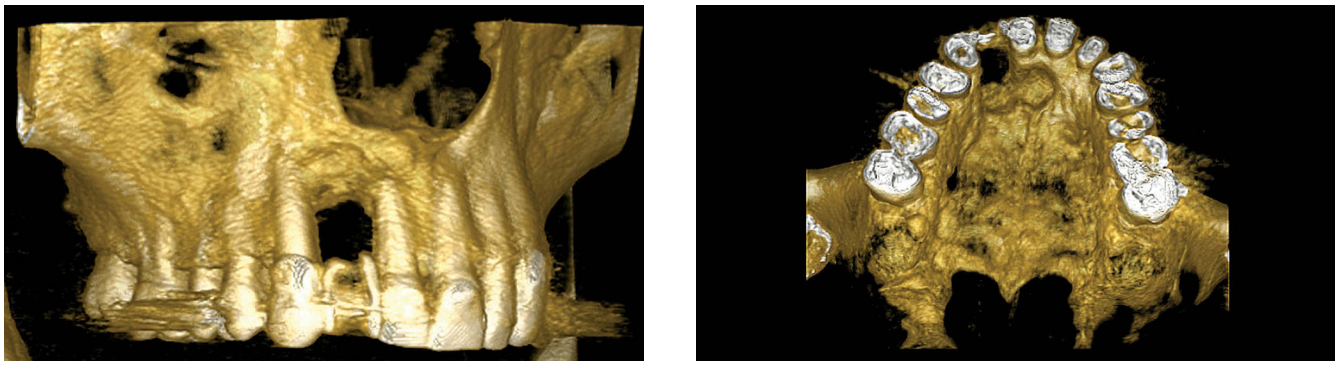


Figure 15 - Tomographic reconstructions of areas with bone loss.

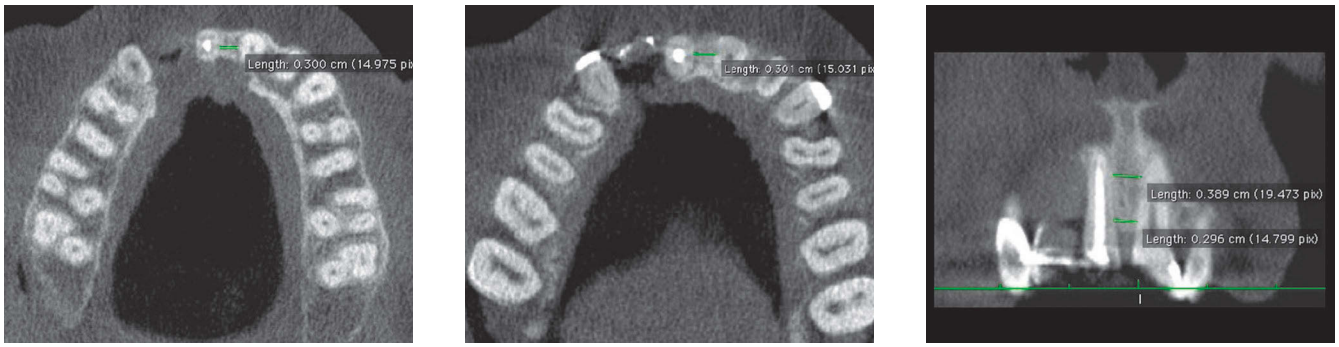


Figure 16 - Tomographic slices of the inter-radicular distance between central incisors, taken before treatment. Nearly complete absence of bone tissue mesially to #11, however, with its structure distally preserved.

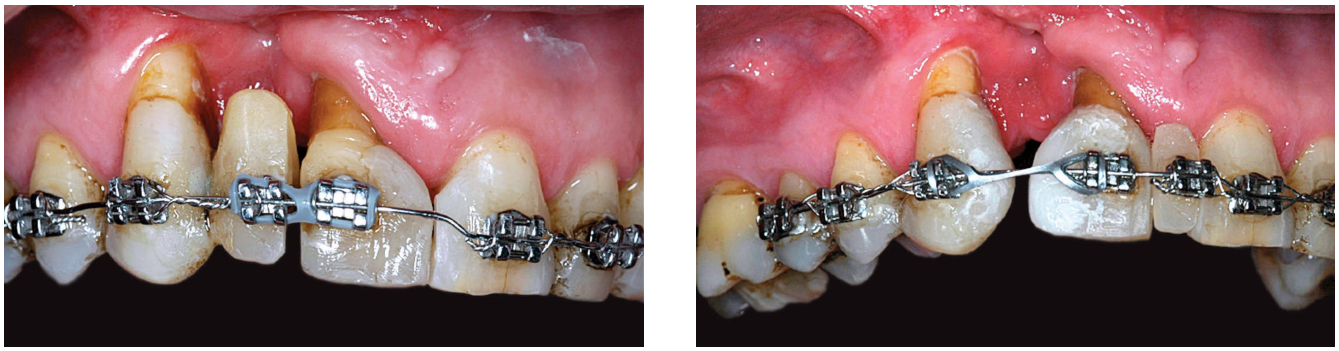
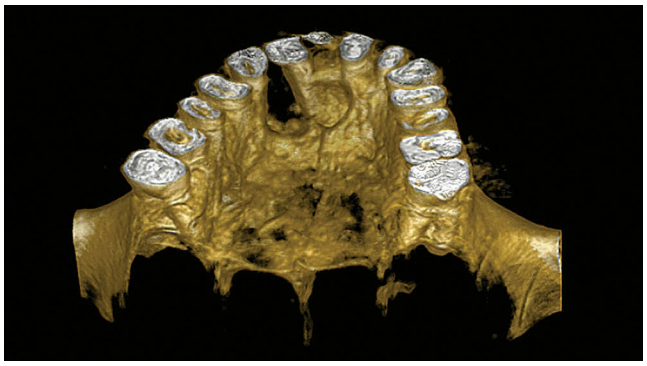


Figure 17 - Beginning of #11 movement towards the affected site.

© 2013 Dental Press Journal of Orthodontics



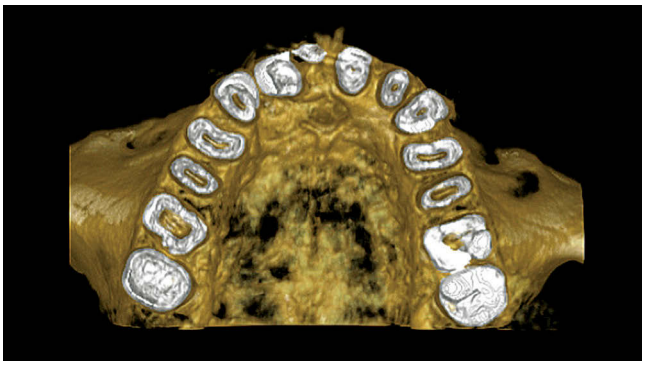
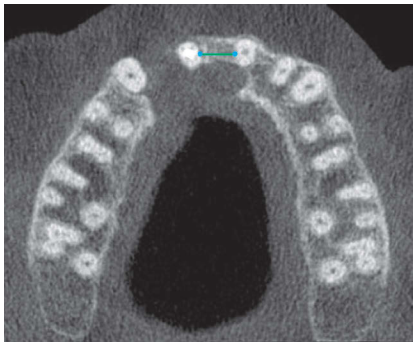
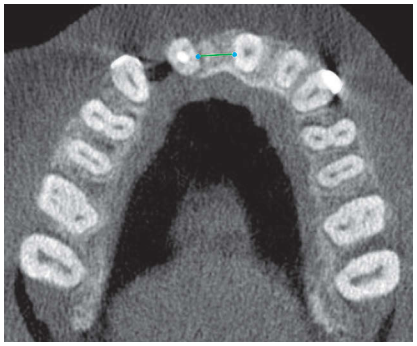


Figure 18 - Tomographic reconstructions after #11 was distalized in place of #12. Despite crown angulation, significant bone gain was observed, preparing the site for implant placement in the #11.





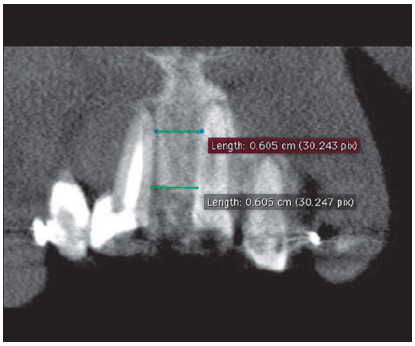


Figure 19 - Tomographic slices demonstrating appropriate space (both vertical and horizontal) for implant placement, taken after treatment.

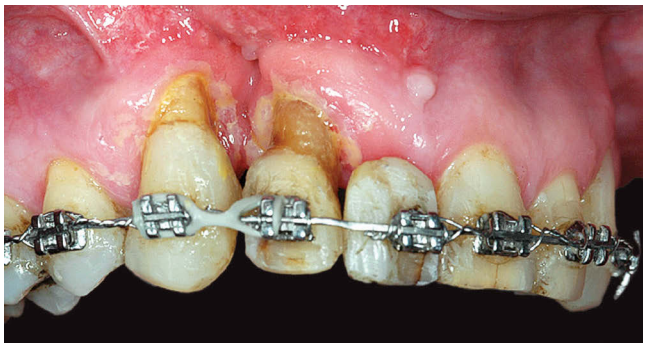
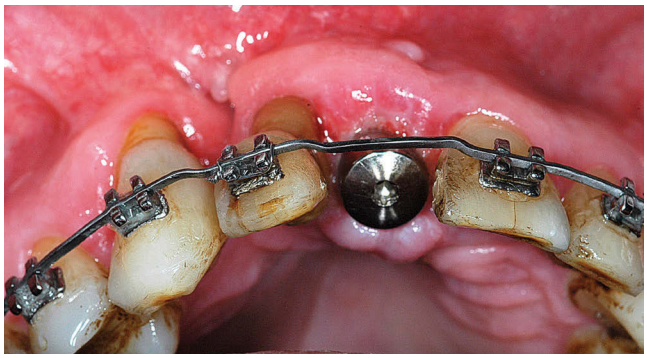


Figure 20 - Clinical aspects of the affected area demonstrating improvements in the area with bone loss, in addition to alveolar displacement for the #11.



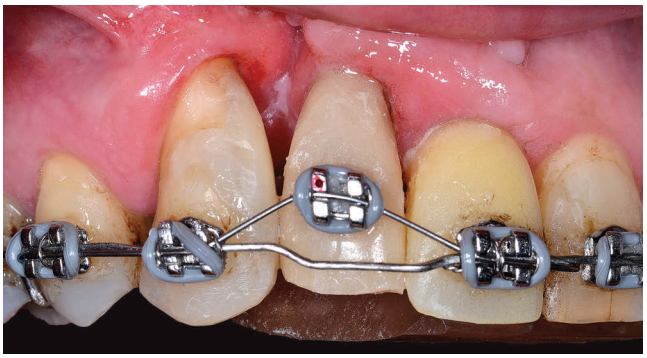


Figure 21 - Implant placement in the #11 region. After new restorations and provisory placement over the central incisor were performed, #12 was extruded a little more in order to obtain vertical bone gain and partial improvement in gingival margin.

© 2013 Dental Press Journal of Orthodontics

Figure 22 - Photographs taken after the orthodontic appliance had been removed, when the patient was referred to periodontal reevaluation and feasibility of bone graft in the bone loss area. The affected site is evident, as can be seen in the radiographs, despite the significant reduction resulting from the treatment and the feasibility of implant placement in #11.

Figure 23 - Intraoral photographs of a case with unusual distal migration in the #45, and atrophic edentulous ridge in the left mandibular posterior segment.

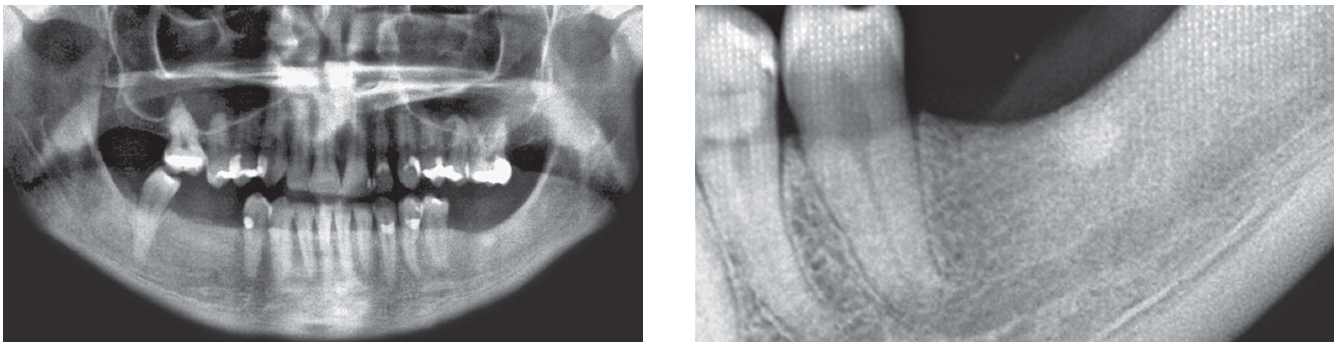


Figure 24 - Panoramic and periapical radiographs of the #36 demonstrate alveolar vertical reduction.

© 2013 Dental Press Journal of Orthodontics

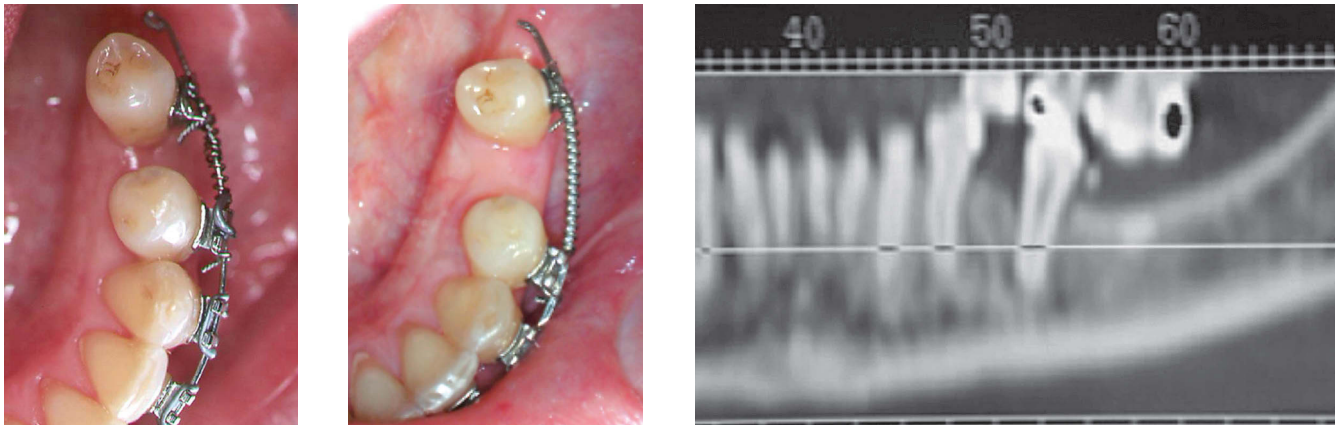


Figure 25 - Orthodontic treatment aimed at distalizing #35 in order to promote alveolar recovery prior to prosthesis placement over the implant. The tomographic slice taken after distalization demonstrated bone quality good enough for rehabilitation.

Figure 26 - Intraoral aspects after orthodontic correction and implant placement.

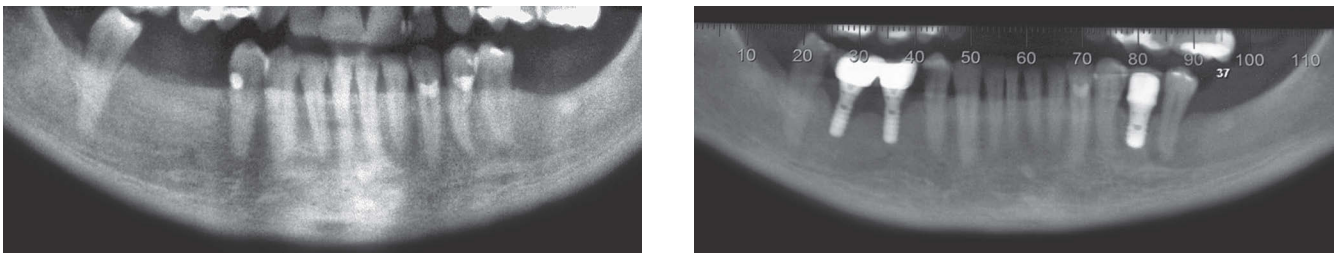


Figure 27 - Tomographic slices before and after treatment.

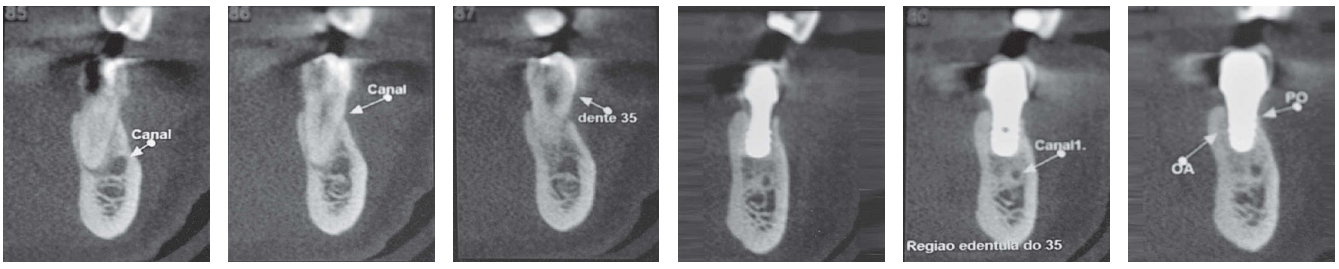


Figure 28 - Tomographic slices before (in the #35) and after (area equivalent to #35) implant placement.

© 2013 Dental Press Journal of Orthodontics

13. Taking into consideration the skeletal maturity at the end of adolescence, and being aware of the little orthopedic gain after this period, what is your opinion about the rapid increase of mandibular advancement appliances in adults? In which cases would these therapies be indicated and contraindicated? (Marcos Janson)

We have routinely indicated mandibular advancement appliances for growing patients (the removable ones, which depend on patient's cooperation, or the fixed ones, which are more efficient in this case). We are aware of the effects at this age: little increase in mandibular growth while the appliance has been used, upper incisor lingual inclination and lower incisors buccal inclination, distalization of upper posterior segment, increase in the anterior lower facial height (ALFH) and little clockwise inclination of the occlusal plane. For these purposes, these effects depend on the facial pattern, and it is the least indicated for dolichofacials due to the direction in which the skeletal effects occur (CoGn and ALFH). Such changes are convenient until skeletal maturity is achieved, as you have mentioned before. However, during adulthood, we can expect dental effects, only, with minimum or no skeletal results. The advancement appliances (APM, Herbst, Jasper Jump, Forsus, etc.) must not be considered as options to replace orthognathic surgery. Therefore, we first have to assess the level of skeletal discrepancy (which must be small) and preliminary compensation in Class II cases. Should there be too much lower incisor buccal inclination, the mandibular advancement appliance is contraindicated, since it will result in even greater inclination — which is non-esthetic for lower lip evertion, and dangerous for submitting the buccal bone plate to overload and occasional resorption, with gingival recession as a consequence. This danger, in particular, is worrying even for young patients. Gingival health must be continuously assessed. A thin gingival biotype and/or the absence of attached gingiva (keratinized) reveals a higher dehiscence risk and potential gingival recession in view of buccal inclination. A Cone Beam Computed Tomography may give us an idea of the amount of bone tissue that is in the buccal root surface of those teeth. In borderline cases, connective tissue graft or free gingiva graft may be indicated to protect the area before tooth movement is performed. Thus, I would say that one must be careful when using mandibular propulsion in adult patients. The skeletal anchorage (mini-implants or mini-plates) may be used to avoid side effect risks when performing tooth movement, only. Therefore, it seems reasonable to indicate the mandibular propulsion for Class II adult patients in cases in which the lower incisors are not excessively buccally inclined, there is little skeletal discrepancy, good periodontal support with a gingival thick biotype (or with graft) and a good facial pattern (meso or brachyfacial). In addition, I indicate intermaxillary anchorage for non-activated mandibular propulsion, in cases of mesialization of lower molars.

14. As a certified member of the Brazilian Board of Orthodontics and Dentofacial Orthopedics, which are the most important criteria you think we should consider when analyzing the orthodontic finishing of clinical cases? What advice do you give for those who intend to apply for the Brazilian Board of Orthodontics and Dentofacial Orthopedics exam? (Marcio Almeida)

That certainly was an enhancing experience! I was encouraged by Dr. Ademir Brunetto, from Curitiba/PR, who is a great supporter of the exam and of our class as well, to apply for the BBO exam in early 2012. I am deeply thankful to Dr. Carlos Jorge Vogel and Dr. Deocleciano Carvalho for their support and endeavor, as well as to many other members of the BBO College of Diplomates (CDBBO). I have to confess that the little time I had between applying for and taking the exam (around three months) was a huge challenge. Thus, my first piece of advice is: start making plans at least one year before the exam. My second piece of advice is: take the preparatory course given by the CDBBO during the congresses held by the Brazilian Dental Association. With the course, the candidate is able to get acquainted with the analyses carried out in the exam, the criteria used to select the cases, based on the complexity degree index (IGC),[3] and the criteria for case finishing evaluation, based on the grading system used by the American Board of Orthodontics[4] (both articles are available in the link *Extras* on the website http://www.bbo.org.br). Both case difficulty criteria[3] and case finishing criteria[4] are a strict clinical challenge. The presented case must be considerably difficult (three cases with IGC higher than 20 and three with IGC higher than 10).

© 2013 Dental Press Journal of Orthodontics

At least one case must involve extractions and only one case involving orthognathic surgery may be included. Once the cases with the least required difficulty have been selected, they must present excellence in finishing, highlighting: accurate alignment, posterior teeth inclination (torque), intercuspation, anteroposterior relationship, overbite and overjet. All these items have a score scale based on the BBO standard ruler (used in the USA as well). Thus, the candidate is able to know how much he is going to score while presenting his cases. All of this is possible if the candidate presents flawless case records, prepared according to the BBO criteria (instructions are available on the website). As clinicians, we often "accept" records that, in fact, we should return to the centers to be written again. Taking this exam makes us rethink our tolerance criteria with regard to inaccurate records. I have to confess that the analysis of some case records, which I would like to take to the BBO, made me realize that such cases did not meet the criteria because the model trimming or the photos were not adequate, among others. So, my third piece of advice is: care for and demand a perfect patient record. It also makes us rethink about those cases in which we often speed up the treatment, without caring for minor details, due to patient's demand (those who do not hesitate to ask: "When am I going to remove the appliances?"). As it has been mentioned many times by the BBO, and to which I strongly agree, "Passing the BBO exam does not make us better than anyone else, but it makes us better than what we were before." I strongly support this initiative which not only brings many benefits to our profession, but also adds value to it as well as to our patients.

REFERENCES

1. Almeida MR. Ortodontia clínica e biomecânica. 1a ed. Maringá: Dental Press; 2010.
2. Arnett GW, Jelic JS, Kim J, Cummings DR, Beress A, Worley CM Jr, et al. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. Am J Orthod Dentofacial Orthop. 1999;116(3):239-53.
3. Cangialosi TJ, Riolo ML, Owens SE Jr, Dykhouse VJ, Moffitt AH, Grubb JE, et al. The ABO discrepancy index: a measure of case complexity. Am J Orthod Dentofacial Orthop. 2004;125(3):270-8.
4. Casko JS, Vaden JL, Kokich VG, Damone J, James RD, Cangialosi TJ, et al. Objective grading system for dental casts and panoramic radiographs. Am J Orthod Dentofacial Orthop. 1998;114(5):589-99.
5. Demito CF, Rodrigues GV, Ramos AL, Bowman SJ. Efficacy of a fluoride varnish in preventing white spot lesions as measured with laser J Clin Orthod. 2011;45(1):25-9; quiz 40.
6. Demito CF, Vivaldi-Rodrigues G, Ramos AL, Bowman SJ. The efficacy of a fluoride varnish in reducing enamel demineralization adjacent to orthodontic brackets: an in vitro study. Orthod Craniofac Res. 2004;7(4):205-10.
7. Demito CF. Efeito da nano-hidroxiapatita associada ao fluoreto na prevenção da desmineralização do esmalte adjacente aos braquetes ortodônticos: " estudo in situ" [dissertação]. Maringá (PR): Universidade Estadual de Maringá; 2013.
8. Dias CS. Efficacy of a fluoride sealant and a fluoride varnish on demineralization around orthodontic brackets: in vitro study. Orthod Pract. 2013;4(4). In press.
9. Janson G, Branco NC, Fernandes TM, Sathler R, Garib D, Lauris JR. Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness A systematic review. Angle Orthod. 2011;81(1):153-61.
10. Janson MRP. Ortodontia em adultos e tratamento interdisciplinar. 1a ed. Maringá: Dental Press; 2008.
11. Knösel M, Eckstein A, Helms H. Durability of esthetic improvement following Icon resin infiltration of multibracket-induced white spot lesions compared with no therapy over 6 months: a single-center, split-mouth, randomized clinical trial. Am J Orthod Dentofacial Orthop. 2013;144(1):86-96.
12. Kokich VO. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006;130(2):141-51.

© 2013 Dental Press Journal of Orthodontics

13. Matheus PD, Demito CF, Scheibel PC, Bowman SJ, Ramos AL. Correlação entre a avaliação microscópica e a leitura por laser-fluorescência de lesões de manchas brancas em dentes bovinos: estudo in vitro. Odonto (UMESP). 2010;18(36):5-13.
14. Pascotto RC, Navarro MF, Capelozza Filho L, Cury JA. In vivo effect of a resin-modified glass-ionomer cement on enamel demineralization around orthodontic brackets. Am J Orthod Dentofacial Orthop. 2004;125(1):36-41.
15. Ramos AL, Sakima MT, Santos-Pinto A, Bowman SJ. Upper lip changes correlated to maxillary incisor retraction: a metallic implant study. Angle Orthod. 2005;75(4):499-505.
16. Ramos AL, Pascotto RC. Estética do sorriso. In: Associação Brasileira de Odontologia, organizador. Programa de Atualização em Ortodontia (Pro-Odonto Ortodontia). 1a ed. Porto Alegre: Artmed; Panamericana; 2007. p. 45-92.
17. Rosa Jr JMP. Estudo prospectivo de movimentação dentária como alternativa para aumento do rebordo alveolar. Ortodontia (São Paulo). 2012;45:515-21.
18. Santos-Pinto A. Que recursos mecânicos o Sr. utilizaria na correção da sobremordida profunda onde a intrusão dos incisivos (superiores e/ou inferiores) é necessária? Rev Clín Ortod Dental Press. 2004;3(4):13-5.
19. Santos-Pinto A. Considerando-se que a sobremordida profunda pode também ser corrigida pela extrusão dos dentes posteriores, qual(is) a(s) mecânica(s) que o Sr. utiliza? Rev Clín Ortod Dental Press. 2004;3(6):9-16.
20. Vivaldi-Rodrigues G, Demito CF, Bowman SJ, Ramos AL. The effectiveness of a fluoride varnish in preventing the development of white spot lesions. World J Orthod. 2006;7(2):138-44.
21. Zange SE, Ramos AL, Cuoghi OA, de Mendonça MR, Suguino R. Perceptions of laypersons and orthodontists regarding the buccal corridor in long- and short-face individuals. Angle Orthod. 2011;81(1):86-90.

Ary dos Santos-Pinto

» PhD in Dentistry, Federal University of Rio de Janeiro (UFRJ).
» PostDoc in Orthodontics, Baylor College of Dentistry.
» Adjunct Professor at the Children's Clinic/Orthodontics Department at State University of São Paulo — Araraquara (UNESP).
» Full professor at the Children's Clinic/Orthodontics Department at State University of São Paulo — Araraquara (UNESP).

Daniela Gamba Garib

» PhD in Orthodontics and Facial Orthopedics, University of São Paulo (USP).
» Associate professor of Orthodontics at the Hospital for Rehabilitation of Craniofacial Anomalies/USP and School of Dentistry — Bauru/USP.

Marcio Rodrigues Almeida

» PhD in Orthodontics, School of Dentistry — Bauru/USP.
» PostDoc in Orthodontics, School of Dentistry — Bauru/USP.
» Full professor at the Masters course in Orthodontics, University of Northern Paraná (UNOPAR).

Marcos Janson

» MSc in Dentistry, School of Dentistry — Bauru/USP.
» Coordinator of the Specialization Course in Dentistry, CIODONTO, Sertãozinho/SP.

© 2013 Dental Press Journal of Orthodontics

Assessment of pain experience in adults and children after bracket bonding and initial archwire insertion

Marcio José da Silva Campos[1], Marcelo Reis Fraga[2], Nádia Rezende Barbosa Raposo[3], Ana Paula Ferreira[4], Robert Willer Farinazzo Vitral[5]

Introduction: Ninety five percent of orthodontic patients routinely report pain, due to alterations in the periodontal ligament and surrounding soft tissues, with intensity and prevalence varying according to age.

Objective: This study aimed to assess toothache and buccal mucosal pain in adults and children during two initial phases of the orthodontic treatment.

Methods: The intensity of toothache and buccal mucosal pain reported by 20 patients, 10 children (11-13 years) and 10 adults (18-37 years) was recorded with the aid of a Visual Analog Scale (VAS), during 14 days — 7 days with bonded brackets only and 7 days with the initial archwire inserted.

Results: There was no significant difference in pain intensity among adults and children. After bracket bonding, 50% of the children and 70% of the adults reported pain. 70% of both groups reported pain after initial archwire insertion. While adults reported constant, low intensity, buccal mucosal pain, the children showed great variation of pain intensity, but with a trend towards decreasing pain during the assessment period. After initial archwire insertion the peaks of toothache intensity and prevalence occurred 24 hours in children and 48 hours in adults.

Conclusions: In general, children reported pain less frequently than adults did, though with greater intensity.

Keywords: Pain. Orthodontic treatment. Visual Analog Scale.

[1] Professor, Department of Operative Dentistry, College of Dentistry, Juiz de Fora Federal University (UFJF).
[2] Professor, Department of Orthodontics, Juiz de Fora Federal University (UFJF).
[3] Associate Professor, Department of Radiology, Juiz de Fora Federal University (UFJF).
[4] Associate professor, Department of Parasitology, Microbiology and Immunology, Juiz de Fora Federal University (UFJF).
[5] Associate Professor, Department of Orthodontics and Pediatrics at Juiz de Fora Federal University (UFJF).

How to cite this article: Campos MJS, Fraga MR, Raposo NRB, Ferreira AP, Vitral RWF. Assessment of pain experience in adults and children after bracket bonding and initial archwire insertion. Dental Press J Orthod. 2013 Sept-Oct;18(5):32-7.

Submitted: December 14, 2010 - **Revised and accepted:** January 16, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Marcio José da Silva Campos
Rua Paracatu, 568, Santa Terezinha, Juiz de Fora/MG – Brazil
CEP: 36.046-040 – E-mail: drmarciocampos@hotmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Patients undergoing orthodontic treatment routinely experience discomfort and pain referred not only to the dental supporting tissue (periodontal ligament)[1-6] due to force applied to the teeth,[1,4,7-11] but also the surrounding soft tissues due to attrition caused by brackets and wires.[1,6,9,12,13]

Approximately 70% of orthodontic patients report pain,[8] reaching 95% when only fixed appliances are used.[3,4,9,14] Due to subjectivity and influence from emotional, cognitive and cultural factors,[15] pain reports may vary between groups with different characteristics. Among these characteristics, age has been the most frequently reported in the literature. Jones,[7] Jones and Richmond[16] reported that pain intensity and duration increased with patients' age. On the other hand, Brown and Moerenhout[10] reported pain of higher intensity in adolescents, compared with children and adults, while Scheurer et al,[4] Erdinç and Dinçer[17] did not find any difference between children and adolescents as well as between adolescents and adults, respectively.

The aim of this study was to assess toothache and buccal mucosal pain experienced by adults and children after both bracket bonding and initial archwire insertion.

MATERIAL AND METHODS

Subjects

Twenty males (10 children and 10 adults) were selected for the study. The following inclusion criteria were used: Absence of deciduous teeth; willingness to undergo orthodontic treatment; no previous orthodontic treatment; good general health; disease-free oral mucosa and periodontal tissue.

The mean age of the children was 12.2 ± 0.7 years (ranging from 11 to 13 years), while the mean age of the adults was 24.7 ± 4.2 years (ranging from 18 to 37 years).

Because the experience of pain is influenced by emotional, cognitive and motivational factors as well as by family behavior standards,[6,18] the following categories were excluded from the study: Dentists or dental students; close relatives or spouses of dentists or of subjects who had used a fixed appliance within the previous 12 months; those who feared dental treatment; and users of psychotropic drugs (antipsychotics, benzodiazepines, anti-seizure drugs or antidepressants), non-steroidal anti-inflammatory drugs (NSAIDs), and analgesics.

Procedures

This study was approved by the Ethics Committee of the UFJF. The participants, all volunteers, signed an informed consent after receiving full explanation about the procedures.

Toothache and buccal mucosal pain (lips and cheeks) were assessed for 14 days, divided into two phases: Bonding phase (days 1-7) and initial archwire phase (days 8-14). During the whole study period, patients did not use any analgesics or anti-inflammatory drugs.

Pain intensity was recorded in a form containing two 100-mm Visual Analog Scales (VAS)[19], one for toothache and the other for buccal mucosal pain (Figs 1 and 3). Forms were filled in by the patients on a daily basis, as soon as they woke up. The VAS ranged from "no pain" to "the worst possible pain".

On the morning of the day preceding the start of assessment, brackets and tubes (Mini Standard Edgewise, American Orthodontics, Wisconsin, USA) were bonded to the buccal surfaces of the upper incisors, canines, premolars and first molars of all patients. On the morning of the 7th day, a 0.014-in pre-formed arch (Titanium Memory Wire, 857-504, American Orthodontics, Wisconsin, USA) was totally inserted in the slots of all brackets and in the tubes, being then fixed with a 0.010-in steel ligature wire.

Statistical analysis

Pain intensity and prevalence were analyzed by group and by phase. A descriptive statistical analysis was initially performed. Mann-Whitney's test was used to assess the significance of pain intensity between groups for each phase of the study. Wilcoxon's test was used to compare the differences between groups, determining the influence of patients' age. While Friedman's test was used to assess variation in pain intensity throughout the study period, Wilcoxon's test was used to assess the difference of pain intensity between consecutive days. The level of significance for the tests was 0.05. The software Statistical Package for the Social Sciences (SPSS 11.0.0) was used for the analyses.

© 2013 Dental Press Journal of Orthodontics

RESULTS

Toothache intensity

The daily means of toothache intensity reported by adults and children during the study period are shown in Figure 1. The peak of toothache intensity occurred on day 8 in children and on day 9 in adults.

The mean of toothache intensity for both groups is shown in Table 1. According to Wilcoxon's test, there was no within-group significant difference between the means of toothache intensity in the bonding and initial archwire phases. However, comparison between the daily pain intensity means showed a significant variation throughout the initial archwire phase in both groups (Table 1). According to Mann-Whitney's test, there was no significant difference between groups (Table 1).

Figure 2 shows the toothache prevalence for each day of both bonding and initial archwire phases. On the days when peaks of pain intensity were observed, 50% of the children (day 8) and 70% of the adults (day 9) reported toothache. During the bonding phase, 50% of the subjects in both groups reported toothache on at least one of the seven days (Table 2), whereas 30% of the adults and 10% of the children reported daily pain during this phase. On the initial archwire phase, however, 70% of the children and adults reported toothache (Table 2) and 60% of the adults and 10% of the children reported pain on a daily basis.

Buccal mucosal pain

Pain intensity on the oral mucosa, reported on a daily basis by the subjects throughout the study period, is shown in Figure 3. Pain was greater in children than in adults, on most days. In spite of the variability of pain intensity reported by the children, this group tended to have decreasing pain during the observation period (linear trend). Conversely, the adults reported lower and less variable buccal mucosal pain intensity.

There was no significant difference of buccal mucosal pain intensity between the bonding and initial archwire phases in both groups. However, a significant variation in daily buccal mucosal pain was observed throughout the bonding phase in the children (Table 1).

Table 1 - Toothache and buccal mucosal pain intensity during the bonding and initial archwire phases.

	Bonding phase			Initial archwire phase			Difference between phases
	Mean (IR)	Range	Variation (P-value)	Mean (IR)	Range	Variation (P-value)	
Toothache:							
Children	0.00 (1.05)	0-94.3	0.130	0.00 (25.50)	0-94.3	0.017*	0.123
Adults	0.00 (3.85)	0-94.4	0.208	9.60 (16.10)	0-63.6	0.008*	0.237
Difference between groups***	0.342			1.000			
Buccal mucosal pain							
Children	0.00 (0.00)	0-94.3	0.043*	0.00 (0.00)	0-80.5	0.782	0.917
Adults	0.00 (4.20)	0-35.3	0.655	0.00 (4.00)	0-69.6	0.112	0.893
Difference between groups***	0.934			0.408			

IR - Interquartile range.
* significant variation in pain intensity throughout the study period (Friedman's test).
** Wilcoxon's test.
*** Mann-Whitney's test.

Table 2 - Prevalence of pain reports during the bonding and initial archwire insertion phases.

	Children		Adults	
	Bonding phase	Initial archwire phase	Bonding phase	Initial archwire phase
Toothache	50%	70%	50%	70%
Buccal mucosal pain	40%	50%	50%	40%
Toothache and buccal mucosal pain	50%	70%	70%	70%

© 2013 Dental Press Journal of Orthodontics

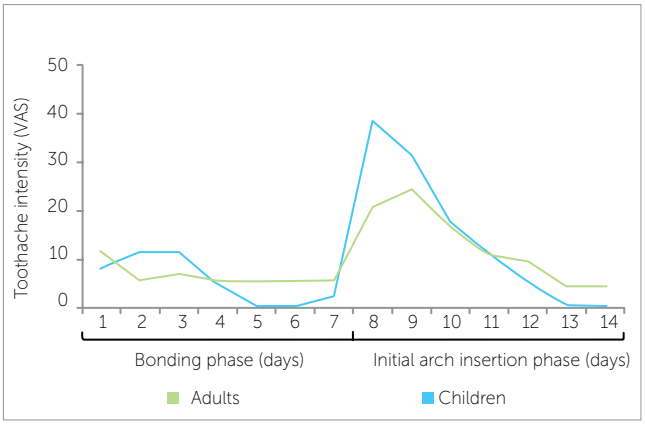


Figure 1 - Toothache intensity reported by the patients during the bonding (days 1-7) and initial archwire insertion (days 8-14) phases.

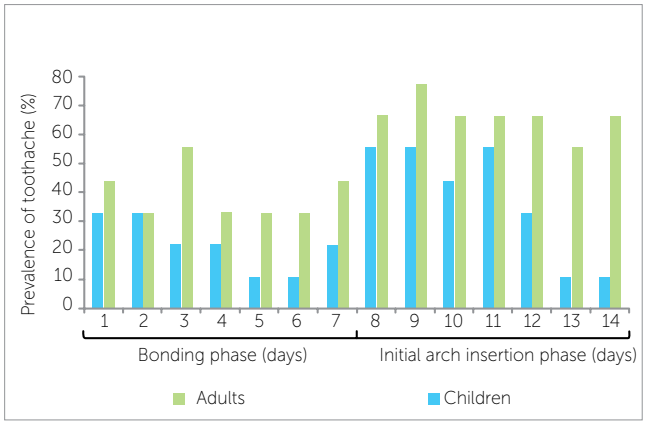


Figure 2 - Prevalence of patients reporting toothache during the bonding (days 1-7) and initial archwire insertion (days 8-14) phases.

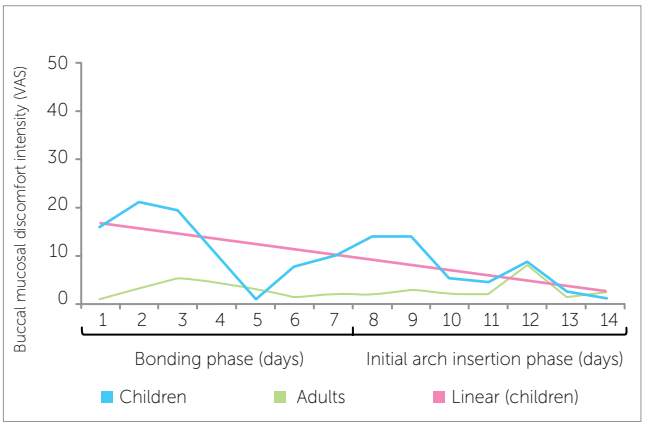


Figure 3 - Buccal mucosal pain intensity during the bonding (days 1-7) and initial archwire insertion (days 8-14) phases.

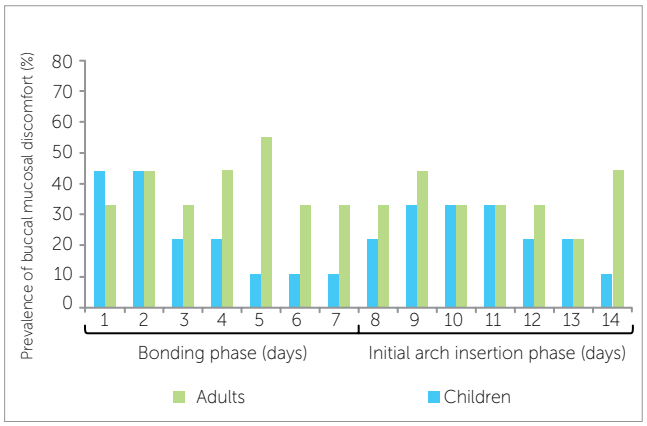


Figure 4 - Prevalence of patients reporting buccal mucosal pain during the bonding (days 1-7) and initial archwire insertion (days 8-14) phases.

The intensity of buccal mucosal pain was greater in children than in adults on both study phases, although such difference was not significant (Table 1).

Figure 4 shows the prevalence of buccal mucosal pain on a daily basis during the bonding and initial archwire phases. The adults had higher prevalence of pain on most days, with little variation throughout the two phases. On the other hand, the children showed a progressive decrease from day 2 to day 7, with an increase from day 8 on, the first day after initial archwire insertion. During the bonding phase, 40% of the children and 50% of the adults reported buccal mucosal pain, with 50% of the children and 40% of the adults reporting pain during the initial archwire phase (Table 2).

DISCUSSION

Orthodontic treatment uses appliances to apply forces to the teeth, so that they can occupy more favorable esthetic and functional positions. Such devices injure the underlying oral mucosa, leading to discomfort and pain.[1,3,6,9] In this study, the adults reported low-intensity and constant buccal mucosal pain during the observation period, while the children had great variability of pain intensity, but with a trend towards less intense pain throughout the study period. This trend towards pain intensity reduction was reported by Jones and Chan,[3] who saw it as a consequence of inflammation and ulceration occurring at the beginning of treatment, occurring progressive adaptation of patients to the orthodontic appliances.

© 2013 Dental Press Journal of Orthodontics

Children reported higher intensity of buccal mucosal pain than the adults, although pain reported by the children was less prevalent on most days when compared with the adults. This shows that injury to the oral mucosa related to the brackets and wires causes pain in fewer children when compared with adults, although the affected children tend to develop greater suffering than the adults.

During the bonding phase, 50% of the subjects in both groups reported toothache, even without any force being applied to the teeth by the orthodontic appliance. This may have occurred due to the association of buccal mucosal pain with the discomfort caused by the lack of adaptation to the recently installed brackets, confusing the patients as to the exact kind of pain experienced during the first studied phase.

Forces applied to the teeth are transmitted to the supporting tissues (periodontal ligament and alveolar bone) which allow tooth mobility through inflammation, often associated with pain.[1-11] Using the same type of initial archwire in all patients, regardless of their degree of tooth misalignment, resulted in the non-standardization of force application to the teeth, which has not been proved to influence the intensity of reported pain.[3,16]

The prevalence of reported pain after initial archwire insertion reaches 81% among adolescents,[3] and ranges from 90 to 95% among adults.[4,9] This higher pain prevalence among adults was not observed in this study, because although the adults had higher prevalence of toothache on all days of the initial archwire phase, the number of individuals reporting pain during this phase was the same in both groups.

After initial archwire insertion, pain reaches its peak in 24 hours, both as to intensity[3,4,7,11,17,20,21] and prevalence.[4,17,21] In this study, the peaks of toothache intensity and prevalence occurred 24 hours after initial archwire insertion in children (day 8) and 48 hours in adults (day 9). Toothache intensity and prevalence peaks occurred on day 9 among adults, because one individual reported pain just on this day. This changed the peak from 24 to 48 hours after initial archwire insertion.

Studies with orthodontic patients[3,7,11] show that toothache intensity drastically and progressively decreases only after 72 hours after orthodontic force application, although in this study the beginning of the decrease in pain intensity was observed immediately after the peak, as reported by Sergl et al.[22] The decrease was sustained until the penultimate day of assessment in both groups. This may be related to a reduction of perception concerning the proprioceptive stimulation,[22,23] or to the fact that the patient has their attention no longer focused on pain.[3] During the last two days (days 13 and 14), the groups presented a small difference between toothache intensity means, which was probably accounted for a higher prevalence of pain reports among the adults (70%) compared to the children (10%).

In general, during the study period, the children had lower prevalence of pain, and reported more intense pain compared to the adults, both for toothache and buccal mucosal pain. This higher pain intensity reported by the children may be due to the fact that the VAS uses the phrase "the worst possible pain". Because of their age, children are less likely to have had previous pain experiences than adults.[24] Notwithstanding the fact, the VAS is recommended for individuals over 5 years of age.[25,26]

CONCLUSION

Pain was frequently reported by male children and adults from both groups after bracket bonding, but mainly after initial archwire insertion. A wide variability of pain intensity was observed throughout the study. Pain intensity, which was higher in children than in adults, progressively decreased immediately after reaching its peak, 48 or 72 hour after the orthodontic procedure, in both groups.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Kvam E, Bondevik O, Gjerdet NR. Traumatic ulcers and pain in adults during orthodontic treatment. Community Dent Oral Epidemiol. 1989;17:154-7.
2. Ngan P, Kess B, Wilson S. Perception of discomfort by patients undergoing orthodontic treatment. Am J Orthod Dentofacial Orthop. 1989;96(1):47-53.
3. Jones M, Chan C. The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two initial aligning arch wires. Am J Orthod Dentofacial Orthop. 1992;102(4):373-81.
4. Scheurer PA, Firestone AR, Burgin WL. Perception of pain as a result of orthodontic treatment with fixed appliances. Eur J Orthod. 1996;18(1):349-57.
5. Firestone AR, Scheurer PA, Bürgin WB. Patients' anticipation of pain and pain-related side effects, and their perception of pain as a result of orthodontic treatment with fixed appliance. Eur J Orthod. 1999;21(4):387-96.
6. Bergius M, Kiliaridis S, Berggren U. Pain in orthodontics: a review and discussion of the literature. J Orofac Orthop. 2000;61(2):125-37.
7. Jones ML. An investigation into the initial discomfort caused by placement of an archwire. Eur J Orthod. 1984;6(1):48-54.
8. Oliver RG, Knapman YM. Attitudes to orthodontic treatment. Br J Orthod. 1985;12(4):179-88.
9. Kvam E, Gjerdet NR, Bondevik O. Traumatic ulcers and pain during orthodontic treatment. Community Dent Oral Epidemiol. 1987;15(2):104-7.
10. Brown DF, Moerenhout RG. The pain experience and psychological adjustment to orthodontic treatment of preadolescents, adolescents, and adults. Am J Orthod Dentofacial Orthop. 1991;100(4):349-56.
11. Fernandes LM, Øgaard B, Skoglund L. Pain and discomfort experienced after placement of a conventional or a superelastic NiTi aligning archwire. A randomized clinical trial. J Orofac Orthop. 1998;59(6):331-9.
12. Pereira BR, Tanaka OM, Lima AAS, Guariza-Filho O, Maruo H, Camargo ES. Metal and ceramic bracket effects on human buccal mucosa epithelial cells. Angle Orthod. 2009;79(2):373-9.
13. Kluemper GT, Hiser DG, Rayens MK, Jay MJ. Efficacy of a wax containing benzocaine in the relief of oral mucosal pain caused by orthodontic appliances. Am J Orthod Dentofacial Orthop. 2002;122(4):359-65.
14. Lew KK. Attitudes and perceptions of adults towards orthodontic treatment in an Asian community. Community Dent Oral Epidemiol. 1993;21(1):31-5.
15. International Association for the Study of Pain. Pain terms: a list with definitions and notes on usage. Pain. 1979;6:249-52.
16. Jones ML, Richmond S. Initial tooth movement: force application and pain - a relationship? Am J Orthod .1985;88(2):111-6.
17. Erdinç AM, Dinçer B. Perception of pain during orthodontic treatment with fixed appliances. Eur J Orthod. 2004;26(1):79-85.
18. Krishnan V. Orthodontic pain: from causes to management: a review. Eur J Orthod. 2007;29(2):170-9.
19. Huskisson EC. Measurement of pain. Lancet. 1974;9:1127-31.
20. Polat Ö, Karaman AI. Pain control during fixed orthodontic appliance therapy. Angle Orthod. 2005;75(2):214-9.
21. Fleming PS, Dibiase AT, Sarri G, Lee RT. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system: a randomized controlled clinical trial. Angle Orthod. 2009;79(1):46-50.
22. Sergl HG, Klages U, Zentner A. Pain and discomfort during orthodontic treatment. Causative factors and effects on compliance. Am J Orthod Dentofacial Orthop. 1998;114(6):684-91.
23. Soltis JE, Nakfoor PR, Bowman DC. Changes in ability of patients to differentiate intensity of forces applied to maxillary central incisors during orthodontic treatment. J Dent Res. 1971;50(3):590-6.
24. Kiliaridis S, Bergius M. Pain and discomfort in orthodontics. In: Graber TM, Eliades T, Athanasiou AE. Risk management in Orthodontics: experts' guide to malpractice. Chicago: Quintessence; 2004. p. 131-43.
25. Langley GB, Sheppeard H. Problems associated with pain measurement in arthritis: comparison of the visual analogue and verbal rating scales. Clin Exp Rheumatol. 1984;2(3):231-4.
26. Seymour RA, Simpson JM, Charlton JE, Phillips ME. An evaluation of length and end-phrase of visual analogue scales in dental pain. Pain. 1985;21(2):177-85.

© 2013 Dental Press Journal of Orthodontics

Class II malocclusion treatment with the Herbst appliance in patients after the growth peak

José Carlos de Castro Alvares[1], Rodrigo Hermont Cançado[2], Fabrício Pinelli Valarelli[2], Karina Maria Salvatore de Freitas[3], Christian Zamberlan Angheben[1]

Objective: The objective of this study was to evaluate dentoskeletal effects in the treatment of Class II malocclusion performed with the Herbst appliance in patients at post-peak stage of growth.

Methods: The sample consisted of 16 patients with Class II malocclusion and average initial and final ages of 14.04 (ranging from 11.50 to 35.66) and 17.14 (ranging from 13.68 to 38.64) years, respectively, who were treated for an mean time of 2.52 years. Lateral cephalograms were obtained at treatment onset (T_1) and completion (T_2) to evaluate the effects of therapy. Initial dental casts were also used to evaluate the overjet and the anteroposterior severity of molar relationship at treatment onset. The cephalometric changes between initial and final stages were compared by means of the non-parametric Wilcoxon test.

Results: The results showed that the Herbst appliance did not promote significant changes in the maxillary component and the effective length of the mandible significantly increased without improving the maxillomandibular relationship. Changes in the maxillary and mandibular dentoalveolar components revealed that the maxillary incisors exhibited retrusion and lingual tipping, while the mandibular incisors presented increased protrusion and buccal tipping. The dental relationships exhibited significant improvements with the treatment.

Conclusion: Based on the present results, it was concluded that the effects of treatment performed with the Herbst appliance in patients at post-peak stage of growth are predominantly of dentoalveolar nature.

Keywords: Angle Class II malocclusion. Head circumference. Functional orthodontic appliance.

» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

[1] MSc in Orthodontics, Faculdade Ingá.
[2] Adjunct Professor of the Masters Course in Orthodontics at Faculdade Ingá.
[3] Postdoctoral in Orthodontics, University of Toronto.

How to cite this article: Alvares JCC, Cançado RH, Valarelli FP, Freitas KMS, Angheben CZ. Class II malocclusion treatment with the Herbst appliance in patients after the growth peak. Dental Press J Orthod. 2013 Sept-Oct;18(5):38-45.

Submitted: January 17, 2012 - **Revised and accepted:** May 14, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Rodrigo Hermont Cançado
Rua do Amparo, 100 – Centro – Diamantina/MG – Brazil
CEP: 39100-000 – E-mail: rohercan@uol.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

The Herbst appliance has been widely used for treating Class II malocclusions due to its great effectiveness.[10] Besides allowing stimulation of mandibular growth, the treatment performed with the Herbst appliances promotes redirecting of maxillary growth, mesial movement of mandibular teeth and distal movement of maxillary teeth.[9] All the aforementioned factors are relevant for both treatment and correction of the Class II malocclusion.

Most studies evaluating the skeletal and dental effects of the Herbst appliances are conducted in patients at the pre-peak stage of growth.[8,9,20,21] On the other hand, studies on the Herbst appliance in patients at the post-peak stage of growth have been widely accepted by the orthodontic community, due to the fact that it may influence the growth of bone bases within a shorter period of time.[13,17,18] However, these studies are less frequent in the scientific literature.[1,4,11]

The objective of this study was to evaluate skeletal and dental effects of the Herbst appliance for treating Class II malocclusion in patients at the post-peak stage of growth.

MATERIAL AND METHODS

Material

This clinical study was approved by the Research Ethics Committee (REC) and all patients signed an informed consent form authorizing the use of their orthodontic records for research purposes. The sample was retrospectively selected and initially comprised all patients with Class II malocclusion treated by one of the authors using the Herbst with Cantilever Bite Jumper (CBJ) appliance, combined with fixed appliances (Fig 1). A total of 28 patients were initially selected, among which 16 were selected to compose the sample according to the following inclusion criteria: 1) Patients without previous orthodontic treatment; 2) No tooth losses up to the permanent first molars; 3) Complete orthodontic records at the onset (T_1) and completion (T_2) of orthodontic treatment; 4) Patients at post-peak stage of growth at treatment onset, as analyzed on carpal radiographs; 5) The treatment of all patients should be performed without extraction of permanent teeth.

The sample consisted of 32 lateral cephalograms obtained at the onset (T_1) and at the completion of the orthodontic treatment (T_2), and 16 dental casts obtained at the onset of the treatment (T_1) of 16 patients (10 females and 6 males) with Class II malocclusion (14 patients with Class II, division 1 malocclusion; and 2 patients with Class II, division 2 malocclusion). These patients presented median initial and final ages of 14.04 (interquartile deviation of 3.68; amplitude of 11.50–35.66) and 17.14 (interquartile deviation of 4.07; amplitude of 13.68–38.64) years, respectively, and were treated for an mean period of 2.52 years (SD = 1.00). They also presented mean overjet of 6.7 mm, evaluated on the initial dental casts (T_1). Considering the severity of anteroposterior relationship between the dental arches, four patients presented ½ Class II, four patients presented ¾ Class II and eight patients had complete Class II. Criterion adopted to classify them as patients at post-peak stage of growth was the evaluation of skeletal maturation stages of the median phalanx of the third finger on carpal radiographs. The patients were considered as patients at post-peak stage of growth when the radiographic interpretation comprised the stage in which the epiphysis did not present the width of the metaphysis up to the stage with complete fusion of epiphysis and metaphysis[7,16] (Table 1).

Figure 1 - Herbst appliance (CBJ) combined with fixed appliance: **A**) right lateral view, **B**) frontal view, **C**) left lateral view.

© 2013 Dental Press Journal of Orthodontics

Table 1 - Detailed description of skeletal maturation stages of patients in the sample.

Name	Gender	Initial age	Skeletal maturation stage
A.P.F	F	20.31	Rut (complete epiphyseal union in the radius)
A.M.S.A	F	11.95	FMui (onset of epiphyseal union in median phalanxes)
C.H.F	M	15.10	FDut (complete epiphyseal union in distal phalanxes)
D.A.R.L	M	16.18	Rut (complete epiphyseal union in the radius)
F.R	F	11.50	MFDui (onset of epiphyseal union in distal phalanxes)
G.P	F	12.29	FMui (onset of epiphyseal union in median phalanxes)
G.Q.V	M	13.90	FMui (onset of epiphyseal union in median phalanxes)
J.F.R	M	12.03	MFDui (onset of epiphyseal union in distal phalanxes)
J.L	F	13.56	FMui (onset of epiphyseal union in median phalanxes)
J.R.C	F	16.61	Rut (complete epiphyseal union in the radius)
L.J	F	14.01	FDut (complete epiphyseal union in distal phalanxes)
L.F.R	M	13.13	FMui (onset of epiphyseal union in median phalanxes)
L.P	F	35.66	Rut (complete epiphyseal union in the radius)
L.I.M	F	27.47	Rut (complete epiphyseal union in the radius)
T.R.V	M	14.17	FMui (onset of epiphyseal union in median phalanxes)
Y.R.Z.V.A	F	14.08	FDut (complete epiphyseal union in distal phalanxes)

All patients in the sample initially received a fixed Roth appliance with 0.022 x 0.028-in slot, and the dental arches were aligned and leveled until a 0.019 x 0.025-in rectangular stainless steel archwire would passively adapt itself to the slot of all brackets. After alignment and leveling, the Cantilever Bite Jumper (CBJ) appliance was placed to correct the anteroposterior Class II relationship observed between molars. The CBJ is a system composed of four stainless steel crowns, for the maxillary and mandibular first molars, respectively, and a cantilever soldered to the crowns of mandibular first molars, extending itself in the anterior direction towards the premolars and canines, to position the pivot of the mandibular arch. The maxillary pivots are soldered to the external aspect of the maxillary crowns and also constitute the system of telescopic tubes and two pistons, which promotes anterior positioning of the mandible by fixing the appliance with screws. Therefore, the Herbst appliance is indicated for cases with Class II division 1 malocclusion when the main problem is mandibular retrognathism, with anterior teeth without marked crowding or after alignment with fixed orthodontic appliances, preferably with lingually tipped mandibular incisors.[14] A transpalatal bar in the maxillary arch and a Nance lingual arch in the mandibular arch were placed for anchorage.

Methods

Lateral cephalograms

In order to evaluate the dentoskeletal changes of the Herbst-CBJ appliance, lateral cephalograms obtained at treatment onset and completion were analyzed. All radiographic images were obtained with the lips at rest and in maximum intercuspation, aided by a Broadbent cephalostat in order to standardize the position of the head. All lateral cephalograms comprising the sample were obtained in three different devices and the magnification of each device was determined for greater accuracy. The different types of devices presented distinct percentages of magnification, ranging from 8.2% to 11.13%.

Cephalometric tracing and achievement of measurements

The lateral cephalograms were digitized in a resolution of 9600 x 4800 dpi in a Microtek ScanMaker i800 scanner (Microtek International, Inc., Carson, CA, USA) and connected to a Pentium microcomputer. The images were transferred to the Dolphin Imaging Premium 10.5 software (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA), through which the cephalometric points of interest were identified and measurements involving planes and lines were obtained.

© 2013 Dental Press Journal of Orthodontics

Cephalometric measurements (Figs 2 and 3)

The following cephalometric measurements were used in this study:

1) Maxillary component: SNA, A-Nperp and Co-A.
2) Mandibular component: SNB, P-Nperp and Co-Gn.
3) Maxillomandibular relationship: ANB and Witts.
4) Growth pattern: SN.GoGn, SN.Ocl, FMA and LAFH.
5) Maxillary dentoalveolar component: 1.NA, 1-NA, 1-Aperp, 1-PP, 6-PTV and 6-PP.
6) Mandibular dentoalveolar component: 1.NB, 1-NB, 1-AP, IMPA, 1-MP and 6-MP.
7) Dental relationships: overjet, overbite and molar relationship.

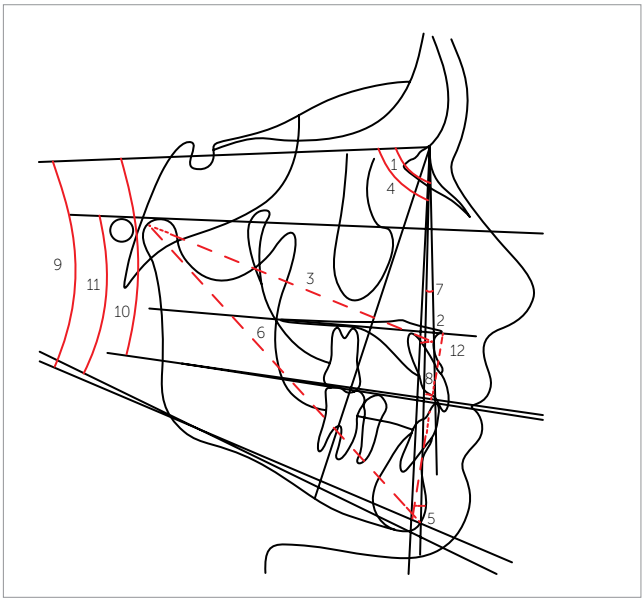


Figure 2 - Skeletal cephalometric measurements: 1) SNA; 2) A-Nperp; 3) Co-A; 4) SNB; 5) P-Nperp; 6) Co-Gn; 7) ANB; 8) Wits; 9) SN.GoGn; 10) SN.Ocl; 11) FMA; 12) LAFH.

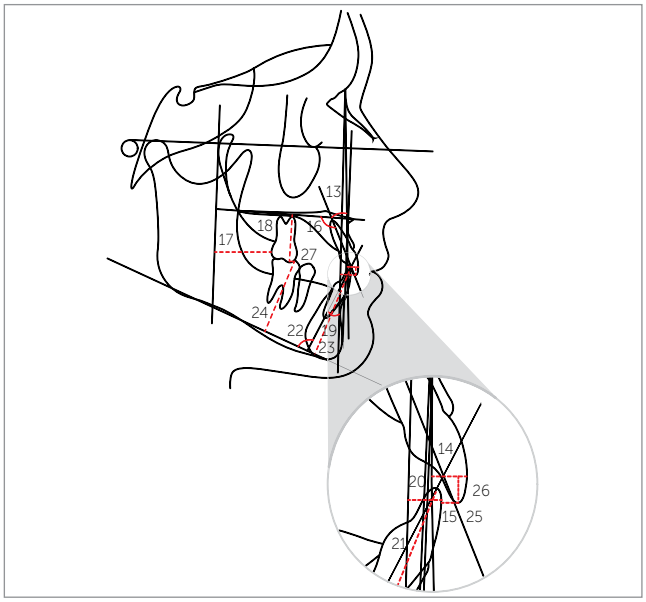


Figure 3 - Dental cephalometric measurements: 13) 1.NA; 14) 1-NA; 15) 1-Aperp; 16) 1-PP; 17) 6-PTV; 18) 6-PP; 19) 1.NB; 20) 1-NB; 21) 1-AP; 22) IMPA; 23) 1-MP; 24) 6-MP; 25) overjet; 26) overbite; 27) molar relationship.

STATISTICAL ANALYSIS

Method error

In order to analyze the intraexaminer error, all measurements were repeated by the same examiner on ten randomly selected lateral cephalograms after a 30-day interval. The application of the Dahlberg formula ($Se^2 = \Sigma d^2/2n$) allowed estimation of casual errors[3]. Systematic errors were evaluated by the dependent t-test[2,6,15].

Comparison of cephalometric measurements between initial (T_1) and final (T_2) stages

The Kolmogorov-Smirnov test was used to verify if the cephalometric data obtained at treatment onset (T_1) and completion (T_2) presented normal distribution. The results revealed that some cephalometric variables did not present normal distribution. Thus, the non-parametric Wilcoxon test was applied to compare the changes between initial (T_1) and final (T_2) stages. All statistical tests were conducted on the *Statistica* software for Windows 7.0 (Stat Soft Inc., Tulsa, Oklahoma, USA) and the results were considered statistically significant for $p < 0.05$.

RESULTS

Four variables (SN.GoGn, LAFH, 1.NA and 6-MP) presented systematic error ($p < 0.05$) and the amplitude of casual errors ranged from 0.13 (1-PP) to 1.25 (A-Nperp).

The results of the Kolmogorov-Smirnov test revealed that the following cephalometric variables did not present normal distribution of data: SNA, SNB and SN.Ocl at treatment onset (T_1) and SNA, SNB and SN.GoGn in treatment changes (T_2-T_1) (Table 2).

In Table 3 it can be observed that:

» The maxillary component was not influenced by the treatment performed with the Herbst appliance.

© 2013 Dental Press Journal of Orthodontics

Table 2 - Kolmogorov-Smirnov test result for initial (T_1) and final values (T_2) as well as changes (T_2-T_1) for the experimental group.

	Initial (T_1)		Final (T_2)		Changes (T_2-T_1)	
	d	p	d	p	d	p
Maxillary component						
SNA (degrees)	0.33720	p < 0.05	0.16173	p > 0.20	0.34321	p < 0.05
A-Nperp (mm)	0.15941	p > 0.20	0.16995	p > 0.20	0.24383	p > 0.20
Co-A (mm)	0.10683	p > 0.20	0.11728	p > 0.20	0.15965	p > 0.20
Mandibular component						
SNB (degrees)	0.40337	p < 0.01	0.10290	p > 0.20	0.39996	p < 0.01
P-Nperp (mm)	0.20420	p > 0.20	0.17342	p > 0.20	0.15178	p > 0.20
Co-Gn (mm)	0.15385	p > 0.20	0.14390	p > 0.20	0.15145	p > 0.20
Maxillomandibular relationship						
ANB (degrees)	0.13175	p > 0.20	0.18423	p > 0.20	0.09585	p > 0.20
Wits (mm)	0.22433	p > 0.20	0.09771	p > 0.20	0.18087	p > 0.20
Growth pattern						
SN.GoGn (degrees)	0.32505	p < 0.10	0.17289	p > 0.20	0.42607	p < 0.01
SN.Ocl (degrees)	0.34652	p < 0.05	0.10566	p > 0.20	0.32497	p < 0.10
FMA (degrees)	0.18584	p > 0.20	0.21232	p > 0.20	0.09516	p > 0.20
AFAI (mm)	0.15122	p > 0.20	0.11475	p > 0.20	0.12362	p > 0.20
Maxillary dentoalveolar component						
1.NA (degrees)	0.15410	p > 0.20	0.16095	p > 0.20	0.12377	p > 0.20
1-NA (mm)	0.15364	p > 0.20	0.20399	p > 0.20	0.25303	p > 0.20
1-Aperp (mm)	0.13260	p > 0.20	0.12851	p > 0.20	0.18649	p > 0.20
1-PP (mm)	0.15810	p > 0.20	0.13327	p > 0.20	0.17488	p > 0.20
6-PTV (mm)	0.14557	p > 0.20	0.14972	p > 0.20	0.16282	p > 0.20
6-PP (mm)	0.19430	p > 0.20	0.18014	p > 0.20	0.16931	p > 0.20
Mandibular dentoalveolar component						
1.NB (degrees)	0.13551	p > 0.20	0.09290	p > 0.20	0.11150	p > 0.20
1-NB (mm)	0.17883	p > 0.20	0.14686	p > 0.20	0.11769	p > 0.20
1-AP (mm)	0.19957	p > 0.20	0.14227	p > 0.20	0.10627	p > 0.20
IMPA (degrees)	0.10522	p > 0.20	0.17987	p > 0.20	0.15662	p > 0.20
1-MP (mm)	0.18251	p > 0.20	0.08313	p > 0.20	0.14496	p > 0.20
6-MP (mm)	0.13172	p > 0.20	0.10799	p > 0.20	0.07635	p > 0.20
Dental relationships						
Overjet (mm)	0.14026	p > 0.20	0.11879	p > 0.20	0.14074	p > 0.20
Overbite (mm)	0.15292	p > 0.20	0.18606	p > 0.20	0.15800	p > 0.20
Molar relationship (mm)	0.10220	p > 0.20	0.13571	p > 0.20	0.14571	p > 0.20

» The effective mandibular length (Co-Gn) presented statistically significant increase with the Herbst appliance.

» The Herbst appliance did not provide any improvements in the maxillomandibular relationship.

» The SN.Ocl and LAFH variables presented statistically significant increase, in which the occlusal plane presented clockwise rotation, with consequent increase of vertical dimension.

» The maxillary incisors exhibited statistically significant extrusion during treatment, as evaluated by the 1-PP variable.

» The mandibular incisors presented buccal tipping and statistically significant protrusion (1.NB, 1-NB and 1-AP).

» The mandibular molars presented statistically significant extrusion (6-MP).

» The overjet, overbite and molar relationship were significantly reduced with treatment.

© 2013 Dental Press Journal of Orthodontics

Table 3 - Non-parametric Wilcoxon test results of comparison between initial (T_1) and final (T_2) stages for evaluation of treatment changes.

Variables	Initial (T_1) (n = 16)		Final (T_2) (n = 16)		P
	Median	Dlq	Median	Dlq	
Maxillary component					
SNA (degrees)	83.50	7.20	81.90	4.70	0.8361
A-Nperp (mm)	0.05	4.10	-0.20	8.25	0.7564
Co-A (mm)	84.75	3.65	85.25	6.00	0.3133
Mandibular component					
SNB (degrees)	77.90	6.50	78.05	7.05	0.1089
P-Nperp (mm)	-8.70	9.65	-8.25	11.40	0.3794
Co-Gn (mm)	107.45	10.40	111.60	7.30	0.0011
Maxillomandibular relationship					
ANB (degrees)	6.00	3.35	4.60	3.20	0.1401
Wits (mm)	1.20	5.30	-1.10	3.55	0.1627
Growth pattern					
SN.GoGn (degrees)	30.50	10.75	29.95	8.50	0.7174
SN.Ocl (degrees)	15.00	6.90	19.40	9.50	0.0340
FMA (degrees)	27.95	4.85	28.05	6.15	0.9176
AFAI (mm)	60.60	9.50	65.60	11.45	0.0011
Maxillary dentoalveolar component					
1.NA (degrees)	18.95	16.25	21.15	11.45	0.2553
1-NA (mm)	4.75	4.50	4.45	3.45	0.3133
1-Aperp (mm)	5.10	3.40	4.25	2.95	0.1873
1-PP (mm)	27.25	7.65	28.50	6.30	0.0299
6-PTV (mm)	19.30	5.20	21.50	6.60	0.3794
6-PP (mm)	17.15	3.00	18.90	3.40	0.1961
Mandibular dentoalveolar component					
1.NB (degrees)	28.25	7.90	32.10	10.60	0.0077
1-NB (mm)	6.20	3.65	7.05	3.65	0.0340
1-AP (mm)	2.00	2.75	3.80	3.25	0.0032
IMPA (degrees)	98.45	11.25	98.15	10.55	0.0557
1-MP (mm)	38.05	5.40	38.50	6.25	0.3066
6-MP (mm)	26.00	3.10	28.65	3.80	0.0011
Dental relationships					
Overjet (mm)	6.40	3.65	3.30	1.30	0.0009
Overbite (mm)	3.85	2.50	1.60	2.50	0.0009
Molar relationship (mm)	1.20	1.55	-1.35	1.80	0.0021

DISCUSSION

Sample selection

The use of fixed functional orthopedic appliances in patients at post-peak stage of growth has been demonstrated in the orthodontic literature. Additionally, the use of these appliances has been encouraged in patients in the descending growth curve. This treatment modality presents some advantages when compared to treatment of patients at pre-peak stage of growth, for instance, a better occlusal stability, due to the fact that all permanent teeth are erupted, thus allowing better intercuspation in a Class I relationship[7]. Moreover, the retention time is reduced because the residual growth after active treatment is smaller[7]. However, the studies found in the literature have been conducted with a small number of patients,

similarly to this study.[1,4,11] Notwithstanding, considering the strict inclusion criteria, especially inclusion of patients at post-peak stage of growth, only, and the difficulties inherent in longitudinal studies, a number of 16 patients may be considered satisfactory.

Dentoskeletal changes promoted by treatment

The cephalometric evaluation of dentoskeletal effects of the treatment revealed that the CBJ does not promote significant restriction of anterior displacement of the maxillary component (Table 3), similarly to previous studies.[19] However, these effects on the maxilla are not in agreement with other authors who conducted similar studies using fixed functional orthopedic appliances.[8,12] Distension of the musculature that holds the mandible in constantly advanced position causes transmission of the action of this muscular force in posterior direction on the maxilla, thus promoting restriction of maxillary growth.[5] This action on the maxilla was not evidenced in this study because all patients in the sample were at post-peak stage of growth and, thereby, the anteroposterior growth of the maxilla had ceased.

Considering the mandibular component, the effective mandibular length (Co-Gn) presented a significant increase of 4.15 mm between initial (T_1) and final stages (T_2) (Table 3). This result was expected and agrees with previous studies.[7,9] This increase in mandibular length provided by the appliance presents individual variability and depends on the skeletal maturity of the patients at the onset of orthopedic treatment.[4,11] The absence of a control group compatible with the patients treated in this study did not allow differentiation between the real effect of the Herbst appliance and the mandibular growth.

In the maxillomandibular relationship, no significant improvements were identified in the bone base relationship, even though the ANB variable presented a slight reduction of 1.40º (Table 3). These results demonstrate that the Herbst appliance, when used at post-peak stage of growth, presents more compensatory action than real correction of the anteroposterior discrepancy in patients with Class II malocclusion.[7] A previous study demonstrated that, in patients at post-peak stage of growth, 37% of the correction of Class II molar relationship derives from skeletal changes and 63% from dental changes, while the overjet involves 27% of skeletal changes and 73% of dental changes.[7]

With regard to the growth pattern of the patient, both SN.Ocl and LAFH variables presented statistically significant increase, suggesting clockwise rotation of the occlusal plane with consequent increase in vertical dimension (LAFH) (Table 3). These results agree with previous findings that reported increase in vertical dimension of the patient due to treatment performed with the Herbst appliance.[8,12] The Herbst appliance was constructed in modified occlusion with increase of the interocclusal space between the posterior teeth, which is common in the fabrication of such appliance, thus allowing extrusion of posterior teeth with consequent increase in vertical dimension and clockwise mandibular rotation.[10] Additionally, the mandibular molars (6-MP) exhibited significant extrusion of 2.65 mm (Table 3).

The evaluation of the maxillary dentoalveolar component did not reveal any significant changes in the tipping and position of maxillary incisors, except for the 1-PP variable that evidenced significant extrusion of these teeth with the treatment (Table 3). Considering the effects on maxillary molars, the results demonstrated that these teeth did not present significant changes both in horizontal (6-PTV) and vertical directions (6-PP) (Table 3). A previous study revealed distal movement of 0.5 mm of the maxillary incisors, which was less important to the correction of the molar relationship and overjet.[9]

The evaluation of the mandibular dentoalveolar component revealed that the mandibular incisors presented significant and marked buccal tipping (1.NB) as well as protrusion of these teeth in the mandible (1-NB and 1-AP). The mandibular molars also exhibited significant extrusion with the treatment (6-MP), which explains more clearly the clockwise rotation of the occlusal plane and the increase of 5.00 mm in the LAFH (Table 3).

The inclination and protrusion of mandibular incisors is widely reported in the literature and occurs as a function of the telescopic mechanism of the Herbst appliance which produces a force directed towards the mandibular anterior region and the mandibular teeth.[7,8,12,13,16]

The treatment effects are more evident in the evaluation of dental relationships. The significant reductions in overjet of 3.10 mm, in overbite of 2.25 mm and in molar relationship of 2.55 mm are changes that

© 2013 Dental Press Journal of Orthodontics

contribute to the correction of anteroposterior and vertical discrepancies in patients with Class II malocclusion (Table 3). These results are a consequence of the combination of dental and skeletal changes promoted by the Herbst appliance[7,12].

CONCLUSION

Based on the present results, it was concluded that effects of treatment performed with the Herbst appliance in patients at post-peak stage of growth are of predominantly dentoalveolar nature.

REFERENCES

1. Bakke M, Paulsen HU. Herbst treatment in late adolescence: clinical, electromyographic, kinesiographic, and radiographic analysis of one case. Eur J Orthod. 1989;11(4):397-407.
2. Baumrind S, Frantz RC. The reliability of head film measurements. 1. Landmark identification. Am J Orthod. 1971;60(2):111-27.
3. Dahlberg G. Statistical methods for medical and biological students. New York: Interscience; 1940.
4. Hansen K, Pancherz H, Hagg U. Long-term effects of the Herbst appliance in relation to the treatment growth period: a cephalometric study. Eur J Orthod. 1991;13(6):471-81.
5. Hirzel HC, Grewe JM. Activators: a practical approach. Am J Orthod. 1974;66(5):557-70.
6. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod. 1983;83(5):382-90.
7. Konik M, Pancherz H, Hansen K. The mechanism of Class II correction in late Herbst treatment. Am J Orthod Dentofacial Orthop. 1997;112(1):87-91.
8. Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance. A cephalometric investigation. Am J Orthod. 1979;76(4):423-42.
9. Pancherz H. The mechanism of Class II correction in Herbst appliance treatment. A cephalometric investigation. Am J Orthod. 1982;82(2):104-13.
10. Pancherz H. The Herbst appliance: its biologic effects and clinical use. Am J Orthod. 1985;87(1):1-20.
11. Pancherz H, Hagg U. Dentofacial orthopedics in relation to somatic maturation. An analysis of 70 consecutive cases treated with the Herbst appliance. Am J Orthod. 1985;88(4):273-87.
12. Pancherz H, Hansen K. Occlusal changes during and after Herbst treatment: a cephalometric investigation. Eur J Orthod. 1986;8(4):215-28.
13. Purkayastha SK, Rabie AB, Wong R. Treatment of skeletal Class II malocclusion in adults: stepwise vs single-step advancement with the Herbst appliance. World J Orthod. 2008;9(3):233-43.
14. Quaglio CL, Henriques RP, Henriques JFC, Freitas MRd. Classe II divisão 1 associada à deficiência transversal maxilar. Tratamento com disjuntor tipo Hyrax e aparelho de Herbst: relato de caso clínico. Rev Dental Press Ortod Ortop Facial. 2009;14(5):118-28.
15. Richardson A. A comparison of traditional and computerized methods of cephalometric analysis. Eur J Orthod. 1981;3(1):15-20.
16. Ruf S, Pancherz H. Dentoskeletal effects and facial profile changes in young adults treated with the Herbst appliance. Angle Orthod. 1999;69(3):239-46.
17. Ruf S, Pancherz H. Orthognathic surgery and dentofacial orthopedics in adult Class II division 1 treatment: mandibular sagittal split osteotomy versus Herbst appliance. Am J Orthod Dentofacial Orthop. 2004;126(2):140-52; quiz 254-5.
18. Ruf S, Pancherz H. Herbst/multibracket appliance treatment of Class II division 1 malocclusions in early and late adulthood. A prospective cephalometric study of consecutively treated subjects. Eur J Orthod. 2006;28(4):352-60.
19. Sidhu MS, Kharbanda OP, Sidhu SS. Cephalometric analysis of changes produced by a modified Herbst appliance in the treatment of Class II division 1 malocclusion. Br J Orthod. 1995;22(1):1-12.
20. Wieslander L. Intensive treatment of severe Class II malocclusions with a headgear-Herbst appliance in the early mixed dentition. Am J Orthod. 1984;86(1):1-13.
21. Wieslander L. Long-term effect of treatment with the headgear-Herbst appliance in the early mixed dentition. Stability or relapse? Am J Orthod Dentofacial Orthop. 1993;104(4):319-29.

© 2013 Dental Press Journal of Orthodontics

Effects of mandibular protraction appliance associated to fixed appliance in adults

Bruno D'Aurea Furquim[1], José Fernando Castanha Henriques[2], Guilherme Janson[2], Danilo Furquim Siqueira[3], Laurindo Zanco Furquim[4]

Objective: This retrospective study aimed to conduct a cephalometric evaluation of the skeletal, dental and soft tissue effects resulting from treatment of adult patients presenting Class II malocclusion, performed with a Mandibular Protraction Appliance (MPA) combined with a fixed orthodontic appliance.

Methods: The sample consisted of teleradiographs obtained before and after treatment of 9 adult patients (initial mean age of 22.48 years) with bilateral Class II, division 1, malocclusion. Paired t test ($p < 0.05$) was applied to compare initial and final values.

Results: t test revealed an increase in anteroinferior facial height and posterior facial height. The dental changes include: extrusion of upper incisors, buccal inclination, protrusion of lower incisors, mesialization and extrusion of mandibular molars. Regarding the soft tissue component, there was an increase in nasolabial angle in addition to upper lip retrusion.

Conclusions: The effects of treating Class II malocclusion adult patients, by means of using Mandibular Protraction Appliance (MPA) combined with a fixed appliance were mostly observed in the mandibular arch, and consisted of buccal inclination, protrusion and intrusion of incisors, and mesialization and extrusion of the molars.

Keywords: Angle Class II Malocclusion. Functional orthodontic appliances. Mandibular advancement. Adult.

[1] PhD Student in Oral Rehabilitation, School of Dentistry of Bauru, University of São Paulo (FOB-USP).
[2] Full and Head Professor, University of São Paulo (USP).
[3] PhD in Orthodontics, FOB-USP. Professor, UNICID.
[4] PhD in Oral Pathology, FOB-USP. Associate Professor, State University of Maringá (UEM).

How to cite this article: Furquim BD, Henriques JFC, Janson G, Siqueira DF, Furquim LZ. Effects of mandibular protraction appliance associated to fixed appliance in adults. Dental Press J Orthod. 2013 Sept-Oct;18(5):46-52.

Submitted: November 24, 2009 - **Revised and accepted:** December 29, 2010

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Bruno D'Aurea Furquim
Rua Arthur Thomas, 999 - Maringá/PR – CEP: 87013-250 – Brazil
Email: brunofurquim@hotmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Treatment of adult patients has become a reality in orthodontic practice for many years.[1,2,3] For cases of adult patients with mandibular deficiency, two treatment approaches are usually available. The first is compensatory, involving premolar extractions, allowing retraction of upper incisors and, as a result, overjet correction, while the second is surgical, repositioning the mandible more anteriorly.[4]

In addition to these two more traditional treatment options, functional fixed appliances constitute yet a third alternative to treat Class II malocclusion without extraction or surgery.[4-12]

The Herbst appliance was the first fixed functional appliance designed for the correction of Class II malocclusion, and also the first one described for this purpose in adult patients.[8] Besides the Herbst appliance, there are other fixed functional appliances effective in the correction of Class II malocclusion such as the Jasper Jumper, the MARA, the AMF and MPA.[5,6,7,13] The Mandibular Protraction Appliance (MPA) stands out for its easy fabrication, low cost and swift installation.[14]

Some studies have compared the treatment of Class II malocclusion with MPA associated to other appliances in adolescent patients.[13,15] Clinical cases of adult patients treated with MPA can be found in the literature.[16,17,18] But no research has yet been conducted to investigate treatment with MPA in a group of adult patients. Thus, this retrospective study aimed to conduct a cephalometric evaluation of the skeletal, dental and soft tissue effects resulting from treatment with MPA in combination with fixed appliance in adult patients presenting with Class II malocclusion.

MATERIAL AND METHODS

In selecting the sample, the following inclusion criteria were applied:

1. Presence of early bilateral Class II, division 1, malocclusion.
2. Absence of agenesis and no permanent teeth missing.
3. Absence of supernumerary teeth.
4. Treatment conducted exclusively with MPA combined with a fixed orthodontic appliance.
5. Class I molar relationship with a reduced overjet at the end of treatment.

Patients were defined as adults based on the cervical vertebral maturation method for evaluation of mandibular growth proposed by Baccetti et al.[21] Patients in the fifth cervical vertebral maturation stage (CVMS V) and above were considered adults. Evaluation was performed using the initial teleradiograph. Patients who raised any doubt as to their classification were excluded from the sample.

The sample consisted of nine Brazilian Caucasian adults (6 females and 3 males) presenting bilateral Class II division 1 malocclusion. The patients had an initial mean age of 22.48 years (S.D. = 5.64, ranging from 15.14 to 29.69 years.) The mean follow-up period was 4.01 years, and the final mean age of the patients was 26.50 years. The patients were treated by experienced professors.

As this was a retrospective study, the teleradiographs were taken at different centers. The anatomical tracing and landmarks were scanned on a flatbed Numonics AccuGrid XNT, model A30TL.F (Austin, Texas/USA). Dentofacial Planner 7.02 software (Toronto, Ontario - Canada) was used for measuring the cephalometric variables since this computer program automatically corrects the radiographic image magnification. Midplane tracing was performed on bilateral structures, except for the molars, given that the more distally positioned molar was used as reference.

Intraexaminer error was determined by taking new measurements of 15 teleradiographs, either initial or final, after an interval of 30 days since the first measurement. Systematic errors were analyzed by dependent test as described by Houston.[19]

For evaluation of casual errors the Dahlberg test was utilized, which shows the average change between the first and second measurements. The test is performed by the formula $S^2 = \Sigma d^2/2n$, where S^2 is the error variance, d represents the difference between the first and second measurement, and n is the number of measurement pairs.[20] Random error was calculated using a Microsoft Excel XP spreadsheet.

Kolmogorov-Smirnov test was used to assess if the values had a normal distribution, thus allowing the dependent t test to be performed. The latter was performed to compare the mean cephalometric values at the beginning and end of treatment.

Statistical tests were carried out using Statistica software. Results where $p < 0.05$ were considered to be statistically significant.

© 2013 Dental Press Journal of Orthodontics

RESULTS

Only two variables (1-PTV and 1-PP) exhibited systematic error approximately one month after the first measurement, and random errors ranged from 0.28 for SML to 2.80 for 1.PP (Table 1).

MPA revealed no significant changes in the maxilla or mandible. As regards growth pattern, only the linear variables (anteroinferior facial height and posterior facial height) changed.

Incisor extrusion was the only significant change noted in the maxillary dentoalveolar component. On the other hand, the mandibular dentoalveolar component showed buccal inclination, incisor protrusion, and molar mesialization and extrusion. The treatment achieved significant correction of overjet and overbite as well as molar relationship. Regarding the soft tissue component, the nasolabial angle increased and the upper lip retracted relative to line E.

DISCUSSION

This study evaluated the dental, skeletal and soft tissue effects of correcting Class II malocclusion in a group of adult patients using Mandibular Protraction Appliances (MPAs). The Cervical Vertebral Maturation Method for assessment of mandibular growth,[21] and the patient's chronological age were the criteria used to classify patients as adults. Given that no other researcher has ever evaluated the effects of MPA on adult patients, the results will be compared with those of other studies that evaluated fixed functional appliances other than MPAs for correction of Class II malocclusion in adults or young adults .

It is noteworthy that the effects observed in this study result from treatment carried out with MPAs and fixed appliances. Further studies are warranted to evaluate not only the overall effects of treatment, but also specific effects observed in the period when the MPA was in place.

Skeletal effects

Other studies are in agreement with the results in terms of MPA effects on the maxilla. Treatment with MPA in a group with initial mean age of 15 years and five months was also unable to produce effects in the maxilla.[6] Nalbantgil et al[7] assessed the effects of Jasper Jumper in a group with an initial mean age of 16.5 years, and reported it had limited effects on the maxilla. Moreover, no significant differences were found between the beginning and end of treatment. However, in comparison with the control group, the authors suggested that Jasper Jumper inhibited the growth potential of the maxilla.

As in the present study, Nalbantgil et al[7] observed no significant effects on mandibular growth in patients with an initial mean age of 16.5 years treated with Jasper Jumper. However, significant changes were observed in the maxillomandibular relationship. Gönner et al[5] observed greater reduction (3 degrees) in the ANB angle, and in older patients (33.7 years / SD 7.9) treated with MARA.

With regard to growth pattern, only the linear variables (anteroinferior facial height and posterior facial height) increased, which can also be construed as a result of late changes in craniofacial growth. Nalbantgil et al[7] also observed no changes in the growth pattern. Ruf and Pancherz[12] observed that the SN.GoGn angle did not change during the Herbst phase, which is consistent with studies of Herbst in children. Decreases in the SN.GoGn angle during the fixed appliance phase and throughout the observation period as well as mandibular advancement caused a reduction in the convexity of the skeletal and soft tissue profile. The opposite seems to have occurred with controls, of which convexity increased over time.

Dental effects

In agreement with the present study, Nalbantgil et al[7] noted extrusion in upper incisors as a result of treatment with Jasper Jumper. They also observed retraction of the upper incisors and distal tipping of the molar crown, which was not observed in this study. This may have been due to the fact that patients in this study were older (22.41 years) than patients evaluated by Nalbantgil et al[7] (16.5 years.) Given that the lower lip droops with aging,[22] extrusion of upper incisors can be regarded as an advantage afforded by this treatment.

The lower dentoalveolar component exhibited significant changes in nearly all variables (buccal inclination, incisor protrusion and intrusion, mesialization and extrusion of molars), except for the vertical position of the incisors as these remained unchanged.

Ruf and Pancherz[11] showed the dental and facial adjustments they achieved in adolescents and young adults. In both groups, Class II and overjet correction

© 2013 Dental Press Journal of Orthodontics

Table 1 - Results of paired t test and Dahlberg's formula applied to variables studied to estimate random and systematic errors, respectively.

VARIABLES	1st measurement	2nd measurement	Difference between means	Dahlberg	p
	Mean ± SD	Mean ± SD			
Maxillary Component					
SNA (degrees)	80.19 ± 4.28	80.77 ± 4.85	0.57	1.93	0.435
A-Nperp (mm)	2.40 ± 4.12	1.53 ± 4.37	-0.87	1.84	0.207
Co-A (mm)	85.93 ± 3.61	86.45 ± 4.00	0.52	0.90	0.118
Mandibular Component					
SNB (degrees)	76.23 ± 4.12	76.85 ± 4.52	0.61	1.26	0.193
Pog-Nperp (mm)	0 ± 5.91	-1.28 ± 6.29	-1.28	1.96	0.072
Co-Gn (mm)	108.21 ± 5.73	108.15 ± 5.75	-0.06	0.79	0.844
Go-Gn (mm)	72.86 ± 4.96	73.58 ± 5.02	0.72	1.87	0.308
Co-Go (mm)	53.21 ± 6.51	52.09 ± 6.16	-1.12	2.22	0.175
Maxillomandibular relationship					
ANB (degrees)	3.97 ± 2.48	3.92 ± 2.30	-0.05	0.90	0.893
NAP (degrees)	4.44 ± 6.74	4.14 ± 6.18	-0.30	1.17	0.501
Co-A/Co-Gn (mm)	79.47 ± 2.11	79.99 ± 1.77	0.51	0.93	0.137
Growth pattern					
FMA (degrees)	20.09 ± 7.74	21.21 ± 7.19	1.12	2.17	0.165
SN.GoGn (degrees)	29.28 ± 9.13	28.58 ± 8.84	-0.70	1.91	0.334
SN.PP (degrees)	7.75 ± 5.62	8.14 ± 4.59	0.39	1.73	0.559
AIFH (mm)	63.39 ± 3.73	62.63 ± 3.55	-0.76	1.54	0.184
S-GO (mm)	74.97 ± 7.81	74.55 ± 7.81	-0.43	1.10	0.306
Maxillary dentoalveolar component					
1.PP (degrees)	101.93 ± 9.72	106.75 ± 5.74	4.82	2.80	0.150
1-PP (mm)	28.26 ± 1.90	27.49 ± 2.01	-0.77	0.98	0.024*
1.NA (graus)	15.81 ± 9.34	17.86 ± 8.94	2.05	2.21	0.085
1-NA (mm)	2.77 ± 3.26	3.17 ± 3.21	0.40	1.03	0.304
1-PTV	56.10 ± 5.01	55.28 ± 5.90	-0.82	1.17	0.050
6-PP (mm)	22.54 ± 1.27	22.47 ± 1.23	-0.07	0.47	0.682
6-PTV	27.34 ± 4.21	26.33 ± 4.32	-1.01	1.75	0.116
Mandibular dentoalveolar component					
IMPA (degrees)	102.81 ± 6.60	102.71 ± 5.85	-0.10	1.54	0.892
1.NB (degrees)	31.39 ± 7.06	31.59 ± 6.18	0.21	1.50	0.720
1-NB (mm)	4.95 ± 2.21	4.74 ± 2.41	-0.21	0.79	0.479
1-PM (mm)	38.09 ± 2.19	38.11 ± 2.38	0.02	1.54	0.973
1-PTV	52.62 ± 4.80	51.59 ± 5.74	-1.03	1.28	0.021*
6-PM (mm)	29.86 ± 2.49	29.84 ± 2.72	-0.02	1.17	0.964
6-PTV	28.25 ± 4.45	27.31 ± 4.75	-0.94	1.67	0.126
Dental relationships					
T.H. (mm)	3.48 ± 0.74	3.69 ± 0.65	0.21	0.45	0.221
T.V. (mm)	3.33 ± 0.97	3.02 ± 1.21	-0.31	0.42	0.221
Molar relationship	-0.91 ± 1.65	-0.99 ± 1.62	-0.07	0.30	0.520
Soft tissue component					
ANL	111.29 ± 6.65	111.41 ± 5.52	0.12	2.88	0.914
SML	6.03 ± 0.97	6.02 ± 0.84	-0.01	0.28	0.950
UL-E	-4.21 ± 1.96	-4.14 ± 1.91	0.07	1.38	0.900
LL-E	-2.09 ± 2.91	-1.81 ± 2.70	0.28	1.68	0.663
UL-Pog'Sn	2.70 ± 1.14	2.92 ± 1.23	0.22	0.83	0.486
LL-Pog'Sn	1.41 ± 2.42	1.67 ± 2.22	0.26	1.26	0.588

*$p < 0.05$.

© 2013 Dental Press Journal of Orthodontics

Table 2 - Comparison between initial and final mean values by paired t test.

VARIABLES	Initial (n = 9)	Final (n = 9)	Difference between means	p
	Mean ± SD	Mean ± SD		
Chronological age				
Age	22.48 ± 5.64	26.50 ± 6.32	4.01	0.000*
Maxillary component				
SNA (degrees)	79.83 ± 6.52	80.24 ± 6.87	0.41	0.255
A-Nperp (mm)	-0.54 ± 3.29	0.07 ± 4.16	0.61	0.215
Co-A (mm)	85.01 ± 8.06	85.20 ± 7.77	0.19	0.537
Mandibular component				
SNB (degrees)	76.70 ± 6.44	77.13 ± 5.93	0.43	0.279
Pog-Nperp (mm)	-3.28 ± 5.38	-1.92 ± 5.47	1.36	0.169
Co-Gn (mm)	109.82 ± 8.34	110.38 ± 7.74	0.56	0.219
Go-Gn (mm)	73.43 ± 4.75	73.90 ± 4.92	0.47	0.110
Co-Go (mm)	53.07 ± 7.85	53.49 ± 7.00	0.42	0.407
Maxillomandibular relationship				
ANB (degrees)	3.14 ± 2.57	3.12 ± 3.20	-0.02	0.959
NAP (degrees)	2.38 ± 6.94	2.33 ± 8.04	-0.04	0.957
Co-A/Co-Gn (mm)	77.41 ± 4.22	77.19 ± 4.30	-0.22	0.422
Growthpattern				
FMA (degrees)	23.18 ± 7.73	22.76 ± 7.75	-0.42	0.378
SN.GoGn (degrees)	30.41 ± 11.13	30.06 ± 10.53	-0.36	0.439
SN.PP (degrees)	7.64 ± 5.44	7.02 ± 5.36	-0.62	0.271
AIFH (mm)	63.18 ± 6.17	64.86 ± 5.36	1.68	0.010*
S-GO (mm)	74.14 ± 10.19	75.58 ± 9.50	1.43	0.011*
Maxillary dentoalveolar component				
1.PP (degrees)	114.51 ± 9.65	111.23 ± 5.94	-3.28	0.192
1-PP (mm)	26.71 ± 3.13	28.22 ± 3.00	1.51	0.027*
1.NA (degrees)	27.06 ± 12.10	23.94 ± 8.98	-3.11	0.220
1-NA (mm)	6.41 ± 4.24	4.79 ± 3.71	-1.62	0.064
1-PTV	57.21 ± 4.25	56.54 ± 5.30	-0.67	0.441
6-PP (mm)	22.69 ± 2.48	23.03 ± 2.37	0.34	0.339
6-PTV	27.07 ± 3.34	27.36 ± 4.19	0.29	0.809
Mandibular dentoalveolar component				
IMPA (degrees)	99.62 ± 4.77	105.37 ± 4.53	5.74	0.000*
1.NB (degrees)	29.14 ± 4.94	35.13 ± 4.48	5.99	0.000*
1-NB (mm)	4.93 ± 2.41	5.78 ± 2.02	0.84	0.023*
1-PM (mm)	39.10 ± 3.31	38.16 ± 2.92	-0.94	0.124
1-PTV	51.59 ± 5.36	53.32 ± 4.96	1.73	0.053*
6-PM (mm)	28.59 ± 3.56	30.87 ± 2.84	2.28	0.001*
6-PTV	26.63 ± 4.35	29.72 ± 4.13	-3.09	0.027*
Dental relationships				
T.H. (mm)	5.62 ± 2.76	3.22 ± 0.57	-2.40	0.035*
T.V. (mm)	3.08 ± 1.75	1.48 ± 1.24	-1.60	0.008*
Molar relationship	0.43 ± 2.06	-2.06 ± 0.30	-2.49	0.007*
Soft tissue component				
ANL	108.19 ± 11.05	109.32 ± 12.46	1.13	0.007*
SML	6.34 ± 1.22	6.12 ± 1.34	-0.22	0.548
UL-E	-3.36 ± 2.38	-4.36 ± 1.94	-1.00	0.006*
LL-E	-2.08 ± 2.84	-2.13 ± 2.42	-0.06	0.888
UL-Pog'Sn	3.27 ± 1.91	2.94 ± 1.77	-0.32	0.365
LL-Pog'Sn	1.37 ± 2.53	1.68 ± 2.04	0.31	0.539

*p < 0.05.

© 2013 Dental Press Journal of Orthodontics

was promoted mostly by dental changes and to a lesser extent by skeletal changes.[10] Adolescent patients showed greater mandibular growth, whereas young adult patients exhibited greater molar mesialization and consequently greater protrusion of the lower incisors. Gönner et al[5] observed an increase of more than 5° in the IMPA of adult patients (33.7 years) treated with MARA combined with fixed appliances. Conversely, Nalbantgil et al[7] observed — in addition to lower incisor protrusion — intrusion of these same teeth, as was the case in the present study.

Buccal inclination of lower incisors and its impact on periodontal status is controversial. Some studies have seen protrusion as a risk factor for gingival recession since an association between recession and buccal movement has been observed.[22-25] Others did not note such association.[26,27,28] To Melsen and Allais,[29] other predisposing factors for gingival recession should be taken into account such as gingival biotype, visible plaque and inflammation.

A positive relationship between the patient's age and the severity of bone loss has been identified.[30,31] According to Ko-Kimura et al,[32] the prevalence of black spaces in post-orthodontic treatment is greater in patients over twenty years old, and these spaces are linked to resorption of the alveolar crest. The average prevalence of black spaces found in the adult orthodontic population post-treatment, regardless of the initial crowding, was 38%,[33] and 43% in adolescents after correction of incisor crowding, according to Burke.[34] Tanaka et al[35] demonstrated that due to crowding the interdental papilla can be crushed and it is only after the dental malocclusions have been corrected that black space may become evident. Tuverson[36] reported that since triangular teeth have no contact areas, but rather contact points, these teeth are more unstable and more susceptible to crowding. According to Olsson and Lindhe,[37] patients with triangular maxillary central incisors (slender and tall) tend to develop more gingival recession than those patients with wider and shorter maxillary central incisors, since there seems to be a relationship between "gingival biotype" and shape of the upper central incisor.

How maxillary incisors are positioned determines to a great extent the motivation that drives adult patients to seek orthodontic treatment. Few of these patients even notice skeletal abnormalities.[38] Therefore, preventive care should be provided for as long as there is orthodontic movement, mainly protrusive movement, in patients with thin gum / triangular incisor "biotype." Special attention should be paid when these features are associated with some degree of crowding and/or visible plaque and inflammation.

Soft tissue effects

Retrusion of the upper lip in terms of variable LL-E and an increased nasolabial angle were observed. These changes may have been influenced by nose growth, since the upper lip remained unchanged in terms of variable UL-Pog'Sn, consistent with the unchanged position of upper incisors in the sagittal direction. Despite the fact that protrusion and labial inclination of the lower incisors did occur, the lower lip did not protrude.

CONCLUSIONS

The effects of treating Class II malocclusion in adults using a Mandibular Protraction Appliance combined with fixed orthodontic appliance were mostly observed in the mandibular arch, and consisted of buccal inclination, incisor protrusion, and mesialization and extrusion of the molars. Incisor extrusion was the only significant change observed in the maxillary arch.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Harris EF, Vaden JL, Dunn KL, Behrents RG. Effects of patient age on postorthodontic stability in Class II, division 1 malocclusions. Am J Orthod Dentofacial Orthop. 1994;105(1):25-34.
2. Kokich V, Mathews D. Managing treatment for the orthodontic patient with periodontal problems. Semin Orthod. 1997;3(1):21-38.
3. LaSota E. Orthodontic considerations in prosthetic and restorative dentistry. Dent Clin North Am. 1988;32(3):447-56.
4. Ruf S, Pancherz H. Orthognathic surgery and dentofacial orthopedics in adult Class II division 1 treatment: mandibular sagittal split osteotomy versus Herbst appliance. Am J Orthod Dentofacial Orthop. 2004;126(2):140-52; quiz 254-5.
5. Gonner U, Ozkan V, Jahn E, Toll DE. Effect of the MARA appliance on the position of the lower anteriors in children, adolescents and adults with Class II malocclusion. J Orofac Orthop. 2007;68(5):397-412.
6. Kinzinger G, Diedrich P. Skeletal effects in Class II treatment with the functional mandibular advancer (FMA)? J Orofac Orthop. 2005;66(6):469-90.
7. Nalbantgil D, Arun T, Sayinsu K, Fulya I. Skeletal, dental and soft-tissue changes induced by the Jasper Jumper appliance in late adolescence. Angle Orthod. 2005;75(3):426-36.
8. Paulsen HU. Morphological changes of the TMJ condyles of 100 patients treated with the Herbst appliance in the period of puberty to adulthood: a long-term radiographic study. Eur J Orthod. 1997;19(6):657-68.
9. Paulsen HU, Karle A. Computer tomographic and radiographic changes in the temporomandibular joints of two young adults with occlusal asymmetry, treated with the Herbst appliance. Eur J Orthod. 2000;22(6):649-56.
10. Ruf S, Pancherz H. Dentoskeletal effects and facial profile changes in young adults treated with the Herbst appliance. Angle Orthod. 1999;69(3):239-46.
11. Ruf S, Pancherz H. Temporomandibular joint remodeling in adolescents and young adults during Herbst treatment: a prospective longitudinal magnetic resonance imaging and cephalometric radiographic investigation. Am J Orthod Dentofacial Orthop. 1999;115(6):607-18.
12. Ruf S, Pancherz H. Herbst/multibracket appliance treatment of Class II division 1 malocclusions in early and late adulthood. A prospective cephalometric study of consecutively treated subjects. Eur J Orthod. 2006;28(4):352-60. Epub 2006 Apr 27.
13. Siqueira D, de Almeira RR, Janson G, Brandão AG, Coelho Filho CM. Dentoskeletal and soft-tissue changes with cervical headgear and mandibular protraction appliance therapy in the treatment of Class II malocclusions. Am J Orthod. 2007;131(4):447.e 21-30.
14. Coelho Filho CM. Mandibular protraction appliances for Class II treatment. J Clin Orthod. 1995;29(5):319-36.
15. Alves P, Oliveira A, Silveira C, Oliveira J, Oliveira Júnior J, Coelho Filho C. Estudo comparativo dos efeitos esqueléticos, dentários e tegumentares, promovidos pelo tratamento da má oclusão Classe II mandibular com o aparelho de Herbst e com o Aparelho de Protração Mandibular. Rev Clín Ortod Dental Press. 2006;5(1):85-105.
16. Bicalho J, Bicalho R. Utilização do APM no tratamento da má oclusão de Classe II, 2ª divisão, em paciente adulto. Rev Clín Ortod Dental Press. 2007;6(1):99-106.
17. Coelho Filho C. Clinical application of the Mandibular Protraction Appliance in upper lateral agenesis and in asymmetric cases. Texas Dent J. 2002;119(7):618-26.
18. Coelho Filho C, White L. Treating adults with the Mandibular Protraction Appliance. Orthodontic Cyber J. 2003 jan [Access 2009 Jul 20]. Available from: http://orthocj.com/2003/01/treating-adults-with-the-mandibular-protraction-appliance/.
19. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod. 1983;83(5):382-90.
20. Dahlberg G. Statistical methods for medical and biological students. Br Med J. 1940;2(4158):358-9.
21. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod. 2002;72(4):316-23.
22. Dorfman HS. Mucogingival changes resulting from mandibular incisor tooth movement. Am J Orthod. 1978;74(3):286-97.
23. Fuhrmann R. Three-dimensional interpretation of labiolingual bone width of the lower incisors. Part II. J Orofac Orthop. 1996;57(3):168-85.
24. Hollender L, Ronnerman A, Thilander B. Root resorption, marginal bone support and clinical crown length in orthodontically treated patients. Eur J Orthod. 1980;2(4):197-205.
25. Wennstrom JL, Lindhe J, Sinclair F, Thilander B. Some periodontal tissue reactions to orthodontic tooth movement in monkeys. J Clin Periodontol. 1987;14(3):121-9.
26. Artun J, Krogstad O. Periodontal status of mandibular incisors following excessive proclination. A study in adults with surgically treated mandibular prognathism. Am J Orthod Dentofacial Orthop. 1987;91(3):225-32.
27. Djeu G, Hayes C, Zawaideh S. Correlation between mandibular central incisor proclination and gingival recession during fixed appliance therapy. Angle Orthod. 2002;72(3):238-45.
28. Hansen K, Pancherz H, Petersson A. Long-term effects of the Herbst appliance on the craniomandibular system with special reference to the TMJ. Eur J Orthod. 1990;12(3):244-53.
29. Melsen B, Allais D. Factors of importance for the development of dehiscences during labial movement of mandibular incisors: a retrospective study of adult orthodontic patients. Am J Orthod Dentofacial Orthop. 2005;127(5):552-61; quiz 625.
30. Van der Geld P, Oosterveld P, Kuijpers-Jagtman AM. Age-related changes of the dental aesthetic zone at rest and during spontaneous smiling and speech. Eur J Orthod. 2008;30(4):366-73.
31. Nelson PA, Artun J. Alveolar bone loss of maxillary anterior teeth in adult orthodontic patients. Am J Orthod Dentofacial Orthop. 1997;111(3):328-34.
32. Ko-Kimura N, Kimura-Hayashi M, Yamaguchi M, Ikeda T, Meguro D, Kanekawa M, et al. Some factors associated with open gingival embrasures following orthodontic treatment. Aust Orthod J. 2003;19(1):19-24.
33. Kurth JR, Kokich VG. Open gingival embrasures after orthodontic treatment in adults: prevalence and etiology. Am J Orthod Dentofacial Orthop. 2001;120(2):116-23.
34. Burke S, Burch JG, Tetz JA. Incidence and size of pretreatment overlap and posttreatment gingival embrasure space between maxillary central incisors. Am J Orthod Dentofacial Orthop. 1994;105(5):506-11.
35. Tanaka OM, Furquim BD, Pascotto RC, Ribeiro GL, Bosio JA, Maruo H. The dilemma of the open gingival embrasure between maxillary central incisors. J Contemp Dent Pract. 2008;9(6):92-8.
36. Tuverson DL. Anterior interocclusal relations. Part I. Am J Orthod. 1980;78(4):361-70.
37. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. J Clin Periodontol. 1991;18(1):78-82.
38. Maltagliati L, Montes L. Análise dos fatores que motivam os pacientes adultos a buscarem o tratamento ortodôntico. Rev Dental Press Ortod Ortop Facial. 2007;12(6):54-60.

© 2013 Dental Press Journal of Orthodontics

Cephalometric evaluation of the predictability of bimaxillary surgical-orthodontic treatment outcomes in long face pattern patients: A retrospective study

Carla Maria Melleiro Gimenez[1], Francisco Antonio Bertoz[2], Marisa Aparecida Cabrini Gabrielli[3], Oswaldo Magro Filho[3], Idelmo Garcia[3], Valfrido Antonio Pereira Filho[3]

Objective: The aim of this study was to compare by means of McNamara as well as Legan and Burstone's cephalometric analyses, both manual and digitized (by Dentofacial Planner Plus and Dolphin Image software) prediction tracings to post-surgical results.

Methods: Pre and post-surgical teleradiographs (6 months) of 25 long face patients subjected to combined orthognathic surgery were selected. Manual and computerized prediction tracings of each patient were performed and cephalometrically compared to post-surgical outcomes. This protocol was repeated in order to evaluate the method error and statistical evaluation was conducted by means of analysis of variance and Tukey's test.

Results: A higher frequency of cephalometric variables, which were not statistically different from the actual post-surgical results for the manual method, was observed. It was followed by DFPlus and Dolphin software; in which similar cephalometric values for most variables were observed.

Conclusion: It was concluded that the manual method seemed more reliable, although the predictability of the evaluated methods (computerized and manual) proved to be reasonably satisfactory and similar.

Keywords: Corrective orthodontics. Predictive value of tests. Oral surgery. Face.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

[1] PhD in Orthodontics, FOA-UNESP.
[2] Head Professor, Department of Pediatric Dentistry, FOA-UNESP.
[3] Assistant Professor, Oral and Maxillofacial Surgery, FOA-UNESP.

How to cite this article: Gimenez CMM, Bertoz FA, Gabrielli MAC, Magro Filho O, Garcia I, Pereira Filho VA. Cephalometric evaluation of the predictability of bimaxillary surgical-orthodontic treatment outcomes in long face pattern patients: A retrospective study. Dental Press J Orthod. 2013 Sept-Oct;18(5):53-8.

Submitted: August 27, 2009 - **Revised and accepted:** April 13, 2010

Contact address: Carla Maria Melleiro Gimenez
Rua Padre Duarte 989, Ap. 24, Centro, Araraquara/SP – Brazil
CEP: 14801-310 – E-mail: carlamg@yahoo.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Accurate diagnosis of both structures involved in malocclusions and the severity of occlusal conditions, facial and functional, leads to the decision of surgical-orthodontic treatment. It is extremely important to carry out an individualized plan in order to obtain successful and consistent results. Initially, preparatory orthodontic procedures are performed prior to orthognathic surgery, aiming to position the teeth in their bone bases. At the latest stage of ideal arch placement, molding is performed in order to articulate the upper and lower models in Class I relationship. Should this relationship be suitable in sagittal, transverse and vertical dimensions, the patient is conducted to the oral and maxillofacial surgeon who will perform the surgical planning in all its particularities.[1]

The prediction tracings show the inclination of the incisors and anticipate all necessary surgical movements, providing visualization of potential results from the tangent to the soft tissue as well as from the tangent to the skeletal tissue. Based on these data, model surgery is performed in semi-adjustable articulator, in which the information concerning the prediction tracing is transferred. This phase will accurately determine both the magnitude and the direction of surgical movements performed to obtain proper occlusion. Afterwards, surgery is performed, followed by orthodontic finishing, removal of orthodontic appliance, placing of retention and post-retention monitoring phases.

This paper focuses on the phase of prediction tracings which is important for carrying out proper surgical planning as well as for guiding the patient and establishing communication with him. Reliability of the proposed result is a constant concern. These tracings create a situation in which it is possible to describe in detail all surgical alterations, leading to an optimized conduct of the case.[13] Conventionally, these tracings are manually carried out, however, there are computer software that perform the prediction of results based on the digitization of cephalometric teleradiographs landmarks, for instance: Dentofacial Planner, OPAL, Quick Ceph Image, COGsoft, TIOPS, Dolphin.[4,16] These software are able to simulate the effect of incisor decompensation and the resultant movements of bony bases, translating them into illustrations and providing a silhouette of post-surgical skeletal and soft tissue profiles. However, it is worth noting that the prediction of these profile changes is difficult due to the variability of soft tissue behavior and differences in their translation accompanying skeletal changes promoted by orthognathic surgery.[17]

The present study is set within this context, with the purpose of comparing, through cephalometry, the accuracy of manual prediction tracings as well as those performed by both Dentofacial Planner Plus and Dolphin Image software, in relation to post-surgical results of long face patients subjected to bimaxillary orthognathic surgery.

MATERIAL AND METHODS

This study was approved by UNESP/Araçatuba Institutional Review Board, and analyzed pre and post-surgical lateral teleradiographs (6 months) of a sample comprised of 25 adult, long face patients, Angle's Class II, who were subjected to combined orthognathic surgery. These teleradiographs were obtained from the Center for Research and Treatment of Buccofacial Deformities (CEDEFACE – Araraquara/SP) and from the Oral and Maxillofacial Surgery and Traumatology course, given at UNESP College of Dentistry — Araraquara.

The inclusion criteria were:

1) Leucoderm, Brazilian, dentate and adult patients of both sexes.
2) Hyperdivergent patients.
3) Class II dental relationship, showing no open bite.
4) Bimaxillary surgical-orthodontic treatment performed in a minimum period of 6 months before the research, as this period assures sufficient regression of edema caused by surgery.
5) Radiographic documentation of initial periods, immediate preoperative phase, and well-performed post-surgical phase.
6) Absence of pathologies, fissures, facial anomalies or asymmetries.
7) Conventional Edgewise orthodontic technique was used for orthodontic preparation.
8) Absence of any other cosmetic and reconstructive surgeries performed on the patient's face during or after surgical-orthodontic treatment.

The sample comprised 22 (88 %) females and 3 (12 %) males with a mean age of 32.24 years (17 to 45 years).

Each teleradiography was traced three times (alternately and at weekly intervals in order to avoid memorization of traces), at an environment with controlled

© 2013 Dental Press Journal of Orthodontics

lighting (dark room). Seventy one landmarks were marked as they are necessary for the digitalization process performed with the Dentofacial Planner Plus software. The last trace of each patient, regarding pre and post-surgical teleradiographs (6 months), was used as a guide for an organized and sequential scan of these cephalometric landmarks. A scan of each trace was repeated twice in order to evaluate the method reproducibility (Intraexaminer Method Error).

Dentofacial ShowCase 2.0 for Microsoft Windows 95 and for Microsoft Windows NT 4.0 was used to scan the preoperative tracing, the prediction tracing obtained from this software as well as manual prediction tracing and post-surgical tracing. Dolphin Imaging 10.5 software (in the case of prediction tracings performed by this program) was used for the cephalometric evaluation, in which a single examiner was calibrated for tracing and digitizing the cephalograms.

Prediction tracings were built manually as well as with the use of Dentofacial Planner Plus (DFPlus) and Dolphin Imaging 10.5 (Dolphin) software. This process was based on data obtained from the surgery that was performed (clinical records in file folders of patients). The following sequence of tracings was obtained for each patient: manual prediction, DFPlus prediction, Dolphin prediction and post-surgical tracing (actual result). This sequence of tracings was subjected to McNamara's[12] as well as Legan and Burstone's[9] analyses for cephalometric evaluation.

The results (linear and angular measures obtained from the cephalometric analyses) were tabulated into Excel. A cephalometric analysis on the results obtained from manual and computerized prediction tracings as well as post-surgical tracings was carried out in order to check prediction error. This comparison was developed in three steps:

1) Evaluation carried out with Student's t test (paired) to determine whether or not there was prediction error statistically different from zero (for each cephalometric analysis measure cited for all prediction methods). The prediction error was given by subtracting post-surgical actual result from the value of cephalometric prediction.
2) Analysis of variance for comparison between post-surgical tracings and manual and computerized prediction tracings.
3) Tukey's test.

RESULTS

Method error

The method error analysis was indicated due to the importance of carrying out critical evaluation to verify the possibility of reproducibility as well as the effectiveness of the methodology used.[11] It should be noted that the data was read twice and that there was mutual agreement between readings, which proves the procedures to be reliable.

Table 1 - Means (M) and standard deviation (SD) of McNamara's cephalometric post-surgical measures and prediction errors means (M.E.) with their standard deviation (SD), according to the prediction methodology used.

Cephalometric measurement	Post-surgical		DFPlus		Dolphin		Manual	
	M	S.D.	E.M.	S.D.	E.M.	S.D.	E.M.	S.D.
A-Nperp	6.5	4.8	-6.6	3.9[b]*	-4.7	2.9[a]*	-6.7	3.9[b]*
Co-Gn	124.3	6.5	-2.3	4.4[a]*	-3.4	7.0[a]*	-8.3	6.5[b]*
CO-A	96.1	6.7	-7.4	4.5[a]*	-7.3	5.7[a]*	-7.3	5.9[a]*
Dif. Mx-Md	28.3	4.2	5.2	5.1[b]*	3.8	5.2[b]*	**-0.9**	5.4[a]
AIFH	77.7	5.5	2.1	3.9[a]*	2.4	5.4[a]*	**1.6**	4.3[a]
Pg-Nperp	0.1	6.3	-4.0	4.8[a]*	-5.3	5.8[a]*	-7.8	6.0[b]*
1-A perp	2.5	3.3	2.8	3.4[b]*	2.5	3.1[b]*	**0.9**	3.4[a]
1-A-Pg	1.8	3.1	3.5	2.0[b]*	4.0	2.6[b]*	2.5	2.5[a]*
FMA	30.6	5.0	-1.8	3.6[a]*	**-0.7**	3.8[a]	**0.0**	4.4[a]
Facial Axis	87.3	4.1	**-1.1**	3.6[a]	7.6	3.0[c]*	-3.9	4.1[b]*
Nasolabial Ang.	100.7	12.2	**0.7**	13.3[a]	11.0	10.4[b]*	**2.3**	13.9[a]

Means with the same letters in a row are not significantly different for Tukey's test at 5%.
* Means significantly different from zero for Student's t test at 5%.
» Bold: Measures of which prediction error was statistically equal to zero (actual result similar to the prediction).
» Underline: Measures with lower prediction error among the three evaluated methods.

Table 2 - Means (M) and standard deviation (SD) of Legan Burstone's cephalometric post-surgical measures, linear (mm) and angular (degrees), and prediction error means (E.M.) with their standard deviation, according to the prediction methodology used.

Cephalometric measurement	Post-surgical		DFPlus		Dolphin		Manual	
	M	S.D.	E.M.	S.D.	E.M.	S.D.	E.M.	S.D.
Sn-G Vert	10.7	4.9	-4.0	2.6^{a*}	-5.3	4.4^{a*}	-4.9	4.5^{a*}
Pg-G Vert	4.0	7.1	-4.7	5.4^{a*}	-8.7	7.8^{b*}	-5.9	7.1a^{b*}
Middle third	67.7	5.6	**0.9**	3.8^{a}			**-1.2**	5.7^{b}
Lower third	74.4	6.0	-1.1	2.9^{b*}			**0.9**	5.1^{a}
Upper Lip Protrusion	5.2	2.3	-1.1	1.8^{b*}	-1.1	1.6^{b*}	**0.5**	1.9^{a}
Lower Lip Protrusion	3.2	3.4	**-0.3**	3.5^{a}	2.9	3.4^{c*}	**0.9**	2.8^{b}
Upper Incisor Exposure	3.5	2.4	**-0.6**	2.2^{a}	**-0.9**	2.2^{a}	2.2	2.4^{b*}
Interlabial Space	3.6	3.7	-2.7	2.7^{b*}	**1.0**	3.1^{a}	3.7	3.1^{c*}
Facial Convexity	15.4	5.3	-2.7	4.5^{ab*}	**-1.1**	4.9^{a}	-3.2	5.5^{b*}
Cervico-mental angle	75.4	9.6	**-2.0**	10.2^{a}	-10.1	11.5^{b*}	-13.8	13.8^{b*}
Nasolabial angle	100.7	12.2	**0.7**	13.3^{a}	11.0	10.4^{b*}	**2.3**	13.9^{a}
Mentolabial sulcus	5.4	1.4	-1.6	1.9^{b*}	-12.2	2.0^{c*}	1.1	2.1^{a*}
Medium / inf.%	91.5	9.4	2.8	6.7^{a*}	7.7	9.2^{c*}	**-2.4**	8.5^{b}

Means with the same letters in a row are not significantly different for Tukey's test at 5%.
* Means significantly different from zero for Student's t test at 5%.
» Bold: Measures of which prediction error was statistically equal to zero (actual result similar to the prediction)
» Underline: Measures with lower prediction error among the three evaluated methods.
NOTE: The averages of the middle and lower facial thirds are not provided by Dolphin Imaging 10.5 software.

DISCUSSION

Each measure regarding the selected analyses was systematically evaluated from a cephalometric point of view[9,12] in order to relate the prediction error: the difference between the actual post-surgical measure and the prediction measure of each method (Dentofacial Planner Plus, Dolphin Imaging, manual prediction tracing). If the difference was zero, it would mean that the prediction would have been identical to the actual post-surgical results, indicating an excellent degree of accuracy concerning predictability. Therefore, the closer the cephalometric measures are to zero, the more accurate the method of predictability. Moreover, positive or negative prediction error indicate that the predicted value is, respectively, higher or lower than the actual value.

In accordance with Student's *t* test, the results shown in Table 1 (McNamara Jr Cephalometric Analysis,[12]) demonstrate that only 8 out of 33 evaluated means were not significantly different from zero; i.e., only eight presented a prediction result that did not differ statistically from the actual final result. These measures were: Maxillomandibular difference (manual method), AIFH (manual method), 1-Aperp (manual method), FMA (manual method and Dolphin), Facial axis (DFPlus), nasolabial angle (manual method and DFPlus). Therefore, the predictions which did not differ statistically from the actual post-surgical result were more frequent when using the manual method (5 cephalometric variables), followed by the DFPlus computerized method (2 cephalometric variables) and Dolphin (only one cephalometric variable).

Analyses of variance were used to compare the three methods concerning the prediction error. When such analyses indicated significant difference between methods, Tukey's test was used for multiple comparisons of means.

Despite presenting statistically significant differences, the following measures were close to the actual result: 1-APg (manual method), Pg-Nperp (DFPlus), CO-A (manual method and Dolphin), CO-Gen (DFPlus), A-Nperp (Dolphin). In this case, the three methods (Manual method, DFPlus and Dolphin) presented the same frequency (2 cephalometric variables for each method).

Results also demonstrated that some cephalometric measures showed very close values between two methods: A-Nperp (manual method and DFPlus), CO-A (manual method, DFPlus, Dolphin), AIFH (DFPlus and Dolphin), 1-A perp (DFPlus and Dolphin), FMA (Dolphin, DFPlus). In this case, Dolphin Imaging and DFPlus computerized methods proved to have a higher frequency of agreement.

The results displayed in Table 2 refer to the cephalometric measures established by Legan and Burstone.[9] From a total of 37 cephalometric means evaluated by Student's *t* test, 14 were not significantly different

from zero, i.e., not statistically different from the actual post-surgical result, which indicates a good level of prediction. These cephalometric references are: middle third of the face (DFPlus and manual method), lower third of the face (manual method), upper lip protrusion (manual method), lower lip protrusion (DFPlus and manual method), upper incisor exposure (Dolphin and DFPlus), interlabial space (Dolphin), facial convexity (Dolphin), cervico-mental angle (DFPlus), nasolabial angle (DFPlus and manual method) proportion of the facial thirds - Medium/Inf.% (manual method). The manual method had the highest number of cephalometric variables (6) with no statistically significant difference concerning the actual post-surgical result; followed by DFPlus (5) and Dolphin (3).

Except for the last two cephalometric measures, the means which significantly differ from zero, regarding a single measure, present equal signs: positive or negative, thus, demonstrating the same behavior towards cephalometric prediction. Analyses of variance were used to compare the three methods concerning the prediction error. Such analyses were complemented by Tukey's test.

Despite presenting statistically significant differences, the following measures were close to the actual result: Sn-G Vert (DFPlus), Pg-G Vert (DFPlus), mentolabial sulcus (manual method). In this regard, the prediction of DFPlus software (2 cephalometric variables) was more often closer to the actual result.

Results also demonstrate that some cephalometric measures showed very close values between two methods: Sn-G Vert (manual method and DFPlus), upper incisor exposure (DFPlus and Dolphin), facial convexity (DFPlus and Dolphin), cervico-mental angle (manual method and Dolphin), nasolabial angle (DFPlus and manual method), Medium / inf.% (DFPlus and manual method). Therefore, manual and DFPlus methods proved to have a higher frequency of agreement, followed by DFPlus and Dolphin. The study of Power et al[16] corroborates the findings of the present study. These authors compared the accuracy of prediction using Dolphin Imaging Software (Version 8.0) and the traditional manual technique; in comparison with actual post-surgical results. Manual tracings proved to be more predictable. The comparison of actual results to the predictions of the software demonstrated clinically significant differences for all measures.

Similarly, in the study carried out by Chunmaneechote and Friede,[3] prediction proves to be higher in the manual method. The authors concluded that conventional prediction tracings were significantly closer to post-surgical results than the pre-programmed proportions ($p < 0.05$).

Smith, Thomas and Proffit[18] evaluated five software (Dentofacial Planner Plus, Dolphin Imaging, Orthoplan, Quick Ceph Image and Vistadent) and their differences in the ability to simulate results in orthognathic surgery. Dentofacial Planner Plus software was considered the best simulator. The results showed that the differences in the ability to simulate results depend on several factors, such as: software performance, easy to use, cost, compatibility, image quality and practical application of available resources. In the present study, the frequency of cephalometric variables that were closer to post-surgical results proved to be higher when using DFPlus software in comparison to Dolphing Imaging software, corroborating the aforementioned authors.

Furthermore, Schultes et al[17] also claim that the prediction of DFPlus software is appropriate. The authors found that the software was frequently in accordance with the real situation regarding the nasal and labial areas, while the highest margins of errors were seen in the submental region. In general, predictability was greater than 80 %, which ensures accurate planning.

Csaszar, Bruker-Csaszar and Niederllmann[5] also evaluated the accuracy of prediction of DFPlus software and concluded that this proves to be satisfactory, although the profile of the labial region presents difficulties of predictability, which indicates the need for further development of this software.

In the study carried out by Gosset et al,[7] which compared the traditional prediction tracings (manual method) and the Dolphin Imaging software tracings with actual post-surgical results, it was shown that seven out of the sixteen measures showed statistically significant differences for the conventional method, while nine measures were statistically significant different for Dolphin Imaging software. Based on these data, the authors concluded that both methods seem to demonstrate reasonable predictability, thus, being similarly accurate. This statement corroborates the findings of this study, since the evaluated methods also demonstrated reasonable predictability, the differences between them were slight and the degree of accuracy observed was similar.

© 2013 Dental Press Journal of Orthodontics

Claiming that it is necessary to have common sense when using any system regarding prediction of results, Lu et al,[10] emphasized that although computerized imaging systems are valuable for establishing communication with patients as well as giving explanations to them, further efforts are needed to improve their accuracy, including considerations related to the stress of soft tissue and quality of muscle tissue. Therefore one must consider that the prediction obtained by imaging systems must be carefully interpreted.

Facing the possibility of high individual variability, Cousley et al[4] compared post-surgical results with prediction tracings and noted that the predictions of some cephalometric variables were reasonably accurate in terms of mean values. However, there was high individual variation for most measures, with the presence of systematic error. In particular, there was a tendency toward orthognathic surgery "overprediction", inducing backward mandibular rotation.

Pektas et al[15] evaluated the accuracy of predictability of tegumentar tissue response resulting from surgical-orthodontic treatment and observed that in the sagittal plane, the tip of the nose was the most accurate area, while the upper lip area presented the highest level of difference. In the vertical plane, the subnasal area was the most accurate, while the lower lip area was the least precise. The authors suggested that the predictions in sagittal plane were superior to those in the vertical plane.

Several authors suggest that variability factors related to the soft tissue (such as thickness, soft tissue tonicity, shape, functional application, and free functional space) be carefully considered when interpreting the predictability within the context of surgical-orthodontic treatment.[6,8,14]

Statistical analysis of the method error proved that the methodology used for marking cephalometric landmarks as well as angular, linear and proportion measures, was reliable and reproducible, which confirms the considerations of Buschang et al,[2] Martins[11] and Trajano et al.[19]

CONCLUSION

The experimental conditions of this study show that:

• The manual method proved to be closer to the cephalometric variables evaluated in relation to the actual post-surgical results, followed by DFPlus and Dolphin.

REFERENCES

1. Araújo CU, Tamaki T. Posição labial em repouso e sorriso e a sua relação com os incisivos centrais superiores. Rev Odontol Univ São Paulo. 1987;1(2):28-34.
2. Buschang PH, Tanguay R, Demirjian A. Cephalometric reliability: a full ANOVA model for the estimation of true and error variance. Angle Orthod. 1987;57(2):168-75.
3. Chunmaneechote P, Friede H. Mandibular setback osteotomy: facial soft tissue behavior and possibility to improve the accuracy of the soft tissue profile prediction with the use of a computerized cephalometric program: Quick Ceph Image Pro: v. 2,5. Clin Orthod Res. 1999;2(2):85-98.
4. Cousley RR, Grant E, Kindelan JD. The validity of computerized orthognathic predictions. J Orthod. 2003;30(2):149-54; discussion 128.
5. Csaszar GR, Brüker-Csaszar B, Niederdellmann H. Prediction of soft tissue profiles in orthodontic surgery with the Dentofacial Planner. Int J Adult Orthodon Orthognath Surg. 1999;14(4):285-90.
6. Gabrielli MFR. Alterações de posição dos tecidos moles da face após osteotomias Le Fort I: um estudo retrospectivo [tese]. Araraquara (SP): Universidade Estadual Paulista; 1990.
7. Gossett CB, Preston CB, Dunford R, Lampasso J. Prediction accuracy of computer-assisted surgical visual treatment objectives as compared with conventional visual treatment objectives. J Oral Maxillofac Surg. 2005;63(5):609-17.
8. Kuyl MH, Verbeeck RM, Dermaut LR. The integumental profile: a reflection of the underlying skeletal configuration? Am J Orthod Dentofacial Orthop. 1994;106(6):597-604.
9. Legan HL, Burstone CJ. Soft tissue cephalometric analysis for orthognathic surgery. J Oral Surg. 1980;38(10):744-51.
10. Lu CH, Ko EW, Huang CS. The accuracy of video imaging prediction in soft tissue outcome after bimaxillary orthognathic surgery. J Oral Maxillofac Surg. 2003;61(3):333-42.
11. Martins LP. Erro de reprodutibilidade das medidas das análises cefalométricas de Steiner e Ricketts pelos métodos convencional e computadorizado [tese]. Araraquara (SP): Universidade Estadual Paulista; 1993.
12. McNamara JA Jr. A method of cephalometric evaluation. Am J Orthod. 1984;86(6):449-69.
13. Omura T, Glickman RS, Super S. Method to verify the accuracy of model surgery and prediction tracing. Int J Adult Orthodon Orthognath Surg. 1996;11(3):265-70.
14. Park YC, Burstone CJ. Soft tissue profile: fallacies of hard tissue standards in treatment planning. Am J Orthod Dentofacial Orthop. 1986;90(1):52-62.
15. Pektas ZO, Kircelli BH, Cilasun U, Uckan S. The accuracy of computer-assisted surgical planning in soft tissue prediction following orthognathic surgery. Int J Med Robot. 2007;3:64-71.
16. Power G, Breckon J, Sherriff M, McDonald F. Dolphin Imaging Software: an analysis of the accuracy of cephalometric digitization and orthognathic prediction. Int J Oral Maxillofac Surg. 2005;34(6):619-26.
17. Schultes G, Gaggl A, Kärcher H. Accuracy of cephalometric and video imaging program Dentofacial Planner Plus in orthognathic surgical planning. Comput Aided Surg. 1998;3(3):108-14.
18. Smith JD, Thomas PM, Proffit WR. A comparison of current prediction imaging programs. Am J Orthod Dentofacial Orthop. 2004;125(5):527-36.
19. Trajano FS, Pinto AS, Ferreira AC, Katu CMB, Cunha RB, Viana FM. Estudo comparativo entre os métodos de análise cefalométrica manual e computadorizada. Rev Dental Press Ortod Ortop Facial. 2000;5(6):57-62.

© 2013 Dental Press Journal of Orthodontics

Factors related to orthodontic treatment time in adult patients

Ana Camila Esteves de Oliveira Melo[1], Lilianne Oliveira Thiers Carneiro[1], Luana Farias Pontes[2], Rodolpho Lobão Cecim[3], José Nazareno Rufino de Mattos[4], David Normando[5]

Introduction: The length of time that it takes an orthodontist to treat adult patients varies widely.

Objective: The aim of this study was to investigate how different variables influence treatment time.

Methods: Seventy clinical case reports of successfully treated adult patients were examined. The patients were selected from 4,723 records held by three experienced orthodontists. The influence exerted by the following variables on treatment time was assessed: age, sex, facial pattern, severity of malocclusion (measured by the PAR index), sagittal relationship of canines, type of brackets (ceramic or metal), tooth extractions, missed appointments and orthodontic appliance issues/breakages, the latter being the dependent variable. Assessment was performed by multiple linear regression analysis, followed by the stepwise method with $P < 0.05$.

Results: The number of times a patient missed their appointment (no-show) ($R^2 = 14.4\%$, $p < 0.0001$) and the number of appliance issues/breakages ($R^2 = 29.71\%$, $p = 0.0037$) significantly affected variability in treatment time, and these two variables together can predict 43.75% (R^2 total) of the overall variability in treatment time. Other factors, such as canine relationship at the beginning of treatment, bracket type (metal or ceramic), tooth extractions, age at start of treatment, severity of the initial malocclusion, sex and facial pattern had no significant bearing on treatment time.

Conclusions: The duration of orthodontic treatment in adults, when performed by experienced orthodontists, is mainly influenced by factors related to patient compliance. However, several factors which were not included in this study may contribute to variability in orthodontic treatment time.

Keywords: Adult. Time factors. Orthodontics.

[1] Specialist in Orthodontics, ABO/PA.
[2] Postgraduate student in Orthodontics, Federal University of Pará (UFPA).
[3] Specialist in Orthodontics, ABO/PA. MSc in Oral Pathology, UFPA.
[4] Professor, Department of Orthodontics, ABO/PA. MSc in Dentistry, UFPA.
[5] Associate Professor, Department of Orthodontics, UFPA.

How to cite this article: Melo ACEO, Carneiro LOT, Pontes LF, Cecim RL, Mattos JNR, Normando D. Factors related to orthodontic treatment time in adult patients. Dental Press J Orthod. 2013 Sept-Oct;18(5):59-63.

Submitted: July 25, 2013 - **Revised and accepted:** August 16, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Ana Camila Esteves de Oliveira Melo
Rua Jerônimo Pimentel, 117 – B. Umarizal – Belém/PA, Brazil
CEP 66055-000 – E-mail: millamelo18@hotmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

In today's society, the quest for esthetic perfection is no longer just an aspiration of the youth. As a result, there is an increasing number of adult patients who seek orthodontic treatment to improve not only function but appearance as well.[1,2]

Among the key factors that affect patients and serve to characterize adult vs. young patients are the absence of active growth, higher occurrence of dental mutilation and periodontal involvement.[2,3] However, the time required for treatment is a major concern of adult patients. Thus, orthodontists must be prepared to provide treatment that meets the specific needs of such patients.

Numerous studies have investigated variables that could influence treatment time in adolescents and adults. Among these factors are aging,[3-7] sex,[4,5,8,9] the use of ceramic vs. metal brackets,[4] molar relationship at the beginning of treatment,[9,10,11] initial severity of the malocclusion,[5-8,11-15] tooth extractions,[4,5,6,8,9,10,15-24] number of missed appointments,[4-7,18,21] issues with the orthodontic appliance (breakages),[4-7,9,21] patients' oral hygiene,[4,8,9,19] the orthodontist's experience,[15] whether or not treatment was performed in a public vs. private facility,[5] and the patients' noncompliance in the use of intraoral elastics.[4,9]

These studies show conflicting results for one and the same variable analyzed. Moreover, some studies indicate that extractions may lengthen treatment time, compared to non-extraction therapy.[5,6,8,9,15,16,18-21,23,24] These results, however, are not unanimous.[14,10,17,22] Another factor that yields conflicting results in the literature is initial severity of the malocclusion. While some authors confirm its effects on treatment time,[5,8,11,12,14,15] others reject it.[6,7,13] Molar relationship also exhibits outcome variability as it may,[9,11] or may not[10] be associated with the duration of treatment.

Despite the disagreement regarding which variables exert a significant influence on orthodontic treatment time, no study has hitherto been published in the literature focusing on adult patients. The aim of this work was to investigate the influence exerted by different variables on the duration of treatment in adult patients.

MATERIAL AND METHODS

The records of 4,723 patients treated by three orthodontists with a professional experience of over 20 years were examined. Exclusion criteria included patients under 18 years with incomplete records, patients with more than one tooth missing per quadrant, patients previously treated by orthognathic surgery, syndromic and cleft patients, Class III malocclusion, retreatment cases, and patients who missed appointments for more than six months in a row or alternately. Thus, 123 adult patients were selected. After analyzing the quality of treatment after it was completed, 53 cases were excluded. The final sample consisted of 70 adult patients whose inclusion criteria were: patients aged 18 to 66 years, 48 females and 22 males, Angle Class I or II malocclusions as assessed based on canine relationship.

Treatment time in months was the main variable analyzed. The following predictor variables were observed at baseline (T_0) and analyzed: Sagittal canine relationship, planned extractions, sex, age, facial pattern, severity of malocclusion, type of brackets (ceramic or metal), missed appointments and appliance issues.

Table 1 shows a summary of nominal variables analyzed in the study.

Severity at the start of treatment was examined by the PAR index, and measured with a universal caliper (Mitutoyo, Brazil, model/code 530-102).

Intraexaminer error was evaluated by performing new measurements and calculating a new PAR index for the models of all selected patients. The first and second measurements were performed with a time interval of 14 days. Dahlberg's formula was applied to estimate random error while systematic error was examined by intraclass correlation.

Initially a correlation matrix was applied in order to examine which predictor variable could be asso-

Table 1 - Summary of nominal variables included in the study.

	n	%
Female	48	68.57
Male	22	31.43
Class I	33	47.14
Class II	37	52.86
Metal brackets	51	72.86
Ceramic brackets	19	27.14
Mesofacial pattern	35	50.00
Brachyfacial pattern	15	21.43
Dolichofacial pattern	20	28.57

© 2013 Dental Press Journal of Orthodontics

ciated with treatment time. Variables with significant correlations were included in the multiple linear regression analysis, which was complemented by linear stepwise regression.

Statistical analysis were performed by BioEstat 5.3 software (Mamirauá Institute, Belém, Pará state, Brazil). All tests were applied adopting a significance level of 5%.

RESULTS

Total mean treatment time was 32.2 months, and mean age at start of treatment was 27.7 years. The average number of appliance issues and months of missed appointments was about 3, and the mean number of extractions was 0.75. Systematic error analysis revealed excellent repeatability (R^2=0.9662) of the PAR index at T_0 (mean=14.06), associated with a small magnitude random error (Table 2).

Correlation analysis revealed that the variables "number of appliance issues", "missed appointments (number of months)", "PAR index at T_0" and "type of brackets (metal or ceramic)" were somewhat correlated ($p < 0.05$) with the main variable, i.e., "length of treatment." The variable "number of extractions" was also included due to its p-value (0.0543), which was very close to the value established for the level of significance (Table 3).

Multiple linear regression revealed that among the five dependent variables included in the analysis, only "number of issues/breakages" and "months of missed appointments (no-shows)" proved significant ($p<0.001$). Stepwise regression showed that together the five variables exerted an influence of 54.33% on treatment time variability, with "number of appliance issues/breakages" showing an influence of 29.71% ($p<0.001$), and "missed appointments" an influence of 14.04% ($p<0.001$), followed by the PAR index at T_0, with an influence of 6.51%, "number of extractions" (2.42%) and finally "type of brackets" exhibited an influence of 1.65% on the total treatment time.

Table 2 - Descriptive analysis of numerical variables.

Variables (n=70)	Descriptive statistics		Error Analysis	
	Mean	SD	Random	Systematic
				R value
Treatment time (months)	32.2	14.06	-	-
Age at T_0 (years)	27.7	9.95	-	-
Number of appliance issues/breakages	3	5	-	-
Months of missed appointments	3.08	2.02	-	-
Number of extractions	0.75	1.41	-	-
PAR index at T_0	14.06	7.75	0.94	0.9662

SD - Standard deviation.

Table 3 - Correlation Matrix and linear regression analysis.

Independent variables (n = 70)	Correlation matrix	Linear regression					
		Multiple			Stepwise		
		p value	F	R^2	p value	R^2	Variability R^2
Number of issues/breakages	0.9963	< 0.0001			< 0.0001	29.71%	29.71%
No-shows (months of missed appointments)	0.9732	< 0.0001			0.0037	43.75%	14.04%
PAR index (T_0)	0.8474	0.0009			0.1689	50.26%	6.51%
Metal x Ceramic	0.6903	0.005			0.1128	51.91%	1.65%
Number of extractions	0.3443	0.0543	15.2284	0.5076	0.0698	54.33%	2.42%
Age at T_0 (years)	0.0218	0.7737			-	-	-
Sex	0.0409	0.4804			-	-	-
Class I vs. Class II	0.1734	0.1645			-	-	-
Facial pattern at T_0	0.054	0.4275			-	-	-

© 2013 Dental Press Journal of Orthodontics

DISCUSSION

Today, establishing distinct goals as the desired outcomes of orthodontic treatment in adult patients is under debate. Thus, assessing the influence of some variables on treatment time is of paramount importance in defining the guidelines of orthodontic treatment in these patients. Some studies have examined factors related to treatment time. However, the mixed results achieved by these different studies — whose samples comprise adults, youth and children — have raised doubts as to the factors that may unequivocally have a bearing on the duration of orthodontic treatment in adults.

This study was therefore geared exclusively towards the study of adult patients treated by three seasoned professionals, each with over 20 years experience, thereby reinforcing and enhancing the reliability of the results. Furthermore, as a result, "lack of experience" is ruled out as a factor that could lengthen the duration of treatment.

The mean duration of treatment in this study was 32.2 months, similar to the findings of Dyer et al.[3] (30.7 months) and Robb et al.[7] (30.6 months).

The variables that showed statistically significant influence on treatment time were "number of months the case was left with no monitoring due to missed or canceled appointments" ($p< 0.0001$), which accounted for 4.14% of the influence on the overall treatment time, and "number of appliance issues/breakages" ($p=0.0037$), with an influence of 29.71%. These results corroborate previous findings.[4,5,7,9,18,21] And although all these studies included adult patients in their samples, they also had children and/or adolescents, which shows that regardless of age, behavioral factors pertaining to the patients themselves can exert substantial influence on the duration of treatment.

Insofar as Class I or Class II relationship is concerned, this study was based on the canine relationship given that patients with missing teeth were also included. This contrasts with the studies found in the literature, which focus solely on molar relationship. Some studies found no influence of the molar relationship on treatment time.[10] However, other studies[9,11] reported that the treatment of patients who present with a Class II at the beginning of treatment seem to take longer than Class I patients. The study by Skidmore et al.[9] may have been influenced by the decision to extract teeth when the treatment was already in an advanced stage as the patient failed to wear intraoral elastics. In turn, in the work of Vu et al.[11] length of treatment may have been affected by the authors' decision to carry out treatment in two phases. In this study, the canine relationship was initially a variable that did not increase the duration of treatment significantly. It should be noted that in the present investigation 13.51% of patients started treatment with a Class II, and eventually had this relationship corrected only at the level of the canines by extracting two maxillary premolars. Given that these patients continued to present with molar Class II malocclusion, one might feel compelled to question the fact that if the molar sagittal relationship had also been corrected, treatment time may have been prolonged.

The variable "type of bracket", whether metal or ceramic, had no bearing on the duration of treatment. This factor has seldom been explored in the literature. It can only be found in a study by Beckwith et al,[4] which concludes that it has no influence on the length of treatment.

The decision to extract or not to extract and the amount of extractions planned for orthodontic treatment has been a widely researched variable that helps to determine to what extent the total treatment time is affected by these extractions. This has been an ongoing concern of orthodontists. Although significant relationships between duration of treatment and the decision to extract, or not, have been widely observed in the literature,[5,6,8,9,15,16,18,19,20,21,23,24] this study could not find a significant relationship between these variables, concluding that the decision to extract or not does not affect treatment time. This outcome resembles the findings of Beckwith et al,[4] Poppwich et al,[10] and Bhattarai et al.[17]

As documented in the literature, patient sex had no impact on the duration of treatment.[4,5,8] One exception is the work of Skidmore et al,[9] which found that male patients are a predictor of longer treatment time. The variable "facial pattern" had not been examined in previous studies in terms of orthodontic treatment time. It was assessed in this study and showed no such influence.

In assessing the severity of the initial malocclusion, as measured in this study through the PAR index,

© 2013 Dental Press Journal of Orthodontics

the authors believed that the patient's initial occlusal problems would likely lengthen treatment time, which might be necessary to tackle those issues satisfactorily. This variable, however, did not play a statistically significant role in the duration of treatment, corroborating previous findings.[6,7,13] Nevertheless, other studies have revealed that the severity of the initial malocclusion influences to a significant extent the duration of treatment.[5,8,11,12,14,15]

It should be noted that all studies referenced in this research involved the investigation of variables likely to influence treatment time. None of them, however, focused exclusively on adult patients, but rather included children and/or adolescent patients in their sample. This realization underscores the importance of conducting further studies geared specifically to adult patients.

CONCLUSIONS

Based on the findings of the study, the following conclusions can be drawn:

1. Patients' behavioral factors (missed appointments and appliance issues/breakages) played a significant part in lengthening treatment time.

2. Other factors such as initial canine relationship, the choice of metal or ceramic brackets, extractions included in the orthodontic plan, initial age, PAR index at the start of treatment, sex and facial pattern had no significant influence on the treatment time of adult patients.

3. Within the scope of this study it was found that these variables accounted for only 54.3% of the overall influence exerted on the duration of treatment, suggesting that other factors should be investigated to determine the actual time length required to perform orthodontic treatment in adults.

REFERENCES

1. Maltagliati LA, Montes LAP. Análise dos fatores que motivam os pacientes adultos a buscarem o tratamento ortodôntico. Rev Dental Press Ortod Ortop Facial. 2007;12(6):54-60.
2. Capelloza Filho L, Braga AS, Cavassan AO, Ozawa TO. Tratamento ortodôntico em adultos: uma abordagem direcionada. Rev Dental Press Ortod Ortop Facial. 2001;6(5):63-80.
3. Dyer GS, Harris EF, Vaden JL. Age effects contrasted on orthodontic with adults treatment: Adolescents. Am J Orthod Dentofacial Orthop. 1991;100(6):523-30.
4. Beckwith FR, Ackerman RJ, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic Treatment. Am J Orthod Dentofacial Orthop. 1999;115(4):439-47.
5. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop. 1992;102(1):45-51.
6. Mavreas D, Athanasiou AE. Factors affecting the duration of orthodontic treatment: a systematic review. Eur J Orthod. 2008;30(4):386-95.
7. Robb SI, Sadowsky C, Schneider BJ, Begole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop. 1998;114(4):383-6.
8. Haralabakis NB, Tsiliagkou K. The effect of six variables and their interrelation on the duration of orthodontic treatment. Hellenic Orthod Rev. 2004;7(1):45-57.
9. Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors influencing treatment time in orthodontic patients. Am J Orthod Dentofacial Orthop. 2006;129(2):230-8.
10. Popowich K, Flores-Mir C, Nebbe B, Heo G, Major PW. Comparison of Class I and Class II treatment duration among three different orthodontic practices. Semin Orthod. 2006;12(1):52-9.
11. Vu CQ, Roberts WE, Hartsfield JK Jr, Ofner S. Treatment complexity index for assessing the relationship of treatment duration and outcomes in a graduate orthodontics clinic. Am J Orthod Dentofacial Orthop. 2008;133(1):9.e1-13.
12. Dyken RA, Sadowsky PL, Hurst D. Orthodontic outcomes assessment using the peer assessment rating index. Angle Orthod. 2001;71(3):164-9.
13. Grewe JM, Hermanson PC. Influence of severity of malocclusion on the duration of orthodontic treatment. Am J Orthod. 1973;63(5):533-6.
14. Miguel JAM, Calheiros AA. A utilização do índice PAR no estudo da relação entre o tempo de tratamento com a severidade inicial e o grau de melhora da maloclusão. Rev Bras Odontol. 2013;60(3):208-12.
15. Taylor PJS, Kerr WIS. Factors associated with the standard and duration of orthodontic treatment. Br J Orthod. 1996;23(4):335-41.
16. Alger DW. Appointment frequency versus treatment time. Am J Orthod Dentofacial Orthop. 1998;94(5):436-9.
17. Bhattarai P, Shrestha RM, Mishra P. Comparison of duration of orthodontic treatment with and without extraction among orthodontic patients. J Nepal Dent Assoc. 2009;10(2):119-21.
18. De Saturno LD, Camardiel A. La duración del tratamiento ortodoncico y sus condicionantes. Acta Odontol Venez. 1999;37(1):17-29.
19. Fisher MA, Wenger RM, Hans MG. Pretreatment characteristics associated with orthodontic treatment duration. Am J Orthod Dentofacial Orthop. 2010;137(2):178-86.
20. Janson G, Maria FR, Barros SE, Freitas MR, Henriques JF. Orthodontic treatment time in 2- and 4-premolar-extraction protocols. Am J Orthod Dentofacial Orthop. 2006;129(5):666-71.
21. Maria FRT. Estudo do tempo de tratamento de casos tratados ortodonticamente com extrações de dois pré-molares superiores comparados aos de extrações de quatro pré-molares [dissertação]. Bauru (SP): Universidade de São Paulo; 2003.
22. Popowich K, Nebbe B, Heo G, Glover KE, Major PW. Predictors for Class II treatment duration. Am J Orthod Dentofacial Orthop. 2005;127(3):293-300.
23. Salazar RL. Avaliação do tempo e do grau de eficiência do tratamento da má oclusão de Classe I realizado com e sem extrações de pré-molares [dissertação]. Bauru (SP): Universidade de São Paulo; 2008.
24. Vig PS, Weintraub JA, Brown C, Kowaiski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop. 1990;97(1):45-51.

© 2013 Dental Press Journal of Orthodontics

Effects of chin advancement surgery in hyoid bone and tongue positions and in the dimension of the oropharynx

Milena Barreto de Arruda Cabral[1], André Carlos de Freitas[2], Telma Martins de Araújo[3], Nilson Pena[4], Rivail Almeida Brandão Filho[5]

Introduction: Advancement genioplasty has been increasingly indicated for the correction of anterior mandibular deficiency as it balances the patient's profile and generates functional changes.

Objective: Thus, the aim of this study was to assess the effects of advancement genioplasty in the oropharyngeal size and in the position of the hyoid bone and tongue.

Methods: The sample comprised 22 lateral cephalometric radiographs of 11 individuals who had undergone advancement genioplasty alone. Eleven of these radiographs depicted the immediate preoperative period (T_0) and the other 11 the postoperative period after at least four months (T_1). The radiographs were scanned and exported to the Radiocef Studio 2.0® software (Radio Memory Ltda., Belo Horizonte, MG, Brazil). The landmarks were then identified and automatically measured by the program.

Results: The results showed statistically significant differences between the horizontal position of the hyoid bone and tongue and in the oropharyngeal size. The hyoid bone and tongue were repositioned anteriorly after surgery ($p = 0.01$), thereby increasing the dimension of the oropharyngeal airspace ($p = 0.01$).

Conclusions: The oropharyngeal dimension increased as the tongue base and hyoid bone were repositioned more anteriorly.

Keywords: Orthognathic surgery. Chin. Oropharynx. Hyoid bone. Tongue.

» The patients displayed in this article previously approved the use of their radiographs.

[1] MSc Student in Orthodontics and Facial Orthopedics, Bahia Federal University (UFBA).
[2] PhD, Oral and Maxillofacial Surgery. Associate Professor, UFBA.
[3] PhD and Full professor, Department of Orthodontics, UFBA.
[4] PhD in Dental Radiology, UNICAMP.
[5] PhD Student in TMD and Associate Professor, UFBA.

How to cite this article: Cabral MBA, Freitas AC, Araújo TM, Pena N, Brandão Filho RA. Effects of chin advancement surgery in hyoid bone and tongue positions and in the dimension of the oropharynx. Dental Press J Orthod. 2013 Sept-Oct;18(5):64-9.

Submitted: June 30, 2011 - **Revised and accepted:** December 03, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Milena Barreto de Arruda Cabral
Av. Araújo Pinho, 62 – 7º andar – Canela – Salvador/BA – Brazil
CEP: 40.110-150 – E-mail: cabralmilena@hotmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Patients with dentofacial deformities increasingly seek combined orthodontic-surgical treatment. Above and beyond the esthetic issues inherent in facial deformity, functional conditions such as chewing, speech, articulation and nasal[1] breathing can be compromised. Genioplasty is a surgical procedure widely used in conjunction with other orthognathic surgeries to correct transverse, vertical and sagittal imbalances of the lower third of the face. Nowadays, it is often indicated to be performed alone as it is considered a relatively simple procedure with predictable results which, when properly indicated, improves facial esthetics.

Chin hypoplasia or deficiency is one of the most frequent deformities found in the anterior region of the mandible.[2] It is often seen in patients with both Angle Class II and Class I malocclusions with appropriate three-dimensional positioning of the maxillomandibular complex. For many of these cases, genioplasty is likely to be the treatment of choice.[3]

By means of genioplasty some deformities specific to the lower third of the face can be corrected by changing the shape and size of the mandibular symphysis, thereby improving soft tissue bone support and patient profile.[2] When performed alone, it is a more conservative surgical procedure involving little morbidity and not requiring intermaxillary fixation nor a lengthy in-patient hospitalization.[4]

Osteotomy extends from the premolar region on one side of the mandible to the opposite side, below the apices of the teeth and the mandibular canal. The tongue muscles, including the geniohyoid and genioglossus muscles, remain attached to the osteotomized bone segment in order to ensure the blood supply necessary for the enlarged chin.[4,5]

The geniohyoid muscle originates from the bottom of the lower genial tubercle of the mental symphysis, extending medially to the mylohyoid region and being attached to the upper margin of the body of the hyoid bone. The mylohyoid muscle originates from the medial surface of the mandible and is attached to the anterior surface of the hyoid bone through its posterior portion.[12]

The genioglossus muscle originates from the genial tubercle of the mandible and has a portion of its fibers connected to geniohyoid muscle fibers so that the hyoid bone moves in tandem with the tongue and oral floor during chewing and breathing.[11]

In healthy individuals, the hyoid bone is situated at the level of the C3-C4 vertebrae and it is important to preserve the size of the upper airspace because it serves as an anchor for the tongue muscles.[14] The distance between the hyoid bone and the mandibular plane is of approximately 12 mm.[15]

The oropharynx is lined with lymphoid tissue and extends itself from the second through the fourth cervical vertebra, participating in the processes of swallowing and breathing.[10]

Dimensional changes in the airspace have been observed after surgical repositioning of the mandible and maxilla[6,7,8] as well as changes in the position of the hyoid bone, tongue and head.[9] Previous studies have shown increases in oropharyngeal dimensions during mandibular advancement surgery and have recognized this surgical procedure as one of the most successful in the treatment of oropharyngeal space deficiency.[7,16,17] Mandibular advancement pushes the geniohyoid and genioglossus muscles forward, causing an anterior movement of the tongue base and hyoid bone, consequently increasing posterior airspace.[18]

The technique of genioplasty with advancement of the genioglossus muscle in patients with mandibular retrognathism promotes increased posterior airspace (PAS) and soft tissue advancement of the mental region.[19]

The aim of this article was to assess whether any changes occur in the oropharyngeal size and in the position of both the hyoid bone and tongue after chin advancement surgery.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of the Bahia Federal University (UFBA), under Opinion nº 40/09. The sample comprised 22 lateral cephalometric radiographs of 11 male and female individuals aged between 16 and 49 years, who were subjected to advancement genioplasty alone. The average chin advancement achieved in patients in this study was of 6.84 mm ± 2.02 mm. These procedures were carried out independently of the research. Eleven of these radiographs depicted the preoperative period (T_0) and 11 the postoperative period of at least four months (T_1) in order to prevent any potential postoperative swelling from interfering in the research outcomes. The radiographs were obtained

© 2013 Dental Press Journal of Orthodontics

with the patient's head immobilized by a cephalostat, orientated by the Frankfort horizontal plane positioned parallel to the floor and the midsagittal plane perpendicular to the floor. At the time when the radiographs were taken patients were instructed to keep their facial muscles at rest and not to swallow.

Initially, all 22 radiographs were scanned using an HP Scanjet G4050 TMA [Transparent Materials Adapter] (HP Development Company, L.P.) with slide scanning capabilities at 200 dpi with 100% resolution. The images were exported to the Radiocef Studio 2.0® software (Radio Memory Ltda., Belo Horizonte, MG, Brazil), and were analyzed with the Mixcef tool.

Subsequently, cephalometric landmarks were identified (Table 1). These landmarks determined the linear distances of the oropharyngeal space (f1-f2), which also revealed the anteroposterior changes in the tongue, vertical position of the tongue (D-PNS) and both the vertical position (H-SOPS) and horizontal position (C3-H) of the hyoid bone (Fig 1). These distances were automatically measured by the software.

Assessment of intra and inter-examiner agreement was conducted by means of remarking through the Radiocef Studio 2.0® software (Radio Memory Ltda., Belo Horizonte, MG, Brazil the landmarks) of five randomly selected radiographs by applying Lin's concordance correlation coefficient. One of the authors performed the tracings twice on the same radiograph, with a 15-day interval between them, and another examiner also marked the landmarks on the same five radiographs.

Cephalometric landmarks	Description
Porion (Po)	The most superior point of the external acoustic conduit
Orbit (Or)	The most inferior point on the inferior margin of the orbit
PNS	Point at the end of the posterior nasal spine
Gonion (Go)	Average of the inferior-most and posterior-most points of the mandibular angle
Point B (Supramentale)	The deepest point in mandibular alveolar process
Pogonion (Pg):	The most anterior point in the contour of the mandibular symphysis
Point C3	The most anteroinferior point of the third cervical vertebra
Point H	The most anterior superior point of the hyoid bone
Point f1	Point located in the posterior wall of the pharynx, on the B-Go line
Point f2	Point located in the posterior wall of the tongue, on the B-Go line
Point D	Point located over the PNS line perpendicular to the Frankfort horizontal plane, forming part of the dorsum of the tongue

Table 1 - Cephalometric landmarks used in the study and their description.

STATISTICAL ANALYSIS

Assessment of intra and inter-examiner agreement was performed by means of applying Lin's concordance correlation coefficient. Paired t test was used to assess the differences between pre- and postoperative measurements. Pearson's correlation was used to assess the correlation between the variables which yielded statistically significant differences and the amount of chin advancement. All test results for p values lower than 0.05 were considered statistically significant.

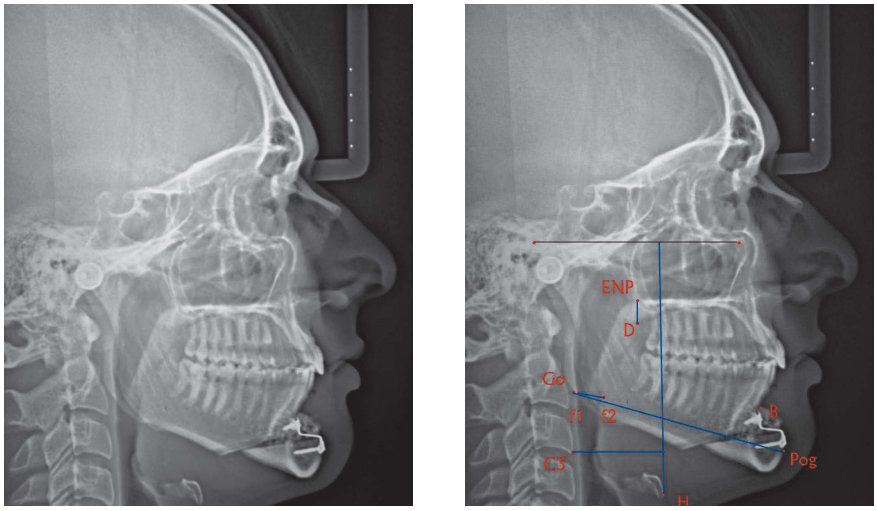


Figure 1 - Tracings performed with Radiocef software.

RESULTS

A high degree of intraexaminer agreement (0.99) was found through the correlation coefficient between the measurements carried out by the researcher at two different times. A high degree of correlation was also found in the inter-examiner assessment, with a coefficient of 0.98. Thus, no statistically significant difference was found for all measures assessed. In light of the results, the values of the first measurements were used for data analysis.

This study disclosed a statistically significant difference in the size of the oropharynx and in the positioning of the hyoid bone in the horizontal direction between both pre- and postoperative periods (Table 2). The oropharynx increased on average 1.83 mm, pointing to a change in the position of the tongue anteriorly ($p = 0.01$) and the hyoid bone moved forward on average 1.59 mm ($p = 0.002$).

In the vertical direction, the change in the hyoid bone and tongue ($p = 0.11$) did not yield statistically significant results. Despite this, the hyoid bone proved to be more superior in over half of the sample ($p = 0.61$).

DISCUSSION

Lateral cephalometric radiographs were used because airspace dimensions as well as tongue and hyoid bone position are properly reproduced in cephalograms where the head is in a natural position.[21] Although radiographic cephalometry provides two-dimensional images, it has been widely used in the study of pharyngeal airspace and craniofacial morphology as it offers considerable advantages, such as low cost and minimal exposure to radiation.[8,9,17] Moreover, according to Barbosa et al,[22] lateral cephalometric radiography is efficient in the diagnosis of adenoid hypertrophy because it strongly correlates with nasal endoscopy, which is considered the gold standard for diagnosing this condition.

The average value of the increase in the oropharynx, though small, can have great clinical significance because, according to Trotman et al,[23] a decrease of 1 mm in diameter of the upper airway of a child can decrease effective airspace by 65%, producing a critical obstruction.

Santos Júnior et al[19] obtained results similar to ours in terms of oropharyngeal dimension and, consequently, the position of the tongue in the horizontal direction. They assessed pre- and postoperative lateral cephalometric radiographs of patients who had undergone genioplasty combined with nasal surgery or uvulopalatopharyngoplasty. The postoperative results, which varied between 4 and 6 months, showed a 2.9 mm mean increase in oropharyngeal space.

Mandibular advancement surgery has revealed an increase in the oropharyngeal size and has been recognized as one of the most successful procedures in the treatment of oropharyngeal space deficiency.[7,16,17,25] According to Carlo et al,[18] the principle underlying increases in oropharyngeal airspace is the fact that this surgery pulls the geniohyoid and genioglossus muscles forward, thereby causing an anterior movement of the tongue base and the hyoid bone and, consequently, increasing the posterior[26] airspace. According to Ellis et al,[5] in advancement genioplasty the tongue muscles, including geniohyoid and genioglossus muscles, must remain attached to the osteotomized bone segment in order to ensure adequate blood supply, minimizing the possibility of resorption and providing long-term stability. Preservation of the pedicle during surgery is responsible for the tongue moving anteriorly and this principle is not only embraced but advocated by other authors to this day.[4,18,19,25,27]

The findings of these research suggest the possibility that, with a relatively simple procedure. i.e., advancement genioplasty, one can expect an increase in oropharyngeal airspace as a result of the anterior repositioning of the base of the tongue and the hyoid bone, thereby

Table 2 - Means of variables at T_0 and T_1.

	Before	After	
	Mean ± SD	Mean ± SD	p-value
f1 – f2	8.49 ± 3.05	10.33 ± 3.12	0.01
C3 – H	37.11 ± 5.54	38.33 ± 5.85	0.01
S – H	116.45 ± 13.32	116.71 ± 13.45	0.84
D – ENP	13.34 ± 4.14	12.00 ± 3.84	0.11

Table 3 - Correlation between the amount of chin advancement and the amount of oropharyngeal airspace increase and anterior repositioning of the hyoid bone.

Variables	Chin advancement	
	Correlation Coefficient	p-value
Increased oropharyngeal size	-0.50	0.11
Anterior hyoid position	0.09	0.79

[1] Pearson's correlation.

© 2013 Dental Press Journal of Orthodontics

improving both esthetic and functional conditions of patients with mandibular deficiency. Further studies must be conducted to assess the beneficial effect of this increase in oropharyngeal on breathing. By no means does chin advancement surgery replace mandibular advancement surgery, but it may be an alternative for some cases.

Ribeiro et al[4] asserted that they failed to account for the amount of mandibular advancement when assessing changes in the same variables studied in this research, a factor that should have been taken into consideration. In this study, assessment of chin advancement alone did not disclose any correlation between the extent of the advancement and the amount of increase in oropharyngeal size ($p = 0.11$), nor between the extent of the advancement and the amount of anterior repositioning of the hyoid bone ($p = 0.79$) (Table 3). In other words, patients who experienced significant chin advancement did not necessarily attain considerable gains in the dimension of the oropharynx nor in anterior hyoid bone repositioning. These results can be explained by the continuous change in the position of the hyoid bone that occurs throughout one's lifetime, regardless of surgical interventions. These changes are age-related and differ in terms of facial pattern.[28] In addition, since only the minimum period in which the surgery was performed was actually timed, the radiographs that depicted the postoperative period might present different time intervals. It is expected that further studies aimed at examining the variance between groups with different levels of advancement will show greater accuracy in the assessment of this correlation.

This investigation did not reveal any significant changes in the vertical position of the tongue and the hyoid bone. Athanasiou et al[29] assessed tongue position after the use of a functional appliance for anterior mandibular repositioning. The authors found it to be more superiorly positioned. They argued that this change was due to increases in oral cavity space and the tendency of the tongue to occupy such space. For them, changes in the tongue occur whenever there is an increase in oral cavity size, which is not the case when advancement genioplasty is performed alone.

Santos Júnior et al[19] showed a decrease of 2 mm on average in the vertical distance between the hyoid bone and the mandibular plane. This may have occurred because in addition to advancement genioplasty most of the sample was also subjected to uvulopalatopharyngoplasty (UPPP), which may have contributed to statistically significant outcomes.

Achilleos et al[9] also showed that the hyoid bone took on a higher position after mandibular advancement surgery, in agreement with results obtained in other studies,[8,16] in which its position remained unchanged in the long-term. When advancement genioplasty was performed alone, changes in the stomatognathic system proved less significant than in mandibular advancement surgery. Additionally, the sample size in this investigation ($n = 11$) may have contributed to the attainment of this result. Thus, further studies using a larger sample size are warranted.

CONCLUSIONS

Based on the results of this study, it is reasonable to conclude that advancement genioplasty alone correlates with a statistically significant increase in the oropharyngeal size as a result of an anterior repositioning of the base of the tongue. Changes in the position of the hyoid bone in the horizontal direction were also observed, probably due to a stretching of the suprahyoid muscles resulting from chin advancement.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Ambrizzi DR, Franz SA, Pereira Filho VA, Gabrielli MAC, Gimenez CMM, Bertoz FA. Avaliação das queixas estético-funcionais em pacientes portadores de deformidades dentofaciais. Rev Dental Press Ortod Ortop Facial. 2002;12(5):63-70.
2. Freitas CE. Mentoplastia: um importante complemento, não uma solução. In: Araújo A. Cirurgia Ortognática. São Paulo: Ed. Santos; 1999. cap. 12, p. 231-74.
3. Triaca A, Furrer T, Minoretti R. Chin shield osteotomy: a new genioplasty technique avoiding a deep mento-labial fold in order to increase the labial competence. Int J Oral Maxillofac Surg. 2009;38(11):1201-25.
4. Proffit WR, Turvey TA, Moriarty JD. Augmentation genioplasty as an adjunct conservative orthodontic treatment. Am J Orthod. 1981;79(5):473-91.
5. Ellis III E, Dechou PC, McNamara JA Jr, Carlson DS, Liskiewicz WE. Advancement genioplasty with and without soft tissue pedicle: an experimental investigation. J Oral Maxillofac Surg. 1984;42(10):637-45.
6. Pinto PA, Ferreira AP, Figueredo A. Perspectiva ortodôntica da cirurgia do mento. Rev Portuguesa Estomatol Med Dent Cir Maxilofac. 2009;50(1):25-34.
7. Ribeiro C. Efeitos da cirurgia ortognática de avanço ou recuo mandibular nas posições do osso hióide, da língua e no tamanho da orofaringe [dissertação]. Salvador (BA): Universidade Federal da Bahia; 2009.
8. Turnbull NR, Battagel JM. The effects of orthognathic surgery on pharyngeal airway dimensions and quality of sleep. Eur J Orthod. 2000;27(3):235-47.
9. Achilleos S, Krogstad O, Lyberg T. Surgical mandibular setback and changes in uvuloglossopharyngeal and head posture: a short and long-term cephamoletric study in males. Eur J Orthod. 2000;22(4):383-94.
10. Nuernberg CHG, Vilella OV. Avaliação cefalométrica da orofaringe. Rev Odonto Ciênc. 2006;21(54):370-5.
11. Pae EK, Blasius JJ, Nanda R. Heterogeneity in vertical positioning of the hyoid bone in relation to genioglossal in men. Angle Orthod. 2004;74(3):343-48.
12. Souza RP, Pagotto SR, Paes Junior AJO, Soares AH, Rapoport A. Diagnóstico por imagem da cavidade oral. Radiol Bras. 2003;36(3):169-72.
13. Guven O, Saraçoglu U. Changes in pharyngeal airway space and hyoid bone positions after body ostectomies and sagittal split ramus osteotomies. J Cranio Surg. 2005;16(1):23-30.
14. Salles C, Campos OS, Andrade NA, Daltro C. Síndrome da apnéia e hipopnéia obstrutiva do sono: análise cefalométrica. Rev Bras Otorrinolaringol. 2005;71(3):369-72.
15. Baik UB, Suzuki M, Ikeda K, Sugawara J, Mitani H. Relationship between cephalometric characteristics and obstructive sites in obstructive sleep apnea syndrome. Angle Orthod. 2002;72(2):124-34.
16. Gonçalves JR, Buschang PH, Gonçalves DG, Wolford LM. Postsurgical stability of oropharyngeal airway changes following counter-clockwise maxillo-mandibular advancement surgery. J Oral Maxillofac Surg. 2006;64(5):755-62.
17. Pereira Filho VA, Jeremias F, Tedeschi L, Souza RF. Avaliação cefalométrica do espaço aéreo posterior em pacientes com oclusão Classe II submetidos à cirurgia ortognática. R Dental Press Ortodon Ortop Facial. 2007;12(5):119-25.
18. Bruno Carlo B, Mauro P, Silvia B, Enrico S. Modified genioplasty and bimaxillary advancement for treating obstructive sleep apnea syndrome. J Oral Maxillofac Surg. 2008;66(9):1971-4.
19. Santos Junior JF, Abrahão M, Gregório LC, Zonato AI, Gumieiro EH. Mentoplastia para avanço do músculo genioglosso em pacientes com síndrome da apnéia-hipopnéia do sono obstrutiva e retrognatismo mandibular. Rev Bras Otorrinolaringol. 2007;73(4):480-6.
20. Heitz C, Lima LMS, Orso VA, Pinto LP, Ferreira AGM. Mentoplastia: do planejamento à técnica cirúrgica. J Bras Ortodon Ortop Facial. 2005;10(55):29-35.
21. Malkoc S, Usumez S, Nur M, Donaghy CE. Reproducibility of airway dimensions and tongue and hyoid positions on lateral cephalograms. Am J Orthod Dentofacial Orthop. 2005;128(4):513-6.
22. Barbosa MC, Knop LAH, Lessa MM, Araújo TM. Avaliação da radiografia cefalométrica lateral como meio de diagnóstico da hipertrofia de adenóide. Rev Dental Press Ortod Ortop Facial. 2009;14(4):83-91.
23. Trotman CA, McNamara JA, Dibbets JM, Van der Weele LT. Association of lip posture and the dimensions of the tonsils and sagittal airway with facial morphology. Angle Orthod. 1997;67(6):425-32.
24. Trenouth MJ, Timms DJ. Relationship of functional oropharynx to craniofacial morphology. Angle Orthod. 1999;69(5):419-23.
25. Prinsell JR. Maxillomandibular advancement surgery for obstructive sleep apnea syndrome. J Am Dent. 2002;133(11):1489-97.
26. Strauss RA, Abubaker AO. Genioplasty: a case for advancement osteotomy. J Oral Maxillofac Surg. 2000;58(7):783-87.
27. Polido WD, Bell WH. Long-term osseous and soft tissue changes after large chin advancements. J Cranio-Maxillofac Surg. 1993;21(2):54-9.
28. Pae EK, Quas C, Quas J, Garret N. Can facial type be used to predict changes in hyoid bone position with age? A perspective based on longitudinal data. Am J Orthod Dentofacial Orthop. 2008;134(6):792-7.
29. Athanasiou AE, Papadopoulos MA, Mazaheri M, Lagoudakis M. Cephalometric evaluation of pharynx, soft palate, adenoid tissue, tongue, and hyoid bone following the use of mandibular repositioning appliance in obstructive sleep apnea patients. Int J Adult Orthod Orthognath Sug. 1994;9(2):273-83.

© 2013 Dental Press Journal of Orthodontics

Auditory characteristics of individuals with temporomandibular dysfunctions and dentofacial deformities

Tatiane Totta[1], Giselda Santiago[2], Eduardo Sanches Gonçales[3], Sandra de Oliveira Saes[4], Giédre Berretin-Felix[5]

Objective: To investigate whether there is any relationship between otological as well as vestibular symptoms, audiological findings and type of temporomandibular disorder (articular, muscular and mixed); and to check the distribution of the temporomandibular disorders (TMD) dysfunction degree in the research population.

Methods: A retrospective study involving 30 patients of both sexes, aged between 18 and 49 years old, diagnosed with TMD and dentofacial deformities, who were subject to clinical evaluation (muscle palpation, auscultation of temporomandibular joint during mandibular motion and measurement of jaw movement), audiological testing (pure tone audiometry and immittance testing) and two questionnaires, one on otological and vestibular symptoms and the other on TMD anamnesis. Based on both the anamnesis questionnaire and the clinical assessment, the subjects were divided according to the type and degree of TMD dysfunction (mild, moderate and severe), and compared regarding the occurrence of auditory signs and symptoms, vestibular symptoms and audiological findings according to TMD type.

Results: The anamnesis questionnaire demonstrated higher prevalence (83.33%) of severe TMD. Subjects with mixed TMD had more complaints about hypoacusis than those with muscular TMD ($p < 0.05$). The results showed no change in either audiological and immittance testing for all assessed individuals.

Conclusion: Otological symptoms are present in subjects with TMD and dentofacial deformities, regardless of the classification of TMD (articular, muscular or mixed). Those with mixed TMD may have higher incidence of complaints about hypoacusis than subjects with muscular TMD. Further studies are needed to investigate the relationship between otological symptoms and the different types of TMD.

Keywords: Temporomandibular joint disorders. Hearing disorders. Audiometry. Malocclusion.

[1] Postgraduate student in Rehabilitation Sciences, Craniofacial Anomalies Rehabilitation Hospital – University of São Paulo (HRAC-USP).
[2] MSc in Rehabilitation Sciences, HRAC-USP.
[3] Associate Professor, Oral and Maxillofacial Surgery and Traumatology, Bauru School of Dentistry, University of São Paulo (FOB-USP).
[4] Professor, Speech Therapy, Sacred Heart University (USC).
[5] Associate Professor, department of Speech Therapy, Bauru School of Dentistry, University of São Paulo (FOB-USP).

How to cite this article: Totta T, Santiago G, Gonçales ES, Saes SO, Berretin-Felix G. Auditory characteristics of individuals with temporomandibular dysfunctions and dentofacial deformities. Dental Press J Orthod. 2013 Sept-Oct;18(5):70-7.

Submitted: November 17, 2009 - **Revised and accepted:** April 27, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Giédre Berretin-Felix
Alameda Dr. Otávio Pinheiro Brizolla, 9-75
Vila Universitária, Bauru/SP - Brazil
CEP: 17012-901 – E-mail: gfelix@usp.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Temporomandibular disorders (TMD) represent a set of clinical signs and multifactorial etiology symptoms characterized by pain in the temporomandibular joint (TMJ) and/or the tissue surrounding it, functional limitations in the jaw or crackling during TMJ movements.[13] The usual classification, according to The American Academy of Orofacial Pain criteria,[18] divides TMDs into groups according to anatomical etiology, respectively: Articular disorder, including the articular surface, the intra-articular disc or the articular bone; muscular disorder, involving the masticatory muscles surrounding the TMJ; or mixed disorder when there are signals of articular and muscular TMD.[12]

There are several factors involved in the etiology of TMD, such as disturbances of occlusion as well as maxillary and mandibular bone bases, degenerative disorder, traumatic factors, muscle disorders such as hyperactivity or hypoactivity, stress and emotional problems as well as functional changes and harmful habits that generate persistent overload in the TMJ or in the muscle.[1,12] Although the literature is discordant with regard to the real influence of malocclusion on the occurrence of TMD, a review carried out by McNamara et al[15] related specific diagnostic groups of TMD to occlusal factors, such as skeletal anterior open bite, overjet greater than 6 to 7 mm, difference between centric relation and maximal habitual intercuspation greater than 4 mm, unilateral crossbite, and absence of five or more posterior dental elements. Regarding Angle's malocclusions, Thilander et al[27] correlated Classes I, II and III to the prevalence of TMD and found higher prevalence of TMD in the group with Class III. However, the literature systematic review analysis of longitudinal studies conducted by Mohlin et al[16] did not find significant clinical associations between different malocclusions, orthodontic treatment and signs and symptoms of TMD.

Auditory complaints and symptoms such as otalgia, tinnitus, hypoacusis, ear fullness and vertigo are often correlated to the presence of TMDs.[9,11,19,21,24,26,28,30]

Several studies have been conducted in order to understand the etiology of auditory symptoms in subjects with TMD, firstly described by Costen.[6] The author suggested that poor positioning of the mandibular condyle, caused by loss of posterior tooth support, could cause blockage of the Eustachian tube, symptoms of otalgia, tinnitus and vertigo. Later, Myrhaug[17] stated that both stress and compression of the structures that conduct sound lead to increase in impedance, oftentimes causing ear fullness of floating feature associated with tinnitus. However, Penkner et al[20] demonstrated that masticatory muscle spasms do not affect the function of the soft palate tensor muscle and the Eustachian tube.

More recently, other studies found an association between pain on palpation of the mandibular condyle and the presence of otalgia in TMD subjects.[8,11,24] Additionally, high prevalence of tinnitus and vertigo[9,28,30] symptoms as well as ear fullness,[8,14,25] was observed in the research population. These conditions may be related both to TMD signs, the presence of muscle tension,[29] and pain on palpation in the masticatory muscles.[14]

With regard to hearing thresholds in subjects with TMD, the literature indicates lowering of airway thresholds in the frequencies of 6000 Hz and 8000 Hz.[25] However, no changes in audiological testing and increased incidence of normal immittance were found.[9]

Although many studies have described auditory symptoms present in TMD patients, few studies have correlated the type of dysfunction (articular, muscle or mixed) to auditory signs and symptoms. Among them, Tuz et al[28] have not found any prevalent occurrence of otalgia symptoms, tinnitus, vertigo or hearing loss among subjects classified as presenting articular, muscular and mixed TMD. On the other hand, the authors found higher prevalence of complaints in this population compared to the control group.

Hence, considering that skeletal malocclusion can be a contributing factor to TMD, this study aims to characterize the hearing function of individuals with TMD and dentofacial deformities according to each one of the TMD groups: articular, muscular or mixed (articular and muscular) and to investigate the distribution of the TMD dysfunction degree (mild, moderate or severe) in the studied population.

MATERIAL AND METHODS

The research subjects comprised 30 young adults of both sexes, clinically diagnosed with temporomandibular disorders by means of implementation of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) Axis I,[7] and who presented dentofacial deformities characterized by skeletal Class II or Angle Class III malocclusion. Exclusion criteria encompassed individuals with a history of central or peripheral neurological disorders, trauma or tumors in the

head and neck, noise exposure and early hearing-loss. This study was conducted at *Universidade do Sagrado Coração*/USC (Sacred Heart University) Bauru, Brazil, and was approved by the University Ethics Committee for Research on Human Beings (Protocol No. 077/2003).

Individuals were selected based on analysis of medical records of patients treated at the Oral and Maxillofacial Surgery Clinic of the College of Dentistry at the aforementioned university. These subjects had undergone a dental clinical evaluation and answered two questionnaires. One questionnaire was the Anamnesis Index (AI)[4,5] based on a modification of the Helkimo anamnesis index,[10] and previously used by Conti et al[4] at a significance level of 5%; while the other investigated the history of otological and vestibular symptoms.

Clinical evaluation was performed by the same examiner, properly trained and calibrated, and considered the following: measurement of both maximum mouth opening and laterality, presence of mandibular deviation or deflection, TMJ(s) palpation, analysis of joint noises and bilateral palpation of the temporal muscles, masseter, posterior digastric muscle, medial pterygoid muscle, sternocleidomastoid and upper trapezius. Based on the aspects investigated in the interview and clinical evaluation, the TMD patients were diagnosed and classified according to The American Academy of Orofacial Pain criteria.[18]

- GI: Group with articular TMD – presence of disc displacement, limitation of maximum mouth opening (less than or equal to 35 mm), mandibular deflection or deviation, spontaneous pain and/or upon TMJ palpation; cases with signs of myogenic TMD were excluded.
- GII: Group with muscular TMD – report of pain in the masticatory muscles during functional examination and/or muscle palpation; cases with arthrogenous TMD signs were excluded.
- GIII: Group with mixed TMD – signs of muscular and articular TMD.

Thus, the GI group (articular TMD) comprised 10 subjects, 7 with Angle Class II malocclusion and 3 with Angle Class III malocclusion. The GII group (muscular TMD) comprised 10 subjects, 4 with Class II and 6 with Class III. And finally, the GIII group (mixed TMD) comprised 10 subjects, 6 with Class II and 4 with Class III.

In the anamnesis index, the following aspects were investigated: Difficulty in mouth opening and jaw laterality, discomfort or muscle pain when chewing, presence of pain and/or muscle fatigue, perception of noise in the TMJ, headaches, neck or shoulder pain, pain in the ears (otalgia) or near them, use of one side of the mouth for chewing, facial pain in the morning and whether the subject considered his bite as normal.[5,12,26] Three possible answers were offered: "yes", "no" and "sometimes"; each "yes" corresponding to 2 points, "sometimes" represented 1 point and "no" represented 0. The items related to frequent headaches, earaches or close to it, and the presence of TMJ noises had a total of 3 points when they were bilaterally or intensively referred.[4] The sum of points allowed the classification of subjects into no-TMD (0 to 3 points), mild TMD (4-8 points), moderate TMD (9-14 points) and severe TMD (15 to 23 points).[4]

For specific investigation on ontological and vestibular symptomatology, the subjects were interviewed by a speech therapist who considered the presence of the following symptoms: vertigo and/or dizziness, tinnitus, ear fullness, earache and hypoacusis. They were also submitted to hearing evaluation at the Center of Health Education (CEPS), Bauru, Brazil, at properly equipped and acoustically treated rooms. The subjects underwent otoscopic examination, pure tone audiometry, logoaudiometry and immittance testing, using the GSI-60 audiometer and AZ-7 imittanciometer.

Pure tone audiometry determines the least quantity of audible acoustic energy (hearing threshold),[23] through the analysis of hearing thresholds for air and bone conduction of each frequency, using pure tones that are generated by two monaural headphones. The subject is instructed to raise his hand to the evaluator every time he listens to the tone stimulus. The evaluator reduces the signal strength tone, decreasingly, in values ranging from 10 to 10 dB(HL) until the hearing threshold is found. There must be confirmation of response in 50% of the 4 stimulation trials and the maximum hearing threshold value of 20 dB(HL)[24] should be considered as normal.

The logoaudiometry is a test of speech discrimination. For this study, the Speech Reception Threshold (SRT) test parameters were evaluated: Speech stimulus has its intensity reduced until is found the

© 2013 Dental Press Journal of Orthodontics

lowest intensity, in which the subject can discriminate 50% of the words dictated to him. The Speech Recognition Index (SRI) test parameters were also evaluated: the subject must repeat a list of 25 monosyllabic words (for each ear), in the same intensity, 40 dB above the tonal threshold mean of the following frequencies: 500, 1000 and 2000 kHz.[23]

Immittance testing represents an indirect test of tubal function, capable of evaluating both static and dynamic air pressure in the middle ear. This exam measures the ability of the tympanic membrane to reflect a sound introduced into the outer acoustic meatus, in response to gradual changes of pressure in the same space, thus, verifying the permeability of the tympanic-ossicular system with the passage of a sound wave within normal limits.[23]

The criteria used to define changes in the audiological tests were the following: Pure tone air-conduction thresholds (in the frequencies of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz) and pure tone bone-conduction (in the frequencies of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) greater than 20 dB(HL); air-bone GAP greater than 10 dB(HL); Speech Recognition Index (SRI, monosyllables) lower than 92%, SRT with values above 20 dB; tympanometric curve deviated from -100 daPa; contralateral acoustic reflexes exceeding 115 dB(HL) (absent); difference between the pure tone air-conduction threshold and reflex threshold less than 60 dB(HL), which would be suggestive of recruitment.[9]

Data analysis was performed by means of descriptive statistics, parametric and nonparametric. To compare the occurrence of auditory and vestibular symptoms according to the three different groups of TMD, the analysis of variance (ANOVA) was applied, as a classification criterion adopting a significance level of $p < 0.05$. To compare the TMD groups regarding the severity of TMJ disorder, the nonparametric Kruskal-Wallis test was applied, considering $p < 0.05$. Friedman test was used to investigate the tympanometric results, considering $p < 0.01$.

RESULTS

The study comprised 30 subjects of both sexes, 24 women and 6 men, aged 18-49 years (mean 27.3 ± 7.05 years), divided into 3 groups: GI (10 subjects with articular TMD), GII (10 subjects with muscular TMD) and GIII (10 subjects with mixed TMD).

With regard to the anamnesis index, it was verified higher prevalence of subjects presenting severe symptoms of dysfunction for the three TMD groups studied, as shown in Table 1. However, no statistically significant difference (p=0.069) was found among them.

Additionally, symptoms of moderate dysfunction occurred in one subject of GI group (10%) and in three subjects of GII group (30%). Mild dysfunction was observed for one subject of GI group (10%), only.

Individuals of articular (GI), muscular (GII) and mixed (GIII) TMD groups were questioned regarding the audiological and vestibular symptoms (Fig 1), and tinnitus and vertigo were reported by most subjects.

Table 1 - Distribution of subjects in accordance with Helkimo Anamnesis Index for each group.

TMD type	Dysfunction severity					
	Mild		Moderate		Severe	
	n	%	n	%	n	%
Articular	1	3.33%	1	3.33%	8	26.67%
Muscular	0	0%	3	10%	7	23.33%
Mixed	0	0%	0	0%	10	33.33%
Total	1	3.33%	4	13.33%	25	83.33%

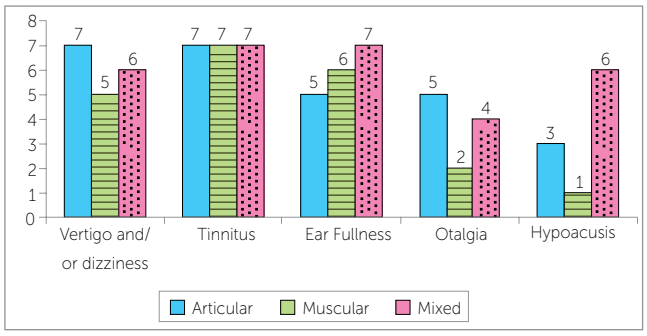


Figure 1 - Distribution of subjects with audiological and vestibular symptoms according to the three different groups of TMD.

Table 2 - Distribution of pure tone air conduction thresholds for all frequencies of each individual from the GI (articular), GII (muscular) and GIII (articular and muscular) groups for the right (RE) and left ears (LE).

Subjects/ Groups	Ears	Frequency							
		250	500	1.000	2.000	3.000	4.000	6.000	8.000
1 / GI	RE	5	10	10	15	10	5	5	10
	LE	5	15	5	15	0	5	10	10
2 / GI	RE	10	10	5	10	10	5	10	10
	LE	5	5	10	5	10	10	5	10
3 / GI	RE	10	5	10	5	5	0	10	10
	LE	15	10	10	5	5	5	10	5
4 / GI	RE	0	0	0	0	0	0	0	5
	LE	5	5	0	0	0	5	5	5
5 / GI	RE	10	10	5	10	15	10	10	10
	LE	0	10	5	10	15	5	5	10
6 / GI	RE	0	0	0	0	0	0	0	0
	LE	10	10	10	5	5	5	0	5
7 / GI	RE	10	10	5	0	5	0	10	5
	LE	5	10	5	10	5	10	10	10
8 / GI	RE	10	0	10	15	10	10	5	5
	LE	10	10	5	10	10	15	10	10
9 / GI	RE	5	5	10	10	10	15	10	10
	LE	5	10	5	10	5	5	10	10
10 / GI	RE	0	5	10	10	15	10	10	10
	LE	10	10	15	10	10	15	10	10
11 / GII	RE	15	15	10	10	10	5	5	10
	LE	15	15	10	10	5	10	5	5
12 / GII	RE	10	10	10	10	5	5	10	10
	LE	10	10	10	5	5	5	20	20
13 / GII	RE	15	15	10	5	5	10	5	5
	LE	15	15	10	5	10	5	15	10
14 / GII	RE	10	10	10	5	5	5	10	10
	LE	10	5	5	5	10	10	5	10
15 / GII	RE	0	5	10	5	5	10	5	5
	LE	0	5	10	10	0	10	10	5
16 / GII	RE	0	5	5	5	10	5	5	10
	LE	0	5	10	10	5	5	10	10
17 / GII	RE	10	5	10	10	10	5	15	10
	LE	5	5	10	5	10	5	10	10
18 / GII	RE	10	15	10	10	5	10	10	10
	LE	5	10	5	10	10	10	10	10
19 / GII	RE	10	10	10	10	10	10	15	15
	LE	10	0	5	5	5	5	10	10
20 / GII	RE	10	10	10	10	15	5	15	10
	LE	10	5	10	15	10	15	10	10
21 / GIII	RE	5	10	5	5	5	5	0	5
	LE	5	10	-5	0	5	5	5	5
22 / GIII	RE	10	5	10	5	5	10	10	10
	LE	15	10	10	5	5	5	10	5
23 / GIII	RE	5	5	0	0	5	5	5	10
	LE	5	5	5	5	10	10	10	10
24 / GIII	RE	0	0	0	5	5	5	0	10
	LE	5	5	5	5	5	10	5	5
25 / GIII	RE	10	10	10	15	10	10	10	10
	LE	10	0	10	10	10	10	10	10
26 / GIII	RE	5	5	10	5	10	5	5	10
	LE	5	10	10	5	5	10	10	10
27 / GIII	RE	10	5	5	0	5	0	10	5
	LE	5	10	5	5	5	10	5	5
28 / GIII	RE	10	5	10	0	10	10	10	10
	LE	15	15	10	5	10	10	10	10
29 / GIII	RE	10	10	5	10	15	5	5	10
	LE	0	10	5	10	15	5	5	10
30 / GIII	RE	0	0	5	5	10	5	10	10
	LE	5	5	10	10	10	10	15	10

© 2013 Dental Press Journal of Orthodontics

Furthermore, otalgia and hypoacusis were less frequently reported for individuals with muscular TMD. Statistical analysis showed that subjects with mixed TMD have more complaints about hypoacusis when compared to subjects with muscular TMD (p=0.0581).

In regard to pure tone audiometry, the subjects of the three TMD groups showed, for both ears, hearing thresholds ranging between 5 and 20 dB(HL), for all air-conduction frequencies tested (Table 2).

As for pure tone bone-conduction thresholds, all subjects presented normal compatible values and showed air-bone GAP lower than 10 dB(HL) for all frequencies tested.

In logoaudiometry, the Speech Recognition Index found for all individuals showed values between 96% and 100% of accuracy, which is consistent with the references of normality. Similarly, normal results in SRT (between 0 and 20 dB(HL)) were observed for the entire sample. The immittance testing showed significant prevalence (p=0.0001) of type A curve, representing consistent results with normal values.

DISCUSSION

In this study, patients were divided into groups according to TMD classification (articular, muscular and mixed) and dysfunction severity (mild, moderate and severe), aiming at elucidating the relationship between audiological / vestibular signs and symptoms and the different types of TMD.

In this sample there was higher incidence of TMD in females (80%) compared to males (20%), and this prevalence is very close to the values reported in the literature, since many studies have shown that TMD signs and symptoms are more common in women aged between 20 to 39 years old.[2,17,20,21,26]

Twenty four women were evaluated in this study, 15 (50%) of which aged between 20 and 29 years old, who were diagnosed with TMD. This result corroborates those obtained by Williamson[29] and Felício.[8]

There is also the hypothesis that degradation of cartilage and articular bone, due to menopause and increase in estrogen and prolactin,[17] may be related to the presence of TMD symptoms in women aged 40-49 years. In this sample, such symptoms were observed in 2 (6.67%) women within this age range.

With regard to the degree of dysfunction, 25 subjects (88.33%) of the sample, among the different groups, showed severe TMD symptoms. The study carried out by Penkner et al[20] found higher prevalence of moderate dysfunction, followed by severe dysfunction, among evaluated subjects with TMD. Keersmaekers et al[11] also measured the symptoms in TMD, by means of applying the Pain and Dysfunction Index,[10] and found significant higher prevalence of severe dysfunction in individuals with TMD concomitant with otalgia, when compared to subjects without otalgia. On the other hand, Silveira et al[26] found higher severity rate of mild TMD, followed by absent, moderate and severe TMD, respectively, in a sample of patients treated in an otorhinolaryngology outpatient unit. To carry out this evaluation, the authors used the same anamnesis questionnaire of the present research. Conti et al[5] investigated the association between malocclusion (Class I and Class II), orthodontic treatment, prevalence and severity of TMD signs and symptoms in 200 adolescents. They found that 34% of them had mild symptoms, according to the anamnesis index applied, while 3.5% had moderate symptoms. The lack of agreement in the literature regarding the degree of TMD prevalence may be related to the different conditions presented by the subjects of the cited studies, and it is important to consider that this study investigated individuals with dentofacial deformities.

As for the auditory and vestibular symptoms, it was found that more than half of the subjects in each studied group had symptoms of vertigo and/or dizziness, tinnitus and ear fullness. Pereira et al[21] also observed 65% of prevalence of tinnitus, otalgia and ear fullness in patients with TMD, as well as Parker and Chole[19] found significant prevalence of tinnitus and vertigo in patients with TMD. A study carried out by Tuz et al[28] also subdivided the subjects according to the types of TMD and found no predilection of audiological symptoms of otalgia, tinnitus, vertigo and hearing loss among groups with muscular, articular or mixed TMD. However, these symptoms were greatly prevalent in the control group of subjects without TMD. Nevertheless, Felício et al[9] found a relationship between subjects with severe pain in muscles and in TMJ, and the propensity for otalgia and tinnitus.

According to the literature, the complaint of ear fullness may be due to muscle changes in patients with TMD, such as the lateral pterygoid muscle spasm, leading to hypertonia of the tensor tympani muscle, causing changes in the cycle of Eustachian tube opening and leading to reduction in ventilation of the middle ear.[17] However, the study of Penkner et al[20] refutes this

hypothesis by means of electromyographic evaluation. Tinnitus sensation and other otologic symptoms, such as otalgia and hypoacusis, have been linked to the presence of TMD(s) in several studies, with four possible models that explain the etiology of otologic symptoms and signs in TMD(s): Embryological, muscular, bone communication and neural network.[22]

In the present study, subjects with articular symptoms associated or not with muscular complaints had higher incidence of otalgia and hypoacusis, although hearing loss had been declined by audiological testing. These findings agree with Ciacanglini et al,[3] who also found significant association between the severity of arthropathy and the perception of audiological symptoms. Such complaints may be justified by the close relationship between TMJ, tympanic cavity and the Eustachian tube,[2] in which the influence of changes in the contraction of the stapedius and cheekbone muscles on the ossicular chain of the middle ear and tympanic membrane, caused by the traction of the articular disc, could impact hearing perception, with otalgia related to central exciting effects and neuromuscular mechanisms involved in the TMD.[22]

The present study identified no changes in audiological tests, corroborating the literature.[8,20] In addition it also found proper tubal function (type A curve) for all subjects, also discovered in other studies.[8,20] However, it disagrees with a similar study[25] that found lower pure tone air-conduction thresholds in 6000 Hz and 8000 Hz frequencies in TMD patients.

It is worth considering the limitations of this study: the heterogeneity of dentofacial deformities present in each studied group as well as the lack of control group with dentofacial balance. Further studies shall be conducted in this direction, attempting to better understand the relationships between malocclusion, temporomandibular dysfunction and audiological/vestibular signs and symptoms.

CONCLUSION

This study found that audiological symptoms are present in subjects with temporomandibular disorders and dentofacial deformities, regardless of TMD classification (articular, muscular or mixed). Subjects with mixed TMD may have higher incidence of complaints of hypoacusis than subjects with muscular TMD, however, with neither hearing loss, diagnosed by audiological testing, nor tympanometric alterations being observed in the research population.

Since this study is preliminary, we highlight the importance of carrying out further studies, with bigger casuistry, in order to investigate the possible relationship between audiological symptomatology and TMD(s) classification.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Bianchini EMG. Articulação temporomandibular e fonoaudiologia. In: Ferreira LP, Befi-Lopes DM, Limongi SCO, organizadores. Tratado de fonoaudiologia. São Paulo: Roca; 2009. cap. 57, p. 532-44.
2. Bubon MS. Documented instance of restored conductive hearing loss. Funct Orthod. 1995;12(1):26-9.
3. Ciacanglini R, Loreti P, Radaelli G. Ear, nose, and throat symptoms in patients with TMD: the association of symptoms according to severity of arthropathy. J Orofacial Pain. 1994;8(3):293-7.
4. Conti PC, Ferreira PM, Pegoraro LF, Conti JV, Salvador MC. A cross-sectional study of prevalence and etiology of signs and symptoms of temporomandibular disorders in high school and university students. J Orofac Pain. 1996;10(3):254-62.
5. Conti A, Freitas M, Conti P, Henriques J, Janson G. Relationship between signs and symptoms of temporomandibular disorders and orthodontic treatment: a cross-sectional study. Angle Orthod. 2003;73(4):411-7.
6. Costen JB. Syndrome of ear and sinus simptons dependent upon disturbed functions of the temporomandibular joint. Ann Otol Rhinol Laryngol. 1934;43:1-15.
7. Dworking SF, LeResche L, editors. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniofamandib Disord. 1992;6:301-55.
8. Felício CM, Oliveira JAA, Nunes LJ, Jeronymo LFG, Jeronymo RRF. Alterações auditivas relacionadas ao zumbido nos distúrbios otológicos e da articulação têmporo-mandibular. Rev Bras Otorrinolaringol. 1999;65(2):141-6.
9. Felício CM, Faria TG, Silva MAMR, Aquino AMCM, Junqueira CA. Temporomandibular disorder: relationship between otologic and orofacial symptoms. Rev Bras Otorrinolaringol. 2004;70(6):786-93.
10. Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. Svensk Tandläk T. 1974;67(2):101-21.
11. Keersmaekers K, De Boever JA, Van den Bergue L. Otalgia in patients with temporomandibular joint disorders. J Prosthet Dent. 1996;75(1):72-6.
12. Kogawa EM. Avaliação da discriminação interoclusal para microespessuras e da força máxima de mordida em pacientes portadores de disfunções temporomandibulares [dissertação]. Bauru (SP): Universidade de São Paulo; 2005.
13. Koh H, Robinson PG. Occlusal adjustment for treating and preventing temporomandibular joint disorders. J Oral Rehabil. 2004;31(4):287-92.
14. Kuttila S, Kuttila M, Le Bell Y, Alanen P, Jouko S. Aural symptoms and signs of temporomandibular disorder in association with treatment need and visits to a physician. Laryngoscope. 1999;109(10):1669-73.
15. McNamara JA, Seligman DA, Okeson JP. Occlusion, Orthodontic treatment, and temporomandibular disorders: a review. J Orofacial Pain. 1995;9(1):73-90.
16. Mohlin B, Axelsson S, Paulin G, Pietilä T, Brattström V, Hansen K, et al. TMD in relation to malocclusion and orthodontic treatment. Angle Orthod. 2007;77(3):542-8.
17. Myrhaug H. The incidence of ear symptoms in cases of malocclusion and temporomandibular joint disturbances. Br J Oral Surg. 1964; 2(1):28-32.
18. Okeson JP. Dor orofacial: guia de avaliação, diagnóstico e tratamento. The American Academy of Orofacial Pain. Chicago: Quintessence; 1998.
19. Parker WS, Chole RA. Tinnitus, vertigo and temporomandibular disorders. Am J Orthod Dentofac Orthop. 1995 fev;107(2):153-158.
20. Penkner K, Köle W, Kainz J, Schied G, Lorenzoni M. The function of tensor veli palatine muscles in patients with aural symptoms and temporomandibular disorder. An EMG study. J Oral Rehabilitation. 2000;27(4):344-8.
21. Pereira KNF, Andrade LLS, Costa MLG, Portal TF. Sinais e sintomas de pacientes com disfunção temporomandibular. Rev CEFAC. 2005;7(2):221-8.
22. Ramirez LM, Ballesteros LE, Sandoval GP. Topical review: temporomandibular disorders in an integral otic symptom model. Int J Audiology. 2008;47(4):215-27.
23. Redondo MC, Lopes Filho O. Testes básicos de avaliação auditiva. In: Lopes Filho O, et al. Tratado de Fonoaudiologia. 2. ed. Ribeirão Preto: Tecmedd, 2005. p. 89-110.
24. Reis AC, Hotta TH, Ferreira-Jerônymo RR, Felício CM, Ribeiro RF. Ear symptomatology and occlusal factors: a clinical report. J Prosthet Dent. 2000;83(1):21-4.
25. Rodrigues ACY, Berretin-Felix G, Jorge JC, Genaro KF. Caracterização das alterações miofuncionais orais e auditivas em indivíduos com disfunção temporomandibular. Pró-Fono. 1998;10(1):51-5.
26. Silveira AM, Feltrin PP, Zanetti RV, Mautoni MC. Prevalência de portadores de DTM em pacientes avaliados no setor de otorrinolaringologia. Rev Bras Otorrinolaringol. 2007;73(4):528-32.
27. Thilander B, Rubio G, Pena L, de Mayorga C. Prevalence of temporo-mandibular dysfunction and its association with malocclusion in children and adolescents: An epidemiologic study related to specified stages of dental development. Angle Orthod. 2002;72(2):146-54.
28. Tuz HH, Onder EM, Kisnisci RS. Prevalence of otologic complaints in patients with temporomandibular disorder. Am J Orthod Dentofacial Orthop. 2003;123(6):620-23.
29. Williamson EH. The inter-relationship of internal derangements of the temporomandibular joint, headache e vertigo and tinnitus: a survey of 25 patients. J Craniomand Pract. 1990;8(4):301-6.
30. Zeigelboim BS, Jurkiewicz AL, Martins-Basseto J, Klagenberg KF. Avaliação vestibular em mulheres com disfunção temporomandibular. Rev CEFAC. 2007;9(2):255-62.

© 2013 Dental Press Journal of Orthodontics

Is there correlation between alveolar and systemic bone density?

Paula Cabrini Scheibel[1], Adilson Luiz Ramos[2], Lilian Cristina Vessoni Iwaki[2]

Objective: The present study assessed the correlation between maxillomandibular alveolar bone density and systemic bone mineral density (BMD).

Methods: Dual-energy X-ray absorptiometry of the anterior and posterior maxillomandibular alveolar bone, of the standard sites for the measurement of BMD (lumbar spine and femur) and the third cervical vertebra was performed on 23 middle-aged women. Periapical radiographs were also obtained, with an aluminum step-wedge as reference for the digital reading of apical bone density of the upper incisors.

Results: Spearman's correlations coefficients revealed that density in the apical region was correlated with that of the femoral neck ($r = 0.433$; $p < 0.05$); BMDs of the posterior regions of the mandible and maxilla were significantly correlated with that of the cervical vertebra ($r = 0.554$, $p \leq 0.01$ and $r = 0.423$, $p \leq 0.05$, respectively); and the anterior maxilla was correlated with the posterior mandible ($r = 0.488$, $p \leq 0.05$).

Conclusion: Bone density of the maxillary alveolar bone was significantly correlated with that of the femoral neck. Among the bone densities of the alveolar regions, only the anterior maxilla and the posterior mandible were significantly correlated. The findings suggested that bone densitometry might be individually and locally evaluated.

Keywords: Bone density. Dental radiography. Densitometry.

» The patients displayed in this article previously approved the use of their facial and intraoral photographs.

[1] MSc in Integrated Dentistry, State University of Maringá.
[2] Associate Professor, State University of Maringá.

How to cite this article: Scheibel PC, Ramos AL, Iwaki LCV. Is there correlation between alveolar and systemic bone density? Dental Press J Orthod. 2013 Sept-Oct;18(5):78-83.

Submitted: June 22, 2011 - **Revised and accepted:** November 08, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Paula Cabrini Scheibel
Av. Dr Luiz Teixeira Mendes, 2266 – Maringá/PR, Brazil
CEP: 87015-001 – E-mail: pscheibel13@gmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

In Dentistry, it is necessary to discuss variations in maxillomandibular bone mass and different responses to dental procedures, such as tooth movement, implant placement and periodontal treatment.[1-13] Research on this issue has mainly focused on healthy adults as well as on those presenting systemic conditions, such as osteoporosis; because such individuals have increasingly sought dental treatment in recent years. Despite the existence of a gold standard for assessing systemic bone loss (densitometry), no normative values have been defined for the maxilla and mandible. Moreover, divergent results have been found regarding correlations between systemic (spine, femur and radius) and maxillomandibular bone mass.

A number of studies have concluded that assessing some morphological patterns observed in dental radiographs — such as mandibular cortical thickness, trabecular pattern, cortical index and optical density — is a promising method that can contribute to the diagnosis of osteoporosis.[6,14-19] In a literature review, Hildebolt[20] reports a possible association between osteoporosis and maxillary bone loss, although not all studies have found such an association. Tanaka et al.[13] conducted histomorphometric analyses of trabecular structural changes in the mandibular alveolar bone of ovariectomized rats and concluded that osteoporotic changes caused by estrogen deficiency and the significant increase in intratrabecular spaces may accelerate the destruction of alveolar bone, leading to tooth loss, especially in older women affected by periodontal disease. However, Miyauchi[11] found no statistically significant differences in densities between premenopausal and postmenopausal women affected by periodontal disease.

The orthodontic community is also concerned about probable biological differences in response to tooth movement. A number of studies have addressed the effects of hormonal imbalance on bone metabolism and its influence on tooth movement, while others have investigated the consequences of administrating particular chemical substances.[21] The rate of alveolar bone remodeling increases in rats with induced osteoporosis, which could enhance tooth movement.[1,2] These findings corroborate faster tooth movement found in dogs with high bone turnover induced by secondary nutritional hyperparathyroidism, and rabbits submitted to osteoporosis induced by the administration of corticosteroids.[22,23]

Considering the small number of studies and the divergent results regarding this topic, the aim of the present study was to assess correlations in bone mineral density (BMD) between the maxillomandibular alveolar bone and the apical region of the upper central incisors, femur, lumbar spine and cervical spine.

MATERIALS AND METHODS

The sample comprised 23 women aged between 32.6 and 48.3 years (mean= 40.2 years). Inclusion criteria were: a signed informed consent, presence of most teeth in the dental arch, no previous orthodontic

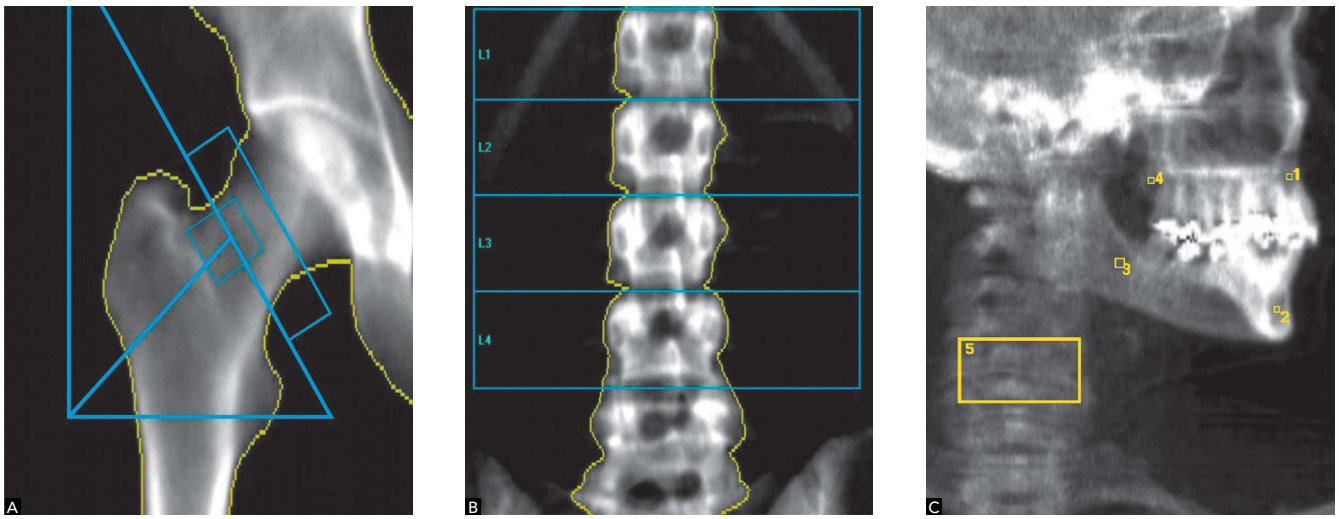


Figure 1 - Regions of interest in: **A**) femur and **B**) lumbar spine. **C**) Regions of interest in alveolar bone apical to upper central incisors (1); alveolar bone between cortical plates of mandibular symphysis (2); alveolar bone distal to mandibular second molar (3); alveolar bone distal to maxillary second molar (4); and third cervical vertebra (5).

© 2013 Dental Press Journal of Orthodontics

treatment, no history of osteoporosis and hyperparathyroidism. All procedures were approved by the Ethics Committee of the State University of Maringá.

The subjects were submitted to dual-energy X-ray absorptiometry (DXA) performed by a Lunar 2003 X-ray bone densitometer (Prodigy 8743, Lunar, GE Medical Systems). Densitometric readings were obtained for the following regions: total hip (TH), femoral neck (FN), first to fourth lumbar vertebrae (L1-L4), third cervical vertebra (C3), alveolar bone distal to the mandibular second molar (PMd), alveolar bone between the cortical plates of the mandibular symphysis (AMd), alveolar bone apical to the upper central incisors (AMx) and alveolar bone distal to the maxillary second molar (PMx) (Fig 1). These values were determined based on the amount of calcium hydroxyapatite in grams per square centimeter (g/cm^2).

The femoral and lumbar exams followed an internationally recognized standard protocol. BMD of the third cervical vertebra and the maxillomandibular regions was determined with the individual in ventral decubitus and the left face over the equipment table, so that the X-ray beam was perpendicular to the sagittal plane.[6,24]

Periapical radiographs of the upper incisors were taken using X-ray equipment (RX Timex 70 C, Gnatus, Ribeirão Preto, SP, Brazil) operating with 70 kVp, 7 mA and a 0.25-second exposure time. A five-step 2 x 20 x 3.5 mm aluminum wedge (Al step-edge) was attached to the apical region perpendicular to the film (Agfa Dentus M2 "Comfort"). Kodak developing and fixing solutions (Kodak Brazil, Commerce and Industry Ltda, São José dos Campos, SP, Brazil) were used to process the radiographs. The radiographic film was processed manually using the time-temperature method. Development time was determined by a table after verifying the liquid temperature (2 minutes in developer with temperature between 20 and 26°C). Intermediate washing was standardized at 30 seconds and fixing time was standardized at 10 minutes.[25] Radiographic images were digitized using a scanner with resolution of 400 ppi (ArtixScan 18000F, Microtek, São Paulo, SP, Brazil).

Figure 2 - Scanned periapical radiograph; region of interest selected in apical region of upper central incisors and on second step of aluminum step-edge (assessed using Adobe Photoshop CS2 software histogram tool).

Employing the histogram tool of Photoshop CS3 software (Adobe System, California, USA), a trapezoidal region of interest (ROI) was outlined in the alveolar bone surrounding the apical region of the upper central incisors to estimate optical density, expressed in grey level values. The lightest area on the film was represented by a pixel intensity value of 256, while the black areas were represented by 0. Each ROI consisted of approximately 2000 pixels. This dimension was used to aid in the selection of the trabecular alveolar bone, avoiding the tooth root, lamina dura, nasal spine and other structures. The digital reading of each step was performed by selecting a rectangular ROI of approximately 2500 pixels (Fig 2). Using the optical densities of the aluminum steps, the mean optical density of the bone between both central incisors could be transformed into aluminum equivalent millimeters (mmEq/Al) to obtain an indication of the anterior maxillary alveolar bone mass (UI_mmEq/Al).

All measurements were determined twice by the same examiner with a 15-day interval between readings. Intraexaminer reliability was statistically analyzed by establishing the difference between duplicate measurements on the densitometric and radiographic images of each patient. The error of the method was calculated using Dahlberg's formula:

$$Se = \sqrt{\frac{\sum d^2}{2n}}$$

In which *d* is the difference between pairs of measurements and *n* is the number of pairs of measurements.[15] Student's t-test was also employed: UI_grey level ($p = 0.96$); 1st step grey level ($p = 0.92$); 2nd step grey level ($p = 0.95$); 3rd step grey level ($p = 0.94$); 4th step grey level ($p = 0.97$); and 5th step grey level ($p = 0.93$). Although no statistically significant differences were found between the first and second measurements, the mean of each region was used in the subsequent statistical tests in order to minimize the random error. The examiner

carrying out the bone measurements was unaware of the identification of each volunteer.

Statistical analysis

Spearman's correlation test was applied to all variables (TH, FN, L1-L4, C3, PMd, AMd, AMx, PMx and UI). This non-parametric test was chosen due to the small sample size and the unusual distribution of data, as determined by the Shapiro-Wilk and Kolmogorov-Smirnov tests. Analyses were carried out using Microsoft Office Excel 2007 (Microsoft, USA) and SPSS 10.0 (SPSS Inc., Chicago, IL, USA) softwares.

RESULTS

Table 1 displays both mean and standard deviation concerning the participants' age, densitometry values of the eight regions assessed by DXA (total hip, femoral neck, lumbar spine, cervical vertebra, alveolar bone of posterior and anterior maxilla and mandible regions) and the digital densities of the alveolar process of the upper incisors apical region.

Table 2 displays the correlation matrix for the densitometric values of all regions assessed (TH, FN, L1-L4, C3, PMd, AMd, AMx, PMx and UI). Statistically significant correlation was found between UI and FN ($r = 0.433$; $p < 0.05$).

DISCUSSION

The present investigation found a correlation between systemic BMD and alveolar bone mass assessed in periapical radiographs and determined in mmEq/Al, which corroborates previous studies.[15,19,26,27]

As trabecular bone is more susceptible to mineral loss,[28] assessing regions with a greater amount of this type of bone is important to understand the relationship between systemic bone and oral status.[26] The mandible is a predominantly cortical bone and should, therefore, be compared with other cortical bones, such as the femur and forearm bones. Similarly, the maxilla is a predominantly trabecular bone and should be compared to the spine and the femur neck.[29] In a 10-year follow-up study, changes in the mandibular bone were correlated with changes in BMD of the forearm bones.[19] Moreover, BMD of the anterior region of the maxilla was correlated with that of the lumbar spine ($r = 0.6$; $p < 0.05$).[30] In the present study, a significant correlation was found between the femoral neck and the alveolar bone of the upper central incisors apical region ($r = 0.433$; $p < 0.05$). Klemetti et al [31] found a correlation between BMD of the layers of the mandibular cortex distal to the mental foramen (as determined by quantitative computed tomography) and BMD of the femoral neck and lumbar spine; however, there was no correlation with trabecular portions of the mandible.

Table 1 - Mean and standard deviation of densitometric bone values in assessed regions (L1-L4, TH, FN, C3, PMd, AMd, AMx, PMx and UI)

Subjects n = 23	Age (years)	L1-L4 (g/cm²)	TH (g/cm²)	FN (g/cm²)	C3 (g/cm²)	PMd (g/cm²)	AMd (g/cm²)	AMx (g/cm²)	PMx (g/cm²)	UI (mmEq/Al)
Mean	40.2	1.160	0.966	0.957	0.871	0.958	1.458	1.401	1.009	3.49
SD	5.4	0.093	0.075	0.095	0.135	0.374	0.317	0.342	0.334	1.309

L1-L4= 1st to 4th lumbar vertebrae. TH = Total hip. FN= Femoral neck. C3= 3rd cervical vertebra. PMd = Alveolar bone distal to mandibular second molar. AMd = Alveolar bone between cortical plates of mandibular symphysis. PMx = Alveolar bone distal to maxillary second molar. UI = Alveolar bone of upper central incisors apical region.

Table 2 - Correlation matrix of densitometric values of TH, FN, C3, L1-L4, PMd, AMd, PMx, AMx and UI; Spearman's test (r).

Site	L1-L4	TH	FN	C3	PMd	AMd	AMx	PMx	UI
L1-L4	1	---	---	---	---	---	---	---	---
TH	**0.5443	1	---	---	---	---	---	---	---
FN	*0.4905	***0.7761	1	---	---	---	---	---	---
C3	***0.6555	**0.5527	**0.5447	1	---	---	---	---	---
PMd	0.2294	0.3403	0.2972	0.3955	1	---	---	---	---
AMd	0.0416	-0.1547	-0.2773	-0.1075	-0.1988	1	---	---	---
AMx	0.0056	-0.0434	0.1758	0.2925	*0.4085	-0.2633	1	---	---
PMx	0.1966	0.068	0.1688	*0.4664	0.2245	0.2086	0.2406	1	---
UI	-0.202	0.2776	*0.4329	0.0787	0.2105	-0.0169	0.2997	0.154	1

Significant correlation: *P ≤ 0.05, ***P ≤ 0.001.

© 2013 Dental Press Journal of Orthodontics

In the present study, significant correlations were found between BMD of the third cervical vertebra, the systemic BMD (total hip, femoral neck and lumbar spine) and the BMD of the posterior alveolar region of the maxilla ($r = 0.466$; $p \leq 0.05$). These data corroborates a previous study carried out by our research group, in which a significant correlation was found between the third cervical vertebra and total hip ($r = 0.63$; $p \leq 0.001$).[32] The few previous studies that have assessed BMD of the cervical spine have found either a weak or no correlation with that of the mandible.[32,33]

Southard et al.[26] found that BMD of the maxillary alveolar process was correlated with that of the lumbar spine ($r = 0.53$; $p \leq 0.001$) and total hip ($r = 0.39$; $p = 0.01$). Conversely, in the present study, BMD of the maxillary alveolar process was correlated with that of the femoral neck ($r = 0.433$; $p < 0.05$). Neither study found a correlation between mandibular and systemic BMD. The cited authors also report a correlation between BMD of the maxilla and mandible ($r = 0.57$; $p \leq 0.001$). The present study found a correlation between BMD of the anterior maxilla and posterior mandible ($r = 0.488$; $p < 0.05$). The divergent results may be partially explained by methodological differences in obtaining maxillary densitometry values. In the present study, periapical radiographs were taken at the upper incisor region, only; while the maxillomandibular regions (PMd, AMd, AMx, and PMx) were assessed by DXA. In the study carried out by Southard et al,[26] BMD of both the maxilla and mandible was assessed using periapical radiographs of the anterior regions and interproximal of the posterior regions. Moreover, the mean values obtained from the available interproximal regions (mesial to second molar) of the maxilla and the mandible were analyzed. According to Lindh et al,[30] although anterior maxillary bone density and systemic bone density may be similar, further studies are required to investigate this relation.

Corten et al[24] found a 0.5% and 3% coefficient of variation for *ex vivo* and *in vivo* mandibular densitometric measurements, respectively, using DXA.[25] The authors stated that improvements may be obtained by repeating the measurements, as X-ray exposure is low. However, von Wowern[34] found high precision using DXA on both the mandible and the maxilla. Periapical radiographs allow the selection of a ROI with more precision than DXA, favoring the selection of trabecular alveolar bone while avoiding the crest, lamina dura, tooth root and other structures. However, neither method enables the distinction between cortical and trabecular bones, which is achieved through computed tomography. Therefore, studies assessing bone density for placing implants[8,30] or orthodontic mini-implants[35] have used tomography.

Among the maxillomandibular regions, only AMx and PMd were correlated, which corroborates the conclusion that the BMD of one site does not necessarily reflect the BMD of another site.[6,8,30] The highest densitometric value was for AMd (1.458 g/cm^2) followed by AMx (1.401 g/cm^2), PMx (1.008 g/cm^2) and PMd (0.958 g/cm^2). In a study involving computed tomography, Oliveira et al[8] also found higher BMD measurements for the anterior mandibular region, followed by the anterior maxilla, posterior mandible and posterior maxilla.

A more detailed study concerning computed tomography[35] has demonstrated that bone density tends to decrease as depth increases, particularly in the posterior area. Mean bone density demonstrated a progressive increase from the posterior to anterior region, except for the mandibular buccal side, for which no significant differences were found. A comparison of mean bone densities between buccal and lingual sides revealed that the lingual side of the mandible had higher values in the anterior area and lower values in the posterior area. On the other hand, no distinct differences were found between buccal and lingual sides of the maxilla. Additionally, a comparison of the mean bone densities between the maxilla and mandible revealed higher values in the latter, with more significant differences on the buccal side of the posterior region. The authors concluded that differences in bone density, in accordance with depth and area, should be considered when selecting and placing mini-implants for orthodontic anchorage.

Although a number of studies have reported a correlation between maxillomandibular alveolar bone mass and systemic BMD (lumbar spine, total femur, femoral neck and radius), differences are found among the methods employed and the specific correlations of the regions assessed. Therefore, further studies are required for establishing a standard method with normative alveolar densitometric values in order to determine these correlations.

© 2013 Dental Press Journal of Orthodontics

CONCLUSION

Based on the results of the present study, the following conclusions can be drawn:

» Bone density of the maxillary alveolar bone was correlated with that of the femoral neck.

» Among the bone densities of the alveolar regions, only the anterior maxilla (AMx) and posterior mandible (PMd) were significantly correlated.

The present findings suggest that alveolar bone densitometry might be individually and locally assessed.

REFERENCES

1. Goldie RS, King GJ. Root resorption and tooth movement in orthodontically treated, calcium-deficient, and lactating rats. Am J Orthod Dentofac Orthop. 1984;85(5):424-30.
2. Verna C, Dalstra M, Melsen B. The rate and the type of orthodontic tooth movement is influenced by bone turnover in a rat model. Eur J Orthod. 2000;22:343-52.
3. Kaley J, Phillips C. Factors related to root resorption in edgewise practice. Angle Orthod. 1991;61(2):125-32.
4. Horiuchi A, Hotokezaka H, Kobayashi K. Correlation between cortical plate proximity and apical root resorption. Am J Orthod Dentofacial Orthop. 1998;114(3):311-8.
5. Otis LL, Hong JSH, Tuncay OC. Bone structure effect on root resorption. Orthod Craniofacial Res. 2004;7(3):165-77.
6. Devlin H, Horner K, Ledgerton D. A comparison of maxillary and mandibular bone mineral densities. J Prosthet Dent. 1998;79(3):323-27.
7. Choël L, Duboeuf F, Bourgeois D, Briguet A Lissac M. Trabecular alveolar bone in the human mandible: a dual-energy x-ray absorptiometry study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003;95(3):364-70.
8. Oliveira RCG, Leles CR, Normanha MD, Lindh C, Ribeiro-Rotta RF. Assessments of trabecular bone density at implant sites on CT images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105(2):231-8.
9. Lindh C, Petersson A, Rohlin M. Assessment of the trabecular pattern before endosseous implant treatment: Diagnostic outcome of periapical radiography in the mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1996;82(3):335-43.
10. Verhoeven JW, Ruijter J, Cune MS, Terlou M. Oblique lateral cephalometric radiographs of the mandible in implantology: usefulness and reproducibility of the technique in quantitative densitometric measurements of the mandible in vivo. Clin Oral Implants Res. 2000;11(5):476-86.
11. Miyauchi FM. Densidade óssea alveolar em mulheres com periodontite na pré- e pós-menopausa [dissertação]. Piracicaba (SP): Universidade Estadual de Campinas; 2004 [Acesso 27 fev 2009]. Disponível em: http://libdigi.unicamp.br.
12. Jagelaviciene E, Kubilius R. The relationship between general osteoporosis of the organism and periodontal diseases. Medicina (Kaunas) 2006 [Access 2009 feb 27];42(8):613-8. Available from: http://medicina.kmu.lt.
13. Tanaka M, Ejiri S, Toyooka E, Kohno S, Ozawa H. Effects of ovariectomy on trabecular structures of rat alveolar bone. J Periodont Res. 2002;37(2):161-5.
14. Lee BD, White SC. Age and trabecular features of alveolar bone associated with osteoporosis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100(1):92-8.
15. Jonasson G, Jonasson L, Kiliaridis S. Changes in radiographic characteristics of the mandibular alveolar process in dentate women with varying bone mineral density: a 5-year prospective study. Bone .2006;38(5):714-21.
16. Tosoni GM, Lurie AG, Cowan AE, Burleson JA, Farmington CT. Pixel intensity and fractal analyses: detecting osteoporosis in perimenopausal and postmenopausal women by using digital panoramic images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;102(2):235-41.
17. Yaşar F, Akgünlü F. The differences in panoramic mandibular indices and fractal dimension between patients with and without spinal osteoporosis. Dentomaxillofac Radiol. 2006;35(1):1-9.
18. Lindh C, Horner k, Jonasson G, Olsson P, Rohlin M, Jacobs R, et al. The use of visual assessment of dental radiographs for identifying women at risk of having osteoporosis: the OSTEODENT project. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106(2):285-93.
19. Jonasson G. Bone mass and trabecular pattern in the mandible as an indicator of skeletal osteopenia: a 10-year follow-up study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108(2):284-91.
20. Hildebolt CF. Osteoporosis and oral bone loss. Dentomaxillofac Radiol 1997;26(1):3-15.
21. Oliveira DD, Bolognese AM, Souza MMG. Selective alveolar corticotomy to assist orthodontic tooth movement. Rev Clín Ortod Dental Press. 2007;6(3):66-72.
22. Midgett RJ, Shaye R, Fruge JF. The effect of altered bone metabolism on orthodontic tooth movement. Am J Orthod Dentofac Orthop. 1981;80(3):256-62.
23. Ashcraft MB, Southard KA, Tolley EA. The effect of corticosteroid induced osteoporosis on orthodontic tooth movement. Am J Orthod Dentofac Orthop. 1992;102(4):310-9.
24. Corten, FG, van't Hof MA, Buijs WCAM, Hoppenbrouwers P, Kalk W, Corstens FHM. Measurement of mandibular bone density ex vivo and in vivo by dual-energy X-ray absorptiometry. Arch Oral Biol. 1993;38(3):215-9.
25. Rosa JE. Considerations about radiographic processing. Rev Catar Odont. 1975;2:29-36.
26. Southard KA, Southard TE, Schlechte JA, Meis PA. The relationship between the density of the alveolar processes and that of post-cranial bone. J Dent Res. 2000;79(4):964-9.
27. Jonasson G, Bankvall G, Kiliaridis S. Estimation of skeletal bone mineral density by means of the trabecular pattern of the alveolar bone, its interdental thickness, and the bone mass of the mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001;92(3):346-52.
28. Cummings SR, Bates D, Black DM. Clinical use of bone densitometry: scientific review. JAMA. 2002;288(15):1889-99.
29. Jonasson G, Kiliaridis S. The association between the masseter muscle, the mandibular alveolar bone mass and thickness in dentate women. Arch Oral Biol. 2004;49(12):1001-6.
30. Lindh C, Obrant K, Petersson A. Maxillary bone mineral density and its relationship to the bone mineral density of the lumbar spine and hip. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;98(1):102-9.
31. Klemetti E, Vainio P, Lassila V, Alhava E. Cortical bone mineral density in the mandible and osteoporosis status in postmenopausal women. Scand J Dent Res. 1993;101(4):219-23.
32. Scheibel PC, Albino CC, Matheus PD, Ramos AL. Correlação entre a densidade óssea mandibular, femural, lombar e cervical. Dental Press J Orthod. 2009;14(4):111-22.
33. Celenk C, Celenk P. Relationship of mandibular and cervical vertebral bone density using computed tomography. Dentomaxillofac Radiol. 2008;37(1):47-51.
34. von Wowern N. In vivo measurement of bone mineral content of mandibles by dual-photon absorptiometry. Scand J Dent Res. 1985;93(2):162-8.
35. Choi J, Park C, Yi S, Lim H, Hwang H. Bone density measurement in interdental areas with simulated placement of orthodontic miniscrew implants. Am J Orthod Dentofacial Orthop. 2009;136(6):766.e1-12.

© 2013 Dental Press Journal of Orthodontics

Horizontal and vertical maxillary osteotomy stability, in cleft lip and palate patients, using allogeneic bone graft

Kelston Ulbricht Gomes[1], Wilson Denis Benato Martins[2], Marina de Oliveira Ribas[2]

Objective: This study was carried out to evaluate maxillary stability after orthodontic-surgical treatment of patients with cleft lip and palate. Cephalometric analysis was applied to two different groups, with and without allogeneic bone graft.

Methods: The sample comprised 48 patients with cleft lip and palate. The test group comprised 25 patients who, after correction of maxillary position, received allogeneic bone graft at the gap created by Le Fort I osteotomy. The control group comprised 23 patients and its surgical procedures were similar to those applied to the test group, except for the use of bone graft. Manual cephalometric analysis and comparison between lateral teleradiographs, obtained at the preoperative phase, immediate postoperative phase and after a minimum period of six months, were carried out.

Results: An higher horizontal relapse was observed in the control group ($p<0.05$). There were no statistically significant differences in vertical relapses between test and control groups ($p>0.05$).

Conclusion: The use of allogeneic bone graft in cleft lip and palate patients submitted to Le Fort I osteotomy contributed to increase postoperative stability when compared to surgeries without bone graft.

Keywords: Orthognathic surgery. Oral surgery. Bone grafting.

[1] PhD in Oral and Maxillofacial Surgery, Pontifical Catholic University of Paraná (PUC-PR).
[2] Professor of Dentistry at PUC-PR.

How to cite this article: Gomes KU, Martins WDB, Ribas MO. Horizontal and vertical maxillary osteotomy stability, in cleft lip and palate patients, using allogeneic bone graft. Dental Press J Orthod. 2013 Sept-Oct;18(5):84-90.

Submitted: January 16, 2012 - **Revised and accepted:** August 17, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Kelston Ulbricht Gomes
Av. Silva Jardim, 2042 – Sala 1205 – Curitiba/PR, Brazil
CEP: 80250-200 – E-mail: kelstongomes@yahoo.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Cleft lip and palate deformities are amongst the most common congenital anomalies of the face.[1]

Cleft lip and palate surgery as well as orthodontic treatment are amongst the therapeutic possibilities for recovering patients' esthetics and function. In patients with cleft lip and palate, some occlusal deleterious situations such as teeth crowding and unilateral crossbite with segments collapse, open bite on the affected side and retrusion of the maxilla, are identified.[2-6]

After the growth spurt, orthognathic surgery is indicated to correct skeletal and dental discrepancies in patients who present dentofacial deformity.

Hirano and Suzuki [7] described potential aspects which are responsible for maxillary retrusion in adult cleft patients: Unfavorable muscular action due to scars caused by early surgeries in lip and palate, pharyngeal flaps and absence of teeth, which reduces occlusal stability.

The stability of orthognathic surgeries depends on the type and the extent of movements performed by the maxilla. Stability is considered difficult especially in patients with cleft lip and palate. Usually, these patients have undergone surgery in the soft and hard palate, which normally results in fibrosis, limiting the extent of both transverse and anteroposterior movements of the maxilla.[8-12]

In order to avoid relapses when treating dentofacial deformities in cleft patients, some authors suggest increasing the time of intermaxillary fixation during the postoperative phase, performing bimaxillary surgeries, using face masks with reverse traction of the maxilla and interpositioning bone grafts between the gaps created by maxillary advancement.[13,14,15]

A successful correction of dentofacial deformities depends on effective stabilization and prompt union of the repositioned bone segments. When there is a large area of contact between the segments, safe and satisfactory bone union is expected. When the contact area is small, there may be instability, relapse or fibrous union (pseudoarthrosis) between segments. In such cases, grafts are recommended. Some authors[16,17] suggest allogeneic bone graft in orthognathic surgery. However, in the aforementioned studies, allogeneic bone graft was performed in patients without cleft lip and palate.

The study of Precious,[18] in 2007, concluded that scars on the upper lip and on the palate interfere with nose, lips, soft adjacent tissues and skeletal development.

When intervention is performed with bone graft and correction of nasolabial musculature at the age of five or six years old, a symmetric function is established, which improves facial development. The primary muscle surgery improves growth and decreases the chances of undergoing orthognathic surgery.[19]

Nique et al [2] have studied the use of allograft bone for alveolar reconstruction in unilateral cleft patients. The receptor area was radiographically observed for a period of 3 to 6 months. The allograft bone is an excellent alternative to repair alveolar cleft, its use brings significant benefits for the patient, eliminating the morbidity of a second surgical site.

Garrison et al[19] evaluated twenty patients who were simultaneously submitted to both alveolar bone graft and Le Fort I osteotomy. The researchers evaluated the extent of maxilla relapse at the anteroposterior and vertical direction through lateral teleradiographs. They concluded that there was no significant change in the horizontal plan, however, in the vertical direction there was a great tendency to relapse. The intermaxillary fixation time lasted for eight weeks and mandibular fixation was used at the orbital rim and zygomatic crest. For the evaluation, cephalometry was adopted, the SN plan was traced and a perpendicular line was drawn from the Nasion. The researchers measured the distance from this line to point A in order to evaluate potential changes in the horizontal direction (anteroposterior). To determine the vertical movement, a line was drawn perpendicular to the SN up to the point A.

Another research, carried out by Heliovaara et al,[20] examined the causes of relapse through a retrospective analysis of 71 patients, 58 of which had unilateral and bilateral clefts. The mean advancement of the maxilla was 6.9 mm. Grafts were harvested from calvaria or mandible and there were used four miniplates for containing the maxilla as well as intermaxillary fixation which was kept during 6 weeks and maintained after releasing fixation with class III elastics. The researchers concluded that the type of cleft (unilateral or bilateral), the scars in the soft palate, muscle tension, adaptation and stability of bone segments are amongst the main causes of relapse in maxillary osteotomies. The occlusal stability is important to prevent relapses.

Hirano and Suzuki[7] evaluated one group comprised of 14 patients with cleft palate only and other group comprised

© 2013 Dental Press Journal of Orthodontics

of 11 patients with bilateral cleft lip and palate. The gaps created by Le Fort I osteotomy were filled with autogenous bone without applying intermaxillary fixation or surgical guide. Patients were evaluated through lateral teleradiographs and point A was used as the reference point. Patients were evaluated at pre- and immediate postoperative phases as well as one year after the surgery. The average relapse in the group with cleft palate only was 8.5% in the horizontal direction and 16.7% in the vertical direction. In the group with bilateral cleft, relapse was 9.4% horizontal, and 17.8% vertical. The authors suggest that the main factors for relapses are: the method used for fixating the osteotomized segments, neuromuscular adaptation, the extent of movement of the maxilla and previous orthodontic preparation.

Ianetti et al[21] evaluated the use of bimaxillary surgeries for minimizing potential relapses in patients with cleft lip and palate. They highlight intense scarring and soft tissue tension as being responsible for relapse. To reduce the relapse, authors suggest overcorrection of the maxilla; however, they warn that major advances of the maxilla can result in velopharynx incompetence. These conclusions were based on the evaluation of 15 patients who underwent combined bimaxillary surgery. In order to improve the stability of the maxilla, the authors suggest performing bone graft in the space created by Le Fort I osteotomy, with the indicated use of intermaxillary elastics for three weeks and the surgical guide being removed after six weeks. The stability evaluation was carried out by means of lateral teleradiographs, taken at the preoperative phase, six weeks, a year and two years after the surgery. The references were point A, the posterior nasal spine and point B. For cases in which only the maxilla was operated, relapse was of 25%, and in cases of maxillary and mandibular osteotomy, relapse was of 8%.[21]

In another study, conducted by Erbe et al,[22] cephalometric analysis was performed during immediate and late postoperative phases (39-110 months) for patients simultaneously undergoing both Le Fort I osteotomies for advancement and autogenous alveolar bone graft. Operative changes in the position of the maxilla were evaluated in vertical and horizontal directions. All parameters used in the cephalometric measurements were manually measured by one single examiner as an attempt to eliminate observer bias. Some reference points were difficult to identify; however, the careful observation of a series of lateral films of the head increased accuracy and the identification of reference points was made possible.

Even with surgical correction of the maxilla, some degree of relapse is expected due to the aforementioned shortcomings and peculiarities (previous surgery on the palate and lack of occlusal stability by the absence of teeth). Bone grafting performed in the space created by both osteotomy and correction of the position of the maxilla can reduce the occurrence of relapse.

Thus, the objective of this study was to evaluate horizontal and vertical stability of maxillary osteotomy using allogeneic bone graft in patients with cleft lip and palate.

MATERIAL AND METHODS

The stability of orthodontic-surgical treatment of patients with cleft lip and palate was evaluated through cephalometric analysis in two different groups, one with and another without the use of allogeneic bone graft.

The study was approved by the local Institutional Review Board under the number 0003716/10.

Material

The sample consisted of 48 patients with cleft lip and palate, submitted to surgery at the Assistance Center for Cleft Lip and Palate (CAIF) in Curitiba, Paraná, Brazil, from January 2006 to March 2009.

All patients underwent orthognathic maxillary surgery, performed with the Le Fort I technique, with rigid internal fixation and intermaxillary fixation lasting for an average of 4 (four) weeks. The test group (TG) consisted of 25 patients of both genders with unilateral and bilateral clefts, with an average age of 23.16 years. The surgeries were isolated in the maxilla or combined with mandibular surgeries. After the maxilla had been repositioned, allogeneic bone graft, from the Bank of Muscle and Bone Tissue of the Clinical Hospital from Federal University of Paraná, was inserted to fill the gaps created by the osteotomies.

The control group (CG) consisted of 23 patients of both genders with cleft lip and palate, unilateral and bilateral types, with an average age of 25.78 years. Surgical procedures were similar to those applied to the TG, except for the use of bone graft. In the selection of patients, those with cleft lip and palate who underwent orthognathic surgery from January 2006 to March 2009, of both sexes and aged above 18 years were included. Patients submitted to orthognathic surgery only in the mandible, as well as those who had undergone more than one orthognathic surgery were excluded. Patients who did not performed alveolar bone graft in childhood were also excluded.

© 2013 Dental Press Journal of Orthodontics

Methods

a) A blind study in which manual cephalometric analysis of the lateral teleradiographs was carried out by one single examiner. Radiographs were obtained at the preoperative phase, immediate postoperative phase and after a minimum period of six months.

b) The records as well as the cephalometric analysis were carried out using advocated parameters and measures.[19,23] The anteroposterior position of the maxilla was determined by drawing the SN plan and a perpendicular line in relation to it, from the Nasion (Na) point. The distance from this line to point A was measured, determining the anteroposterior preoperative maxilla position which was compared to the postoperative position, over time (h) (Fig 1).

c) A perpendicular line was drawn from the SN plane towards point A in order to determine the preoperative vertical position of the maxilla which was compared to the postoperative position, over time (v) (Fig 1).

d) Having such reference points as guides, the maxillary tracing in the preoperative radiograph was superimposed over the first postoperative (immediate) radiograph. Tracings were repeated, resulting in horizontal and vertical linear values which correspond to the amount of movement obtained with surgery.

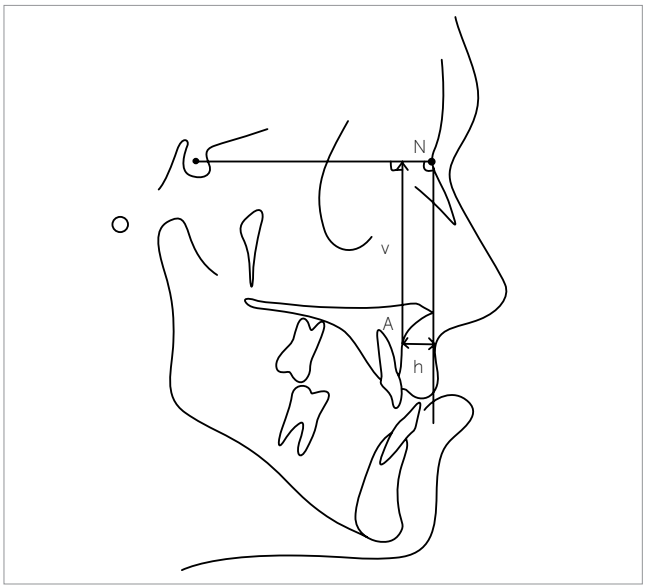


Figure 1 - Cephalometric tracings: reference lines and points used for evaluating postoperative results. S= Sella; N= Nasion; A= Point A; h= horizontal measurement; v= vertical measurement (Adapted from: Garrison et al[19]).

e) With a new radiograph obtained afterwards, at least 6 months after the first one, the process of comparison was repeated by means of superimposing the tracings. At this time, the immediate postoperative radiograph was used and the values for assessing the occurrence of relapse were obtained.

f) The purpose of these measurements was to linearly measure possible vertical and horizontal postoperative changes, over time, and relate them to the use of bone grafts.

RESULTS

Both groups (CG and TG) presented normal distribution with regard to the following variables: horizontal advancement, horizontal relapse, vertical movement and vertical relapse. The average horizontal advancement was similar in both groups. The average vertical movement was higher in TG than in CG (Table 1).

Horizontal relapse was higher in CG ($p < 0.05$). There were no statistically significant differences in vertical relapses between TG and CG ($p > 0.05$) (Tables 2 and 3).

Variables such as gender, type of procedure and type of cleft did not influence the stability of the surgery in any group ($p > 0.05$) (Figs 2, 3 and 4).

The CG had a follow-up period longer than the TG. However, despite this difference, there is no correlation between this variable and horizontal or vertical relapses (Pearson Correlation Coefficient $p > 0.05$). (Table 4; Figs 5 and 6).

By using Pearson Correlation Coefficient it was obtained a p-value> 0.05, indicating that there is no correlation between the two variables. Therefore, despite the follow-up time of the group with graft was smaller than in the group with no graft, there was no correlation between this variable and relapse, both horizontal and vertical.

Table 1 - Descriptive statistics of variables according to each group.

Variable	Group	n	Mean ± SD	Median
Horizontal advancement (mm)	Without bone graft	23	5.52 ± 2.25	6.00
	With bone graft	25	5.44 ± 2.36	6.00
Horizontal relapse (mm)	Without bone graft	23	-1.09 ± 1.12	-1.00
	With bone graft	25	-0.36 ± 0.95	0.00
Vertical movement (mm)	Without bone graft	23	1.61 ± 2.76	2.00
	With bone graft	25	4.00 ± 3.54	3.00
Vertical relapse (mm)	Without bone graft	23	-0.30 ± 1.29	0.00
	With bone graft	25	-0.88 ± 1.48	0.00

© 2013 Dental Press Journal of Orthodontics

Table 2 - Student's t-test carried out in order to assess whether the mean horizontal and vertical relapses are different from zero in the group without bone graft.

Group without bone graft		
Variable	n	Mean ± SD
Horizontal relapse (mm)	23	-1.087 ± 1.124
Vertical relapse (mm)	23	-0.304 ± 1.294

One-sample test Test value = 0			
Variable	T	D.F.	p-value
Horizontal relapse (mm)	-4.635	22	0.0001
Vertical relapse (mm)	-1.127	22	0.271

P-value< 0.05 indicates that the variable mean is different from zero.

Table 3 - Student's t-test carried out in order to assess whether the mean horizontal and vertical relapses are different from zero in the group with bone graft.

Group with bone graft		
Variable	n	Mean ± SD
Horizontal relapse (mm)	25	-0.360 ± 0.952
Vertical relapse (mm)	25	-0.880 ± 1.481

One-sample test Test value = 0			
Variable	T	D.F.	p-value
Horizontal relapse (mm)	-1.890	24	0.070
Vertical relapse (mm)	-2.970	24	0.006

P-value< 0.05 indicates that the variable mean is different from zero.

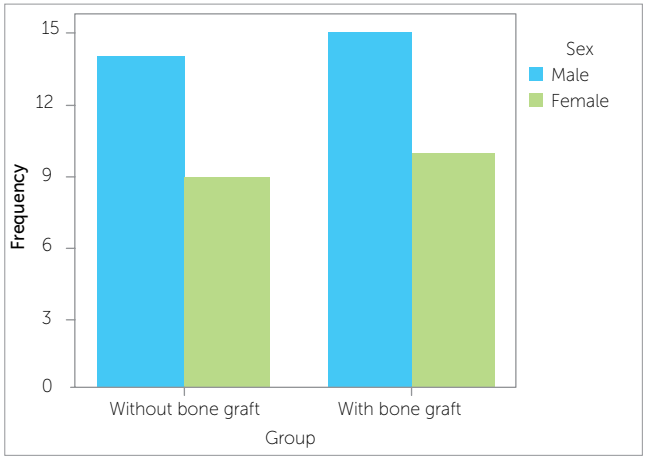


Figure 2 - Distribution frequency according to the variable sex.

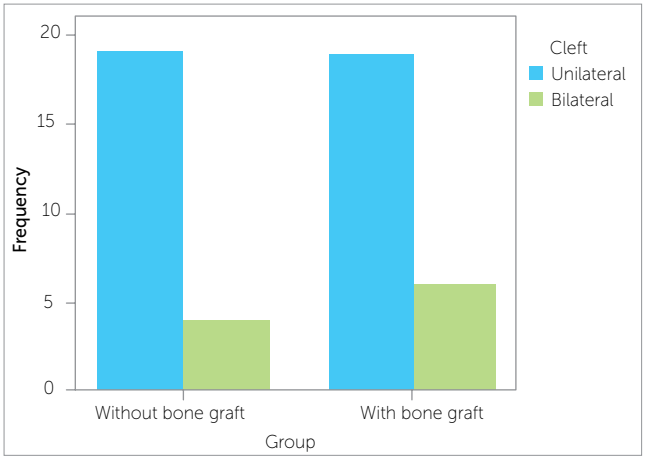


Figure 3 - Distribution frequency according to the variable type of cleft.

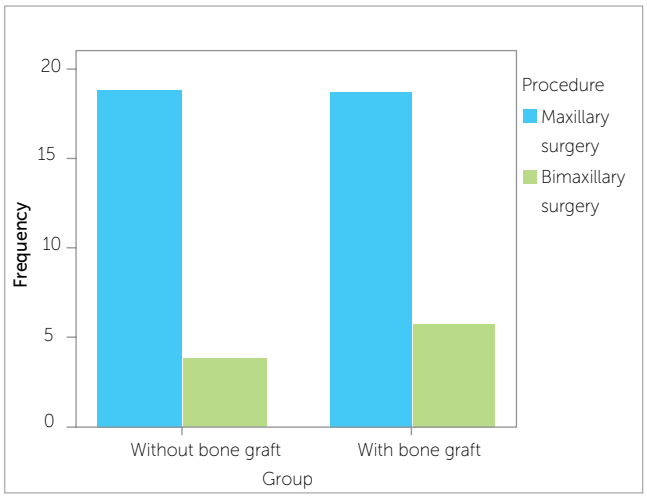


Figure 4 - Distribution frequency according to the variable type of procedure.

DISCUSSION

The authors agree with the literature regarding the instability of orthognathic surgery in patients with cleft lip and palate. The cause of instability is attributed to some variables such as several previous surgeries, fibrous tissue resulted from previous procedures, changes in dentition and muscle balance. At the same time, for non-cleft patients, stability and predictability in orthognathic surgery usually vary depending on the direction and magnitude of the surgical procedures, generally in that order of importance.[9,10]

The literature indicates a significant trend towards a higher number of postoperative relapses in cleft patients than in patients with non-cleft maxillary hypoplasia who underwent orthognathic surgery.[9,14]

© 2013 Dental Press Journal of Orthodontics

Figure 5 - Confidence interval with regard to age in each group.

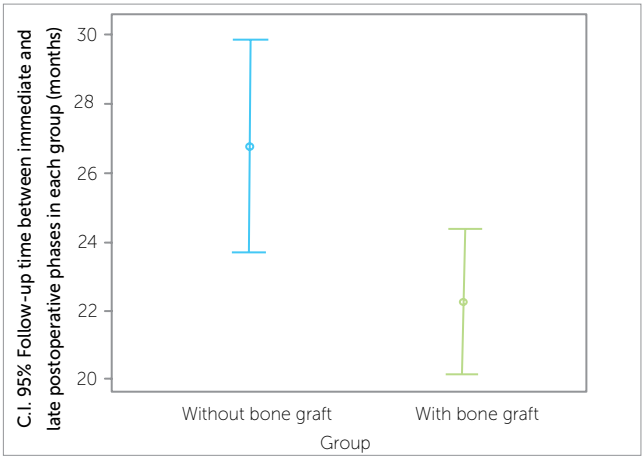


Figure 6 - Confidence interval with regard to postoperative follow-up period in each group.

Table 4 - Descriptive statistics of variables.

Variable	Group	n	Mean ± SD	Median
Age (years)	Without bone graft	23	25.78 ± 8.11	23.00
	With bone graft	25	23.16 ± 4.66	23.00
Follow-up time between immediate and late postoperative phases	Without bone graft	23	24.87 ± 11.37	23.00
	With bone graft	25	17.68 ± 8.38	17.00

Some authors suggested that to improve stability, a better, more effective and rapid healing should be provided by means of performing bone grafts adapted in the gaps created by the correction of the maxilla.[16,17] To evaluate the effectiveness of the grafting procedure, the authors proposed a study carried out by means of cephalometric analysis of patients undergoing orthognathic surgery.

Additionally, taking into account the benefits observed with the use of allogenic bone graft, the authors included in the study patients who had allogeneic graft-type only, since it is known that allogenic bone grafting offers several advantages such as easy handling, great amount of available material, cost reduction and, especially, decrease in patient's postoperative morbidity. Nique et al[2] studied the use of allograft in patients with alveolar defects and cleft lip and palate, obtaining good results for bone integration. Other authors have also had good results concerning allograft bone grafting in orthognathic surgery for non-cleft patients.[16,17]

As for the methods, the authors used those already described in the literature, for instance, radiographic evaluation by means of cephalometric analysis performed at three different stages (preoperative, immediate postoperative and late postoperative).[7,19-22] As shown in the studies of Erbe et al[22] and Iannetti et al,[21] these methods demonstrated to be efficient, since they were manually performed by one single and trained examiner.

After applying the methodology, the results showed more horizontal relapse in the CG (without graft) than the observed in the TG (with grafting), i.e., more stability was obtained with the use of grafts. This fact was also observed by Hirano and Suzuki;[7] however, in their study, relapses occurred both horizontally and vertically and the only different approach was the use of autogenous bone graft to fill the gaps created by osteotomies, which may suggest the formation of an autograft mechanical barrier that is less efficient to restrict the movements of relapse.

At last, the present results corroborate the studies of Heliovaara et al[20] and Iannetti et al,[21] demonstrating the positive effects of performing bone grafting in order to minimize relapses in orthognathic surgery for cleft patients.

CONCLUSIONS

The use of allogeneic grafts in cleft patients undergoing Le Fort I maxillary osteotomy contributes to increase postoperative stability when compared to surgeries without bone grafting.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Ankola AV, Nagesh L, Hegde P, Karibasappa GN. Primary dentition status and treatment needs of children with cleft lip and/or palate. J Indian Soc Pedod Prev Dent. 2005;23(2):80-82.
2. Nique T, Fonseca RJ, Upton LG, Scott R. Particulate allogeneic bone grafts into maxillary alveolar clefts in humans: a preliminary report. J Oral Maxillofac Surg. 1987;45(5):386-92.
3. Spina Vea. Classificação das fissuras lábio-palatinas. Sugestão de modificação. Rev Hosp Clin Fac Med São Paulo. 1972;27(1):5-7.
4. Bill J, Proff P, Bayerlein T, Weingaertner J, Fanghanel J, Reuther J. Treatment of patients with cleft lip, alveolus and palate: a short outline of history and current interdisciplinary treatment approaches. J Craniomaxillofac Surg. 2006;34 Suppl 2:17-21.
5. Schultes G, Gaggl A, Karcher H. Comparison of periodontal disease in patients with clefts of palate and patients with unilateral clefts of lip, palate, and alveolus. Cleft Palate Craniofac J. 1999;36(4):322-7.
6. Dahllof G, Ussisoo-Joandi R, Ideberg M, Modeer T. Caries, gingivitis, and dental abnormalities in preschool children with cleft lip and/or palate. Cleft Palate J. 1989;26(3):233-7; discussion 37-8.
7. Hirano A, Suzuki H. Factors related to relapse after Le Fort I maxillary advancement osteotomy in patients with cleft lip and palate. Cleft Palate Craniofac J. 2001;38(1):1-10.
8. Bailey LJ, Cevidanes LH, Proffit WR. Stability and predictability of orthognathic surgery. Am J Orthod Dentofacial Orthop. 2004;126(3):273-7.
9. Kerawala CJ, Stassen LF, Shaw IA. Influence of routine bone grafting on the stability of the non-cleft Le Fort 1 osteotomy. Br J Oral Maxillofac Surg. 2001;39(6):434-8.
10. Ayliffe PR, Banks P, Martin IC. Stability of the Le Fort I osteotomy in patients with cleft lip and palate. Int J Oral Maxillofac Surg. 1995;24(3):201-7.
11. Bishara SE, Chu GW, Jakobsen JR. Stability of the LeFort I one-piece maxillary osteotomy. Am J Orthod Dentofacial Orthop. 1988;94(3): 184-200.
12. Proffit WR, Phillips C, Turvey TA. Stability following superior repositioning of the maxilla by LeFort I osteotomy. Am J Orthod Dentofacial Orthop. 1987;92(2):151-61.
13. Steinberg B, Padwa BL, Boyne P, Kaban L. State of the art in oral and maxillofacial surgery: treatment of maxillary hypoplasia and anterior palatal and alveolar clefts. Cleft Palate Craniofac J. 1999;36(4):283-91.
14. De Riu G, Meloni SM, Raho MT, Gobbi R, Tullio A. Delayed iliac abscess as an unusual complication of an iliac bone graft in an orthognathic case. Int J Oral Maxillofac Surg. 2008;37(12):1156-8.
15. Bothur S, Blomqvist JE, Isaksson S. Stability of Le Fort I osteotomy with advancement: a comparison of single maxillary surgery and a two-jaw procedure. J Oral Maxillofac Surg. 1998;56(9):1029-33; discussion 33-4.
16. Christian JM, Peterson LJ. Frozen femoral head allogeneic bone grafts for orthognathic surgery. J Oral Maxillofac Surg. 1982;40(10):635-9.
17. Scheffer P, Blanchard P, Attar A, Assa A. Cryopreserved allografts in orthognathic surgery]. Rev Stomatol Chir Maxillofac. 1988;89(4):220-8.
18. Precious DS. Treatment of retruded maxilla in cleft lip and palate: orthognathic surgery versus distraction osteogenesis: the case for orthognathic surgery. J Oral Maxillofac Surg. 2007;65(4):758-61.
19. Garrison BT, Lapp TH, Bussard DA. The stability of Le Fort I maxillary osteotomies in patients with simultaneous alveolar cleft bone grafts. J Oral Maxillofac Surg. 1987;45(9):761-65.
20. Heliovaara A, Ranta R, Hukki J, Rintala A. Skeletal stability of Le Fort I osteotomy in patients with isolated cleft palate and bilateral cleft lip and palate. Int J Oral Maxillofac Surg. 2002;31(4):358-63.
21. Iannetti G, Cascone P, Saltarel A, Ettaro G. Le Fort I in cleft patients: 20 years' experience. J Craniofac Surg. 2004;15(4):662-9.
22. Erbe M, Stoelinga PJ, Leenen RJ. Long-term results of segmental repositioning of the maxilla in cleft palate patients without previously grafted alveolo-palatal clefts. J Craniomaxillofac Surg. 1996;24(2):109-17.
23. Louis PJ, Waite PD, Austin RB. Long-term skeletal stability after rigid fixation of Le Fort I osteotomies with advancements. Int J Oral Maxillofac Surg. 1993;22(2):82-6.

© 2013 Dental Press Journal of Orthodontics

Comparison of the changes of alveolar bone thickness in maxillary incisor area in extraction and non-extraction cases: Computerized tomography evaluation

Paulo Roberto Barroso Picanço[1], Fabricio Pinelli Valarelli[2], Rodrigo Hermont Cançado[2], Karina Maria Salvatore de Freitas[3], Gracemia Vasconcelos Picanço[1]

Objective: To compare, through computed tomography, alveolar bone thickness changes at the maxillary incisors area during orthodontic treatment with and without tooth extraction.

Methods: Twelve patients were evaluated. They were divided into 2 groups: G1 - 6 patients treated with extraction of right and left maxillary first premolars, with mean initial age of 15.83 years and mean treatment length of 2.53 years; G2 - 6 patients treated without extraction, with mean initial age of 18.26 years and mean treatment length of 2.39 years. Computed tomographies, lateral cephalograms and periapical radiographs were used at the beginning of the treatment (T_1) and 18 months after the treatment had started (T_2). extraction Space closure occurred in the extraction cases. Intragroup and intergroup comparisons were performed by dependent and independent t test, respectively.

Results: In G1, the central incisor was retracted and uprighted, while in G2 this tooth showed vestibularization. Additionally, G1 presented a higher increase of labial alveolar bone thickness at the cervical third in comparison with G2. The incidence of root resorption did not present significant differences between groups.

Conclusion: There were no changes in alveolar bone thickness when extraction and nonextraction cases were compared, except for the labial alveolar bone thickness at the cervical third of maxillary incisors.

Keywords: Alveolar ridge. Tooth movement. Tooth extraction. Tomography.

[1] MSc in Orthodontics, Uningá. Professor, Paulo Picanço Center of Orthodontics.
[2] Adjunct Professor, Uningá.
[3] Post-Doc in Orthodontics, University of Toronto. Professora, Uningá.

How to cite this article: Picanço PRB, Valarelli FP, Cançado RH, Freitas KMS, Picanço GV. Comparison of the changes of alveolar bone thickness in maxillary incisor area in extraction and non-extraction cases: Computerized tomography evaluation. Dental Press J Orthod. 2013 Sept-Oct;18(5):91-8.

Submitted: October 21, 2010 - **Revised and accepted:** October 22, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Fabrício Valarelli
Rua Manoel Pereira Rolla, 12-75, apto 503 – Bauru/SP – CEP: 17012-190
E-mail: fabriciovalarelli@uol.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Orthodontic movement can be quick or slow, depending on the physical characteristics of the applied force, the size and the biological response of the periodontal ligament.[1] According to Vardimon, Oren and Ben-Bassat,[2] there is an axiom in orthodontics that says: "tooth movement leaves marks on the bone", however, this fact is not always favorable. In vertical direction, during tooth extrusion, the changes in the underlying bone tissue may not follow tooth displacement, leading to an increase in clinical length of the tooth crown, oftentimes undesirable. In transverse and anteroposterior directions, bone dehiscence and fenestration have been reported when the incisors are either protruded or retracted.[3,4] According to Handelman,[5] labial and lingual/palatal bone cortical plates at incisors' apexes may represent anatomical limits to orthodontic tooth movement. The literature has speculated that protrusion and vestibularization of the maxillary incisors may produce labial bone cortical dehiscence while teeth retraction affects the palatal bone plate, although this would be reversible only if the teeth returned to their original position.[6]

Designing the limits of tooth movement before beginning the orthodontic treatment may be extremely beneficial, especially in situations in which skeletal discrepancy is severe or the maxilla and/or mandible can accommodate, in a limited way, the repositioning of the teeth after orthodontic movement.[5,7]

To detect bone levels, the following methods may be used: periapical radiographs, lateral cephalograms and panoramic radiographs. Notwithstanding, bidimensional radiographs reveal some limitations, such as image superimposition and distortions as well as the inability of measuring bone thickness in panoramic and periapical radiographs.[7,8] Taking these factors into account, computed tomography (CT) has been considered of paramount importance for diagnosing initial bone levels as well as bone level changes during orthodontic treatment.[9,10]

The aim of this study was to compare, through computed tomography, the alveolar bone thickness changes at the maxillary incisors area during orthodontic treatment with or without maxillary premolar extractions.

MATERIAL AND METHODS

Sample

Twelve patients of both genders were selected in the orthodontic clinic Paulo Picanço. Inclusion criteria were: 1) permanent dentition; 2) absence of systemic disease that may alter bone metabolism; 3) nonsmoker; 4) patients who are not using steroid-based drugs; 5) absence of chronic kidney disease; 6) if female, patients who do not present low level of estrogen; 7) presence of all six maxillary anterior teeth; 8) patients who have not undergone tooth trauma, alveolar bone fracture or luxation in maxillary incisors; 9) patients who do not present a prosthetic crown on maxillary incisors; 10) absence of alveolar cleft in the maxillary anterior area.

The sample was divided into two groups: G1 – 6 patients (5 male; 1 female) with mean initial age of 15.83 ± 4.87 years, presenting Class II malocclusion, treated with 2 maxillary premolar extractions during a mean period of 2.53 ± 0.49 years; G2 – 6 patients (5 male; 1 female), with mean initial age of 18.26 ± 6.42 years, 3 showing Class I and 3 Class II malocclusion, treated without extractions during a mean treatment period of 2.39 ± 0.66 years.

Patients were treated by post-graduation students oriented by the same professor, following the same diagnosis pattern, treatment planning and orthodontic mechanics (Edgewise, 0.018 x 0.025-in brackets – Morelli – Sorocaba, SP, Brazil).

Methods

Computed tomographies were performed at the beginning of the orthodontic treatment (T_1) and 18 months after the treatment had started, (T_2). The exams confirmed extraction space closure. Additionally, periapical radiographs were performed at T_1 and T_2 using the parallelism technique in order to evaluate external root resorption of the maxillary incisors. Lateral cephalograms were performed to evaluate anteroposterior and vertical changes as well as the inclination of these teeth.

For cephalograms and tomographs evaluation, image digitalization and measurement processing, Dolphin Imaging Premium 10.5 software (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA) was used.

UL (labial) and UP (palatal) variables were obtained from the long axis of the maxillary incisor and a point of reference (zero point) marked at the enamel-cementum junction (ECJ). From this point of reference, three lines were traced towards apical direction, with a 3 mm interval, up to the most external limit of the labial (UL) and palatal (UP) alveolar bone, perpendicularly to the tooth long axis (Fig 1).

© 2013 Dental Press Journal of Orthodontics

On the lateral cephalograms, the following variables were analyzed: 1-PTV incisal, 1-PTV apical, FMA, PFH/AFH, Wits, 1.NA, H-11 and UL+UP.

The degree on initial and final root resorption was analysed through periapical radiographs, based on the scores of Levander and Malmgren's score system:[11] 0 – lack of root resorption; 1 – presence of apical irregularities; 2 – presence of root resorption up to 2 mm; 3 – presence of root resorption from 2 mm to one third of the root original length; 4 – presence of root resorption greater than one third of the original length of the root. Root length was obtained from measuring the distance from root apex to ECJ, following the incisor long axis (Fig 2).

Method error

To determine intraexaminer error, both lateral cephalograms and tomographies were reevaluated in 6 randomly selected patients after a month interval. Systematic error was determined by dependent t test while casual error was determined by the Dahlberg's formula. Kappa test was used to establish root resorption score error.

Statistical analysis

The following statistical tests were employed: difference between two means for carrying out the sample calculation, chi-square test for intergroup comparison concerning the malocclusion type; independent t test for intergroup age and treatment period comparison; dependent t test for intragroup initial and final stages comparison; independent t test for intergroup initial and final stages as well as treatment changes comparison. All tests were performed with Statistica software (Statistica for Windows, version 7.0, Statsoft, 2005). The results were considered significant at $p < 0.05$.

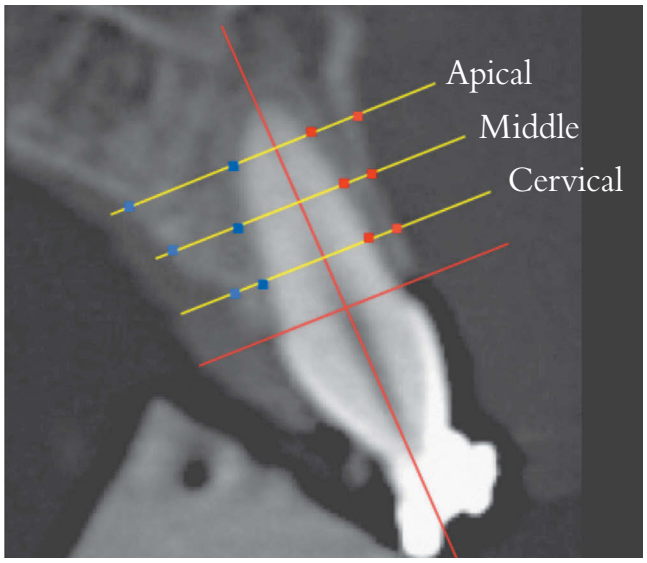


Figure 1 - Alveolar bone thickness assessment evaluated through computed tomography.

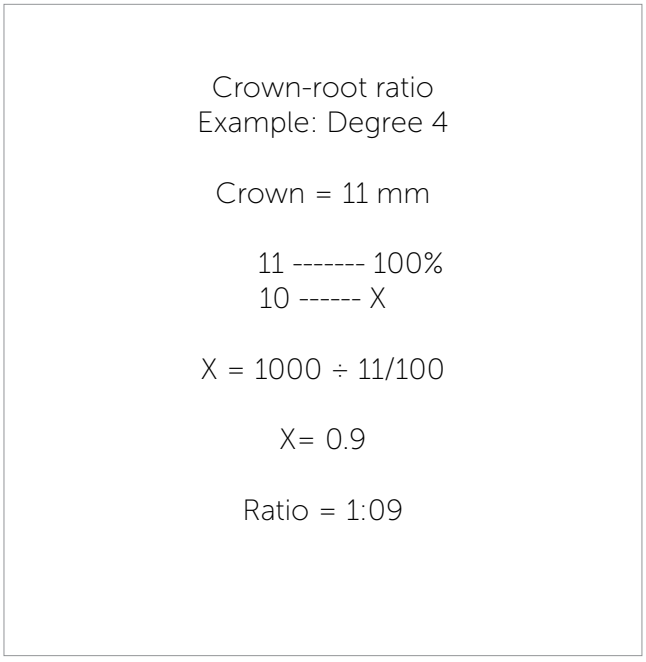
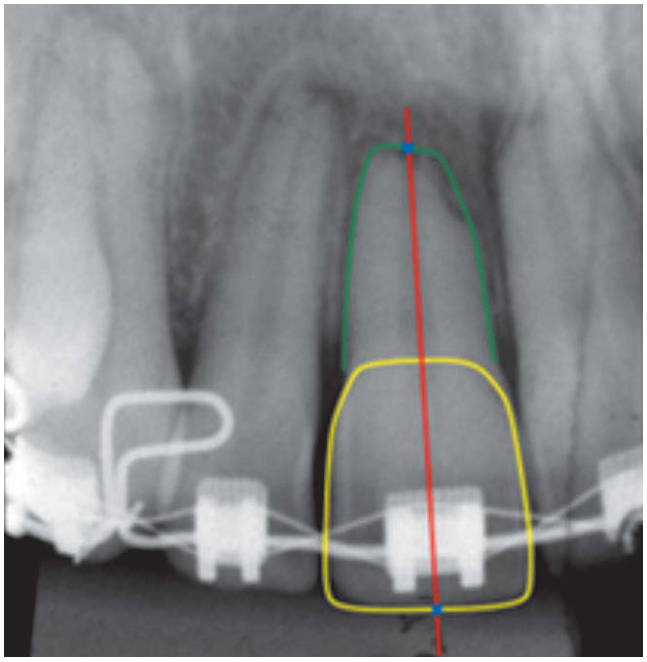


Figure 2 - Crown-root ratio and maxillary central incisor length assessment.



RESULTS

The 1-PTV apical variable showed the greatest casual error (1.57 mm). Systematic error occurred only for the following variables: 1-PTV incisal and UP middle. Kappa coefficient demonstrated a concordance percentage of 90%.

There were differences in the distribution of the malocclusion type between groups (Table 1). The groups were compatible regarding gender, initial and final ages as well as treatment period (Table 2).

At the initial stage (T_1), only 1-PTV apical showed statistically significant difference between groups, indicating that in G1 the maxillary incisor was more protruded than in G2 (Table 3).

The comparison between G1 (treated with two maxillary premolar extractions) stages (T_1 and T_2) demonstrated that there was a decrease in the crown-root ratio and in the central incisor length, a retraction of these teeth both in apical (1-PTV apical) and incisal (1-PTV incisal) measurements, a decrease in anteroposterior discrepancy (ANB), an increase of the UL cervical (labial cervical third) measurement and decrease of the UP cervical (palatal cervical third) and UP middle (palatal middle third) measurements (Table 4).

In G2 (treated without extractions), the comparison between T_1 and T_2 demonstrated that there was a decrease in the crown-root ratio, in the central incisor length, in FMA angle, in the relation between posterior and anterior face height, vestibularization of the maxillary incisors (1.NA) and a decrease in the UP middle measurement as well (Table 5).

At T_2, there was statistically significant difference between the groups in two variables: 1-PTV incisal and UL cervical. The difference in 1-PTV incisal indicated that, at the end of the treatment, central incisors in G1 were more retruded than in G2 while the difference in UL cervical showed higher bone thickness at this area in G1 than in G2 (Table 6).

With regard to treatment changes (T_2-T_1), the 1-PTV incisal, 1-PTV apical and 1.NA measurements were statistically significant different between groups, revealing that G1 showed maxillary incisor's retraction and uprighting while G2 exhibited this tooth protrusion and vestibularization (Table 7). Additionally, UL cervical measurement was also significantly different between groups indicating an increase of labial bone thickness in G1 when compared to G2 (Table 7).

With regard to root resorption degree, there were no significant differences between groups at any of the evaluated periods (Table 8).

DISCUSSION

Handelman[5] claims that a thin tooth alveolus or an inappropriate alveolar cavity for the amount of desirable tooth movement must be considered as a risk for

Table 1 - Intergroup comparison of malocclusion type (chi-square test).

Group	Class I	Class II	Total
1	0	6	6
2	3	3	6
Total	3	9	12
$\chi^2 = 4.00$; GL= 1; p = 0.045*			

*Statistically significant difference (P<0.05).

Table 2 - Intergroup comparison of initial and final ages as well as treatment period (independent t tests).

Variables (years)	G1 Extraction of #14 and #24 teeth (n = 6)	G2 Without extractions (n = 6)	p
	Mean ± SD	Mean ± SD	
Initial age	15.83 ± 4.87	18.26 ± 6.42	0.477
Final age	18.36 ± 4.84	20.65 ± 6.45	0.502
Treatment period	2.53 ± 0.49	2.39 ± 0.66	0.682

Table 3 - Intergroup comparison of variables studied during the initial stage (T_1) (independent t tests).

Variables	G1 Extraction of #14 and #24 teeth n = 6	G2 Without extraction n = 6	p
	Mean ± SD	Mean ± SD	
Crown-root ratio (mm)	1.44 ± 0.20	1.52 ± 0.16	0.444
Length 11 (mm)	24.92 ± 1.91	25.48 ± 2.17	0.643
1-PTV incisal(mm)	63.78 ± 6.35	55.65 ± 6.65	0.055
1-PTV apical (mm)	51.71 ± 4.57	36.66 ± 5.04	0.000*
FMA (degrees)	23.81 ± 5.11	25.22 ± 5.02	0.640
PFH/AFH (mm)	0.63 ± 0.07	0.70 ± 0.06	0.153
ANB (degrees)	4.10 ± 1.71	3.29 ± 2.98	0.580
Wits (mm)	-0.20 ± 4.57	-0.26 ± 5.12	0.982
1.NA (degrees)	27.96 ± 10.67	21.06 ± 6.32	0.202
H-11 (mm)	20.51 ± 1.98	18.05 ± 3.56	0.169
UA+UP (mm)	18.11 ± 8.95	13.46 ± 3.75	0.267
UA cerv (mm)	0.84 ± 0.52	0.67 ± 0.41	0.539
UP cerv (mm)	1.68 ± 0.91	1.20 ± 0.49	0.283
UA middle (mm)	0.61 ± 0.28	0.47 ± 0.30	0.398
UP middle (mm)	2.77 ± 1.64	2.01 ± 0.62	0.315
UA apical (mm)	1.31 ± 0.84	0.99 ± 0.36	0.408
UP apical (mm)	4.24 ± 2.45	3.03 ± 1.38	0.318

*Statistically significant difference (P < 0.05).

© 2013 Dental Press Journal of Orthodontics

Table 4 - Comparison between initial (T_1) and final (T_2) stages of group 1, with premolar extractions (dependent t tests).

Variables	Initial stage (T_1) n = 6	Final stage (T_2) n = 6	Changes T_2-T_1	p
	Mean ± SD	Mean ± SD		
Crown-root ratio (mm)	1:1.44 ± 0.20	1:1.32 ± 0.25	-0.12	0.009*
Length. 11 (mm)	24.92 ± 1.91	23.65 ± 2.12	-1.27	0.013*
1-PTV incisal (mm)	63.78 ± 6.35	52.45 ± 4.18	-11.33	0.003*
1-PTV apical (mm)	51.71 ± 4.57	43.30 ± 5.17	-8.41	0.013*
FMA (degrees)	23.81 ± 5.11	23.28 ± 5.13	-0.53	0.458
PFH/AFH (mm)	0.63 ± 0.07	0.64 ± 0.08	0.01	0.258
ANB (degrees)	4.10 ± 1.71	2.61 ± 1.38	-1.49	0.006*
Wits (mm)	-0.20 ± 4.57	-0.50 ± 5.05	-0.30	0.752
1.NA (degrees)	27.96 ± 10.67	20.99 ± 4.08	-6.97	0.136
H-11 (mm)	20.51 ± 1.98	19.09 ± 2.09	-1.42	0.399
UA+UP (mm)	18.11 ± 8.95	13.53 ± 3.18	-4.58	0.133
UA cerv (mm)	0.84 ± 0.52	1.48 ± 0.40	0.64	0.025*
UP cerv (mm)	1.68 ± 0.91	0.28 ± 0.69	-1.40	0.001*
UA middle (mm)	0.61 ± 0.28	1.77 ± 1.43	1.16	0.077
UP middle (mm)	2.77 ± 1.64	1.15 ± 0.96	-1.62	0.005*
UA apical (mm)	1.31 ± 0.84	3.27 ± 3.44	1.96	0.170
UP apical (mm)	4.24 ± 2.45	2.69 ± 2.09	-1.55	0.200

*Statistically significant difference (P<0.05).

Table 5 - Comparison between initial (T_1) and final (T_2) stages of group 2, without extractions (dependent t tests).

Variables	Initial stage (T_1) n = 6	Final stage (T_2) n = 6	Changes T_2-T_1	p
	Mean ± SD	Mean ± SD		
Crown-root ratio (mm)	1.52 ± 0.16	1.43 ± 0.14	-0.09	0.013*
Length 11 (mm)	25.48 ± 2.17	24.59 ± 1.86	-0.89	0.005*
1-PTV incisal (mm)	55.65 ± 6.65	63.26 ± 6.00	7.61	0.142
1-PTV apical (mm)	36.66 ± 5.04	41.80 ± 4.04	5.14	0.138
FMA (degrees)	25.22 ± 5.02	23.16 ± 4.60	-2.06	0.015*
PFH/AFH (mm)	0.70 ± 0.06	0.72 ± 0.07	0.02	0.034*
ANB (degrees)	3.29 ± 2.98	2.82 ± 2.34	-0.47	0.482
Wits (mm)	-0.26 ± 5.12	-0.28 ± 5.51	0.02	0.986
1.NA (degrees)	21.06 ± 6.32	24.63 ± 6.61	3.57	0.007*
H-11 (mm)	18.05 ± 3.56	19.90 ± 3.27	1.85	0.267
UA+UP (mm)	13.46 ± 3.75	14.35 ± 4.89	0.89	0.662
UA cerv (mm)	0.67 ± 0.41	0.61 ± 0.57	-0.06	0.762
UP cerv (mm)	1.20 ± 0.49	0.53 ± 0.59	-0.67	0.132
UA middle (mm)	0.47 ± 0.30	0.63 ± 0.61	0.16	0.658
UP middle (mm)	2.01 ± 0.62	1.21 ± 0.81	-0.80	0.049*
UA apical (mm)	0.99 ± 0.36	0.99 ± 0.78	0.00	0.995
UP apical (mm)	3.03 ± 1.38	2.47 ± 1.28	-0.56	0.406

*Statistically significant difference (P<0.05).

Table 6 - Intergroup comparison of the studied variables at the final stage (T_2) (independent t tests).

Variables	G1 Extraction of #14 and #24 teeth n = 6	G2 Without extraction n = 6	p
	Mean ± SD	Mean ± SD	
Crown-root ratio (mm)	1.32 ± 0.25	1.43 ± 0.14	0.343
Length 11 (mm)	23.65 ± 2.12	24.59 ± 1.86	0.434
1-PTV incisal (mm)	52.45 ± 4.18	63.26 ± 6.00	0.004*
1-PTV apical (mm)	43.30 ± 5.17	41.80 ± 4.04	0.586
FMA (degrees)	23.28 ± 5.13	23.16 ± 4.60	0.968
PFH/AFH (mm)	0.64 ± 0.08	0.72 ± 0.07	0.133
ANB (degrees)	2.61 ± 1.38	2.82 ± 2.34	0.855
Wits (mm)	-0.50 ± 5.05	-0.28 ± 5.51	0.944
1.NA (degrees)	20.99 ± 4.08	24.63 ± 6.61	0.277
H-11 (mm)	19.09 ± 2.09	19.90 ± 3.27	0.621
UA+UP (mm)	13.53 ± 3.18	14.35 ± 4.89	0.738
UA cerv (mm)	1.48 ± 0.40	0.61 ± 0.57	0.012*
UP cerv (mm)	0.28 ± 0.69	0.53 ± 0.59	0.515
UA middle (mm)	1.77 ± 1.43	0.63 ± 0.61	0.103
UP middle (mm)	1.15 ± 0.96	1.21 ± 0.81	0.907
UA apical (mm)	3.27 ± 3.44	0.99 ± 0.78	0.146
UP apical (mm)	2.69 ± 2.09	2.47 ± 1.28	0.828

*Statistically significant difference (P < 0.05).

Table 7 - Intergroup comparison of the studied variables concerning treatment changes (T_2-T_1) (independent t tests).

Variables	G1 Extraction of #14 and #24 teeth n = 6	G2 Without extraction n = 6	p
	Mean ± SD	Mean ± SD	
Crown-root ratio (mm)	-0.12 ± 0.07	-0.08 ± 0.05	0.402
Length 11 (mm)	-1.26 ± 0.82	-0.89 ± 0.46	0.359
1-PTV incisal (mm)	-11.33 ± 5.44	7.61 ± 10.73	0.003*
1-PTV apical (mm)	-8.40 ± 5.48	5.13 ± 7.15	0.004*
FMA (degrees)	-0.53 ± 1.62	-2.05 ± 1.40	0.113
PFH/AFH (mm)	0.00 ± 0.01	0.02 ± 0.01	0.209
ANB (degrees)	-1.48 ± 0.82	-0.47 ± 1.52	0.182
Wits (mm)	-0.29 ± 2.18	-0.01 ± 2.23	0.830
1.NA (degrees)	-6.97 ± 9.62	3.57 ± 2.04	0.025*
H-11 (mm)	-1.42 ± 3.79	1.85 ± 3.63	0.157
UA+UP (mm)	-4.58 ± 6.27	0.88 ± 4.66	0.117
UA cerv (mm)	0.63 ± 0.49	-0.06 ± 0.47	0.031*
UP cerv (mm)	-1.39 ± 0.51	-0.66 ± 0.90	0.113
UA middle (mm)	1.15 ± 1.27	0.16 ± 0.86	0.145
UP middle (mm)	-1.62 ± 0.86	-0.80 ± 0.76	0.111
UA apical (mm)	1.95 ± 2.98	0.00 ± 0.74	0.151
UP apical (mm)	-1.54 ± 2.57	-0.56 ± 1.51	0.436

*Statistically significant difference (P < 0.05).

© 2013 Dental Press Journal of Orthodontics

Table 8 - Intergroup comparison of external root resorption (ERR) variable at initial and final stages as well as treatment changes (Mann-Whitney).

Variable	G1 Extractions of #14 and #24 teeth n = 6	G2 Without extractions n = 6	p
	Mean ± SD	Mean ± SD	
ERR T_1	0,16 ± 0,40	0,16 ± 0,40	1,000
ERR T_2	1,50 ± 1,04	1,00 ± 0,00	0,336
ERR T_{2-1}	1,33 ± 0,81	0,83 ± 0,40	0,240

the occurrence of unfavorable sequelae to orthodontic movement, especially fenestration, bone dehiscence and root resorption. This information can influence the patient's treatment planning which, prior to orthodontic treatment, can be diagnosed as unfavorable to great teeth movement. The tridimensional analysis provided by computed tomography is of great importance for an accurate assessment of craniofacial morphology because through this examination, it is possible to obtain more reliable information on the dimensions and levels of facial bone tissues when compared to traditional bidimensional examinations. Moreover, CT is considered as a noninvasive, fast, high-accurate diagnosis method.[7,12,13]

It is important to underline the difficulty and the merit of obtaining a sample comprising 12 patients not only examined with lateral cephalograms, computed tomographies and periapical radiographs at the beginning of the treatment and after 18 months, but also who meet the aforementioned inclusion criteria of this study methodology. As the study was accomplished using CT, which is difficult to be obtained due to the cost and the ethical question concerning radiation exposure, the sample of 12 patients,, is considered acceptable.

Methods

Measurements were performed on the maxillary central incisor because this is the tooth that shows more resorption during orthodontic movement.[14,15] Periapical radiograph was the examination chosen to evaluate root resorption because it presents less distortion and more details when compared to panoramic radiograph and lateral cephalograms.[11]

Lateral cephalograms were used to obtain standard cephalometric measurements as well as to measure the alveolar thickness at the apical area of the right maxillary central incisor from a linear distance traced parallel to the palatal plane extending from labial to palatal cortical plate.[5]

Computed tomography was performed by two different radiology centers, by the same examiner in each one of them. CTs were obtained during T_1 (the beginning of the orthodontic treatment) and T_2 (after tooth extraction space closure). CT scans were used to evaluate bone thickness at the cervical, middle and apical thirds of the root of the right maxillary central incisor, tracing three lines parallel to the ECJ plane at a 3 mm interval. These measurements aimed to identify lack of bone tissue which may indicate fenestration or bone dehiscence. Fenestration is the lack of bone tissue in a restricted area of the tooth root[16] while dehiscence occurs when the lack of bone involves the alveolar bone ridge.[16]

Results

The results demonstrate that there was no difference between genders, i.e., the intergroup comparison showed compatibility regarding the number of males and females in each group. Additionally, there was no difference concerning the variables "age" and "treatment period". Considering the variable "malocclusion type", the samples were not compatible at the beginning of the treatment. G1 exhibited 3 patients with Class II malocclusion which did not influence the results of this study because the objective was to evaluate the changes in bone thickness at incisors area during the retraction of the anterior teeth, i.e., the importance was in performing or not the retraction of the anterior teeth regardless of the malocclusion type.

Regarding the variables studied during T_1, only 1-PTV demonstrated statistically significant difference. This occurred because G2 presented less protrusion of maxillary anterior teeth when compared to G1. This result was already expected, since great dentoalveolar protrusion of G1 patients probably influenced the decision to perform teeth extraction in this group. Premolar extractions have been frequently employed aiming to reduce dentoalveolar protrusion.[17]

During treatment, G1 (with extractions) underwent changes in the crown-root ratio, maxillary incisor length, 1-PTV incisal, 1-PTV apical and in the maxillomandibular relationship. These changes were expected due to premolar extractions and space closure caused by retraction of the maxillary anterior teeth.[18] Alveolar bone thickness at the labial cervical third (UL cervical) significantly increased. Bone thickness decreased at the palatal cervical and middle thirds (UP cervical and UP middle).

© 2013 Dental Press Journal of Orthodontics

As Handelman[5] reported, tooth movement can alter the distance between alveolar cortical plates in relation to the roots of the orthodontically moved teeth, i.e., the anteroposterior movement of the incisors can lead to bone loss in the direction of the movement.[19]

The changes occurring in G2 (without extractions), during the treatment phase, were significant in the following variables: crown-root ratio, incisor length, FMA, PFH-AFH, 1.NA, and UP middle. Similarly to G1, there were significant root resorptions in the studied teeth due to tooth movement during treatment.[20,21] The maxillary incisors presented significant vestibularization. This occurred for two main reasons: the incisors alignment that were slightly crowded and the Curve of Spee flatting during treatment.

At the final stage (T_2), the results of the studied variables indicated a statistically significant difference in two variables: 1-PTV incisal and UL cervical. At this stage, 1-PTV incisal of G2 was greater than 1-PTV incisal of G1, indicating that in G2, the maxillary central incisors were more protruded at the end of the treatment than those of G1. This occurred due to the sum of the statistically significant retraction (1-PTV incisal and 1-PTV apical) suffered by the incisors of G1 and the vestibularization (1.NA) suffered by the incisors of G2 during the treatment period (Tables 4 and 5). UL cervical also presented a statistically significant difference between Groups at T_2. The maxillary incisors of G1 presented a statistically significant decrease of the labial alveolar bone thickness at the cervical third in relation to the maxillary incisors of G2. This effect occurred because G1 (with extractions) underwent maxillary incisors retraction during treatment and G2 (without extractions) presented only vestibularization of these teeth.

The intergroup comparison concerning the variables changes occurring as a result of the treatment (Table 7) demonstrates that 1-PTV incisal and 1-PTV apical exhibited statistically significant differences. With regard to the 1-PTV incisal, the group with extractions presented a maxillary incisor retraction of 11.33 mm while the group without extractions presented a protraction of 7.61 mm. In respect to 1-PTV apical, the group with extractions presented a maxillary incisor retraction of 8.40 mm while the group without extractions presented a protraction of 5.13 mm. The sum of these changes resulted in the statistically differences showed by these variables in relation to these groups of study. Such differences have already been proved by several previous studies comparing dentoskeletal changes between extraction and nonextraction cases.[22,23,24]

The inclination of the incisors evaluated by the variable 1.NA also underwent a statistically significant difference between groups. While in G1 the incisors showed a palatal change of 6.97°, in G2, without extractions, the incisors were vestibularized in 3.57°. This result was expected, since G1 presented retraction of maxillary incisors during the extraction space closure and G2 had these teeth vestibularized by the alignment and leveling of the teeth that presented mild crowding and overbite, as described above.

According to Lupi, Handelman and Sadowsky,[25] both the treatment carried out with extractions and the amount of force used for orthodontic movement may influence alveolar bone loss. These authors also claim that bone dehiscence and fenestration have been reported when the incisors are protracted or retracted; maxillary incisor protraction produces a dehiscence in labial alveolar bone while its retraction affects the palatal alveolar ridge.[25]

The change in UL cervical also showed a significant difference between groups. In G1, labial bone thickness at the cervical area presented an increase of 0.67 mm while in G2 bone thickness decreased 0.06 mm. These changes were also expected due to the same aforementioned reasons. The other variables analyzed on CT scans, aiming to assess the alveolar bone thickness at other root areas, did not undergo any significant changes between groups, therefore demonstrating strong evidence that the alveolar cortical plates could be submitted to re-anatomization, modifying their shape and position.[2,26] These results do not agree with the hypothesis of Hadelman regarding the limitation of tooth movement by alveolar cortical plates,[5] showing that alveolar bone remodeling is possible during tooth movement induced by biological forces.[2,26]

External root resorption

External root resorption is one of the consequences caused by orthodontic movement. This study evaluated the degree of external root resorption through the scores proposed by Levander and Malmgren in 1988.[11] According to Cheng et al[27] one of the biological factors influencing inflammatory root resorption during orthodontic movement is the root morphology, moreover, age, gender, metabolism velocity and tooth anomaly,

factors which the clinician cannot control, also influence inflammatory root resorption during orthodontic movement. Factors related to the treatment are: amount of movement, treatment time and the magnitude of the applied force.[28,29]

This study did not find statistically significant differences in root resorption between the groups, however, it is not advisable to affirm that these resorptions did not occur or were not clinically important. According to some authors, patients submitted to retraction of anterior teeth through lingual root torque presenting low bone thickness, i.e., small alveolar width, clinically demonstrate a decrease in alveolar bone thickness and a greater tendency towards external root resorption.[2,30]

CONCLUSIONS

There were no changes in alveolar bone thickness when extractions and nonextraction cases were compared, except for labial alveolar bone thickness at the cervical third of the maxillary incisors.

REFERENCES

1. Krishnan V, Davidovitch Z. Cellular, molecular, and tissue-level reactions to orthodontic force. Am J Orthod Dentofacial Orthop. 2006;129(4):469-e1-32.
2. Vardimon AD, Oren E, Ben-Bassat Y. Cortical bone remodeling/tooth movement ratio during maxillary incisor retraction with tip versus torque movements. Am J Orthod Dentofacial Orthop. 1998;114(5):520-9.
3. Artun J, Krogstad O. Periodontal status of mandibular incisors following excessive proclination. A study in adults with surgically treated mandibular prognathism. Am J Orthod Dentofacial Orthop. 1987;91(3):225-32.
4. Yared KF, Zenobio EG, Pacheco W. Periodontal status of mandibular central incisors after orthodontic proclination in adults. Am J Orthod Dentofacial Orthop. 2006;130(1):6 e1-8.
5. Handelman CS. The anterior alveolus: its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. Angle Orthod. 1996;66(2):95-109; discussion 109-10.
6. Karring T, Nyman S, Thilander B, Magnusson I. Bone regeneration in orthodontically produced alveolar bone dehiscences. J Periodontal Res. 1982 May;17(3):309-15.
7. Garcia R, Claro C, Chagas R, Almeida G. Espessura do processo alveolar da região anterior da maxila e mandíbula em pacientes com discrepância óssea ântero-posterior. Rev Dental Press Ortod Ortop Facial. 2005;10(5):137-48.
8. Kim HJ, Yun HS, Park HD, Kim DH, Park YC. Soft-tissue and cortical-bone thickness at orthodontic implant sites. Am J Orthod Dentofacial Orthop. 2006;130(2):177-82.
9. Capelozza Filho L, Fattori L, Maltagliati LA. Um novo método para avaliar as inclinações dentárias utilizando a tomografia computadorizada. Rev Dental Press Ortod Ortop Facial. 2005;10(5):23-9.
10. De Vos W, Casselman J, Swennen GR. Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: a systematic review of the literature. Int J Oral Maxillofac Surg. 2009;38(6):609-25.
11. Levander E, Malmgren O. Evaluation of the risk of root resorption during orthodontic treatment: a study of upper incisors. Eur J Orthod. 1988;10(1):30-8.
12. Consolaro A. Tomografia volumétrica (Odontológica) versus helicoidal (Médica) no planejamento ortodôntico e no diagnóstico das reabsorções dentárias. Rev Clín Ortod Dental Press. 2007;6(4):108-11.
13. Rodrigues AF, Vitral RWF. Aplicações da tomografia computadorizada na Odontologia. Pesq Bras Odontoped Clín Integrada. 2007;7:317-24.
14. Parker RJ, Harris EF. Directions of orthodontic tooth movements associated with external apical root resorption of the maxillary central incisor. Am J Orthod Dentofacial Orthop. 1998;114(6):677-83.
15. Janson G, De Luca Canto G, Martins D, Henriques J, De Freitas M. A radiographic comparison of apical root resorption after orthodontic treatment with 3 different fixed appliance techniques. Am J Orthod Dentofacial Orthop. 2000;118(3):262-73.
16. Carranza F, Newman M, Takei H. Periodontia clínica. 9a ed. Rio de Janeiro: Guanabara Koogan; 2002.
17. Baumrind S, Korn EL, Boyd RL, Maxwell R. The decision to extract: part II. Analysis of clinicians stated reasons for extraction. Am J Orthod Dentofacial Orthop. 1996;109(4):393-402.
18. Luppanapornlarp S, Johnston LE Jr. The effects of premolar-extraction: a long-term comparison of outcomes in "clear-cut" extraction and nonextraction Class II patients. Angle Orthod. 1993;63(4):257-72.
19. Wehrbein H, Bauer W, Diedrich P. Mandibular incisors, alveolar bone, and symphysis after orthodontic treatment. A retrospective study. Am J Orthod Dentofacial Orthop. 1996;110(3):239-46.
20. Consolaro A. Reabsorção dentária na movimentação ortodôntica. In: Reabsorções dentárias nas especialidades clínicas. 1a ed. Maringá: Dental Press; 2002. p. 259-89.
21. Marques LS, Ramos-Jorge ML, Rey AC, Armond MC, Ruellas AC. Severe root resorption in orthodontic patients treated with the edgewise method: prevalence and predictive factors. Am J Orthod Dentofacial Orthop. 2010;137(3):384-8.
22. Basciftci FA, Usumez S. Effects of extraction and nonextraction treatment on Class I and Class II subjects. Angle Orthod. 2003;73(1):36-42.
23. Kocadereli I. Changes in soft tissue profile after orthodontic treatment with and without extractions. Am J Orthod Dentofacial Orthop. 2002;122(1):67-72.
24. Rains MD, Nanda R. Soft-tissue changes associated with maxillary incisor retraction. Am J Orthod. 1982;81(6):481-8.
25. Lupi JE, Handelman CS, Sadowsky C. Prevalence and severity of apical root resorption and alveolar bone loss in orthodontically treated adults. Am J Orthod Dentofacial Orthop. 1996;109(1):28-37.
26. Meikle MC. The dentomaxillary complex and overjet correction in Class II, division 1 malocclusion: objectives of skeletal and alveolar remodeling. Am J Orthod. 1980;77(2):184-97.
27. Cheng LL, Turk T, Elekdag-Turk S, Jones AS, Petocz P, Darendeliler MA. Physical properties of root cementum: Part 13. Repair of root resorption 4 and 8 weeks after the application of continuous light and heavy forces for 4 weeks: a microcomputed-tomography study. Am J Orthod Dentofacial Orthop. 2009;136(3):320 e1-10; discussion -1.
28. Brezniak N, Wasserstein A. Orthodontically induced inflammatory root resorption. Part I: The basic science aspects. Angle Orthod. 2002;72(2):175-9.
29. Mirabella AD, Artun J. Risk factors for apical root resorption of maxillary anterior teeth in adult orthodontic patients. Am J Orthod Dentofacial Orthop. 1995;108(1):48-55.
30. Horiuchi A, Hotokezaka H, Kobayashi K. Correlation between cortical plate proximity and apical root resorption. Am J Orthod Dentofacial Orthop. 1998;114(3):311-8.

© 2013 Dental Press Journal of Orthodontics

Translation and cross-cultural adaptation of an instrument designed for the assessment of quality of life in orthognatic patients

Adriana Monteiro de Araújo[1], José Augusto Mendes Miguel[2], Eveline Coutinho Baldoto Gava[3], Branca Heloisa de Oliveira[4]

Introduction: The Orthognathic Quality of Life Questionnaire (OQLQ) was developed in 2000 and validated in 2002, aiming at assessing the impact and the benefits of orthosurgical treatment on patients' quality of life.
Objective: Cross-culturally translate into Brazilian Portuguese and back-translate into English a quality of life instrument, assuring maintenance of its properties.

Methods: At first, equivalence of concepts and items was discussed by a group of specialists who scrutinized all questionnaire items. Additionally, four patients in need of orthosurgical treatment were interviewed by means of the focus group methodology. Relevance of the questionnaire items was assured prior to its translation which was carried out by two translators who worked independently. Both translations were tested in 20 patients and then consolidated. The consolidated questionnaire version was back-translated into English by two translators who worked independently, and the consolidated back-translation was assessed by the authors of the original questionnaire as well as by the researchers.

Results: The OQLQ was translated into Brazilian Portuguese. This translation was tested in a pilot study comprising 12 patients, aged between 16 and 34 years old.

Conclusion: The OQLQ Brazilian Portuguese translation proves to be an appropriate instrument to access the impact of dentofacial deformities on the quality of life of patients in the Brazilian public health system and who are in need of orthosurgical treatment.

Keywords : Quality of life. Oral surgery. Validation studies.

[1] Specialist in Orthodontics, Rio de Janeiro State University (UERJ).
[2] Specialist in Orthodontics, Rio de Janeiro State University (UERJ). MSc and PhD in Dentistry. Associate Professor of Orthodontics at Rio de Janeiro State University (UERJ).
[3] PhD in Collective Health/Epidemiology, Institute of Social Medicine (IMS) / UERJ, 2003. Associate Professor, Department of Preventive and Community Dentistry at College of Dentistry, Rio de Janeiro State University (UERJ).
[4] Specialist in Orthodontics, Rio de Janeiro State University (UERJ). Master's degree student at Rio de Janeiro State University (UERJ).

How to cite this article: Araújo AM, Miguel JAM, Gava ECB, Oliveira BH. Translation and cross-cultural adaptation of an instrument designed for the assessment of quality of life in orthognatic patients. Dental Press J Orthod. 2013 Sept-Oct;18(5):99-106.

Submitted: August 22, 2011 - **Revised and accepted:** January 09, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Adriana Monteiro de Araújo
Av. Almirante Barroso, 28 – Souza – Belém/PA, Brazil
CEP: 66613-020 – E-mail: ortodontia.adriana@gmail.com

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Health-related quality of life (HRQL) among patients with malocclusions and severe dentofacial deformities may be affected in various ways. They may experience functional limitations, emotional problems and social difficulties, even to the extent of considering life less satisfactory.[1,2] In cases in which improper skeletal relationships cannot be compensated by means of using orthodontic therapy only, orthognathic surgery proves to be an alternative for treating dentofacial deformities, as it provides more stable correction and better esthetic results.[3]

Patients' request for orthodontic treatment is based on their complaints about appearance and other psychological and social factors.[4] Patient's perception of their dentofacial deformity should be the main factor influencing their decision on whether or not to have orthosurgical treatment.[3] The success of this type of treatment and the alterations in HRQL that it may produce depend on proper patient selection.[5]

The Orthognathic Quality of Life Questionnaire (OQLQ) was developed in the United Kingdom, in 2000, aiming to assess the success of orthosurgical treatment in terms of its effect on HRQL, from the patient's point of view.[6] The OQLQ consists of 22 questions, divided into 4 domains: 8 questions regarding social aspects of deformity, 5 questions regarding facial esthetics, 5 questions regarding oral functions, and 4 questions regarding awareness of facial deformity. The answers are given using a 4-point rating scale in order to measure to what extent the condition described in each question bothers the patient (1= "bothers you a little"; 4 = "bothers you a lot"). In 2002, the validity and responsiveness of the questionnaire were demonstrated. To the validation process, the OQLQ was correlated to other HRQL impact assessment measures, and responsiveness was tested by means of comparing the scores that patients obtained on the OQLQ before and after treatment. The results proved the questionnaire to be useful both in clinical practice and in research projects.[7] The OQLQ has already been adapted to other cultures [8,9] and used in many countries to assess the impact of dentofacial deformities and the effects of orthosurgical treatment on quality of life in cross-sectional[5,10] and longitudinal[11,12] studies.

Many patients in need of orthosurgical treatment appeal for the public health system and for university health services. However, since this treatment is expensive, complicated and lengthy, not everyone can be immediately assisted in the public health system and university facilities. As a result, priorities must be set, and the OQLQ has proved to be a useful instrument for healthcare professionals to establish those priorities.

The purpose of this article is to describe the process of adapting the OQLQ questionnaire into Brazilian Portuguese in order to make it suitable to be used in Brazilian public and university dental services.

METHODS

Ethical approval

This research was approved by the Institutional Review Board of Pedro Ernesto University Hospital at Rio de Janeiro State University (CEP/HUPE Registration: 2705/2010. CAAE: 0150.0.228.000-10). Patients who stated their acceptance in writing by means of an Informed Consent Form were the only ones allowed to participate in the research.

Adaptation of the questionnaire

Equivalence of concepts and items

Before starting the translation and back-translation processes, which intended to achieve semantic equivalence between the Brazilian version of the OQLQ and the original instrument; suitability of the conceptual model used to develop the questionnaire and relevance of the items of which it is comprised were evaluated within the context of Brazilian culture.[13] These aspects were analyzed by a team of specialists (TS) consisted of two orthodontists, one postgraduate student in Orthodontics and a dentist with experience in developing and adapting quality of life instruments. Every item in the original English version was carefully read and discussed. Afterwards, four patients in need of orthosurgical treatment were interviewed at the UERJ Orthodontics Clinic. The interviews were videotaped so that they could be analyzed later. The goal was to identify the terms used by the patients themselves to describe how their dentofacial deformities interfered with their quality of life and, in particular, verify how the interviewees referred to the problems raised in the questionnaire and which were considered by the specialists involved in the previous phase as potentially difficult to explain in Portuguese. The videos were analyzed by the postgraduate student in Orthodontics, who also took into consider-

© 2013 Dental Press Journal of Orthodontics

ation the patient's feelings, attitudes and motivation in relation to the problems discussed in the questionnaire.

Semantic equivalence

The OQLQ Brazilian adaptation process followed the guidelines proposed by Guillemin et al,[14] Ruperto et al.[15] and Tubert-Jeannin et al.[16] which comprised six stages (Fig 1): (i) translation; (ii) preliminary testing of the translated questionnaires; (iii) consolidation of the questionnaire; (iv) back-translation; (v) review of the translations and back-translations; and (vi) development of a synthesized questionnaire.

Translation

The questionnaire was translated into Portuguese by two Brazilians who worked independently, whose mother tongue is Portuguese and who are proficient in English. The goals of the questionnaire were explained to both translators (T1 and T2), who were advised to use terms employed by the target population in daily life, allowing the questionnaire to be easily understood by patients in the public health system.

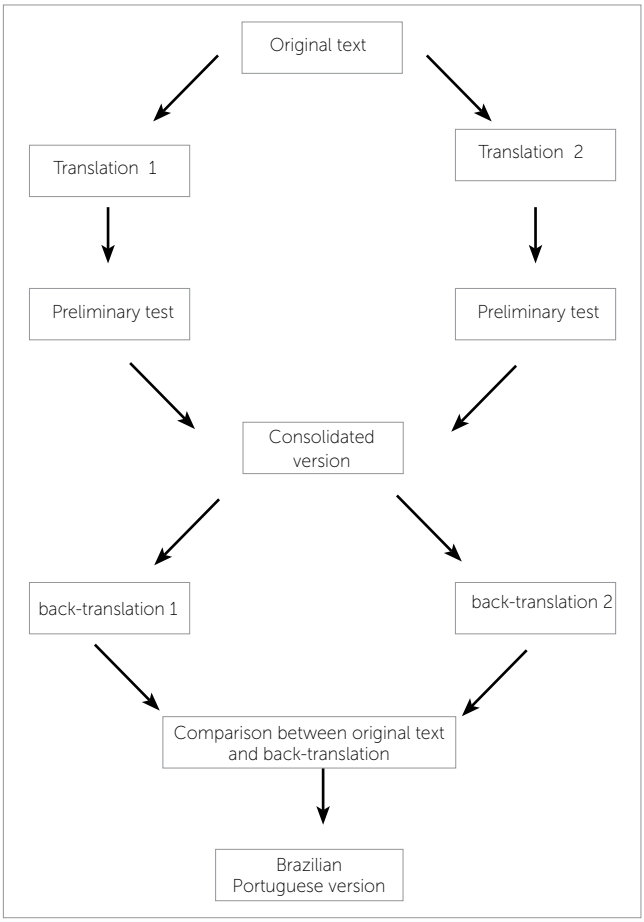


Figure 1 - Methodology used to achieve semantic equivalence in the process of translating the Orthognathic Quality of Life Questionnaire (OQLQ) into Portuguese.

Preliminary test of the translated questionnaires

A preliminary test of the questionnaire was carried out with 20 orthognathic patients recruited at the UERJ Orthodontics Clinic; 10 patients answered T1 questionnaire while the other 10 answered T2 questionnaire. The aim was to assess, from the interviewees' point of view, whether the questions on the questionnaire represented the impact of dentofacial deformities on their quality of life. In addition, the meaning of several words and expressions used in the questionnaire was questioned in order to determine whether or not they were being understood. Interviewees were also asked about the need for replacing any words or expressions.

Questionnaire consolidation

The specialists discussed both translations of the questionnaire based not only on the results obtained from the interviews, which were conducted with members of the target population during the preliminary test, but also from the analyses of the previously recorded videos. Afterwards, they determined how the questionnaire items would be written and how the intensity of patient's' discomfort towards the problems included on the questionnaire would be assessed. Thereafter, three other patients with dentofacial deformities were interviewed and videotaped in order to test their comprehension of the statements and questions in the consolidated version. After those interviews, the consolidated version of the translations was finalized.

Back-translation

The OQLQ questionnaire was back-translated into English by two translators (B1 and B2) who worked independently. Although their native language is English, they are proficient in Portuguese. In contrast to the first translators, the back — translators were not told about the objectives and concepts involved in the questionnaire in order to avoid any bias. They discussed the discrepancies in their results and carried out the consolidated version of the back-translation.

Translations and back-translations review

The consolidated versions of the OQLQ translations and back-translations were sent to the authors of

© 2013 Dental Press Journal of Orthodontics

the original questionnaire by e-mail for their evaluation. After receiving the results of this evaluation, the team of specialists (TS) met again to compare the original version of the OQLQ questionnaire with the back-translated version, taking into consideration the authors' opinions of the original questionnaire.

Developing the final questionnaire

Based on the results of the preceding phase, the specialists proposed a final version of the questionnaire which was written in Brazilian Portuguese and intended to be used in a pilot study, aiming at assessing other types of equivalence as well.

Pilot study

The pilot study was conducted at the clinic of the graduate program in Orthodontics at UERJ and involved 12 patients (9 male and 3 female) with an average age of 25 years. All patients involved in the research presented malocclusions with skeletal discrepancies. Two researchers involved in the project conducted the pilot test and were present during the application of the 12 questionnaires in order to ensure standardization of the method used to explain the questionnaire to the target public. Should patients have any doubts about the questions, the researchers were advised not to influence their answers. The purpose of this pilot study was to test all the phases of later studies aimed at evaluating the psychometric properties of the instrument.

RESULTS

Equivalence of concepts and items

When the team of specialists assessed the suitability of the conceptual model, as well as the relevance of the questionnaire items in the context of Brazilian culture, they highlighted some words that could have created doubts in the process of translation into Brazilian Portuguese, namely: "self-conscious" (Items 1 and 14), "jaw" (Item 6), "studying" (Items 8 and 9), "often stare at" (Items 12 and 13), "lack confidence" (Item 18), "get depressed" (Item 20), "staring at me" (Item 21) and "upset me" (Item 22).

Analysis of the recorded interviews carried out with the four patients, demonstrated that the words considered hard to translate were in fact well understood. The group responsible for the research project discussed the results of the analyses carried out by the team of specialists as well as the information obtained from the interviews, and concluded that it would be appropriate to keep all the items from the original questionnaire.

Semantic equivalence

Table 1 shows the items from the original English OQLQ questionnaire, the results derived from the translations and from consolidation of the questionnaire, as well as the results derived from the consolidated version back-translation.

Translation

Both translations proved to be similar, with little discrepancy related to specific terminology (Table 1).

Preliminary test of the translated questionnaires and consolidation of the questionnaire

Conducting the preliminary test corroborated the need for a better evaluation of the questions, such as the understanding of the words: "self-conscious", "staring at me" and "lack confidence".

Ten patients (five from T1 and five from T2), meaning 50% of the interviewees, did not report any doubts about the questions and were able to answer them without any assistance. As for the other 10 patients, eight of them (four from T1 and four from T2) reported doubts about the word "self-conscious" (Items 1 and 14); one patient (T1) did not know the meaning of "jaw"; three patients (T1) did not find the term "to stare" (Items 12 and 13) to be very clear; two patients (T2) reported doubts about the term "lack confidence" (Item 18); and three patients (T1) reported doubts about Item 22: "Comments about my appearance really upset me, even when I know that people are only joking".

Some patients suggested using words such as "evaluate" instead of "analyze" (Items 8 and 9 - T1); "notice" instead of "stare" (Items 12 and 13 - T1); "gaze" instead of "stare" (Items 12 and 13 – T1) "compare" instead of "gaze" (Items 12 and 13 - T2); "get to know" instead of "meet" (Item 16 - T2); "irritate, upset or not be good for", to replace "hurt" (Item 22 - T1); and "image" instead of "appearance" (Items 14, 17, 20 and 22 - T1).

Based on the results of the preliminary test and the interviews, the decisions made by the team of specialists about the form and content of the consolidated questionnaire originated the consolidated translated questionnaire, shown in Table 1.

© 2013 Dental Press Journal of Orthodontics

Table 1 - The OQLQ translations into Brazilian Portuguese, their consolidated version and back-translation.

Item	OQLQ original	Translation 1	Translation 2	Consolidated version	Back-translation
Title	Orthognathic Quality of Life Questionnaire	Questionário Ortognático de Qualidade de Vida	Questionário de Qualidade de Vida em Cirurgia Ortognática	Questionário de Qualidade de Vida para Pacientes Orto-cirúrgicos	Questionnaire on the Quality of Life of Dental Surgery Patients
Instructions	Final condition-specific measure. Please read the following statements carefully. In order to find out how important each of the statements is to you. Please circle 1, 2, 3, 4 or N/A where: 1 means it bothers you a little 4 means it bothers you a lot 2/3 lie between these statements N/A means the statement does not apply to you or does not bother you	Por favor, leia cuidadosamente as frases a seguir. Para descobrir o quanto importante cada uma das frases são para você, circule 1, 2, 3, 4 ou N/A quando: 1 Significa que te incomoda um pouco 4 Significa que te incomoda muito 2 + 3 Fica entre os dois níveis acima N/A Significa que a frase não se aplica a você ou não te incomoda de forma alguma	Favor, ler as seguintes afirmativas cuidadosamente a fim de descobrir o quão importante cada uma das alternativas é para você, favor fazer um círculo em 1, 2, 3, 4 ou N/A, onde: 1 Significa que isto te incomoda um pouco 4 Significa que isto te incomoda muito 2 + 3 Estão entre estas duas afirmativas N/A Significa que a afirmativa não se aplica a você ou não te incomoda de forma alguma	Por favor, leia cuidadosamente as afirmativas a seguir. Para que saibamos o quanto cada uma das afirmativas é importante para você, por favor circule 1,2,3,4 ou N/A, onde: 1- Significa que isto te incomoda um pouco 4 - Significa que isto te incomoda muito 2 + 3 – Ficam entre te incomodar um pouco e te incomodar muito N/A – Significa que a afirmativa não se aplica a você ou isto não te incomoda de forma alguma	Please read the following statements carefully. Please show how much the circumstances described in the following statements bother you by circling 1, 2, 3, 4 or N/A where: 1 means they bother you slightly 4 means they bother you intensely 2/3 means you they bother you somewhere between slightly and intensely N/A means that the statement does not apply to you or that you are not bothered by them in any way
1	I am self-conscious about the appearance of my teeth	Eu tenho consciência do aspecto dos meus dentes	Tenho consciência da aparência dos meus dentes	Eu fico inseguro com a aparência dos meus dentes	I feel insecure as to the appearance of my teeth
2	I have problems biting	Tenho dificuldade em morder	Tenho problemas para morder	Eu tenho problemas para morder	I have trouble biting
3	I have problems chewing	Tenho problemas em mastigar	Tenho problemas para mastigar	Eu tenho problemas para mastigar	I have trouble chewing
4	There are some foods I avoid eating because the way my teeth meet makes it difficult	Evito alguns alimentos porque a maneira como meus dentes encaixam dificulta comê-los	Há alguns alimentos que evito comer porque, a maneira como meus dentes se encontram, torna isto difícil	Há alguns alimentos que evito comer porque a maneira como os meus dentes se encaixam, torna isso difícil	There are some kinds of food I avoid as they can be hard toe at due to the way my teeth fit together
5	I don't like eating in public places	Eu não gosto de comer em lugares públicos	Não gosto de comer em lugares públicos	Eu não gosto de comer em lugares públicos	I don't like eating in public
6	I get pains in my face or jaw	Tenho dores na minha face ou mandíbula	Tenho dores em meu rosto ou maxilar	Eu tenho dores na minha face ou no maxilar	I suffer from facial or jaw pain
7	I don't like seeing a side view of my face (profile)	Eu não gosto de ver minha face de lado (perfil)	Não gosto de ver a vista lateral do meu rosto (perfil)	Eu não gosto de ver o meu rosto de lado (perfil)	I don't like to see my face from the side (in profile)
8	I spend a lot of time studying my face in the mirror	Eu passo muito tempo analisando minha face no espelho	Passo muito tempo estudando o meu rosto no espelho	Eu passo muito tempo analisando o meu rosto no espelho	I spend a lot of time analyzing my face in the mirror
9	I spend a lot of time studying my teeth in the mirror	Eu passo muito tempo analisando meus dentes no espelho	Passo muito tempo estudando meus dentes no espelho	Eu passo muito tempo analisando os meus dentes no espelho	I spend a lot of time analyzing my teeth in the mirror
10	I dislike having my photograph taken	Eu não gosto de ser fotografado	Não gosto que tirem fotografia de mim	Eu não gosto que tirem fotografia de mim	I don't like having my picture taken
11	I dislike being seen on video	Eu não gosto de me ver em vídeo	Não gosto de ser visto em vídeo	Eu não gosto de ser visto em vídeo	I don't like being filmed
12	I often stare at other people's teeth	Eu frequentemente encaro os dentes das pessoas	Frequentemente fixo o olhar nos dentes de outras pessoas	Eu costumo olhar fixamente para os dentes das pessoas	I tend to stare at other people's teeth
13	I often stare at other people's faces	Eu costumo encarar as faces das pessoas	Frequentemente fixo o olhar no rosto de outras pessoas	Eu costumo olhar fixamente para os rostos de outras pessoas	I tend to stare at other people's faces
14	I am self-conscious about my facial appearance	Eu tenho consciência da aparência da minha face	Tenho consciência sobre minha aparência facial	Eu fico inseguro com a aparência do meu rosto	I feel insecure as to how my face looks
15	I try to cover my mouth when I meet people for the first time	Eu tento cobrir minha boca quando conheço pessoas pela primeira vez	Tento cobrir minha boca quando encontro pessoas pela primeira vez	Eu tento cobrir a minha boca quando encontro pessoas pela primeira vez	I try to cover my mouth whenever I meet someone for the first time
16	I worry about meeting people for the first time	Eu me preocupo em conhecer pessoas pela primeira vez	Eu me preocupo em encontrar pessoas pela primeira vez	Eu me preocupo em encontrar pessoas pela primeira vez	I worry about meeting people for the first time
17	I worry that people will make hurtful comments about my appearance	Eu me preocupo que pessoas podem fazer comentários maldosos sobre minha aparência facial	Eu me preocupo que as pessoas façam comentários ofensivos sobre minha aparência	Eu me preocupo que as pessoas irão fazer comentários que magoam sobre a minha aparência	I worry that people will make hurtful comments about my appearance
18	I lack confidence when I am out socially	Tenho pouca confiança quando saio socialmente	Sinto falta de confiança quando estou fora socialmente	Eu sinto falta de confiança quando eu saio socialmente	I feel I lack confidence when I go out socially
19	I do not like smiling when I meet people	Eu não gosto de sorrir quando conheço pessoas	Não gosto de sorrir quando me encontro com pessoas	Eu não gosto de sorrir quando me encontro com pessoas	I don't like to smile when I get together with people
20	I sometimes get depressed about my appearance	Eu as vezes fico deprimido por causa de minha aparência	Às vezes fico deprimido com a minha aparência	Eu às vezes fico deprimido por causa da minha aparência	I sometimes get depressed about my appearance
21	I sometimes think that people are staring at me	Eu as vezes acho que pessoas estão me encarando	Às vezes penso que as pessoas estão me olhando fixamente	Eu às vezes acho que as pessoas estão me encarando	I sometimes think people are staring at me
22	Comments about my appearance really upset me, even when I know people are only joking	Comentários sobre minha aparência me machucam mesmo quando sei que as pessoas estão apenas brincando	Comentários sobre a minha aparência realmente me aborrecem mesmo quando sei que as pessoas estão apenas brincando	Comentários sobre minha aparência me chateiam ou aborrecem mesmo quando sei que as pessoas estão apenas brincando	Comments on my appearance really anger or upset me, even when I know they are being said as a joke

© 2013 Dental Press Journal of Orthodontics

Back-translation

The translators suggested a change in the first part of the wording of the questionnaire. However, the group responsible for the study claimed that this would result in a substantial change in comparison to the original questionnaire. The translators also found the expression "facial pains" to be very generic, given that in the Brazilian context more specific terms such as headache, pain behind the eyes, etc. would be used. In addition, they thought that the word "depressed" might be too strong a translation of "*deprimido*", and suggested other words in English, such as "dejected" or "down".

Translations and back-translations review

The consolidation of the back-translations was evaluated by the main author of the original study. She commented that in the wording of the questionnaire, the term "intensely" seemed extreme and exaggerated. The author also suggested replacing "as to" with "about" in Item 1, and commented that, in Item 22, the word "anger" was not equivalent to the original questionnaire, and that it would be appropriate to keep the idea of "upset".

Developing the final questionnaire

A final version of the OQLQ questionnaire, written in Brazilian Portuguese was, thus, obtained to be tested in terms of its validity and reliability (Fig 2).

Pilot study

12 (100%) interviewees took part in the pilot study, 9 of which (75%) were male and 3 (25%) female, with age ranging from 16 to 34 years old, with an average age of 25. According to the Criteria of Brazilian Economic Classification, the study population belonged to social classes A (n=6; 49.99%) and B (n=6; 49.99%).

The pilot study corroborated the need for a subsequent evaluation study of the psychometric properties of the instrument. The average time for the interviews varied from 15 to 25 minutes.

Questionário de Qualidade de Vida para Pacientes Orto-cirúrgicos

Por favor, leia cuidadosamente as afirmativas a seguir. Para que saibamos o quanto cada uma das afirmativas é importante para você, por favor circule 1, 2, 3, 4 ou N/A, onde:

1 - Significa que isto te incomoda um pouco.

4 - Significa que isto te incomoda muito.

2 + 3 - Ficam entre te incomodar um pouco e te incomodar muito.

N/A - Significa que a afirmativa não se aplica a você ou isto não te incomoda de forma alguma.

Não se aplica a mim Não me incomoda	Me incomoda POUCO			Me incomoda MUITO
N/A	1	2	3	4

1. Eu fico inseguro com a aparência dos meus dentes.
2. Eu tenho problemas para morder.
3. Eu tenho problemas para mastigar.
4. Há alguns alimentos que evito comer porque a maneira como os meus dentes se encaixam torna isso difícil.
5. Eu não gosto de comer em lugares públicos.
6. Eu tenho dores na minha face ou no maxilar.
7. Eu não gosto de ver meu rosto de lado (perfil).
8. Eu passo muito tempo analisando meu rosto no espelho.
9. Eu passo muito tempo analisando meus dentes no espelho.
10. Eu não gosto que tirem fotografia de mim.
11. Eu não gosto de ser visto em vídeo.
12. Eu costumo olhar fixamente para os dentes das pessoas.
13. Eu costumo olhar fixamente para os rostos de outras pessoas.
14. Eu fico inseguro com a aparência do meu rosto.
15. Eu tento cobrir a minha boca quando encontro as pessoas pela primeira vez.
16. Eu me preocupo em encontrar as pessoas pela primeira vez.
17. Eu me preocupo que as pessoas irão fazer comentários que magoam sobre a minha aparência.
18. Eu sinto falta de confiança quando eu saio socialmente.
19. Eu não gosto de sorrir quando me encontro com pessoas.
20. Eu às vezes fico deprimido por causa da minha aparência.
21. Eu às vezes acho que as pessoas estão me encarando.
22. Comentários sobre a minha aparência realmente me chateiam ou aborrecem, mesmo quando sei que as pessoas estão apenas brincando.

Figure 2 - Consolidated version of the Orthognathic Quality of Life Questionnaire (OQLQ) in Brazilian Portuguese, for testing.

DISCUSSION

A translated instrument must be able to achieve in the target culture the same effect it has in its original context. Lack of cross-cultural equivalence hinders the validity of the collected information, making it impossible to properly use the instrument to study the concept that it aims to study.[17] In order to achieve the desired effect, we carried out a careful process of translation into Brazilian Portuguese and back-translation into English of the OQLQ questionnaire and, before having a final version of the instrument, the different versions of the

© 2013 Dental Press Journal of Orthodontics

questionnaire in Portuguese were subjected to evaluation by specialists in the field as well as tests carried out by patients. In addition, the authors of the original questionnaire were consulted. This strategy allowed us to cross-check the specialists' opinions on how the items in the questionnaire were written against the perceptions of the population to which the instrument is actually intended to be applied, thus, enabling the identification of expressions that are more suitable for proper understanding of the questions in the instrument without altering the ideas and concepts underlying the questions in the original instrument.

In comparing the original version of the OQLQ questionnaire to the consolidated version of the back-translations, we were able to verify that they were similar and that the small differences found had arisen from changes considered necessary during the phase of assessing semantic equivalence, due to suggestions made by the specialists or the patients. Those changes were maintained since they were considered important for the clarity of the questionnaire translated into Portuguese.

We also found that it was necessary to change the format of the questionnaire, as had occurred in the study carried out by Bock et al,[8] whereby the scale with the degrees of discomfort was added below each question so that patients would not have to go back to the text of the questionnaire before answering each question.

Given that the patients were at least 16 years old and demonstrated no difficulties during the interviews and the preliminary test, we decided to let patients complete the questionnaire themselves during the pilot study, as had been suggested by the authors of the original instrument in English.[6,7] Nevertheless, we must emphasize that although patients were recruited at a clinic in the public health system, all of them belonged to the A and B socioeconomic classes, which may not reflect socioeconomic and educational levels of those patients in need for orthosurgical treatment who normally use public dental services.

Additionally, it is important to highlight the fact that there has been a recent publication of a research describing the psychometric properties of the OQLQ Brazilian version.[9] That study involved a convenience sample comprised of 25 patients selected in the states of Santa Catarina and Rio Grande do Sul and provides information about the internal consistency and structural validity of the Brazilian questionnaire. That publication was discovered after the process of data collection and analysis had already been completed. Because of that, we contacted the author of the original questionnaire and she encouraged us to continue with the present study. The previously published study used an adaptation methodology which was different from the one used in the present study. In addition, it focused on the equivalence of measurement between the translated questionnaire and the original, without providing any details on how the translated questionnaire was obtained, taking into account: the number of translations and back-translations done, patient participation in the process of identifying the most suitable words for the Brazilian context, contributions made by the authors of the original instrument in English to the final version of the instrument, socioeconomic characteristics of the participants, among others. We, thus, believe that the present study can be considered original, since it offers to dentists and researchers a contribution that is different from the one provided by the aforementioned study. In addition, one must take into account the fact that Brazil is a country of continental dimensions with a broad cultural diversity, which means that questionnaires adapted, validated and reliable to be used with certain populations may not have the same effectiveness when used with other groups.[18]

The questionnaire produced in the present study was used with patients from a public hospital in Rio de Janeiro, in order to assess its reliability and validity. The results are being analyzed and will be presented in a future publication.

CONCLUSION

Despite being hard work and time-consuming, the process of achieving semantic equivalence in the cross-cultural adaptation of the OQLQ, used with populations that appeal for public health services in Brazil, was developed on a solid conceptual base and with a carefully defined methodology. Such process allowed us to produce a valuable instrument for assessing the quality of life of Brazilian orthognathic patients, aiming to compare the effects of dentofacial deformities and orthosurgical treatment on Brazilians and on people from other countries and cultures.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Rusanen J, Lahti S, Tolvanen M, Pirttiniemi P. Quality of life in patients with severe malocclusion before treatment. Eur J Orthod. 2010;32(1):43-8.
2. Esperao PT, de Oliveira BH, de Oliveira Almeida MA, Kiyak HA, Miguel JA. Oral health-related quality of life in orthognathic surgery patients. Am J Orthod Dentofacial Orthop. 2010;137(6):790-5.
3. Bell R, Kiyak HA, Joondeph DR, McNeill RW, Wallen TR. Perceptions of facial profile and their influence on the decision to undergo orthognathic surgery. Am J Orthod. 1985;88(4):323-32.
4. de Oliveira CM, Sheiham A. Orthodontic treatment and its impact on oral health-related quality of life in Brazilian adolescents. J Orthod. 2004;31(1):20-7; discussion 15.
5. Al-Bitar ZB, Al-Omari IK, Al-Ahmad HT, El Maaytah MA, Cunningham SJ. A comparison of health-related quality of life between Jordanian and British orthognathic patients. Eur J Orthod. 2009;31(5):485-9.
6. Cunningham SJ, Garratt AM, Hunt NP. Development of a condition-specific quality of life measure for patients with dentofacial deformity: I. Reliability of the instrument. Community Dent Oral Epidemiol 2000;28(3):195-201.
7. Cunningham SJ, Garratt AM, Hunt NP. Development of a condition-specific quality of life measure for patients with dentofacial deformity: II. Validity and responsiveness testing. Community Dent Oral Epidemiol. 2002;30(2):81-90.
8. Bock JJ, Odemar F, Fuhrmann RA. Assessment of quality of life in patients undergoing orthognathic surgery. J Orofac Orthop. 2009;70(5):407-19.
9. Bortoluzzi MC, Manfro R, Soares IC, Presta AA. Cross-cultural adaptation of the orthognathic quality of life questionnaire (OQLQ) in a Brazilian sample of patients with dentofacial deformities. Med Oral Patol Oral Cir Bucal. 2011;16(5):e694-9.
10. Lee CK, King NM, Lo EC, Cho SY. The relationship between a primary maxillary incisor with a talon cusp and the permanent successor: a study of 57 cases. Int J Paediatr Dent. 2007;17(3):178-85.
11. Choi WS, Lee S, McGrath C, Samman N. Change in quality of life after combined orthodontic-surgical treatment of dentofacial deformities. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109(1):46-51.
12. Lee S, McGrath C, Samman N. Impact of orthognathic surgery on quality of life. J Oral Maxillofac Surg. 2008;66(6):1194-9.
13. Herdman M, Fox-Rushby J, Badia X. 'Equivalence' and the translation and adaptation of health-related quality of life questionnaires. Qual Life Res. 1997;6(3):237-47.
14. Guillemin F, Bombardier C, Beaton D. Cross-cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. J Clin Epidemiol. 1993;46(12):1417-32.
15. Ruperto N, Ravelli A, Pistorio A, Malattia C, Cavuto S, Gado-West L, et al. Cross-cultural adaptation and psychometric evaluation of the Childhood Health Assessment Questionnaire (CHAQ) and the Child Health Questionnaire (CHQ) in 32 countries. Review of the general methodology. Clin Exp Rheumatol. 2001;19(4 Suppl 23):S1-9.
16. Tubert-Jeannin S, Pegon-Machat E, Gremeau-Richard C, Lecuyer MM, Tsakos G. Validation of a French version of the Child-OIDP index. Eur J Oral Sci. 2005;113(5):355-62.
17. Reichenheim ME, Moraes CL, Hasselmann MH. Equivalência semântica da versão em português do instrumento "Abuse Assessment Screen (AAS)" usado no rastreamento da violência contra a mulher na gravidez. Rev Saúde Pública. 2000;34(6):610-6.
18. Oliveira BH, Nadanovsky P. Psychometric properties of the Brazilian version of the Oral Health Impact Profile-short form. Community Dent Oral Epidemiol. 2005;33(4):307-14.
19. Gava ECB, Miguel JAM, Araújo, AM, Oliveira BH. Psychometric properties of the Brazilian Version of the Orthognathic Quality of Life Questionnaire, Journal of Oral and Maxillofacial Surgery, 2013. No prelo.

© 2013 Dental Press Journal of Orthodontics

Evaluation of life quality of patients submitted to orthognathic surgery

Ana Catarina Alves e Silva[1], Roberta Almeida Silveira Carvalho[2], Thiago de Santana Santos[3], Nelson Studart Rocha[4], Ana Cláudia Amorim Gomes[5], Emanuel Dias de Oliveira e Silva[6]

Objective: To compare changes related to self-esteem and appearance satisfaction between pre and postsurgical phases in patients undergoing orthognathic surgery and to assess the quality of life and psychosocial changes of these patients six months after surgery.

Methods: A longitudinal observational qualitative study was performed. The sample comprised 15 patients with dentofacial deformities who underwent orthognathic surgery. One questionnaire and two forms were answered during pre and postoperative phases.

Results: The results showed that 13.3% of patients demonstrated self-esteem improvement, especially in relation to appearance satisfaction. Improvements were also noted in social, occupational and family relationships. With regard to the assessment of quality of life, according to the World Health Organization questionnaire, the lowest improvement averages corresponded to environmental control.

Conclusion: Orthognathic surgery brings along many emotional changes that should be considered before and after surgery, since the patients' psychological state may be favorable and/or unfavorable during recovery, influencing their quality of life, self-esteem and appearance satisfaction.

Keywords: Quality of life. Oral surgery. Orthodontics.

[1] MSc Student in Social Health, Federal University of Pernambuco (UFPE).
[2] Specialist in Endodontics, School of Dentistry of Recife (FOR).
[3] PhD Student in Oral and Maxillofacial Surgery, School of Dentistry of Ribeirão Preto (FORP/USP).
[4] PhD in Oral and Maxillofacial Surgery and Trauma, School of Dentistry of Pernambuco (FOP/UPE).
[5] Professor of Oral and Maxillofacial Surgery and Trauma, FOP/UPE.
[6] Head of Residency in Oral and Maxillofacial Surgery and Trauma, Oswaldo Cruz University Hospital (HUOC/UPE).

How to cite this article: Alves e Silva AC, Carvalho RAS, Santos TS, Rocha NS, Gomes ACA, Oliveira e Silva ED. Evaluation of life quality of patients submitted to orthognathic surgery. Dental Press J Orthod. 2013 Sept-Oct;18(5):107-14.

Submitted: February 01, 2010 - **Revised and accepted:** April 12, 2010

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Thiago de Santana Santos
Av. Gal. Newton Cavalcanti, 1.650 - Camaragibe/PE - CEP: 54.753-220 – Brazil
E-mail: thiago.ctbmf@yahoo.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Beauty is highly valued in society and it is considered a determining element in interpersonal relationships. Orthognathic surgery allows improvements in masticatory, phonetic and breathing functions as well as in facial esthetics, being an expressive way of raising the quality of life of people with dentofacial deformities. This surgical procedure aims to improve patients' self-esteem, esthetics and function; therefore, any facial changes resulting from the surgery can positively influence patients' personal and social life as well as their psychological state. However, physical and/or psychological complications may occur, such as nerve sensitivity or the patients' difficulty in becoming adapted to their new appearance.[15]

In the health field, the interest in quality of life issues is relatively recent. With regard to subjectivity, it comprises the perception of people about their own health and nonmedical aspects of their life, taking into account how people evaluate their personal situation in relation to particular quality of life parameters. Most studies focus on quantitative results concerning the treatment of deformities while only a few focus on the patients' point of view, qualitatively evaluating them.[24]

According to Fleck et al,[8] quality of life was defined by the Quality of Life Group of the World Health Organization as "an individual's perception of their situation in life, considering the culture context and value system on which they live and in relation to their goals, expectations, standards and concerns." Despite the growing importance of quality of life assessments in different medical areas, there had not been any assessment tool developed within a cross-cultural perspective and which could be used internationally. Therefore, a 100-question assessment questionnaire was initially created (WHOQOL-100).[23]

The need for shorter forms that require little time to be filled out, yet offering satisfactory psychometric readings, was the main reason why the Quality of Life Group of the World Health Organization decided to create an abbreviated version (WHOQOL-bref) of the initial questionnaire (WHOQOL-100). The WHOQOL-bref comprises 26 questions, two questions on general quality of life issues and 24 questions on specific subjects which characterized the original questionnaire. A confirmatory factor analysis was performed to analyze four aspects of which the WHOQOL-bref is comprised of: physical, psychological, social relationships and environmental.[18]

The aim of this study was to compare the changes related to self-esteem and appearance satisfaction between pre and postsurgical phases in patients undergoing orthognathic surgery and to evaluate the quality of life of these patients six months after the surgery.

MATERIAL AND METHODS

This study was qualitative, analytical and comprised an observational, longitudinal research. Its target population consisted of 15 randomly selected patients who presented dentofacial deformities and underwent corrective orthognathic surgery at the Oral Surgery and Maxillofacial Trauma division of the Oswaldo Cruz University Hospital, at the University of Pernambuco (HUOC/UPE). Patients with cleft lip and palates as well as other uncontrolled pathologies were not included.

This study had a minimum follow-up period of six months and it was carried out in two different stages: 1) at the presurgical phase, performed on the day of the patients' hospitalization, 2) at the postoperative phase, performed 6 months after the surgery.

A questionnaire and two forms were used to collect the data. An informed consent form and an approval protocol issued by the Ethics Committee of the University of Pernambuco (number 054/07) were attached to the questionnaires to inform the patients and/or their guardian about their participation in the research. A written authorization was requested as well.

Presurgical phase

At this stage, we applied a self-administered questionnaire (answered by the patients) which consisted of eleven multiple choice and/or open-ended questions. Their purpose was to assess the satisfaction of patients with their appearance and social relationships before the surgery (Fig 1).

Postsurgical phase

At this stage, two forms were applied. Form I consisted of fifteen multiple choice and/or open-ended questions assessing the same variables.

Form II consisted of the WHOQOL-Bref questionnaire validated by the World Health Organization (WHO) to assess quality of life (Fig 2).

For data analysis, absolute and percentile distributions, as well as statistic measurements, were obtained. The McNemar's test, the Fisher exact test (provided that

© 2013 Dental Press Journal of Orthodontics

the conditions for using the chi-square test were not confirmed) and the Student t test with equal and unequal variables (inferential statistical techniques) were applied to those measurements. The verification concerning the hypothesis of equality of variances was performed using the Levene's F test. Data were imported to an Excel spreadsheet and statistical calculations were carried out using SPSS 13.0. The method error considered for the statistical tests was of 5.0%.

RESULTS

The age of the subjects ranged from 17 to 35 years, with a mean value of 25 years old, a 5.70 year standard deviation and a variation coefficient of 22.80%.

The prevalent surgical procedures were "two-jaw corrections" (26.7%), followed by "maxillary advancement" (13.3%) and "mandibular setback" (13.3%). "Bite problems" were the most frequent reported reasons for seeking treatment, corresponding to 40%.

No patient had undergone psychological or speech therapy before or after the surgery. Most patients claimed to have a good self-esteem before and after the surgery. 13.3% of patients who had claimed to have fair self-esteem claimed to have a good self-esteem 6 months after the surgery (Table 1).

Before the surgery, a little more than half (53.3%) of patients claimed to be little satisfied with their own appearance, 40.0% claimed to be satisfied and only one patient claimed to be very satisfied. After the surgery, 33.3% out of 53.3% of patients who had claimed to be "little satisfied" became "satisfied", and 20% claimed to be "very satisfied".

Regarding social relationships, 64.3% reported that their professional relationships continued the same after surgery, 21.4% reported slight improvements and 14.3% reported significant improvements. Moreover, 60.0% of patients reported that social relationships continued the same after surgery, 20.0% reported slight improvements and 20.0% reported significant improvements in social relationships after surgery.

When asked about their satisfaction in regards to the surgical outcomes (Table 2), 93.3% of patients stated that the surgical outcomes met their expectations and two-thirds (66.7%) would undergo surgery again.

Research control:

Number: _____

Name: _____

Sex: ( ) F ( ) M Age: _____ Race: _____

Address: _____

_____

Phone: (__)_____

Educational background:

☐ 1º Incomplete ☐ 2º Incomplete ☐ 3º Incomplete

☐ 1º Complete ☐ 2º Complete ☐ 3º Complete

Occupation: _____

What type of surgery will you go through?

☐ Maxillary advancement ☐ Maxillary setback

☐ Superior repositioning of the maxilla ☐ Inferior repositioning of the maxilla

☐ Segmental maxillary surgery ☐ Mandibular advancement

☐ Mandibular setback ☐ Mentoplasty

☐ Combined maxillary and mandibular surgery ☐ Maxillary expansion

What made you seek treatment?

☐ I thought I needed. ☐ My relatives though I needed

☐ My friends thought I needed ☐ My dentist though I needed.

Why did you seek treatment?

☐ Bite problems ☐ Esthetic reasons

☐ Both

☐ Other. What: _____

How do you consider your self-esteem today?

☐ Good ☐ Bad ☐ Fair

Are you satisfied with your appearance?

☐ No ☐ A little

☐ Satisfied ☐ Very satisfied

Are you undergoing orthodontic treatment? ☐ Yes ☐ No

Are you undergoing psychological therapy? ☐ Yes ☐ No

Are you undergoing speech therapy? ☐ Yes ☐ No

How are your social relationships before the surgery?

☐ Good ☐ Fair ☐ Bad

How are your family relationships before the surgery?

☐ Good ☐ Fair ☐ Bad

How are your professional relationships before the surgery?

☐ Good ☐ Fair ☐ Bad

Figure 1 - Self-administered questionnaire applied at presurgical phase.

Most patients (86.7%) would recommend surgery to their family members, however, one third (33.3%) claimed to have postsurgical complaints and when asked about the main reasons concerning postsurgical complaints, the answers were: 24-hour postsurgical recovery (66.7%), difficulty for eating (60.0%), one- week postsurgical recovery (46.7%) and maxillomandibular immobilization with rubber bands (33.3%).

With regard to the statistics on quality of life concerning each of the four areas of the WHOQOL-bref, the results demonstrate that the lowest mean was recorded for environmental area (70.22), ranging from 81.50 to 85.78 in the other three areas. However, except for two patients in the physical and psychological areas and one patient in each of the other areas, all the others had their quality of life classified as high (Tables 3 and 4).

Assessments on the quality of life according to the WHO questionnaire showed that the mean value was higher among patients who went through maxillary surgery than those patients who underwent mandibular surgery, according to physical and environmental areas (Fig 3). The opposite occurred in the psychological and social relationships areas, revealing that the greatest difference was recorded in the physical area (88.50 x 78.00), followed by the social relationships area (88.00 x 81.33). However, the only significant difference was recorded for the physical area ($p < 0.05$).

Research control:

Number: _____

Name: _____

Sex: ( ) F ( ) M Age: _____ Race: _____

Address: _____

_____

Phone: (__)_____

Educational background:

☐ 1º Incomplete ☐ 2º Incomplete ☐ 3º Incomplete

☐ 1º Complete ☐ 2º Complete ☐ 3º Complete

Occupation: _____

What type of surgery did you go through?

☐ Maxillary advancement ☐ Maxillary setback

☐ Superior repositioning of the maxilla ☐ Inferior repositioning of the maxilla

☐ Segmental maxillary surgery ☐ Mandibular advancement

☐ Mandibular setback ☐ Mentoplasty

☐ Combined maxillary and mandibular surgery ☐ Maxillary expansion

Postoperative period (months): _____

How do you consider your self-esteem after the surgery?

☐ Good ☐ Bad

☐ Fair

How do you see yourself today?

☐ Same as before ☐ A little better

☐ People say I look better ☐ Much better

Are you satisfied with your appearance today?

☐ No ☐ A little

☐ Satisfied ☐ Very satisfied

Did you get the results you expected?

☐ Yes ☐ No

Do you have complaints regarding the surgery?

☐ No ☐ Yes. What? _____

What was the most bothersome aspect of surgery?

☐ No ☐ Yes. What? _____

What was the most bothersome aspect of surgery?

☐ Immediate postoperative phase ☐ Hospitalization

☐ 24-hour postoperative phase ☐ One-week postoperative phase

☐ Eating issues ☐ Immobilization

☐ Paresthesia ☐ Other. What? _____

Would you undergo surgery again?

☐ Yes ☐ No

Would you recommend the surgery to your family members?

☐ Yes ☐ No

Are you undergoing psychological therapy? ☐ Yes ☐ No

Are you undergoing speech therapy? ☐ Yes ☐ No

What changed in your life after the surgery?

Social relationships

☐ Same as before ☐ A little better ☐ Much better

_____

Family relationships

☐ Same as before ☐ A little better ☐ Much better

_____

Professional relationships

☐ Same as before ☐ A little better ☐ Much better

_____

Figure 2 - Self-administered questionnaire applied at postoperative phase.

Table 1 - Self-esteem evaluation before and after the surgery.

Self-esteem (before)	Self-esteem (after)						P Value
	Good		Fair		TOTAL		
	n	%	n	%	n	%	
Good	12	80.0	-	-	12	80.0	p* = 0.500
Fair	2	13.3	1	6.7	3	20.0	
TOTAL	**14**	**93.3**	**1**	**6.7**	**15**	**100.0**	

* McNemar test was applied.

Table 3 - Quality of life score assessment for each area according to the postsurgical evaluation.

Statistics	Area			
	Physical	Psycho-logical	Social rela-tionships	Environ-mental
Mean	81.50	80.59	85.78	70.22
Standard deviation	8.12	6.20	12.31	7.91
Variation coefficient	9.96	7.69	14.35	11.26
Minimum	67.50	66.67	53.33	56.67
Maximum	95.00	88.89	100.0	83.33

Table 4 - Quality of life score assessment for each area according to the postsurgical evaluation.

Statistics	Area							
	Physical		Psychologi-cal		Social rela-tionships		Environmen-tal	
	n	%	n	%	n	%	n	%
Low*	2	13.3	2	13.3	1	6.7	1	6.7
High	13	86.7	13	86.7	14	93.3	14	93.3
TOTAL	**15**	**100.0**	**15**	**100.0**	**15**	**100.0**	**15**	**100.0**

*(1) The highest limits for each high area were: 71.5% -100.0% physical, 70.9% -95.8% psychological, 71.1% -100.0% social relationships and 57.2%-93.7% environmental.

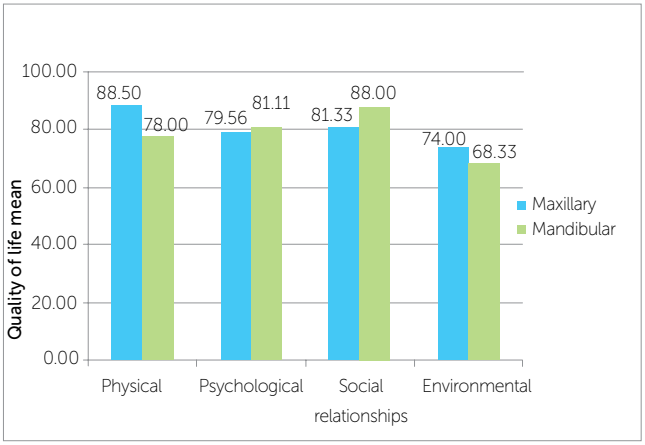


Figure 3 - Quality of life means for each area according to the type of surgery carried out.

Table 2 - Distribution of surveyed patients according to postsurgical variables.

Variables	n	%
How do you see yourself today?		
Same as before	1	6.7
A little better	2	13.3
People say I look better	1	6.7
Much better	11	73.3
Did you get the results you expected?		
Yes	14	93.3
No	1	6.7
Do you have complaints regarding the surgery?		
Yes	5	33.3
No	10	66.7
TOTAL	**15**	**100.0**
What was the most bothersome aspect of surgery?		
Immediate presurgical phase	1	6.7
24-hour postoperative phase	10	66.7
Eating issues	9	60.0
Paresthesia	3	20.0
Hospitalization	1	6.7
One-week postoperative phase	7	46.7
Maxillomandibular immobilization with rubber bands	5	33.3
Other	2	13.3
Basis*	**15**	
Would you undergo surgery again?		
Yes	10	66.7
No	5	33.3
Would you recommend the surgery to your family members?		
Yes	13	86.7
No	2	13.3
TOTAL	**15**	**100.0**

* (1) If a single subject mentioned more than one bothersome factor, a basis of the percentages calculations is recorded instead of the total value.

DISCUSSION

Psychological aspects of patients going through orthognathic surgery, has just recently become target of investigation and the WHO questionnaires[1,8,11,23] has shown to be an efficient tool to evaluate the quality of life of these individuals.

In this study, we used two forms for pre and postsurgical assessment and the WHOQOL-Bref questionnaire for postsurgical assessment, corroborating the methodology used by Modig et al.[15] This questionnaire, recommended by the WHO for quality of life assessments, was the method chosen for this study because there has not been a validated questionnaire

for assessing quality of life in orthognathic surgery issued in Portuguese as recommended by Lee et al.[11]

The time on which the questionnaires are applied, at pre and postsurgical phases, have been addressed in the literature. Most authors recommend that the questionnaires should be applied on the day of the presurgical orthodontic preparation and six months after the surgery.[4,5,6,11] The suggestion of a six-month postsurgical phase is due to the fact that, within this period, the edema decreases, allowing a better visualization of esthetic facial and oral function changes, and the patient returns to social interaction.[4,5,11] However, some questionnaires were applied six weeks or a year after the surgery,[4,21] once improvements concerning the edema, neurosensory changes as well as bite and speech problems have been identified.[15,21,26] Some authors recommend that the questionnaires should be applied when removing orthodontic braces or only post-surgically, with no need of applying the presurgical questionnaire.[14] Despite the fact that in the studies of Sadek and Salem[21] the questionnaires were applied a few days before the surgery, this study applied them a day prior to the surgery. This method had not been used in previous articles, therefore, it may have been the source of biased answers, since that day is when the patients are under extreme presurgical tension. On the other hand, the method of applying the questionnaire six months after the orthognathic surgery was also the method of analysis of several previous studies.[4,5,6,11]

The reasons patients seek orthosurgical treatment are, oftentimes, exclusively related to esthetics or function, and in most cases such reasons are combined.[3,5,7,11,14,16,19,26,28,29] Considering that the surgical procedure may result in irreversible changes on the patients' face and personality, both specialist and family should not influence the patients' decision. Thus, the final decision to undergo surgery should come from the patients.[10,17] Taking these factors into account, the results obtained in this study seemed favorable in regards to the short-term risks and complications that patients go through in order to obtain long-term benefits. Esthetic reasons alone accounted for 20% of the cases, corroborating some publications[11,15,16] while disagreeing with others which observed that esthetic motivation prevailed over function.[21,26,29]

Patients seeking professional resources in order to improve their appearance are also seeking to recover their personal and social image. In addition, their expectations are directly related to their degree of satisfaction.[6,27] Studies have reported that individuals going through orthognathic surgery, who are more concerned with esthetics aspects than others, may have psychological problems. However, the frequency of people with psychological disorders is higher when it comes to plastic surgery.[10,15]

The study carried out by Kiyak et al[10] concluded that despite the problems related to the surgery, satisfaction was quite high at the postoperative phase: 84.2% of the subjects said they would go through surgery again and 92.3% said they would recommend it to another person. In this study, we have observed that from the fifteen subjects, 66.7% said they would go through surgery again if necessary and 86.7% said that despite some postsurgical discomfort they would recommend surgical correction to family members, corroborating previous publications.[11,14,26]

During the presurgical phase of this study, three (13.3%) patients claimed to have a fair self-esteem, however, they reported that their self-esteem improved after the surgery, classifying their self-esteem as good at the postoperative phase. These factors were also observed in earlier publications.[4,15,16,21,26,29]

The patients' presurgical motivation, their personality, psychological state and other postoperative circumstances such as pain, edema, presence of jaw immobilization, temporary or permanent anesthesia and difficulty eating, are considered as reference to assess the degree of the patients' satisfaction. A detailed and careful presurgical planning and a proper surgical execution are crucial factors for a successful treatment. It is necessary to know each patient individually and the reasons why they are seeking treatment because, oftentimes, facial anomalies or discrepancies can only be addressed through orthognathic surgery.[2,19]

Among the patients evaluated in this study, 33.3% reported surgical complaints. Sixty percent of patients who had difficulty adjusting a liquid/soft diet, and three patients reported weight loss ranging from 5 to 10 kg a month after the surgery. All patients in this study wore orthodontic rubber bands during the postsurgical phase, removing them only for eating and brushing. It is common for patients to lose weight after

© 2013 Dental Press Journal of Orthodontics

orthognathic surgery due to the decrease in the masticatory function, even when there is no jaw immobilization with rubber bands. Thus, it can be suggested that this difficulty adapting to new eating habits observed in this study may be attributed to the surgery or to the severity of dentofacial deformity, corroborating the findings of Araújo[2] and Ribas et al.[19]

The sample of this study is heterogeneous since the patients selected had not only transverse jaw deformities, but also Classes II and III skeletal deformities. On the other hand, this method is used by several studies that qualitatively evaluate different individuals with deformities aiming at increasing the sample size.[4,10-15,17,21,26] However, the homogeneity of dentofacial deformities is recommended by some authors,[16,27,29] since it reduces survey discrepancies, i.e., patients who have large asymmetric facial deformities will show noticeable esthetic facial changes, or individuals with transverse jaw deficiencies who only undergo surgically assisted rapid expansion of maxilla will show minimal changes.

It is recognized that facial changes significantly change the patients' facial appearance and can change the life of an individual in various ways. This has been noticed through the growing number of patients seeking surgical treatment for correcting dentofacial deformities in the last few years.[25] Based on oncological and chronic diseases, strong concerns have been raised on the increase in life expectancy.[18] Thus, the development of means to measure the quality of life of these patients has been a challenge for researchers, since they must be able to verify whether these interventions meet the desired goals.[22] The results obtained in this study showed improvements in the quality of life of patients after orthognathic surgery as well as improvements related to psychosocial factors. Many patients reported that a few months after the surgery they could observe mainly favorable esthetic results which contributed to improvements in self-esteem and favored social and professional relationships. Moreover, the care and attention received from the patients' family members during the recovery process improved their proximity and contributed to unify the family bonds even more.

According to Ribeiro,[20] speech therapy acts in regulating the TMJ muscles and the stomatognathic functions and in reducing the rate of dentofacial deformity relapse after surgery. Although the Oswaldo Cruz University Hospital offers speech and psychological therapy services, no patient has been treated by those services at presurgical and postsurgical phases. Despite the fact that the importance of a multidisciplinary approach has been highlighted in the literature, especially with regard to patients undergoing orthognathic surgery, this integration does not often occur, corroborating this study. Therefore, the need for a multidisciplinary team should be emphasized due to its immeasurable value in the rehabilitation process, and, as a consequence, the well-being of the patient.

Patients seeking professional resources to address a health deficiency are not only pursuing cure, but also acceptance, understanding, support and affection towards emotionally triggered conditions.[12,25] Moreover, patients undergoing surgical procedures have significant psychological reactions such as fear, anxiety and expectations that could hinder their recovery and the way they cope with the surgical situation.

Some characteristics of the patients' mental health should be assessed prior to surgery, including depression, anxiety, panic, aggression, drug and alcohol use, problems in school as well as family and social relationships. The overview of these factors may give an insight into the psychological and emotional capacity of the patients undergoing orthognathic surgery.[3]

Additionally, it is important to know the patients' expectations since the less anxiety a patient presents, the better the chance of success and postsurgical satisfaction. Factors such as pessimism, anxiety and low social support lead to higher risks for problems.[10,13] Before elective surgeries, a sincere communication between the surgeon and the patient is of paramount importance as it enables the establishment of trust, allowing the patient to participate in discussions regarding the risks and benefits of the surgery; both postsurgical recovery and lifestyle.[2,15]

We recognize that the low number of subjects and the heterogeneity concerning the types of dentofacial deformities as well as the surgeries that have been carried out are some of the limitations of this study and may have influenced the results.

Unlike orthodontic treatment, which produces gradual changes in dentofacial structure when performed alone, orthognathic surgery causes sudden changes. These physical and psychological changes can be so drastic that they may lead the patients to either sudden satisfaction or regret.

© 2013 Dental Press Journal of Orthodontics

CONCLUSION

When it comes to surgical-orthodontic treatment, esthetic results are considered important motivators influencing the surgical decision making. The main objective of dialogue between specialist and patient is to define what dissatisfies the latter, allowing the surgeon to establish a bond of trust that allows the patient to participate in discussions concerning the surgical risks and benefits .

The need for orthognathic surgery brings along many emotional changes that should be considered before and after the surgery, since the patients' psychological state may be favorable and/or unfavorable during recovery, influencing their quality of life, self-esteem and appearance satisfaction.

REFERENCES

1. Andrade ER, Sousa ER, Minayo MCS. Intervenção visando a auto-estima e qualidade de vida dos policiais civis do Rio de Janeiro. Ciênc Saúde Coletiva. 2009;14(1):275-85.
2. Araújo A. Cirurgia ortognática. 1a ed. São Paulo: Ed. Santos; 1999.
3. Bellucci CC, Kapp-Simon KA. Psychological considerations in orthognathic surgery. Clin Plast Surg. 2007;34(3): e11-16.
4. Choi WS, Lee S, McGrath C, Samman N. Change in quality of life after combined orthodontic-surgical treatment of dentofacial deformities. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109(1):46-51.
5. Cunningham SJ, Garratt AM, Hunt NP. Development of a condition-specific quality of life measure for patients with dentofacial deformity: II. Validity and responsiveness testing. Community Dent Oral Epidemiol. 2002;30(2):81-90.
6. Cunningham SJ, Hunt NP, Feinmann C. Psychological aspects of orthognathic surgery: a review of the literature. Int J Adult Orthodon Orthognath Surg. 1995;10(3):159-72.
7. Dervis E, Tuncer E. Long-term evaluations of temporomandibular disorders in patients undergoing orthognathic surgery compared with a control group. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002 Nov;94(5):554-60.
8. Fleck MPA, Louzada S, Xavier M, Chachamovich E, Vieira G, Santos L, et al. Aplicação da versão em português do instrumento abreviado de avaliação da qualidade de vida "WHOQOL-bref". Rev Saúde Pública. 2000;34(2):178-83.
9. Jensen SH. The psychosocial dimensions of oral and maxillofacial surgery: a critical review of the literature. J Oral Surg. 1978;36(6):447-53.
10. Kiyak HA, West RA, Hohl T, McNeill RW. The psychological impact of orthognathic surgery: a 9-month follow-up. Am J Orthod. 1982;81(5):404-12.
11. Lee S, McGrath C, Samman N. Impact of orthognathic surgery on quality of life. J Oral Maxillofac Surg. 2008;66(6):1194-9.
12. Lovius BB, Jones RB, Pospisil OA, Reid D, Slade PD, Wynne TH. The specific psychosocial effects of orthognathic surgery. J Craniomaxillofac Surg. 1990;18(8):339-42.
13. MacGregor FC. Patient dissatisfaction with results of technically satisfactory surgery. Aesthetic Plast Surg. 1981;5(1):27-32.
14. Meade EA, Inglehart MR. Young patients treatment motivation and satisfaction with orthognathic surgery outcomes: the role of "possible selves". Am J Orthod Dentofacial Orthop. 2010;137(1):26-34.
15. Modig M, Andersson L, Wårdh I. Patients' perception of improvement after orthognathic surgery: Pilot study. Br J Oral Maxillofac Surg. 2006;44(1):24-7. Epub 2005 Sep 12.
16. Nicodemo D, Pereira MD, Ferreira LM. Cirurgia ortognática: abordagem psicossocial em pacientes Classe III de Angle submetidos à correção cirúrgica da deformidade dentofacial. Rev Dental Press Ortod Ortop Facial. 2007;12(5):46-54.
17. Ponzoni D, Engers MEA, Oliveira MG, Puricelli E. Percepções, expectativas e manifestações de pacientes submetidos à cirurgia ortognática. RBC. 2006;4:244-50.
18. Ramos-Cerqueira ATA, Crepaldi AL. Quality of life in chronic pulmonary diseases: conceptual and methodological aspects. J Pneumol. 2000;26(4):207-13.
19. Ribas MO, Reis LFG, França BHS, Lima AAS. Cirurgia ortognática: orientações legais aos ortodontistas e cirurgiões bucofacial. Rev Dental Press Ortod Ortop Facial. 2005;10(6):75-83.
20. Ribeiro MC. Atuação fonoaudiológica no pré e pós-operatório em cirurgia ortognática. J Bras Fonoaudiol. 1999;1:61-8.
21. Sadek H, Salem G. Psychological aspects of orthognathic surgery and its effect on quality of life in Egyptian patients. La Revue de Santé de la Méditerranée Orientale. 2007;13(1):150-9.
22. Salvadori AM, Lamas JLT, Zanon C. Desenvolvimento de instrumento de coleta de dados de enfermagem para pacientes com câncer de pulmão em quimioterapia ambulatorial. Esc Anna Nery Rev Enferm. 2008;12(1):130-5.
23. Seidl EMF, Zannon CMLC, Troccoli BT. Pessoas vivendo com HIV/AIDS: enfrentamento, suporte social e qualidade de vida. Psicol Reflex Crit. 2005;18(2):188-95.
24. Seidl EMF, Zannon CMLC. Qualidade de vida e saúde: aspectos conceituais e metodológicos. Cad Saúde Pública. 2005;20(2):580-8.
25. Souza LCM, Silveira ME, Cappellette M, Alael MG. Cirurgia ortognática e Ortodontia. 1a ed. São Paulo: Ed. Santos; 1998.
26. Türker N, Varol A, Ögel K, Basa S. Perceptions of preoperative expectations and postoperative outcomes from orthognathic surgery: Part I: Turkish female patients. Int J Oral Maxillofac Surg. 2008;37(8)710-5.
27. Veronez FS, Tavano LDA. Modificações psicossociais observadas pós-cirurgia ortognática em pacientes com e sem fissuras labiopalatinas. Arq Ciênc Saúde. 2005;12(3):133-7.
28. Westermark A, Shayeghi F, Thor A. Temporomandibular dysfunction in 1.516 patients before and after orthognathic surgery. Int J Adult Orthodon Orthognath Surg. 2001;16(2):145-51.
29. Zhou YH, Hagg U, Rabie AB. Concerns and motivations of skeletal Class III patients receiving orthodontic-surgical correction. Int J Adult Orthodon Orthognath Surg. 2001;16(1):7-17.

© 2013 Dental Press Journal of Orthodontics

Evaluation of the vertical alterations of the upper second molars after the alignment and leveling phase using the MBT technique

Alael Barreiro Fernandes de Paiva Lino[1], Julio Wilson Vigorito[2]

Objective: This study aimed at comparing the distocervical angulations of upper second molars crowns of groups with normal occlusion and with Angle Class I and II malocclusions. Additionally, it aimed to analyze the changes occurring after alignment and leveling performed with MBT technique.

Methods: The sample of normal occlusions comprised 32 lateral teleradiographs, while the sample of malocclusions comprised 38 initial and post-leveling lateral teleradiographs.

Results: The results did not show statistically significant differences between morphological characteristics of the normal occlusion group and the malocclusion group. On the other hand, after alignment and leveling, statistically significant reduction was observed in distocervical inclinations with extrusion of the distal portion of upper second molars.

Keywords: Dental occlusion. Design of orthodontic appliances. Radiography. Corrective orthodontics.

[1] Resident of Orthodontics, School of Dentistry - University of São Paulo (USP).
[2] Full Professor of Orthodontics, School of Dentistry - University of São Paulo (USP).

» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

How to cite this article: Lino ABFP, Vigorito JW. Evaluation of the vertical alterations of the upper second molars after the alignment and leveling phase using the MBT technique. Dental Press J Orthod. 2013 Sept-Oct;18(5):115-20.

Submitted: December 11, 2009 - **Revised and accepted:** December 29, 2010

Contact address: Alael Barreiro Fernandes de Paiva Lino
Av. Professor Lineu Prestes, 2.227, Cidade Universitária
CEP: 05.508-000 – São Paulo – SP – Brazil
E-mail: alael@usp.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

The University of São Paulo College of Dentistry postgraduate program offers a course that provides clinical practice of research about MBT pre-adjusted appliances. It aims to qualify students to perform the Straight-Wire MBT technique on the treatment of malocclusions, with or without teeth extractions, based on the researches developed in the program and the material that has been documented. By means of observing the clinical results and the elements of diagnosis obtained after orthodontic alignment and leveling of treated groups, it was noticed, in some cases, premature contacts and occlusal interferences on the region of second molars. This fact encouraged the study of the characteristics of this area and any potential alterations occurring after dental alignment and leveling.

MBT appliances were assembled according to what the technique suggests,[11] regarding height and angulation of the orthodontic accessories. These variables are described in the orthodontic literature with the purpose of maintaining and preparing both functional characteristics and anchorage, in order to obtain normal occlusion free of occlusal interferences. Teeth angulations are obtained by means of changing the brackets position or inserting second-order bends on stainless steel arches[12] on the upper second molars. These variations aim to control the anchorage, maintain the initial tooth position and prevent occlusal interferences on mandibular movement.[6,10,12,14,16]

In order to prepare the anchorage, a previous study[12] determine that the upper second molar movement be performed with cervicodistal angulation of 20°, with the orthodontic arch in 10° of angulation on this tooth's region. Another possibility to perform angulation on the upper second molar is inserting the accessory with angulation of 15 degrees[14] or bonding the tube on the same plane after basic leveling of first molars to upper canines.[10] On the other hand, some authors recommend inclusion on the mechanics of second molars in cases of extraction of four first premolars, third molars or in cases of buccolingual crossing. In normal clinical situations, it is necessary to await the natural establishment of the occlusion.[18] In 1972, after studying 120 models of individuals with characteristics of normal occlusion, Andrews[1] presented an article suggesting six keys of normal occlusion that should be obtained after orthodontic therapy. These occlusal characteristics served as a basis for introducing the Straight-Wire appliance. This appliance has on its design, brackets slots with pre-angulation following the mesiodistal angulation of the vestibular surface. In relation to the upper second molar, Andrews' findings showed, on average, a mesial angulation of the clinical crown in 0.39 degrees.[4] The literature about preadjusted appliances proposes several values such as 5 degrees,[11] 3 degrees,[7] 4.09 degrees,[17] 0 degrees,[15] -0.30 degrees[17] and -5 degrees.[5] In addition to angulation, the height in which the orthodontic accessories are positioned on the teeth is a recurrent variable in orthodontic clinics.

Vigorito[16] mentions in his book that the occlusal-cervical height of the bracket on the upper second molar must be 0.5 mm lower than that on the upper first molar, with 0° of angulation and insertion of caudal angle on the orthodontic arch on the upper second molar region. As for the MBT technique,[11] it is recommended to use the accessories installation table in which it is stated that the mean height for the upper second molar is 2.0 mm and 3.0 mm for the first molars. As verified in the studies previously mentioned, there are different prescriptions concerning the angulation to be expressed on the upper second molar, varying from the MBT prescription, that indicates 5° of mesial angulation, to the researches indicating that the upper second molars present and must keep, during and after the orthodontic therapy, a cervicodistal angulation.[5,6,9,10,12,14,16] The present study aimed to compare the characteristics of mesiodistal angulation and vertical positioning[9] of the upper second molars between the normal occlusion group, which had the control function, and the malocclusion group. In addition, it aimed at verifying the alterations occurring after alignment and leveling performed with MBT preadjusted appliances. Based on the aforementioned objectives, this study proposed:

1. To verify potential differences in vertical and angular positions of the upper second molars, observed in lateral teleradiographs, by means of comparing Class I and II malocclusion to normal occlusion.
2. To evaluate, through cephalograms, the position of the upper second molars comparing initial and final phases of alignment and leveling performed with MBT technique.

© 2013 Dental Press Journal of Orthodontics

MATERIAL AND METHODS

Sample

The control group consisted of a normal occlusion sample comprising 32 lateral teleradiographs obtained from Brazilian, leukoderma individuals, 16 of which were males and 16 females, aged between 12 and 17 years and 1 month old, with permanent dentition classified as normal dental occlusion, and with no previous orthodontic treatment. The malocclusion sample comprised 76 lateral teleradiographs obtained from 38 Brazilian, leukoderma patients of both genders, with permanent teeth and Angle Class I and Class II malocclusions, under treatment at, Corrective Orthodontic MBT preadjusted Clinic, at the University of São Paulo (USP) College of Dentistry. The radiographs were divided into two groups: T_1r which corresponds to initial teleradiographs and T_2r which corresponds to the final phases of alignment and leveling.

Appliance assemblage

MBT appliances were assembled according to what the technique suggests,[11] regarding height and angulation of the orthodontic accessories in the region of second molars.

Image digitizing

Radiograph digitizing

The radiographs were scanned and the images were imported by the Radiocef Studio 4.0 software, kindly granted by Radio Memory Ltda (www.radiomemory.com.br). On this software, cephalometric landmarks were marked and the magnitudes, necessary for this research, were defined.

Landmarks determination

Landmarks were directly marked on the images of the structures of interest. The landmarks used were:

Cephalometric landmarks (Fig 1)

» Landmark D7: Most distal landmark of the upper second molar image.

» Landmark M7: Most mesial landmark of the upper second molar image.

» Landmark PTMs: Most upper point of the pterygomaxillary fossa.

» Landmark PTM: Most lower point of the pterygomaxillary fossa which corresponds to the pterygomaxillary fissure.

Determination of the lines of orientation.

Radiographic lines and planes (Fig 2)

» Pterygomaxillary fossa long axis (vertical PTM): line that joins landmarks PTMs to PTM.

» Perpendicular to the long axis of the pterygomaxillary fossa (horizontal PTM): Line traced from the landmark PTM perpendicular to the pterygomaxillary fossa long axis.

» D7-horizontal PTM: Orthogonal to horizontal line PTM up to landmark D7.

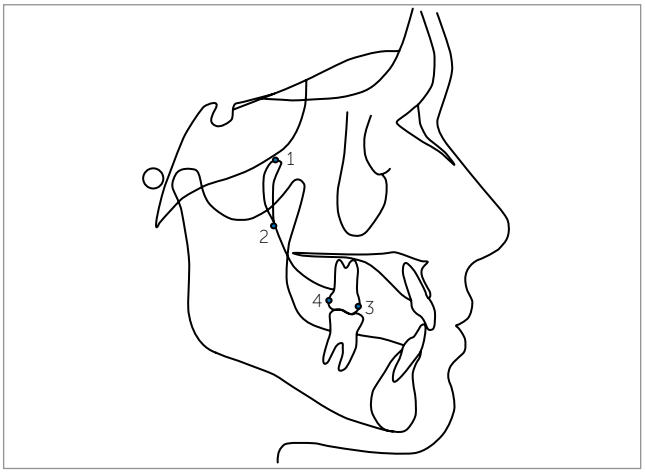


Figure 1 - Cephalometric landmarks demarcated on the lateral teleradiograph. **1**) PTMs, **2**) PTM, **3**) M7, **4**) D7.

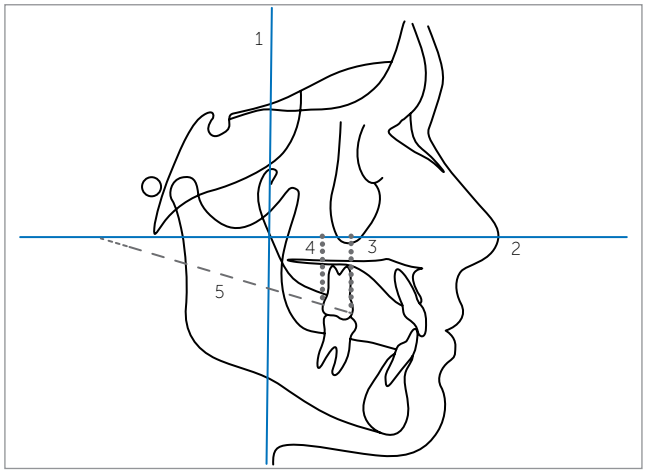


Figure 2 - Lines demarcated on the lateral teleradiograph. **1**) Vertical line PTM. **2**) Horizontal line PTM. **3**) M7-Horizontal line PTM. **4**) D7-Horizontal line PTM. **5**) md7 line.

© 2013 Dental Press Journal of Orthodontics

» M7-horizontal PTM: Orthogonal to horizontal line PTM between landmark M7.

» Mesio-distal line of the upper second molar (line md7): Line that joins landmarks M7 to D7.

2.5 Determining the magnitudes.

Radiographic magnitudes (Fig 3)

» D7-horizontal PTM Height (distal height): Orthogonal distance between landmark D7 with horizontal line PTM.

» M7-horizontal PTM Height (mesial height): Orthogonal distance between landmark M7 with horizontal line PTM.

» md7 - horizontal PTM Angle line (cervicodistal angle): Formed by intersection of horizontal line PTM with line md7.

Statistical methods

Descriptive statistics were obtained by means of verifying both mean and standard deviation of all magnitudes studied. Normal distribution of data was assessed through Shapiro-Wilks test. The means of the magnitudes obtained from the teleradiographs and after alignment and leveling were compared through one-way ANOVA test complemented by Tukey test at 5%. To verify the method error, the samples were reevaluated and the values obtained from the second measurement process were submitted to *t* test for systematic error verification, while the Dahlberg method was used for random error verification.

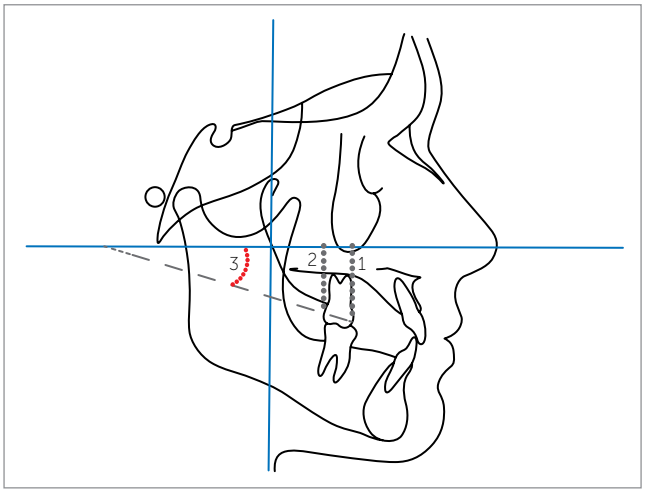


Figure 3 - Linear and angular magnitudes determined no the lateral teleradiograph. **1**) mesial height. **2**) distal height. **3**) cervicodistal angle.

RESULTS

The descriptive statistics obtained from the teleradiographs are presented in Table 1.

Comparisons between the means of the linear magnitudes observed in the teleradiographs are shown in Table 2.

Comparisons between the means of the angular magnitudes observed in the teleradiographs are presented in Table 3.

DISCUSSION

Table 1 - Descriptive statistics of cephalometric magnitudes values.

	Mean	SD
Normal occlusion distal height	25.02	3.21
Normal occlusion mesial height	29.95	3.11
Initial malocclusion distal height	26.32	3.96
Initial malocclusion mesial height	31.26	4.24
Post-leveling malocclusion distal height	30.32	4.24
Post-leveling malocclusion mesial height	32.52	4.27
Normal occlusion cervicodistal angulation	26.24	5.43
Initial malocclusion cervicodistal angulation	25.85	6.82
Post-leveling malocclusion cervicodistal angulation	11.93	6.44

Table 2 - Comparison between the means of linear magnitudes observed in the teleradiograph by one-way ANOVA test complemented by Tukey at 5%.

	A	B	C	D	E	F
A	-	**	*	**	**	**
B	*	-	**	*	*	*
C	*	*	-	**	**	**
D	*	*	*	-	*	*
E	*	*	*	*	-	**

A) Normal occlusion distal height. **B**) Normal occlusion mesial height. **C**) Initial malocclusion distal height. **D**) Initial malocclusion mesial height. **E**) Post-leveling malocclusion distal height. **F**) Post-leveling malocclusion mesial height *: non-significant difference. **: significant difference.

Table 3 - Comparison between the means of angular magnitudes observed in the teleradiograph by one-way ANOVA test complemented by Tukey at 5%.

	G	H	I
G	-	*	**
H	*	-	**

G) Normal occlusion cervicodistal angle. **H**) Malocclusion initial time cervicodistal angle. **I**) Post-leveling malocclusion cervicodistal angle. *) non-significant difference. **) significant difference.

© 2013 Dental Press Journal of Orthodontics

Systematic error evaluation demonstrated reproducibility ($p < 0.01$), while random error variability ranged from 0.62 for mesial height to 0.70 for distal height of the normal occlusion group. The results of the method error validated the results obtained from the analysis of cephalometric magnitudes, thus, supporting discussion about the clinical implications of installing orthodontic accessories on the upper second molars. Distocervical angulation of the upper second molars is a characteristic found in individuals with normal occlusion (Fig 4).[6,9] According to the results of this research, it was possible to observe that the group with malocclusion showed the same characteristics regarding the vertical positioning of upper second molars in relation to the control group (Fig 5). After alignment and leveling, the characteristics observed in the second molars were significantly altered (Fig 6). The cervicodistal angle of the upper second molar was significantly reduced from 25.85° to 11.93° due to extrusion of the distal surface and maintenance of the vertical position of the mesial surface. Significant alteration was observed in the vertical positioning of the upper second molar distal surface. At the initial phase, it was 26.32 mm, while after leveling it was 30.32 mm On the other hand, the vertical position of the mesial face did not show significant differences after alignment. Relevant literature provides researches that indicate lower angulations on upper second molars than what has been suggested in this study.[4,7,11,15,17] We also found authors indicating negative inclination[6,8,9,10,12,14] to preserve and prepare the anchorage during orthodontic mechanics as well as keep the functional position of the upper second molar aiming to avoid premature contacts and interference in mandibular eccentric movements.

Thus, we can conclude that angular alterations performed on the upper second molars for preparing and maintaining the anchorage or for leveling and alignment, must be corrected in order to restore the characteristics of this region.

Additionally, the results obtained from this research demonstrate that the use of pre-adjusted accessories with MBT prescription significantly reduces mesiodistal angulation[6,10] and changes the vertical positioning of the teeth observed in both normal occlusion and malocclusion groups. Aiming to minimize any possible errors while installing the accessories, this research carefully followed, by means of the suggested bonding table, the recommendations of the MTB technique.[11]

Clinically, the obtained results allow us to suggest that the accessory positioning should be performed on the second molar with disto-occlusal angle and with a height lower than that performed on the first molar. This way, extrusion would be controlled and angulation would be preserved. Furthermore, we observed the need of installing and modifying the accessories in order to determine disto-occlusal angulation around 5°. With such a prescription, the characteristics of both

Figure 4 - Lateral teleradiograph – normal occlusion.

Figure 5 - Pre-treatment lateral teleradiograph of the malocclusion group.

Figure 6 - Post-leveling lateral teleradiograph of the malocclusion group.

© 2013 Dental Press Journal of Orthodontics

position and angulation of the upper second molar would be preserved. We believe that further researches must be carried out in order to indicate modifications in the prescription of accessories for upper second molars and thus, keep the functional characteristics present in the region of these teeth, minimizing the risk of premature contacts and occlusal interferences as well as enabling vertical control to be managed.

CONCLUSIONS

1. No statistically significant differences were observed in the angular characteristics of the second molars when both the normal occlusion and the malocclusion groups were compared. The clinical crowns of the second molars are always angulated in distocervical direction.
2. The upper second molars presented differences in the angulation of the crowns when compared to the beginning and to the group of normal occlusion, with a decrease due to extrusion of the distal portion. Significant reduction of the mesiodistal angulation of upper second molars and extrusion of the distal portion were observed.

REFERENCES

1. Andrews LF. Six keys to normal occlusion Am J Orthod. 1972;62(2):296-309.
2. Andrews LF. Straight-wire appliance, explained and compared. J Clin Orthod, 1976;10(3):174-95.
3. Andrews LF. Straight-wire appliance, origin, controversy, commentary. J Clin Orthod. 1976;10(2):99-114.
4. Andrews LF. Straight-wire: the concept and appliance. 1st ed. San Diego: K-W; 1989.
5. Baptista JM. Ortodontia personalizada. 1ª ed. São Paulo: Ed. Santos; 2004.
6. Carvalho DS. Avaliação da posição morfo-funcional dos segundos molares permanentes superiores em pacientes: tratados ortodonticamente e dotados de oclusão normal [tese]. São Paulo (SP): Faculdade de Odontologia da USP; 1989.
7. Currim S, Wadkar PV, Objective assessment of occlusal and coronal characteristics of untreated normals: a measurement study. Am J Orthod Dentofacial Orthop. 2004;125(5):582-8.
8. Holdaway RA, Bracket angulation as applied to the edgewise appliance. Angle Orthod. 1952;22(4):227-326.
9. Lino ABFP, Vigorito JW. Avaliação cefalométrica da posição vertical das faces mesial e distal dos segundos molares superiores em indivíduos com oclusão normal. In: Dominguez GC, organizador. Nova visão em ortodontia e ortopedia funcional dos maxilares. 1a ed. São Paulo: Ed. Santos; 2006. v. 1, p. 51-6.
10. Lino AP. Ortodontia corretiva técnica MD3. 1ª ed. São Paulo: Artes Médicas; 2001.
11. McLaughlin RP, Bennett JC, Trevisi HJ, Mecânica sistematizada de tratamento ortodôntico. 1ª ed. São Paulo: Artes Médicas; 2004.
12. Merrifield LL, The sequential directional force edgewise technique. In: Johnston LE Jr. New vistas in orthodontics. 1ª ed. Philadelphia: Lea & Febiger; 1985.
13. Parker WS. Consideration of pure Begg technique. Angle Orthod. 1969;39(1):1-10.
14. Root TL. Level anchorage edgewise. In: Johnston LE Jr. New vistas in orthodontics. 1ª ed. Philadelphia: Lea & Febiger; 1985.
15. Roth RH. Functional occlusion for the orthodontist - Part I. J Clin Orthod. 1981;15(1):32-51.
16. Vigorito JW. Ortodontia clínica, diagnóstico e terapêutica. 1ª ed. São Paulo: Santa Madonna; 2004.
17. Watanabe K, Koga M. A morphometric study with setup models for bracket design. Angle Orthod. 2001;71(6):499-511.
18. Zielinsky L. El plan de tratamiento ortodoncico y la oclusión como objetivo. 1a Parte. Ortodoncia,1978;33(88):137-47.

© 2013 Dental Press Journal of Orthodontics

Influence of treatment including second molars on final and postretention molar angulation

Luiz Filiphe Gonçalves Canuto[1], Karina Maria Salvatores de Freitas[2], Marcos Roberto de Freitas[3], Rodrigo Hermont Cançado[4]

Objective: Evaluate axial mesiodistal inclinations of the mandibular molars in orthodontically treated cases, analyzing whether inclusion of second mandibular molars in treatment mechanics has any influence on final and postretention molars angulations.

Methods: The sample comprised 150 panoramic radiographs of 50 patients. Patients were treated with extraction of four first premolars and divided into 2 groups: Group 1 comprised 25 subjects without inclusion of mandibular second molars during orthodontic treatment, whereas Group 2 comprised 25 subjects with inclusion of mandibular second molars. Panoramic radiographs at three observation times were evaluated: pretreatment, posttreatment and postretention. The statistical analysis included one-way analysis of variance (ANOVA) for intragroup evaluation and independent t-tests for intergroup comparisons.

Results: Intragroup analysis demonstrated significant uprighting of mandibular first and second molars during treatment in Group 2, which remained stable during the postretention stage. Intergroup comparison demonstrated that Group 2 presented first and second molars significantly more uprighted in relation to Group 1 in both post-treatment and postretention stages.

Conclusions: It was concluded that inclusion of mandibular second molars in the orthodontic mechanics is relevant not only to correct the angulation of these teeth, but also to aid mandibular first molars uprighting.

Keywords: Panoramic X-ray. Tooth angulation. Tooth movement.

[1] Professor of graduate program in Orthodontics at the Brazilian Dental Association / Pernambuco (ABO-PE).
[2] Professor of the graduate program in Orthodontics at UNINGÁ.
[3] Full professor of Pediatric Dentistry, Orthodontics and Public Health at USP, Bauru Dental School.
[4] Associate professor at UNINGÁ.

How to cite this article: Canuto LFG, Freitas KMS, Freitas MR, Cançado RH. Influence of treatment including second molars on final and postretention molar angulation. Dental Press J Orthod. 2013 Sept-Oct;18(5):121-7.

Submitted: September 20, 2011 - **Revised and accepted:** December 27, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Luiz Filiphe Gonçalves Canuto
Rua José Bonifácio, 205 – Sl 109 – Madalena – Recife/PE, Brazil
CEP: 50.710-000 – E-mail: luizfiliphecanuto@yahoo.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

The importance of appropriate mesiodistal teeth angulation in orthodontic patients has been emphasized by many clinicians. In 1972, Andrews reported that tooth angulation is one of the 6 keys to be evaluated in ideal static occlusions.[1]

It has been reported that the final spatial orientation of each tooth should be such that it can best withstand the forces during function. Corrected angulation is universally accepted, and other several related parameters have been studied. These include periodontal health,[1,2,3] even distribution of occlusal forces through contact points, tight posterior occlusion, no spaces as well as retention and stability of orthodontically closed extraction sites.[1,4-7] The American Board of Orthodontics has included assessment of mesiodistal angulation in panoramic radiographs as a parameter for evaluating finished cases for orthodontists aspiring to be board diplomate.

Adequate mesiodistal teeth angulations with roots parallel to each other are frequently mentioned in the literature[1,3,8,9-13] as a fact that not only improves teeth alignment stability in their apical bases, but also allows normal maxilomandibular occlusion.[6] Moreover, an adequate mesiodistal positioning allows a uniform distribution of occlusal forces through contact points and contributes to overall treatment stability.[3,6,10]

Given the importance of appropriate mesiodistal teeth angulation in orthodontic patients regarding quality and stability of treatment, the authors aimed to investigate the influence of mandibular second molars inclusion in orthodontic mechanics on final and postretention molar angulations.

MATERIAL AND METHODS

Material

The sample comprised 150 panoramic radiographs of 50 young patients of both genders. The radiographs were taken from the files of Pediatric Dentistry, Orthodontics and Public Health Department at University of São Paulo (USP), Bauru Dental School. Each case was evaluated at three stages: pretreatment (T_1), posttreatment (T_2) and after a minimum of 3 years of follow-up (T_3).

When selecting the sample, the following inclusion criteria were applied: cases initially presenting Class I or Class II malocclusion, treated with fixed Edgewise appliances and extraction of four first premolars. All subjects had all permanent teeth erupted except the third molars at the pretreatment stage. Other inclusion criteria were patients with no history of previous interceptive orthodontic treatment, absence of root dilaceration or mandibular skeletal asymmetries.

After active treatment, all patients wore a modified Hawley retainer in the maxillary arch, full time for the first 12 months and during sleep for the next 6 months. A lingual canine-to-canine mandibular bonded retainer was placed and left for a mean period of 3 years.

Methods

The sample was divided into two groups:

» Group 1: 25 patients (14 female; 11 male) in whom the mandibular second molars were not included in treatment mechanics.

» Group 2: 25 patients (15 female; 10 male) with mandibular second molars included in treatment mechanics.

The mean pretreatment age was 13.29 ± 1.44 years for Group 1 and 12.95 ± 1.26 years for Group 2. The mean treatment, retention and postretention evaluation times of each group are shown in Table 1.

First and second molar angulations were evaluated with panoramic radiographs (orthopantomography) traced manually by a single investigator, in acetate paper (Ultraphan Paper®, Berlin, Germany).

Table 1 - Descriptive statistics of treatment, retention and postretention evaluation mean times for Groups 1 and 2, with and without inclusion of second molars, respectively.

Time (years)	Group 1 2nd molar not included (n=25)	Group 2 2nd molar included (n=25)
	Mean ± SD	Mean ± SD
Treatment	2.41 ± 0.64	2.45 ± 0.53
Retention	1.33 ± 0.51	1.49 ± 0.76
Posttreatment	4.84 ± 2.38	4.18 ± 2.47

© 2013 Dental Press Journal of Orthodontics

Tracing method

The tracing procedure of the initial, posttreatment and postretention radiographs was conducted in four phases: a) Delineation of dentoskeletal structures; b) Definition of reference points; c) Definition of horizontal and vertical reference lines; d) Measurement of tooth angulation (Fig 1).

a) Delineation of dentoskeletal structures:

The external outline of the mandible, mental foramen, and outlines of mandibular first and second molars roots and crowns were traced.

b) Definition of landmarks:

The definition of the landmarks was performed as proposed by Tavano et al:[14]

1) Right mental foramen (RMF) – The central point of the right mental foramen.
2) Left mental foramen (LMF) – The central point of the left mental foramen.

c) Tracing of horizontal and vertical reference lines:

1) Intermental line (IL): Line passing through the centers of the right and left mental foramens.
2) First and second molars long axes: The long axes of the mentioned teeth were determined as the mean of the images of mesial and distal root canals[13].

d) Angles measurement:

The angles formed by the Intermental line (IL) and the long axes of the first and second mandibular molars were then measured (Fig 1).

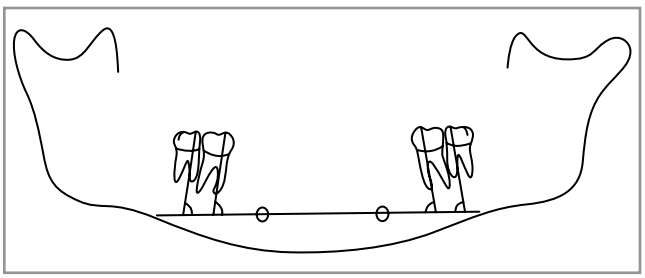


Figure 1 - Manual tracing performed at initial, final and posttreatment panoramic radiographs involving the delineation of dentoskeletal structures, demarcation of landmarks (RMF and LMF), vertical and horizontal reference lines and measurement of dental angulations.

Statistical analyses

Statistical analysis was performed with Statistica software (Statistica for Windows, version 7.0, StatSoft Inc).

To avoid type I error (probability of accepting the alternative hypothesis H1 and be wrong) sample was calculated considering α = 5% (type I error), β = 20% (type II error), an estimated variability (s) of 5 degrees and a minimum detectable difference (d) of 5 degrees.

In each group, means and standard deviations for the mesiodistal inclination of the four evaluated teeth (left mandibular first molar-36; left mandibular second molar-37; right mandibular first molar-46; and right mandibular second molar-47) were determined. The intragroup comparison of these variables at the three observation stages was performed by one-way dependent ANOVA and Tukey tests as a second step. For intergroup comparison, t-tests were used. Prior to the use of ANOVA and t-tests, analyses of data normality and homoscedasticity of the groups was performed with Kolmogorov-Smirnov and Levene tests, respectively.

Method error

Within a week interval from the first measurement, 30 randomly selected radiographs were retraced and remeasured by the same examiner. The random error was calculated according to Dahlberg's formula ($Se^2 = \Sigma d^2/2n$) and the systematic error was calculated with dependent t-tests, for $p<0.05$.

RESULTS

Results for power analysis showed that a sample with 23 patients in each group would give a 80% ability to detect differences, whereas a sample comprising 26 patients in each group would give 85%.

Results for the data distribution evaluation performed by the Kolmogorov-Smirnov test showed $p > 0.05$ for both groups, for all variables evaluated, indicating that the data had normal distribution. Levene test was used to verify homoscedasticity. All results exhibited $p>0.05$ for both groups, during the three stages evaluated. Thus, it was concluded that there was homogeneity of variables and that the ANOVA test could be applied for intragroup analysis.

The results for intragroup comparison in Group 1 (#37 and #47 teeth not included) demonstrated no statistically significant differences between the mean values for the mesiodistal inclinations of the teeth (36, 37, 46 and 47) at

© 2013 Dental Press Journal of Orthodontics

the three evaluated stages. On the other hand, results for the intragroup comparison in Group 2 (#37 and #47 teeth included) demonstrated significant uprighting of mandibular first and second molars throughout treatment, which remained stable during the postretention stage (Table 2).

Intergroup comparison demonstrated that Group 2 presented the first and second molars significantly uprighted in relation to Group 1 at both posttreatment and postretention stages (Table 3).

No significant systematic errors were detected and the major random error was of 1.27 degrees for the left mandibular first molar mesiodistal inclination.

DISCUSSION

Throughout this research, significant efforts were expended in order to minimize, or at least control the errors deriving from the procedures involved in panoramic radiograph tracings, demarcation of landmarks and measurement of the variables investigated. Knowledge of the methodology precision provided more reliable results. It was observed that the results obtained for random and systematic errors were within acceptable parameters, thus, not influencing the results and conclusions of the present study.

The methodology of this study was based on previous researches[9,13,14] that also used panoramic radiographs to obtain tooth angulation measurements. Panoramic radiographs are ordinarily used in orthodontic practice to provide significant information about teeth, axial inclinations, maturation periods, and surrounding tissues.[8,12,13,19] Some authors suggest that dental axial inclinations be radiographically checked at the beginning and end of orthodontic treatment.[3,5,7-10,13,16,17,19] Panoramic radiographs may be the technique of choice since it provides significant amount of diagnostic information obtained by viewing all teeth as well as the basal bone at once. In addition, it is the best option to evaluate teeth axial inclinations and root parallelism after orthodontic treatment.[2,5-7,11,12,13,15,17,24]

As occurring in other radiographic methods, the dimensions of structures in panoramic radiographs can be magnified[5,7,8,11,12,13,15-19] and due to distortions, hori-

Table 2 - Means and standard deviations of mesiodistal inclinations of the teeth (36, 37, 46 and 47) at the three evaluation stages (T_1, T_2 and T_3) for Groups 1 (second molars not included in treatment, n = 25) and 2 (second molars included, n = 25) and results of dependent ANOVA and Tukey tests.

Molar angulation	Initial (T_1)	Posttreatment (T_2)	Postretention (T_3)	p
	Mean ± SD	Mean ± SD	Mean ± SD	
36 G1	$59.60^{A} \pm 5.27$	$62.22^{A} \pm 6.57$	$62.56^{A} \pm 5.01$	0.13
36 G2	$56.80^{A} \pm 5.60$	$66.04^{B} \pm 4.87$	$66.26^{B} \pm 5.37$	0.00*
37 G1	$57.92^{A} \pm 8.07$	$56.66^{A} \pm 6.03$	$57.94^{A} \pm 8.35$	0.79
37 G2	$55.24^{A} \pm 6.70$	$65.56^{B} \pm 6.96$	$66.50^{B} \pm 6.94$	0.00*
46 G1	$62.92^{A} \pm 6.35$	$67.60^{A} \pm 6.94$	$65.08^{A} \pm 6.59$	0.05
46 G2	$64.68^{A} \pm 4.08$	$71.42^{B} \pm 3.97$	$70.88^{B} \pm 5.83$	0.00*
47 G1	$60.54^{A} \pm 8.01$	$62.98^{A} \pm 6.38$	$63.52^{A} \pm 9.90$	0.39
47 G2	$57.26^{A} \pm 10.24$	$70.08^{B} \pm 8.77$	$68.10^{B} \pm 6.03$	0.00*

*Statistically significant for $p < 0.05$. Different letters mean a statistically significant difference between the phases.

Table 3 - Means and standard deviations of mesiodistal inclinations of the teeth (36, 37, 46 and 47) at the three evaluation stages (T_1, T_2 and T_3) for Group 2 (second molars included) and results of dependent ANOVA and Tukey tests.

Molar angulation	Initial (T_1)	Posttreatment (T_2)	Postretention (T_3)	p
	Mean ± SD	Mean ± SD	Mean ± SD	
36	$56.80^{A} \pm 5.60$	$66.04^{B} \pm 4.87$	$66.26^{B} \pm 5.37$	0.00*
37	$55.24^{A} \pm 6.70$	$65.56^{B} \pm 6.96$	$66.50^{B} \pm 6.94$	0.00*
46	$64.68^{A} \pm 4.08$	$71.42^{B} \pm 3.97$	$70.88^{B} \pm 5.83$	0.00*
47	$57.26^{A} \pm 10.24$	$70.08^{B} \pm 8.77$	$68.10^{B} \pm 6.03$	0.00*

*Statistically significant for $p < 0.05$. Different letters mean a statistically significant difference between the phases.

© 2013 Dental Press Journal of Orthodontics

zontal measurements are unreliable.[17,19] In this study, panoramic radiograph magnification did not influence the results, as the same radiographic equipment and similar techniques were used for both groups. Thus, when Groups 1 and 2 were compared, the possible influence of this variable was eliminated.

Accuracy of tooth length and angulation measurements on panoramic radiographs is thought to be highly dependent on head positioning technique.[18,20] Stramotas et al[18] noted a significant error ($p < 0.05$) in such measurements when the occlusal plane was tilted up anteriorly by 8 degrees. A lateral cant of the occlusal plane less than 10 degrees without an upward anterior rotation showed no significant effect on the measurements. Regarding angular measurements, the literature reports that the analysis of dental angulations through panoramic radiographs can be performed with good reliability[8,11,12,13,15,17,18,19] and that there is some tolerance of variation in head position.[18] During the radiographic examination, all patients who comprised the sample were positioned with both the occlusal plane parallel and the sagittal plane perpendicular to the ground.

Recent studies have compared the accuracy of assessing mesiodistal root angulations with posttreatment panoramic radiographs and with cone-beam computed tomography (CT). The results show that CT is the most accurate method for assessing dental angulation.[21,22] Thus, assessment of mesiodistal tooth angulations with panoramic radiograph should be approached with caution and reinforced by a thorough clinical examination of the dentition.[23] However, due to economic as well as biological reasons, CT should not be considered for clinical routine, but rather only for mesiodistal root angulations evaluation, before, during or after orthodontic treatment. The use of panoramic radiograph as data source may be considered a limitation of this study. The use of CT could result not only in a more accurate assessment of the mesiodistal root angulations, but it could also enable tridimensional evaluation of the teeth. Another limitation of this research is the fact that it evaluated the mandibular molars changes, only.

Results of Group 1 (#37 and #47 teeth not included) intragroup comparison demonstrated no statistically significant differences between the mean values for the mesiodistal inclinations of the teeth (36, 37, 46 and 47) at the three evaluation stages (T_1, T_2 and T_3) (Table 2). However, results of Group 2 (37 and 47 included) intragroup comparison demonstrated significant uprighting of mandibular first and second molars during treatment, which remained stable at the postretention stage (Table 2). Regarding the assessment of changes in mesiodistal dental inclination as a result of orthodontic treatment, there are few studies that could be used for comparisons, and most of them are related to patterns of normal occlusion.

In an attempt to establish a basis for quantitative evaluation of mesiodistal axial inclinations of permanent teeth after orthodontic treatment, Ursi et al[13] conducted a study that determined the normal mean values for dental angulations through panoramic radiographs. For the authors, the mesiodistal root angulations of high quality orthodontic treatment exhibited in the final panoramic radiographs should be similar to normal occlusion values. In the present study, it was noted that the mean values obtained for the mesiodistal inclinations of the teeth (36, 37, 46 and 47) at posttreatment and postretention phases in Group 2 (with inclusion of the second molars) were closer to the normal values proposed by Ursi et al.[13]

In 2002, Brandão[9] evaluated if alterations in the mesiodistal axial inclination of the mandibular anterior teeth would present any influence in the relapse of their crowding. The panoramic radiographic and dental casts of each patient were evaluated at the beginning (T_1), at the end (T_2) and five-year posttreatment (T_3) phases. Results showed that the mesiodistal axial inclinations of the teeth at the beginning of treatment were different from those observed in normal occlusion cases in 85% of the evaluated teeth. However, 45% of the teeth at the end, and 55% at the five-year posttreatment phase showed mean values similar to those of normal occlusion. Evaluation of mesiodistal axial inclination stability at the five-year posttreatment phase demonstrates that 75% of the teeth proved to maintain the angulation obtained at the end of the treatment, regardless of being similar or not to the normal values. The changes in the mesiodistal axial inclination between T_2 and T_3 did not influence the relapse of mandibular anterior crowding.

In 2006, Almeida-Pedrin et al[8] evaluated, through panoramic radiographs, the mesiodistal axial inclinations of the maxillary anterior teeth at the beginning and end of nonextraction orthodontic treatment. The experimental sample comprised 40 Caucasian patients who were treated orthodontically with a standard Edgewise technique, without extractions. The mesiodistal axial inclinations of the maxillary anterior teeth of

Table 4 - Intergroup comparison of mesiodistal inclinations of the teeth (36, 37, 46 and 47) at the three evaluation stages (T_1, T_2 and T_3) with t-test.

Molar angulation	Group 1 Second molar not included (n = 25)	Group 2 Second molar included (n = 25)	p
	Mean ± SD	Mean ± SD	
36 T_1	59.60 ± 5.27	56.80 ± 5.60	0.07
36 T_2	62.22 ± 6.57	66.04 ± 4.87	0.02*
36 T_3	62.56 ± 5.01	66.26 ± 5.37	0.01*
37 T_1	57.92 ± 8.07	55.24 ± 6.70	0.20
37 T_2	56.66 ± 6.03	65.56 ± 6.96	0.00*
37 T_3	57.94 ± 8.35	66.50 ± 6.94	0.00*
46 T_1	62.92 ± 6.35	64.68 ± 4.08	0.25
46 T_2	67.60 ± 6.94	71.42 ± 3.97	0.02*
46 T_3	65.08 ± 6.59	70.88 ± 5.83	0.00*
47 T_1	60.54 ± 8.01	57.26 ± 10.24	0.21
47 T_2	62.98 ± 6.38	70.08 ± 8.77	0.00*
47 T_3	63.52 ± 9.90	68.10 ± 6.03	0.05

*Statistically significant for $p < 0.05$.

the experimental group at T_1 were different from those of the control group for 50% of the evaluated teeth. In contrast, the inclinations at T_2 were consistent with the normal anatomical configuration of the controls. The authors concluded that panoramic radiograph is an effective tool for evaluating the mesiodistal axial inclinations of maxillary anterior teeth.

In 2009, Sella et al.[25] compared the normal mean values of mesiodistal axial angulations, proposed by Ursi et al,[13] with mesiodistal axial angulations of canine teeth, premolars and inferior molars in individuals aged between 18 and 25 years old, with and without the presence of the mandibular third molars. The authors concluded that the groups presented similar angular values for the canine teeth, premolars and inferior molars in such a way that the presence of the third molars did not influence dental angulations.

The intergroup comparison (Table 4) demonstrated statistically significant differences with regards to mesiodistal inclinations of mandibular first and second molars at T_2. Patients with mandibular second molars included in treatment mechanics presented mandibular first and second molars more uprighted. At T_3, mesiodistal inclinations of the molars remained significantly different between groups, except for the mean values for angulation of mandibular right second molars (#47 – T_3) that, despite not statistically significant ($p = 0.05$), were, on average, approximately 5 degrees more uprighted in comparison to Group 1. There are some limitations hindering comparison between these intergroup results with other studies, namely: the nonexistence of previous studies with similar objectives in the literature and their methodological differences. However, based on the results of this research, it may be inferred that the inclusion of second mandibular molars in orthodontic mechanics benefits not only the mandibular second molars, but also first molars uprighting, as the mandibular first molars in Group 2 were more uprighted at posttreatment and postretention stages (Tables 2 and 3). Additionally, the results suggest that the inclusion of second molars in orthodontic mechanics probably consists in a distal support that improves first molar uprighting.

There are some doubts and controversies about the necessity of second molars inclusion during orthodontic treatment. Two of the major goals of treatment consist in leveling the curve of Spee and correcting overbite. Thus, nothing is more rational than using the second molars to provide an anchorage that allows anterior teeth

© 2013 Dental Press Journal of Orthodontics

intrusion and correction of the curve of Spee. When using Class II elastics, the second molar inclusion increases arch length. Therefore, there is not only an increase in the horizontal component of force, but also a decrease of the vertical component. This fact is generally favorable because it facilitates sagittal interarch adjustment and prevents first molars extrusion. In extraction cases, mandibular second molars inclusion provides posterior anchorage improvement and avoids inclination and rotation of the first molars. It is also indicated for crossbites, proclined or rotated second molars cases as well as surgical cases. However, there are clinical situations in which inclusion of second molars may be contraindicated, such as in patients with initial anterior open bite and vertical facial growth tendency.

CONCLUSION

Inclusion of mandibular second molars in orthodontic mechanics is relevant not only for the correction of mandibular second molars mesiodistal inclination, but also for first molars uprighting.

REFERENCES

1. Andrews LF. The six keys to normal occlusion. Am J Orthod. 1972;62(3):296-309.
2. Dempster WT, Adams WJ, Duddles RA. Arrangement in the jaws of the roots of the teeth. J Am Dent Assoc. 1963;67:779-97.
3. Hatasaka HH. A radiographic study of roots in extraction sites. Angle Orthod. 1976;46(1):64-8.
4. Beyron H. Optimal occlusion. Dent Clin North Am. 1969;13(3):537-54.
5. Ingervall B. Functionally optimal occlusion: the goal of orthodontic treatment. Am J Orthod. 1976;70(1):81-90.
6. Mayoral G. Treatment results with light wires studied by panoramic radiography. Am J Orthod. 1982;81(6):489-97.
7. Williams R. Eliminating lower retention. J Clin Orthod. 1985;19(5):342-9.
8. Almeida-Pedrin RR, Pinzan A, Almeida RR, Ursi W, Almeida MR. Panoramic evaluation of mesiodistal axial inclinations of maxillary anterior teeth in orthodontically treated subjects. Am J Orthod Dentofacial Orthop. 2006;130(1):56-60.
9. Brandão AG. Estudo ortopantomográfico longitudinal das inclinações axiais mesiodistais em pacientes tratados ortodonticamente com extrações dos quatro primeiros pré-molares [dissertação]. Bauru (SP): Faculdade de Odontologia de Bauru; 2002.
10. Edwards JG. The prevention of relapse in extraction cases. Am J Orthod. 1971;60(2):128-44.
11. Jesuino FA, Costa LR, Valladares-Neto J. Mesiodistal root angulation of permanent teeth in children with mixed dentition and normal occlusion. J Appl Oral Sci. 2010;18(6):625-9.
12. Lucchesi MV, Wood RE, Nortje CJ. Suitability of the panoramic radiograph for assessment of mesiodistal angulation of teeth in the buccal segments of the mandible. Am J Orthod Dentofacial Orthop. 1988;94(4):303-10.
13. Ursi WJ, Almeida RR, Tavano O, Henriques JF. Assessment of mesiodistal axial inclination through panoramic radiography. J Clin Orthod. 1990;24(3):166-73.
14. Tavano O, Ursi WJS, Almeida RR, Henriques JFC. Determinação de linhas de referência para medições angulares em radiografias ortopantomográficas. Odontol Mod. 1989;16(9):22-5.
15. Akcam MO, Altiok T, Ozdiler E. Panoramic radiographs: a tool for investigating skeletal pattern. Am J Orthod Dentofacial Orthop. 2003;123(2):175-81.
16. McKee IW, Glover KE, Williamson PC, Lam EW, Heo G, Major PW. The effect of vertical and horizontal head positioning in panoramic radiography on mesiodistal tooth angulations. Angle Orthod. 2001;71(6):442-51.
17. McKee IW, Williamson PC, Lam EW, Heo G, Glover KE, Major PW. The accuracy of 4 panoramic units in the projection of mesiodistal tooth angulations. Am J Orthod Dentofacial Orthop. 2002;121(2):166-75.
18. Stramotas S, Geenty JP, Petocz P, Darendeliler MA. Accuracy of linear and angular measurements on panoramic radiographs taken at various positions in vitro. Eur J Orthod. 2002;24(1):43-52.
19. Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: mandibular linear dimensions and angles. Am J Orthod Dentofacial Orthop. 1986;90(1):45-51.
20. McDavid WD, Welander U, Brent Dove S, Tronjje G. Digital imaging in rotational panoramic radiography. Dentomaxillofac Radiol. 1995;24(2):68-75.
21. Bouwens DG, Cevidanes L, Ludlow JB, Phillips C. Comparison of mesiodistal root angulation with posttreatment panoramic radiographs and cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2011;139(1):126-32.
22. Van Elslande D, Heo G, Flores-Mir C, Carey J, Major PW. Accuracy of mesiodistal root angulation projected by cone-beam computed tomographic panoramic-like images. Am J Orthod Dentofacial Orthop. 2010;137(4 Suppl):S94-9.
23. Owens AM, Johal A. Near-end of treatment panoramic radiograph in the assessment of mesiodistal root angulation. Angle Orthod. 2008;78(3):475-81.
24. Strang RHW. Factors associated with successful orthodontic treatment. Am J Orthod. 1952:38(10):790-800.
25. Sella RC, Mendonça MR, Cuoghi OA. Avaliação ortopantomográfica das angulações mesiodistais de caninos, pré-molares e molares inferiores com e sem a presença dos terceiros molares. Rev Dental Press Ortod Ortop Facial. 2009;14(6):97-108.
26. Janson M. Ortodontia em adultos e tratamento interdisciplinar. 2a ed. Maringá: Dental Press; 2010.

© 2013 Dental Press Journal of Orthodontics

Intra-articular injections with corticosteroids and sodium hyaluronate for treating temporomandibular joint disorders: A systematic review

Eduardo Machado[1], Daniel Bonotto[2], Paulo Afonso Cunali[3]

Introduction: In some cases, conservative treatment of internal derangements of the Temporomandibular Joint (TMJ) is considered little responsive. Thus, it is necessary to accomplish treatments that aim at reducing pain and improve patients' functions who present arthrogenic temporomandibular disorders.

Objective: This study, by means of a systematic review of the literature, aimed to analyze the effectiveness of intra-articular injections with corticosteroids and sodium hyaluronate for treating internal derangements of the TMJ.

Methods: Carry out a research in the following databases: MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs, and BBO, considering publications issued between 1966 and October of 2010, focusing on randomized or quasi-randomized controlled clinical trials, single or double-blind.

Results: After applying the inclusion criteria we collected 9 articles, 7 of which were randomized controlled double-blind clinical trials and 2 randomized controlled single-blind clinical trials.

Conclusion: After analyzing the literature, it was found that intra-articular injection with corticosteroids and sodium hyaluronate seems to be an effective method for treating internal derangements of the TMJ. However, further randomized controlled clinical trials, with representative samples and longer follow-up time must be carried out in order to assess the real effectiveness of this technique.

Keywords: Corticosteroids. Sodium hyaluronate. Temporomandibular joint. Temporomandibular joint dysfunction syndrome. Temporomandibular joint disorders.

[1] Specialist in Temporomandibular Disorders (TMD) and Orofacial pain, Federal University of Paraná (UFPR).
[2] MSc in Health Sciences, Pontifical Catholic University of Paraná (PUC-PR) Professor, Graduation Program in TMD and Orofacial pain, UFPR.
[3] PhD in Sciences, Federal University of Sao Paulo (UNIFESP). Professor, Graduation and Post-Graduation Programs in Dentistry, UFPR.

How to cite this article: Machado E, Bonotto D, Cunali PA. Intra-articular injections with corticosteroids and sodium hyaluronate for treating temporomandibular joint disorders: A systematic review. Dental Press J Orthod. 2013 Sept-Oct;18(5):128-33.

Submitted: November 23, 2011 - **Revised and accepted:** February 20, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Eduardo Machado
Rua Francisco Trevisan, 20 – Santa Maria/RS – Brazil
CEP: 97050-230 – E-mail: dr.eduardomachado@yahoo.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

The condyle/articular disc complex incoordination is among the temporomandibular joint disorders. It results from the collapse regarding the normal function of the disc on the condyle and it is due to disc collateral ligaments incompetence and lower retrodiscal plate. Examples of this case are disc displacements with and without reduction which may be associated with inflammatory changes such as capsulitis, synovitis and retrodiscitis or with degenerative changes such as osteoarthritis and osteoarthrosis of the Temporomandibular Joint (TMJ).[1]

The protocols for initial treatment consists of choosing reversible and little invasive therapies, such as occlusal splints, non-steroidal anti-inflammatory drugs (NSAID), analgesics, physiotherapy, thermotherapy, microcurrent, functional repose and patient advice. However, in some cases, conservative treatment becomes little responsive due to current structural changes.[1] Thus, more complex procedures such as intra-articular injections with corticosteroids or sodium hyaluronate, arthrocentesis, arthroscopy or open surgery for TMJ appear as therapeutic options to control and treat TMJ internal derangements.

In such cases, intra-articular injections with corticosteroids and sodium hyaluronate — the hyaluronic acid sodium salt, a clinical procedure known as viscosupplementation — appear as an alternative of a treatment that is less invasive than surgical procedures for TMJ. Thus, this study aimed at analyzing, through a systematic literature review and within the context of an evidence-based Dentistry, the effectiveness of intra-articular injections with corticosteroids and sodium hyaluronate as a treatment for TMJ internal derangements.

MATERIAL AND METHODS

We carried out a computerized research in the following databases: MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs and BBO, considering publications issued between 1966 and October of 2010. The research descriptors comprised terms widely used within the line of research proposed by this study. The research descriptors used were "corticosteroids", "hyaluronic acid", "sodium hyaluronate", "temporomandibular disorder," "temporomandibular joint", "craniomandibular disorder", "tmd", "tmj", "osteoarthritis" and "osteoarthrosis", which were crossed in search engines. The initial list of articles, evaluated by their title and abstract, was submitted to review carried out by two appraisers who applied inclusion criteria hereinbelow to determine the final sample of articles. Should there have been any discrepancy between the results obtained by the reviewers, a third appraiser would be consulted and requested to read the full version of the article.

The inclusion criteria for selecting the articles were:

- Studies involving human subjects in which the effectiveness of TMJ intra-articular injections with corticosteroids and/or sodium hyaluronate (SH) in the treatment of temporomandibular joint disorders was evaluated.
- Studies in which corticosteroids and/or SH were compared to placebo or combined with other therapies such as arthrocentesis or arthroscopy.
- Diagnostic criteria for TMDs based on clinical examinations and/or computed tomography (CT) or nuclear magnetic resonance images (MRI).
- We included randomized controlled clinical trials (RCTs) or quasi-randomized, single or double-blind trials, only.
- No language restriction concerning publications issued between 1966 and October of 2010.

RESULTS

The initial list of articles comprised 412 possible studies. After applying the inclusion criteria, we obtained 9 randomized controlled clinical trials, 7 of which were double-blind and 2 single-blind, as shown in Figure 1.

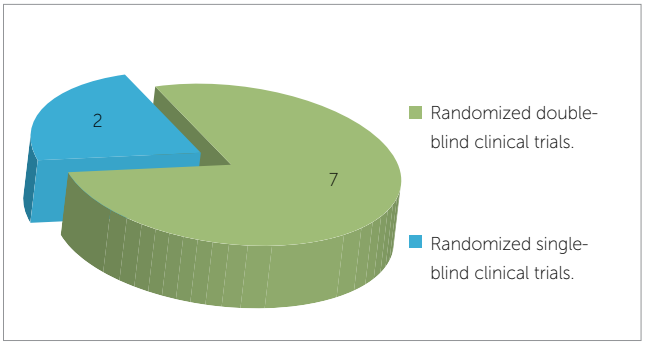


Figure 1 - Selected studies design.

Table 1 - Studies included in the research and which compare corticosteroids, sodium hyaluronate, and placebo.

Authors and year of publication	Study design	Criteria for TMD diagnosis	Final sample size (n)	Evaluation period	Results
Kopp et al[2] 1985	Double-blind, controlled RCT	HelkimoIndex, pain, mandibular function and joint sounds	18 tt SH 15 tt CO (Beta-methasone)	4 weeks	Both groups had pain reduced. No statistical differences between groups.
Kopp et al[3] 1991	Double-blind, controlled RCT.	Patients with rheumatoid arthritis and TMJ internal derangements	14 tt SH 14 tt CO (Methyl-prednisolone) 13 tt SS (placebo)	4 weeks	Improvements in the 3 groups with SH and CO showing the best results.
Bertolami et al[4] 1993	Double-blind, controlled RCT.	Helkimo Index	80 tt SH 41 tt SS (placebo)	6 months	SH: significant improvement in patients with DDWR.
Hepguler et al[5] 2002	Double-blind, controlled RCT.	Helkimo Index modified	19 tt SH 19 tt SS (placebo)	6 months	SH: effective in DDWR cases.
Shi et al[6] 2002	Double-blind, controlled RCT.	Articular pain and tenderness, jaw function and TMJ sounds.	35 tt SH 28 tt CO (Prednisolone)	4-5 weeks	SH and CO groups: improvements related to pain and function. No statistical differences between groups.
Bjørnland et al[7] 2007	Double-blind, controlled RCT.	RDC: TMJ osteoarthritis and myofascial pain.	20 tt SH 20 tt CO (Celestone)	6 months	Both groups had pain reduced, but SH was more effective.
Møystad et al[8] 2008	Double-blind, controlled RCT.	RDC: TMJ osteoarthritis and CT examination.	17 tt SH 19 tt CO (Celestone)	6 months	Progression, regression and absence of changes were identified in treated and untreated TMJs.

RCT: randomized clinical trial; tt: treatment; SH: sodium hyaluronate; CO: corticosteroids; SS: saline solution; DDWR: disc displacement with reduction.

Table 2 - Studies included in the research and which compare arthrocentesis or arthroscopic followed or not by injection with corticosteroid and/or sodium hyaluronate.

Authors and year of publication	Study design	Criteria for TMD diagnosis	Final sample size (n)	Evaluation period	Results
McCain et al[9] 1989	Single-blind, controlled RCT.	Pain, tenderness and joint sounds	33 TMJs: arthroscopy + RL + SH 22 TMJs: arthroscopy + RL	8 weeks	No statistically significant differences between groups.
Alpaslan et al[10] 2001	Single-blind, controlled RCT.	Pain, limited mouth opening, sounds and radiographic evaluation	26 TMJs: arthrocentesis + SH 19 TMJs: arthrocentesis + SS	24 months	Arthrocentesis with SH: superior effects than without SH.

RCT: randomized clinical trial; RL: ringer lactate, SH: sodium hyaluronate; SS: saline solution.

Kappa coefficient between reviewers was of 1.00 and the results of the selected studies are presented in Tables 1 and 2.

DISCUSSION

The qualification of the generated scientific evidence is related to the methodological criteria and the designs adopted by the authors in the clinical studies. Thus, criteria such as randomization, blinding, sample size calculation, calibration, control of involved factors, among others, aimed at making scientific evidence more precise and reliable and this information should be provided in order to facilitate readers' appreciation and discussion of the scientific article.[11,12] Furthermore, knowledge about the study designs which generate the highest levels of evidence must be of common knowledge: meta-analysis, systematic reviews and randomized clinical trials.

© 2013 Dental Press Journal of Orthodontics

Hyaluronic acid (HA) is a mucopolysaccharide acid present in ground substance animal tissues. It is the major component of the synovial fluid and has an important role in lubrication, nutrition, homeostasis and load absorption of articular tissues.[13,14,15] In cases of inflammatory and degenerative changes of joints, the concentration and molecular weight of HA id reduced.[16,17] Viscosupplementation with sodium hyaluronate increases the concentration and molecular weight of HA in the synovial fluid,[18] restoring tissues lubrication and nutrition as well as minimizing mechanic stress.[15,19] Moreover, intra-articular SH injection presents an analgesic effect by blocking receptors and endogenous substances that cause pain in synovial tissues. In addition, it promotes a release of adhesion areas between the articular disc and the mandibular fossa, increasing joint mobility and allowing better synovial fluid circulation.[19]

At first, the intra-articular sodium hyaluronate injection was used in race horses with traumatic arthritis.[20] Afterward, it was based on studies on the osteoarthritis model, induced in animals, and combined with the inhibition of osteoarthritis development.[21] In the mid-70's, viscosupplementation with sodium hyaluronate began to be used in humans for osteoarthritis treatment of large joints such as knee, hip and shoulder,[22] being indicated for the internal derangements of TMJ after 1979.[23]

Glucocorticoids are yet the most effective anti-inflammatory drugs available, promoting symptomatic improvements of a series of clinical manifestations. However, they present risks of potential adverse effects which affect several organs depending on the dosage and, mainly, the duration of the treatment. For short periods (up to two weeks), even at high doses, the probability of causing adverse side effects is low. In long-term treatments, serious side effects appear, limiting the effectiveness of glucocorticoids in chronic diseases. Glucocorticoids have a very original mechanism of action, essentially genomic (transcriptional) and characterized by the activation (transactivation) or inhibition (transrepression) of numerous target genes. These molecules act in many cells, including not only innate immunity cells (macrophages, granulocytes, mast cells) and adaptive immunity cells (lymphocytes), but also other cells (fibroblasts, epithelial and endothelial cells).[24]

The results of this systematic review show that many of the selected studies had small samples and short follow-up periods. In addition, the results highlight the absence of a universal and standardized method for diagnosing TMD which hampers comparison between clinical trials. In this systematic review, different authors used different indexes for diagnosing TMD: RDC/TMD,[25] Helkimo index,[26,27] adaptations of these or other criteria, highlighting the necessity of further randomized controlled clinical trials using universal, standardized and valid index in representative samples and with a longer follow-up period.

According to the studies included in accordance with the methodological criteria of this systematic review, significant scientific evidence demonstrates that viscosupplementation with sodium hyaluronate is an effective treatment for TMJ internal derangements at short[2,3,6] and medium[4,5,7] terms, with results that are similar[2,3,6] or greater[7] than the ones obtained by corticosteroids intra-articular injections. Furthermore, combining SH with arthrocentesis brought major improvements after surgery, greater than those obtained by the group that did not receive SH.[10] On the other hand, combining or not SH with arthroscopy did not show any statistically significant differences.[9] Some limitations can be associated with some of this evidence: Small samples,[2,3] short follow-up time[2,3,6,9] and lack of information on how many patients were lost or drop-out during the study.[4,9,10] Such limitations reduce the power of the scientific evidence generated.

Other clinical studies assessing viscosupplementation with sodium hyaluronate, which present good evidence level, but were not included in this systematic review due to some issues concerning the criteria of randomization[28] or blinding,[29,30] indicate symptoms reduction and functional improvements in cases with joint TMD, with results that lasted during follow-up.[28,29,30] Evaluations of SH intra-articular injections protocols showed results statistically equivalent to therapy carried out with occlusal splints for 6 months.[28]

Computed tomography examinations, which proposed to assess changes in osteoarthritic TMJ due to intra-articular injections, show that progression, regression and absence of changes in cases with

© 2013 Dental Press Journal of Orthodontics

osteoarthritis are observed in TMJ that have been treated and in contralateral TMJ that have not been treated, showing no statistically significant differences between sodium hyaluronate and corticosteroid.[8] Moreover, they highlight the importance of assessments carried out by imaging examinations associated with clinical criteria in order to analyze the progression or regression of TMJ osteoarthritis.

The accomplishment of further randomized controlled clinical trials, with representative samples and longer follow-up periods, shall enable not only the evaluation concerning the real effectiveness of corticosteroids and sodium hyaluronate, but also the obtainment of an objective protocol for using them. This technique seems to perform well in refractory situations regarding conservative treatments, arthralgias with limitation of movement and/or severe joint sounds, arthralgia associated with moderate and severe degenerative changes and in cases of movement limitation caused by disc displacement without reduction and adhesions.

At first, in cases of temporomandibular disorders, the focus must be noninvasive, conservative and reversible, making use of therapeutics such as occlusal splints, pharmacotherapy, physiotherapy, thermotherapy, microcurrent, functional rest, and patient advice. In those cases in which conservative treatment is not responsive, corticosteroids and sodium hyaluronate intra-articular injections appear as a non-surgical, low invasive and safe alternative which is associated with good results at short and medium terms when treating internal derangements of TMJ.

With regard to the orthodontic specialty, it is important to consider knowledge based on evidence and relative to the action mechanisms and clinical applications of many different therapeutic options for TMD patients, so that the orthodontist and the patient are aware of the therapeutic option regarding the intra-articular injections with corticosteroids and sodium hyaluronate as well as its safety and efficacy in refractory cases concerning conservative treatment.

CONCLUSIONS

- According to randomized controlled clinical trials, the intra-articular injections with corticosteroids and sodium hyaluronate seem to be an effective method to control TMJ internal derangements at short and medium terms.
- In short-term treatments, the effects of intra-articular injections with sodium hyaluronate are similar to those regarding the injections with corticosteroids, while in long-term treatments, injections with sodium hyaluronate showed better results.
- Further randomized controlled clinical trials with representative samples and long follow-up times are necessary to assess the real effectiveness of the intra-articular injections with corticosteroid and sodium hyaluronate technique and to establish an objective protocol.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. Okeson JP. Management of temporomandibular disorders and occlusion. 4th ed. St. Louis: Mosby; 1998.
2. Kopp S, Wenneberg B, Haraldson T, Carlsson GE. The short-term effect of intra-articular injections of sodium hyaluronate and corticosteroid on temporomandibular joint pain and dysfunction. J Oral Maxillofac Surg. 1985;43(6):429-35.
3. Kopp S, Akerman S, Nilner M. Short-term effects of intra-articular sodium hyaluronate, glucocorticoid, and saline injections on rheumatoid arthritis. J Craniomandib Disord. 1991;5(4):231-8.
4. Bertolami CN, Gay T, Clark GT, Rendell J, Shetty V, Liu C, et al. Use of sodium hyaluronate in treating temporomandibular joint disorders: a randomized, double-blind, placebo controlled clinical trial. J Oral Maxillofac Surg. 1993;51(3):232-42.
5. Hepguler S, Akkoc YS, Pehlivan M, Ozturk C, Celebi G, Saracoglu A, et al. The efficacy of intra-articular sodium hyaluronate in patients with reducing displaced disc. J Oral Rehabil. 2002;29(1):80-6.
6. Shi ZD, Yang F, He ZX, Shi B, Yang MZ. Comparative study on effects of sodium hyaluronate and prednisolone injections on experimental temporomandibular joint osteoarthritis of rabbits. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. (Chinese Journal of Reparative and Reconstructive Surgery). 2002;16(1): 5-10.
7. Bjørnland T, Gjaerum AA, Møystad A. Osteoarthritis of the temporomandibular joint: an evaluation of the effects and complications of corticosteroid injection compared with injection with sodium hyaluronate. J Oral Rehabil. 2007;34(8):583-9.
8. Møystad A, Mork-Knutsen BB, Bjørnland T. Injection of sodium hyaluronate compared to a corticosteroid in the treatment of patients with temporomandibular joint osteoarthritis: a CT evaluation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105(2):53-60.
9. McCain JP, Balazs EA, de la Rua H. Preliminary studies on the use of a viscoelastic solution in arthroscopic surgery of the temporomandibular joint. J Oral Maxillofac Surg. 1989;47(11):1161-8.
10. Alpaslan GH, Alpaslan C. Efficacy of temporomandibular joint arthrocentesis with and without injection of sodium hyaluronate in treatment of internal derangements. J Oral Maxillofac Surg. 2001;59(6):613-8.
11. Susin C, Rosing CK. Praticando odontologia baseada em evidências. 1ª ed. Canoas: ULBRA, 1999.
12. Susin C, Rosing CK. A importância do treinamento, reprodutibilidade e calibragem para a qualidade dos estudos. Rev Fac Odontol Porto Alegre. 2000;40(2):3-6.
13. Balazs EA, Denlinger JL. Viscosupplementation: a new concept in the treatment of osteoarthritis. J Rheumatol Suppl. 1993;20(39):3-9.
14. Lehninger A, Nelson A. Princípios de Bioquímica. 3ª ed. São Paulo: Sarvier; 2002.
15. Nitzan DW, Etsion I. Adhesive force: the underlying cause of the disc anchorage to the fossa and/or eminence in the temporomandibular joint--a new concept. Int J Oral Maxillofac Surg. 2002;31(1):94-9.
16. Listrat V, Ayral X, Patarnello F, Bonvarlet JP, Simonnet J, Amor B, et al. Arthroscopic evaluation of potential structure modifying activity of hyaluronan (Hyalgan) in osteoarthritis of the knee. Osteoarthr Cartil. 1997;5(3):153-60.
17. Radin EL, Paul IL. Joint lubrication with artificial lubricants. Arthritis Rheum. 1971;14(1):126-9.
18. Swann DA, Radin El. Role of hyaluronic acid in joint lubrication. Ann Rheum Dis. 1974;33(4):318-26.
19. Quinn JN, Bazan NG. Identification of prostaglandin E2 and leukotriene B4 in the synovial fluid of painful, dysfunctional temporomandibular joints. J Oral Maxillofac Surg. 1990;48(9):968-71.
20. Rydel NW, Butler J, Balazs EA. Hyaluronic acid in synovial fluid VI. Effect of intra-articular injection of hyaluronic acid on the clinical symptoms of arthritis in track horses. Acta Vet Scand. 1970;11(2):139-55.
21. Xinmin Y, Jian H. Treatment of temporomandibular joint osteoarthritis with viscosupplementation and arthrocentesis on rabbit model. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100(3):35-8.
22. Peyron JG, Balazs EA. Preliminary clinical assessment of Na-hyaluronate injection into human arthritic joints. Pathol Biol. 1974;22(8):731-6.
23. Kopp S, Wenneberg B. Effects of occlusal treatment and intraarticular injections on temporomandibular joint pain and dysfunction. Acta Odontol Scand. 1981;39(2):87-96.
24. Wannmacher L, Ferreira MBC. Antiinflamatórios esteróides. In: Fuchs D, Wannmacher L, editores. Farmacologia Clínica. 2a ed. Rio de Janeiro: Guanabara Koogan; 1998. p. 194-202.
25. Dworkin SF, Leresche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord. 1992;6(4):301-55.
26. Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. Sven Tandlak Tidskr. 1974;67(2):101-21.
27. Helkimo M. Studies on function and dysfunction of the masticatory system. III. Analyses of anamnestic and clinical recordings of dysfunction with the aid of indices. Sven Tandlak Tidskr. 1974;67(3):165-81.
28. Guarda-Nardini L, Masiero S, Marioni G. Conservative treatment of temporomandibular joint osteoarthrosis: intra-articular injection of sodium hyaluronate. J Oral Rehabil. 2005;32(10):729-34.
29. Basterzi Y, Sari A, Demirkan F, Unal S, Arslan S. Intraarticular hyaluronic acid injection for the treatment of reducing and nonreducing disc displacement of the temporomandibular joint. Ann Plast Sur. 2009;62(3):265-7.
30. Guarda-Nardini L, Oliviero F, Ramonda R, Ferronato G. Influence of intra-articular injections of sodium hyaluronate on clinical features and synovial fluid nitric oxide levels of temporomandibular osteoarthritis. Reumatismo. 2004;56(4):272-7.

© 2013 Dental Press Journal of Orthodontics

Therapeutic exercises for the control of temporomandibular disorders

Alberto da Rocha Moraes[1], Monique Lalue Sanches[1], Eduardo Cotecchia Ribeiro[2], Antonio Sérgio Guimarães[3]

Introduction: Temporomandibular disorder (TMD) is a multifactorial disease. For this reason, it is difficult to obtain an accurate and correct diagnosis. In this context, conservative treatments, including therapeutic exercises classified as stretching, relaxation, coordination, strengthening and endurance, are oftentimes prescribed.

Objective: Thus, the aim of the present article was to conduct a literature review concerning the types of exercises available and the efficacy for the treatment of muscular TMD.

Methods: The review included researches carried out between 2000 and 2010, indexed on Web of Science, PubMed, LILACS and BBO. Moreover, the following keywords were used: Exercise, physical therapy, facial pain, myofascial pain syndrome, and temporomandibular joint dysfunction syndrome. Studies that did not consider the subject "TMD and exercises", used post-surgery exercises and did not use validated criteria for the diagnosis of TMD (RDC/TMD) were not included.

Results: The results comprised seven articles which proved therapeutic exercises to be effective for the treatment of muscular TMD. However, these studies are seen as limited, since therapeutic exercises were not applied alone, but in association with other conservative procedures. In addition, they present some drawbacks such as: Small samples, lack of control group and no detailed exercise description which should have included intensity, repetition, frequency and duration.

Conclusion: Although therapeutic exercises are considered effective in the management of muscular TMD, the development of randomized clinical trials is necessary, since many existing studies are still based on the clinical experience of professionals.

Keywords: Temporomandibular joint dysfunction syndrome. Myofascial pain syndromes. Physical therapy modalities. Exercise.

[1] Specialist in TMD and Orofacial pain, UNIFESP.
[2] PhD in Anatomy and Associate Professor at the Morphology and Genetics Department, UNIFESP.
[3] PhD in Morphology, UNIFESP.

How to cite this article: Moraes AR, Sanches ML, Ribeiro EC, Guimarães AS. Therapeutic exercises for the control of temporomandibular disorders. Dental Press J Orthod. 2013 Sept-Oct;18(5):134-9.

Submitted: April 19, 2011 - **Revised and accepted:** December 03, 2011

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address: Monique Lalue Sanches
Rua Pereira da Nóbrega, 324 – Apto 43 – São Paulo/SP – Brazil
CEP: 01.549-020 – E-mail: moniquelsanches@uol.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

Temporomandibular disorder (TMD) is a collective term that covers a broad spectrum of clinical problems of the temporomandibular joint (TMJ), masticatory muscles and associated structures. It is mainly characterized by pain, joint sounds and irregular or limited mandibular function.[1,2] It is most prevalent in females aged between 20 and 45 years old[3] and it is subdivided by the American Academy of Orofacial Pain (AAOP) into muscular TMD and articular TMD; with the muscular type being much more prevalent, although it is possible for both to occur concomitantly.[1] TMD classification is based on different forms and methods. The classification developed by Dworkin et al, named as Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD)[4] is one of the most used.

TMD has no specific etiological factor, however risk factors that affect the dynamic balance of the masticatory system have been identified. These risk factors are divided into traumatic, anatomical, physiopathological and psychosocial.[1,3] For this reason, and for having a benign course,[5] it often becomes difficult to obtain definite, accurate and correct diagnosis. Additionally, conservative, reversible treatment is oftentimes prescribed, since the majority of TMDs are of muscular origin.[6–10] Treatment includes heat or cold therapy, cognitive-behavioral therapy, use of intraoral appliances and different types of physical exercises. However, current evidence of the effectiveness of physical exercises is poor due to a limited number of appropriate randomized clinical trials.[11] Nevertheless, recent articles conducted under elaborated criteria have shown the real effects of this type of treatment, which corroborates their effectiveness.[5.6,7,9,10,12,13,14] Exercise is the first treatment choice for patients with muscular TMD, since it presents low cost and good effectiveness,[9,15] in addition to having the same prognosis of treatment performed with oral stabilization appliances.[12,14]

In order to analyze the effectiveness as well as the different types of exercises available for the treatment of muscular TMD, a literature review was carried out. The review included researches conducted between 2000 and 2010, indexed on Web of Science, PubMed, LILACS and BBO. Additionally, the following keywords were used: Exercise, physical therapy, facial pain, myofascial pain syndrome, and temporomandibular joint dysfunction syndrome. In selecting the sample, the following inclusion criteria were applied: Articles addressing not only diagnosis of muscular TMD by means of validated criteria (RDC/TMD), but also the use of therapeutic exercises for its treatment. Studies that did not consider the subject "exercises and TMD", used post-surgery exercises and were in a language other than Portuguese or English were excluded. Based on this information, the goal of this study was to present, through a review, the modalities of exercises available for the treatment of muscular TMD. The effectiveness of such exercises was assessed as well.

Therapeutic exercises are intended to perform muscle contractions and body movements in order to improve the overall function of individuals. Additionally, they aim at helping patients to find out the real necessity of exercises in their daily routine. This includes exercise positive and progressive performance as well as adjustment in terms of the type and amount of appropriate forces applied to the body system, aiming at treating the deficiency by improving musculoskeletal function and maintaining well-being.[9]

Exercises used for the treatment of muscular TMD are intended to reduce pain, improve coordination of masticatory muscles, reduce muscle spasm and hyperactivity, restore the original muscle length, strengthen the muscles involved, and promote tissue repair and regeneration.[6,9,16–20]

TYPES OF EXERCISES

Stretching and relaxation

This type of exercise aims to decrease tension of the muscle fibers.[10] It can be performed passively, when there is help for achieving the desired movement, or in an active way, when the movement is performed without any assistance.[18] These exercises are recommended when motion range is limited and pain is present.[1,18,19,21] The elevator jaw muscles are stretched when the jaw moves downwards (opening the mouth).[8,9] This is considered an isotonic exercise because it presents dynamic muscle work, with rhythmic alternation between contraction and relaxation.[22]

Muscles can also be stretched by means of the reciprocal inhibition technique in which opposing mus-

© 2013 Dental Press Journal of Orthodontics

cles are contracted isometrically (counter-resistance force), actively assisting the movement of stretching and consequent relaxation of the muscle.[12,23]

The contraction-relaxation technique, also used to stretch shortened muscle fibers, is the contraction of a strained muscle followed by its relaxation, which allows passive stretching of this muscle.[16,23]

One of the exercises frequently used to promote relaxation and stretching of the elevator jaw muscles involves opening and closing the mouth slowly, with the apex of the tongue positioned on the lingual surface of the maxillary incisors (pronunciation of the letter "N").[10] Pronouncing the letter "N" several times a day and keeping the tongue in this position, with lips closed, also promotes muscular relaxation.[9,19]

This technique must be performed several times a day in order to assure its effectiveness.[10]

Coordination exercises

Elevation and depression movements of the jaw are performed bilaterally, symmetrically and with equal intensity. When this does not occur, it results in movement incoordination. Many times, besides causing limited range of motion and pain, TMD also causes incoordination of jaw movements, thus causing joint sounds.[21]

The therapy that promotes coordination of the muscles involved in the movements cited above includes exercises of opening and closing the mouth slowly in front of a mirror with a straight vertical line drawn, with the patient trying to keep the midline of the lower dental arch parallel to the mirror during the execution of movements.[8,17,24] This same exercise is also performed by placing right and left index fingers in the lateral pole region of the mandibular condyle, with the purpose of assisting movement coordination.[3,9] Twenty repetitions of this exercise, three times a day, are recommended.

Another way to promote coordination of masticatory muscles is to exercise a resisted isometric contraction of low intensity in the opposite direction of the movement performed.[25]

Strengthening and endurance exercises

Muscular strength is mainly achieved by isometric exercises, although it can also be obtained by isotonic (concentric and eccentric)[24] and isokinetic[22] exercises. Isometric exercises promote muscular contraction without the occurrence of adjacent joint movement, thus, it is considered a static muscle exercise.[22]

Isometric exercises for the masticatory muscles are performed by applying a counter-resistant force to the movement being performed.[16] Forcefully placing the chin on a closed hand during depression jaw movement (mouth opening), and hindering its elevation (closing) by pressing the inferior incisors with the index and middle fingers are considered muscular strengthening exercises that depress and elevate the jaw, respectively. In lateral jaw movements, the counter-resistance force is applied by means of pressing the lateral area of the mandibular body with the index and middle fingers, exerting a force opposite to the movement performed. These exercises should be repeated several times a day. An excessive counter-resistance force should not be applied, in which case reciprocal inhibition would occur,[25] causing loss of exercise function; that is, it would cease to be an exercise for strengthening and become an exercise for relaxation.

RESULTS

Results are shown in Table 1.

DISCUSSION

The model of chronic pain used to give insight into the etiology, maintenance, and management of TMD comprises a mixture of biological factors embedded in a matrix of psychological and psychosocial factors that produce a sensation of pain which is unique and specific to each individual. Therefore, no isolated factor contributes to the understanding of how clinicians decide on treatment options or how patients respond to long-term treatment,[7] which results in a variety of studies with very different outcomes.[10,13,18,19] Individuals who report pain and functional limitation, oral parafunctional habits, pain in other regions of the body and disease summarization present TMD of greater severity and longer duration.[26]

Prescription of exercises as the treatment of choice requires not only knowledge of the anatomy of the muscles with regard to their shape, type, function and location (fixed attachment and mobile attachment),

© 2013 Dental Press Journal of Orthodontics

but also knowledge of the biomechanics of the affected joint. With that in mind, it is possible to develop and prescribe an unlimited number of exercises.

Exercises for stretching and relaxation are prescribed as a first-choice therapy when painful symptomatology is present. Basically, they are aimed to decrease pain by means of increasing local circulation. They also work to improve flexibility and range of motion.[1,18,19,21] Coordination exercises improve joint muscle function, mobility and biomechanics, reestablishing synchronism of jaw movements. Such exercises comprise mouth-opening and mouth-closing isotonic exercises.[8,17,24] On the other hand, strengthening and endurance exercises hinder relapse of TMD and are performed through isometric exercises along with the application of a light counter-resistant force.

Table 1 - Studies concerning the achievement of therapeutic exercise in the treatment of muscular TMD classified by diagnostic criteria of RDC/TMD, combined with other therapeutic techniques or alone.

Year/author	Title	n	Treatment	Result (*)
Carlson et al[15] 2001	Physical self-regulation training for the management of temporomandibular disorders	44	G1 – oral appliance G2 – postural relaxation, diaphragmatic breathing, proprioceptive re-education	G2 was more effective than G1
Dworkin et al[7] 2002	A randomized clinical trial of a tailored comprehensive care treatment program for temporomandibular disorders	117	G1 – stretching, coordination exercise, medication, oral appliance G2 – stretching, postural relaxation, diaphragmatic breathing, cognitive-behavioral treatment	*Short term: G2 more effective. Long term: G1 = G2*
Nicolakis et al[24] 2002	Effectiveness of exercise therapy in patients with myofascial pain dysfunction syndrome	20	Massage, stretching, isometric exercises, coordination exercise, mobilization, postural correction, breathing with relaxation	Effective
De Laat et al[5] 2003	Counseling and physical therapy as treatment for myofascial pain of the masticatory system	26	G1 – counseling + G2 G2 – massage and stretching	G1 and G2 were effective
Michelotti et al[8] 2004	The additional value of a home physical therapy regimen versus patient education only for the treatment of myofascial pain of the jaw muscles: Short-term results of a randomized clinical trial	70	G1 – counseling. G2 – relaxation, massage, stretching, coordination exercises, diaphragmatic breathing	G2 was more effective than G1
Truelove et al[14] 2006	The efficacy of traditional, low-cost and non splint therapies for temporomandibular disorder: A randomized controlled trial	200	G1 – relaxation, passive stretching G2 – G1 + rigid oral appliance G3 – G1 + soft oral appliance	Results: Similar and effective G1 = G2 = G3
Mulet et al[20] 2007	A randomized clinical trial assessing the efficacy of adding 6x6 exercises to self-care for the treatment of masticatory myofascial pain	45	G1 – counseling, relaxation and stretching G2 – G1 + 6X6 exercise from Rocabado	Results: Similar and effective G1 = G2

* It was assessed the effectiveness regarding the decrease of pain and increase of mandibular movement amplitude.

© 2013 Dental Press Journal of Orthodontics

It should be noted that therapeutic exercises have been classified into different types for didactic purposes, only. Additionally, exercises are designed for groups of muscles, not for single muscles or isolated situations. For example, the contraction of a muscle group automatically causes its antagonists to stretch and vice versa.

Patient's awareness is also of great importance to achieve treatment success. Training the patient on how to do the exercises and checking if they have been performed correctly are measures that should be taken in order to reduce patient's errors and increase the likelihood of managing the TMD.[9]

Patients with breathing problems frequently report depression, fatigue and sleep disorders. As a consequence, they present alterations in pain sensitivity.[15] Primary and accessory respiratory muscles usually contribute to craniofacial pain and associated symptoms in the cervical region. Therefore, they influence head posture.[27]

Some authors have considered body posture to be important in the diagnosis and prognosis of TMD,[19,24] since postural exercises are also recommended to restore or optimize alignment of the craniomandibular system.[18]

Researches addressing the use of exercises to manage muscular DTM present some limitations which must be highlighted. Terms such as manual therapy, mobilization, manipulation and therapeutic exercises are too generic and may involve different forms of movement. Therefore, a detailed description of the techniques used is very important not only to allow study reproducibility, but also to confirm its results.[18,28] Such description should include frequency, number of repetitions, intensity of performance, treatment period and manner of conducting the exercises. Moreover, the prescribed exercises are usually performed in conjunction with other therapies, making it difficult to verify the real effectiveness of the proposed exercise. Additionally, most studies do not have a control group, which leads one to question whether the exercise was really effective or if there was clinical relapse due to the natural course of the disease.[8] Furthermore, several studies present a major flaw in terms of defining which subgroup of TMD was treated, thus, raising doubts about the effectiveness of the treatment prescribed.[17] Likewise, the limited number of samples studied is not enough to yield significant conclusions regarding the recommended treatment, besides being usually based on empirical findings.[3] However, since the majority of the exercise techniques used is based on clinical experience, one of the major limitations is the lack of randomized clinical trials based on standardized research criteria.[29]

The results of the present study demonstrate that the success of therapies that recommend the use of exercises in the treatment of muscular TMD is directly related to a correct diagnosis.

Additionally, although therapeutic exercises present a promising future in the control of TMD, further randomized studies should be carried out in order to provide more knowledge on how to prescribe such exercises (duration, frequency, etc.) and to access their actual efficacy in the different subtypes of TMD.

© 2013 Dental Press Journal of Orthodontics

REFERENCES

1. De Leeuw R, editor. Orofacial pain: Guidelines for assessment, Diagnosis, and management. 4th ed. Chicago: Quintessence; 2008. p. 129-58.
2. Sessle BJ, Lavigne GJ, Lund JP, Dubner R, editors. Orofacial pain: from basic science to clinical management. 2nd ed. Chicago: Quintessence; 2008. p. 179-85.
3. Carlsson GE, Magnusson T, Guimarães AS. Tratamento das disfunções temporomandibulares na clínica odontológica. São Paulo: Quintessence; 2006. p. 9-23.
4. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord. 1992;6(4):301-55.
5. De Laat A, Stappaerts K, Papy S. Counseling and physical therapy as treatment for myofascial pain of masticatory system. J Orofac Pain. 2003;17(1):42-9.
6. Greene CS. The etiology of temporomandibular disorders: Implications for treatment. J Orofac Pain. 2001;15(2):93-116.
7. Dworkin SF, Turner JA, Mancl L, Wilson L, Massoth D, Huggins KH, et al. A randomized clinical trial of a tailored comprehensive care treatment program for temporomandibular disorder. J Orofac Pain. 2002;16(4):259-76.
8. Michelotti A, Steenks MH, Farella M, Parisini F, Cimino R, Martina R. The additional value of a home physical therapy regimen versus patient education only for the treatment of myofascial pain of the jaw muscles: short-term results of a randomized clinical Trial. J Orofac Pain. 2004;18(2):114-25.
9. Michelotti A, De Wijer A, Steenks M, Farella M. Home exercises regimes for the management of non-specific temporomandibular disorders. J Oral Rehabil. 2005;32(11):779-85.
10. Clark GT. Classification, causation and treatment of masticatory myogenous pain and dysfunction. Oral Maxillofac Surg Clin North Am. 2008;20:145-57.
11. Fricton JR, Ouyang W, Nixdorf DR, Schiffman EL, Velly AM, Look JO. Critical appraisal of methods used in randomized controlled trials of treatment for temporomandibular disorders. J Orofac Pain. 2010;24(2):139-51.
12. Magnusson T, Syrén M. Therapeutic jaw exercises and interocclusal appliance therapy. Swed Dent J. 1999;23(1):27-37.
13. Medlicott MS, Harris SR. A systematic review of the effectiveness of exercise, manual therapy, electrotherapy, relaxation training, and biofeedback in the management of temporomandibular disorder. Phys Ther. 2006;86(7):955-73.
14. Truelove E, Huggins KH, Mancl L, Dworkin SF. The efficacy of traditional, low-cost and nonsplint therapies for temporomandibular disorder: a randomized controlled trial. J Am Dent Assoc. 2006;137(8):1099-107.
15. Carlson CR, Bertrand PM, Ehrlich AD, Maxwell AW, Burton RG. Physical self-regulation training for the management of temporomandibular disorders. J Orofac Pain. 2001;15(1):47-55.
16. Quinn JH. Mandibular exercises to control bruxism and deviation problems. J Craniomandibular Pract. 1995;13(1):30-4.
17. Nicolakis P, Erdogmus B, Kopf A, Djaber-Ansari A, Piehslinger E, Fialka-Moser V. Exercise therapy for craniomandibular disorders. Arch Phys Med Rehabil. 2000;81:1137-42.
18. McNeely ML, Armijo Olivo S, Magee DJ. A systematic review of the effectiveness of physical therapy interventions for temporomandibular disorders. Phys Ther. 2006;86(5):710-25.
19. Fricton J. Myogenous temporomandibular disorders: diagnostic and management considerations. Dent Clin North Am. 2007;51(1):61-83.
20. Mulet M, Decker KL, Look JO, Lenton PA, Schiffman EL. A randomized clinical trial assessing the efficacy of adding 6X6 exercises to self-care for the treatment of masticatory myofascial pain. J Orofac Pain. 2007;21(4):318-28.
21. Marbach JJ. Temporomandibular pain and dysfunction syndrome. History, physical examination,and treatment. Rheum Dis Clin North Am. 1996;22(3):477-98.
22. Biasoli MC. Tratamento fisioterápico na terceira idade. Rev Bras Med. 2007;64(11 n. esp):62-8.
23. Simons DG, Travell JG, Simons LS. Dor e disfunção miofascial. Manual dos pontos de gatilho, volume I – Parte superior do corpo. 2ª ed. São Paulo: Artmed; 2005. p. 91-152.
24. Nicolakis P, Erdogmus B, Kopf A, Nicolakis M, Piehslinger E, Fialka-Moser V. Effectiveness of exercise therapy in patients with myofascial pain dysfunction syndrome. J Oral Rehabil. 2002;29(4):362-8.
25. Santiesteban J. Isometric exercises and a simple appliance for temporomandibular joint disfunction: a case Report. Phys Ther. 1989;69(6):463-6.
26. Van Selms MKA, Lobbezoo F, Naeije M. Time courses of myofascial temporomandibular disorder complaints during a 12-month follow-up period. J Orofac Pain. 2009;23(4):345-52.
27. Hruska RJ. Influences of dysfunctional respiratory mechanics on orofacial pain. Dent Clin North Am. 1997;41(2):211-21.
28. Maluf AS, Moreno BGD, Alfredo PP, Marques AP, Rodrigues G. Exercícios terapêuticos nas desordens temporomandibulares uma revisão da literatura. Fisioter Pesq. 2008;15(4):408-15.
29. La Touche R, Fernandez-de-las-Penas C, Fernandez-Carnero J, Escalante K, Angulo-diaz-parreno S, Paris-Alemany A, et al. The effects of manual therapy and exercise directed at the cervical spine on pain and pressure pain sensitivity in patients with myofascial temporomandibular disorders. J Oral Rehabil. 2009;36(9):644-52.

© 2013 Dental Press Journal of Orthodontics

Compensatory orthodontic treatment of Angle Class II malocclusion with posterior open bite

José Newton Torres[1]

The present case report addresses the treatment of an Angle Class II malocclusion in an adult female patient, long face pattern, with posterior open bite and dental arches extremely expanded, due to previous treatment. The patient and parents rejection to a treatment with orthognathic surgery led to orthodontic camouflage of the skeletal discrepancies. This clinical case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) as one of the requirements to become a BBO Diplomate.

Keywords: Angle Class II. Anterior open bite. Orthodontic camouflage.

INTRODUCTION

Female patient searched for treatment at the age of 18.7 months, with the chief complaint that, after 7 years with removable appliances, she was not satisfied with the final result and was not able to "chew food with posterior teeth", swallowing the food in big pieces. There was no relevant data in her medical history.

DIAGNOSIS

The patient presented a Class II skeletal pattern, characterized by mandibular deficiency, with ANB = 6° (SNA = 82° and SNB = 76°) (Tab 1). The profile was convex, with obtuse nasolabial angle, nasal apex slightly to the right, long face pattern, absence of passive lip sealing, increased lower facial third and short neck-chin line (Fig 1). The intraoral exam detected an Angle Class II, division 1 malocclusion, expanded and asymmetric upper and lower arches, 6-mm overjet, posterior open bite, only with second molar occlusal contact and excessive wearing on the upper and lower molar cusps, due to an attempt of occlusal adjustment (Figs 1 and 2). The upper and lower incisors were protruded and with buccal tipping, with apical rounding of the upper incisor roots (Figs 3 to 5).

[1] Specialist in Orthodontics and Facial Orthopedics by the ACD/Campinas. Director of the Brazilian Association of Orthodontics and Facial Orthopedics (ABOR) and BBO Diplomate.

How to cite this article: Torres JN. Compensatory orthodontic treatment of Angle Class II malocclusion with posterior open bite. Dental Press J Orthod. 2013 Sept-Oct;18(5):140-6.

» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

Contact address: José Newton Torres
SCN Qd 2, bloco D, entrada A, sala 911 – Brasília / DF – Brazil
CEP: 70.712-903 – Email: torres.jn@terra.com.br

© 2013 Dental Press Journal of Orthodontics

Figure 1 - Initial facial and intraoral photographs.

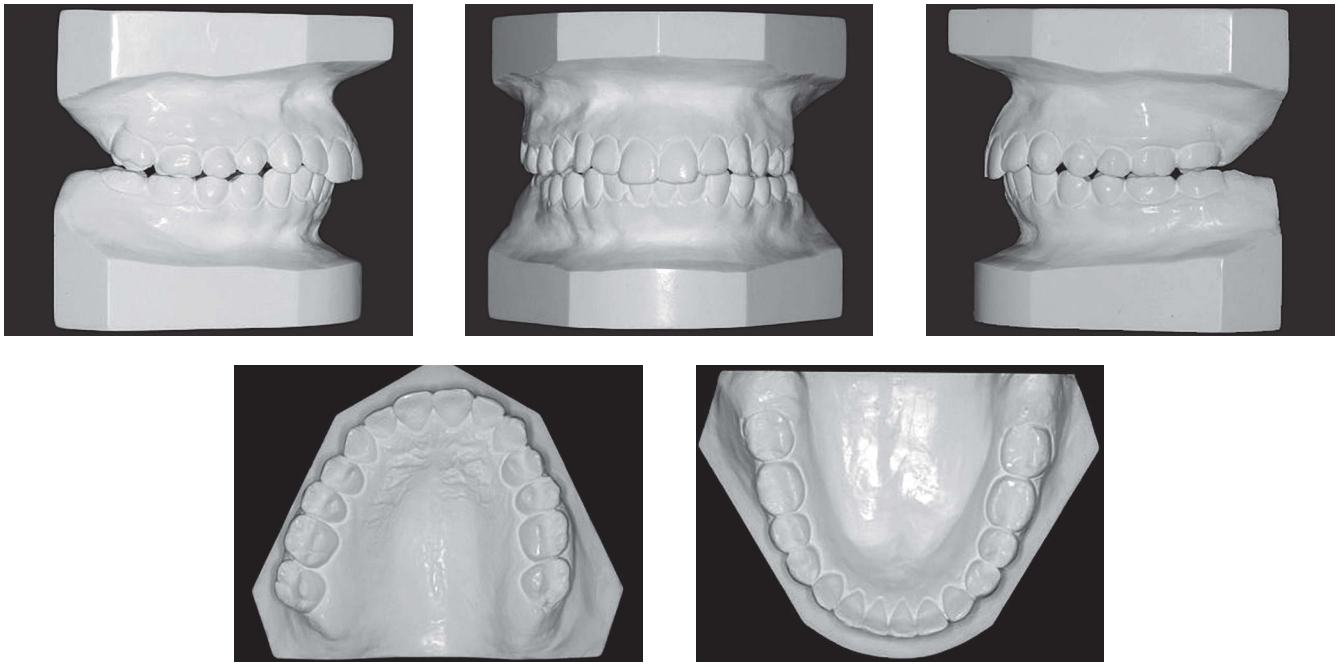


Figure 2 - Initial dental casts.

© 2013 Dental Press Journal of Orthodontics

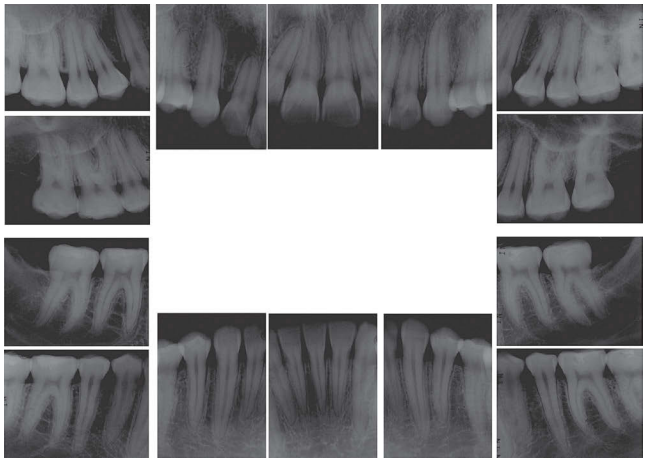


Figure 3 - Initial periapical radiographs.

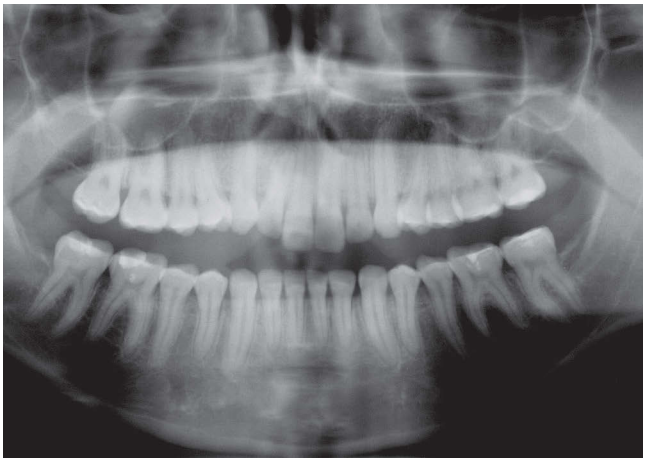


Figure 4 - Initial panoramic radiographs.

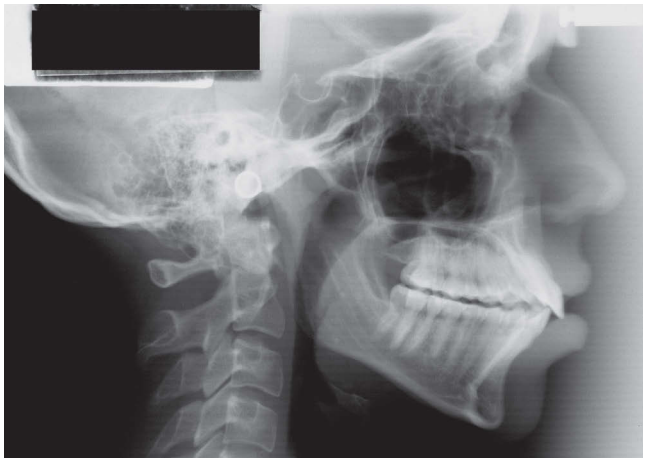


Figure 5 - Initial lateral cephalometric radiographs.

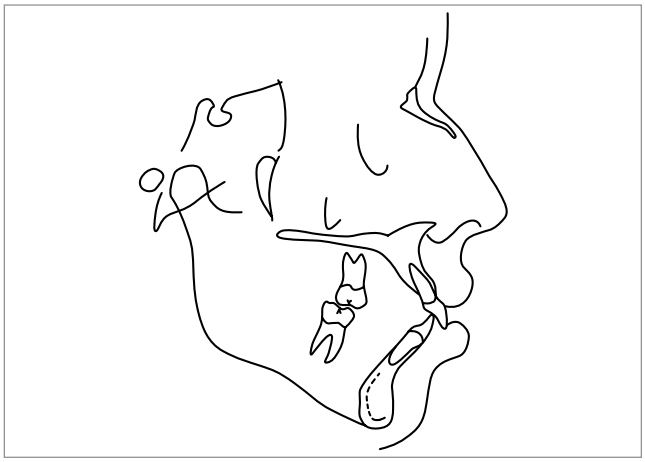


Figure 6 - Initial cephalometric tracing.

TREATMENT PLAN

The first treatment plan option presented to the parents and the patient was the surgical-orthodontic combined treatment, which was immediately refused. Thus, an alternative with orthodontic camouflage was presented, which consisted on the use of upper and lower fixed orthodontic appliances, and four premolars extraction. The spaces after extraction would be, then, used to correct the molar and canine relationships, and also the overjet, allowing occlusion of the anterior teeth. Contraction of the upper arch would be performed with the use of a removable palatal bar, with contracted archwires for both upper and lower dental arches. For finishing and intercus-

© 2013 Dental Press Journal of Orthodontics

pation braided archwires and intermaxillary elastics (5/16-in) would be used. The retention planned was a wraparound removable upper plate, and lingual canine-to-canine fixed retainer.

Thus, the treatment objectives were to reduce the SNA angle, by retracting the upper incisors, maintaining the maxilla and mandible in their vertical position, contracting upper and lower dental arches, correcting molar and canine relationship, the open bite, overbite and overjet, improving facial profile, if possible.

TREATMENT PROGRESS

The maxillary and mandibular first and second molars were banded and the other teeth were bonded. Straight-wire brackets (0.022-in x 0.028-in), Roth's prescription, were used. A contracted palatal bar was placed in the upper first molars and the extraction of upper first premolars was requested, followed by the extraction of lower second premolars. Alignment and leveling was started after extracting these teeth with 0.014-in, 0.016-in, 0.018-in NiTi archwires; in addition, Australian 0.020-in wire, 0.017 X 0.025-in NiTi and 0.019 X 0.025-in stainless steel (SS) archwires were used. Then, space closure was performed with the aid of 0.019 X 0.025-in SS archwires with prevalence of upper anterior teeth retraction, and anchorage loss of lower posterior teeth. After a few appointments, difficulty in moving teeth of the lower right side was observed. Thus, mini-implants placement in this region was performed for skeletal anchorage, until the total closure of spaces.

Intercuspation was performed as planned, using 0.021 X 0.025-in braided archwires and 5/16-in intermaxillary elastics (150 gf).

RESULTS

There was maintenance of the vertical position in both arches, with slight reduction of the SNA angle, which led to a reduction of the ANB angle (Table 1). The relationship for molars and canines in key of occlusion was obtained on both sides, closing of the posterior open bite, correction of overjet and contraction of upper and lower arches were also achieved (Figs 7 and 8). A decrease in upper and lower intermolar distance of 10 mm and 11 mm, respectively, was observed, as well as a decrease of upper and lower intercanine distance of 3 mm in both arches. A slight increase of the nasolabial angle was observed, due to the retrusion of anterior upper teeth, with little alteration of the facial profile, keeping the absence of passive lip sealing, and hyperactive mentalis muscle.

A good root parallelism was obtained at the end of treatment, as observed in the panoramic radiograph (Fig 9). Periapical radiographs showed slight increase in the apical root remodeling of incisors (Fig 10).

On cephalometric superimpositions extrusion of first upper molar was observed, which was compensated by the mesial movement of the lower molar (Figs 13 and 14), contributing for the maintenance of the mandibular plane angle. The great reduction of the intermolar distance obtained was possible due to the mesial movement of these teeth, which came to occupy a narrower region on the basal bones. For retention a canine-to-canine fixed retainer was used on the lower arch, and a wraparound removable plate on the upper dental arch.

FINAL CONSIDERATIONS

Class II skeletal discrepancy, with an increased facial lower third, can be corrected by redirecting growth in young patients, or through orthognathic surgery, in adult patients.[1] In both cases, it is possible to perform orthodontic camouflage when growth was not adequate or when the patient does not accept combined surgical-orthodontic treatment.[2,3]

In the present case, premolar extractions provided the space needed for the correction of upper incisor inclination, contraction of both arches and the mesial movement of lower molars. These changes favored the open bite closure in the posterior region, the correction of Class II relationship and overjet reduction.

© 2013 Dental Press Journal of Orthodontics

Figure 7 - Final facial and intraoral photographs.

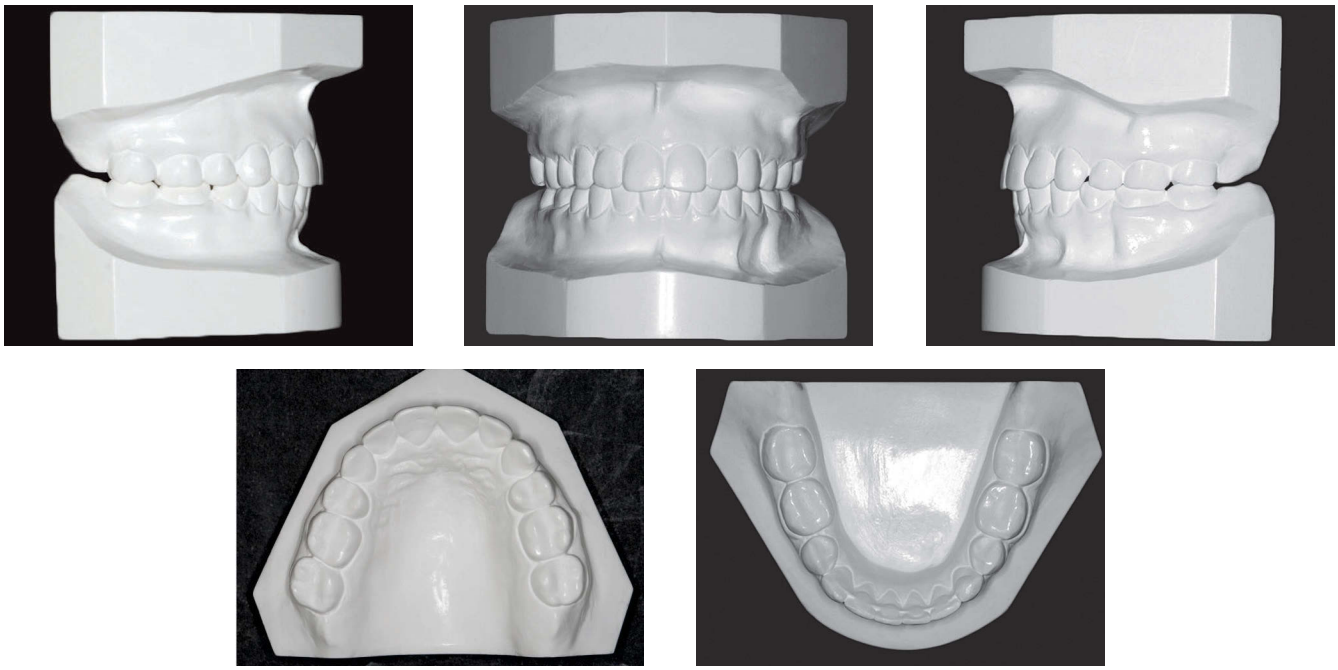


Figure 8 - Final dental casts.

Figure 9 - Final panoramic radiograph.

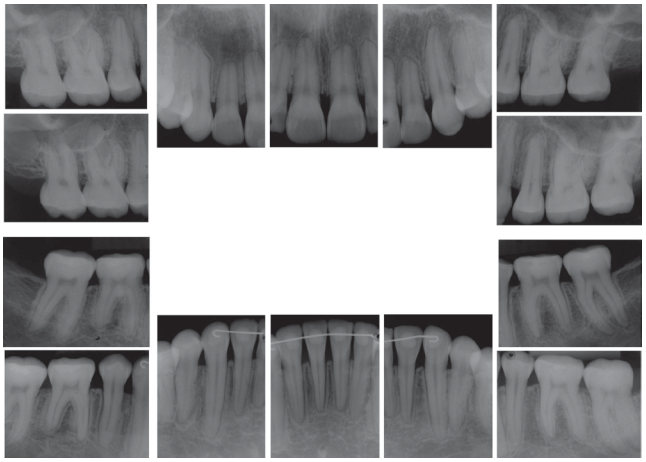


Figure 10 - Final periapical radiographs.

Figure 11 - Final lateral cephalometric radiograph.

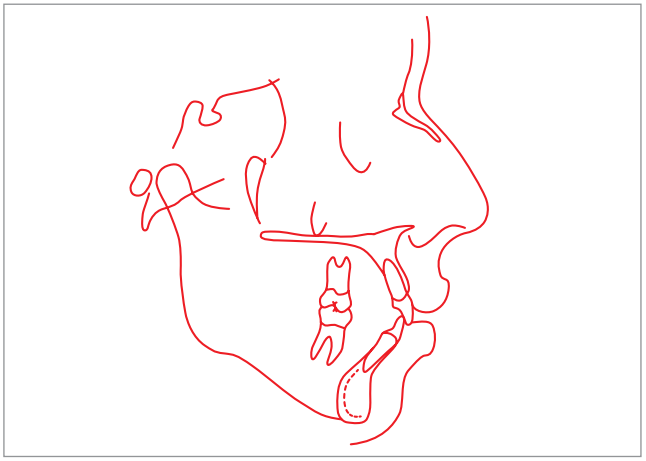


Figure 12 - Final cephalometric tracing.

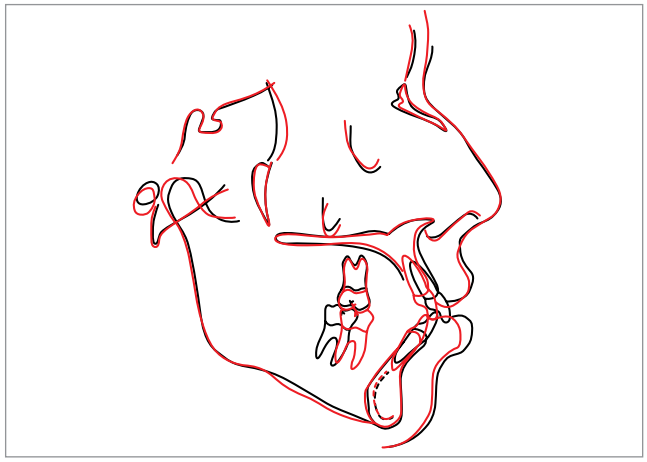


Figure 13 - Superimposition of initial (black) and final (red) cephalometric tracings, with register on SN.

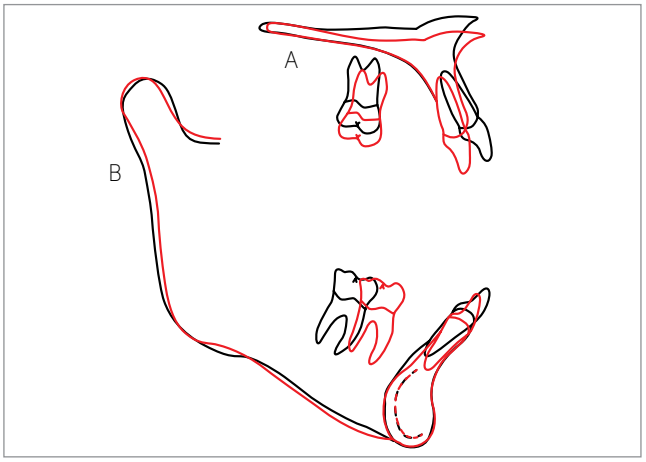


Figure 14 - Partial superimposition of maxilla (**A**) and mandible (**B**), evidencing tooth movement.

© 2013 Dental Press Journal of Orthodontics

Table 1 - Initial and final cephalometric values.

	Measures		Normal	Initial	Final	A/B diff.
Skeletal pattern	SNA	(Steiner)	82°	82°	81°	1
	SNB	(Steiner)	80°	76°	77°	1
	ANB	(Steiner)	2°	6°	4°	2
	Facial angle	(Downs)	0°	10°	7°	3
	Y axis	(Downs)	59°	60°	63°	3
	Facial angle	(Downs)	87°	87°	85°	2
	SN-GoGn	(Steiner)	32°	36°	36°	0
	FMA	(Tweed)	25°	27°	29°	2
Dental pattern	IMPA	(Tweed)	90°	105°	99°	6
	$\underline{1}$.NA (degrees)	(Steiner)	22°	28°	20°	8
	$\underline{1}$-NA (mm)	(Steiner)	4 mm	10 mm	8 mm	2
	$\overline{1}$.NB (degrees)	(Steiner)	25°	36°	31°	5
	$\overline{1}$-NB (mm)	(Steiner)	4 mm	14 mm	11 mm	3
	$\frac{1}{1}$ - Interincisal angle	(Downs)	130°	108°	125°	17
	$\overline{1}$-APo (mm)	(Ricketts)	1 mm	9 mm	7 mm	2
Profile	Upper lip – S line	(Steiner)	0 mm	2 mm	1 mm	1
	Lower lip – S line	(Steiner)	0 mm	7 mm	4 mm	3

REFERENCES

1. Tulloch JF, Lenz BE, Phillips C. Surgical versus orthodontic correction for Class II patients: Age and severity in treatment planning and treatment outcome. Semin Orthod. 1999;5(4):231-40.
2. Bishara SE, Cummins DM, Jakobsen JR, Zaher AR. Dentofacial and soft tissue changes in Class II, division 1 cases treated with and without extractions. Am J Orthod Dentofacial Orthop. 1995;107(1):28-37.
3. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 4th ed. St. Louis: Mosby Elsevier; 2007.

© 2013 Dental Press Journal of Orthodontics

Finishing procedures in Orthodontics: dental dimensions and proportions (microesthetics)

Roberto Carlos Bodart Brandão[1], Larissa Bustamente Capucho Brandão[2]

Objective: The objective of the present article is to describe procedures that can be performed to achieve excellence in orthodontic treatment finishing. The content is limited to microesthetics, which comprises the concept of ideal dental dimensions and proportions (white esthetics) and its correlation with the periodontium (pink esthetics). Standards of normality are described both in their real dimensions (dental height and width), and in those effectively perceived by the observer, the virtual dimensions.

Methods: The best scientific evidence was sought in the literature to support the clinical procedures that must guide the professional to obtain maximum esthetic quality on their treatments. Therefore, it is necessary to investigate what the other specialties in Dentistry expect from Orthodontics and, specially, what they have to offer. Clinical cases will be used to illustrate the dental movement that might maximize treatment outcome and to confront the ideal standards with the current state of the art.

Conclusion: Treatment quality is directly related to the amount of procedures implemented by the orthodontist, associated with concepts and resources from Periodontics and Dental Prosthesis. Microesthetics cannot be seen in isolation, but rather as the key to establish a pleasant smile (miniesthetics) in addition to a harmonious face (macroesthetics) and a human being with high self-esteem (hyper-esthetics).

Keywords: Orthodontics. Dentistry. Dental esthetics. Smile.

How to cite this article: Brandão RCB, Brandão LBC. Finishing procedures in Orthodontics: dental dimensions and proportions (microesthetics). Dental Press J Orthod. 2013 Sept-Oct;18(5):147-74.

Submitted: August 05, 2013 - **Revised and accepted:** August 30, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

[1] Adjunct professor of Orthodontics, Federal University of Espírito Santo (UFES).
[2] Specialist in Orthodontics, Fluminense Federal University (UFF).

Contact address: Roberto Carlos Bodart Brandão
Av. Américo Buaiz, 501/1007 – Torre Norte – Enseada do Suá
CEP: 29.050-911 – Vitória/ES — Brazil
E-mail: consultorio@ortobrandao.com.br

© 2013 Dental Press Journal of Orthodontics

INTRODUCTION

The subject of orthodontic finishing is instigating and extensive. After all, it is all about achieving the objectives of orthodontic treatment, seeking excellence of results, justifying the patient's financial investment and, consequently, prior professional referral, so that new treatments can be initiated. Adequately finishing the cases means investing in professional longevity, remaining in our work place with approval of the society — colleagues and patients, in an increasingly competitive market, as a private pension in its true meaning, which is: to prepare the future.

For being quite a large subject, orthodontic treatment finishing must be discussed in four different and, at the same time, complementary, topics:

1) Fundamental principles.
2) Esthetic orthodontic procedures.
3) Transdisciplinary approaches.
4) Occlusal adjustment.

We began to discuss orthodontic finishing in a reverse order when the article *Occlusal adjust in Orthodontics: why, when and how* was published.[8] This reverse order was purposeful. If the orthodontist intends to perform a quick and stable treatment, he must begin backwards, i.e., establish the best molar intercuspation as soon as possible, then premolars, enabling the perfect canine occlusion. Thus, a stable and reproducible occlusion, with no premature contacts, is established first. This is the foundation for the success in orthodontic finishing; the esthetic procedures will only be complete and durable if there is stability in dental occlusion.[8]

We also had the opportunity to approach the fundamental principles that guide orthodontic finishing in an interview,[9] in which it was asserted that finishing begins even before the appliance is placed, paradoxical as it may seem. Most often, we are concerned about the finishing phase during the last months of orthodontic treatment, specially when the rectangular arches are placed. When this occurs, there is a waste of time and opportunities that could shorten and optimize orthodontic finishing. A solid planning and an individualized appliance placement define a better finishing. And it is worth remembering that treatment onset is when there is greater patient collaboration. When this collaboration is demanded at the final moments of treatment, what we have is a tired and, often, unmotivated patient.[9]

An interesting division of esthetics in Orthodontics is that presented by Sarver and Ackerman,[48] who divided it into three sections: 1) Microesthetics, which includes the dental aspect, considering the arrangement of teeth on the arches, their color, shape, dimensions and proportions; 2) Miniesthetics, which includes smile esthetics, how teeth are exposed and perceived in smile dynamics, specially its relation with the lips; 3) Macroesthetics, which refers to the face, its harmony and proportions, and the esthetic impact of the several structures in its composition (Fig 1).

In this article, the Microesthetics approach, specially the dental dimensions and proportions, with its variations, will be discussed within the topic *Esthetic orthodontic procedures*.

Figure 1 - Esthetical approaches according to Sarver and Ackerman[48]: **A**) Macroesthetics, seeks the harmony of facial structures; **B**) Miniesthetics, evaluated by the oral structures that comprise the smile; **C**) Microesthetics, related to the teeth and to the periodontium.

© 2013 Dental Press Journal of Orthodontics

ESTHETIC IMPACT OF DENTAL DIMENSIONS AND PROPORTIONS

The fact that the evaluation of facial beauty is essentially subjective cannot be forgotten. The artist Albrecht Dürer,[16] from the XVI century, wrote: " I don't know what beauty is, but I do know it affects many things in life", and considered that, although the concept of facial beauty is immersed in subjectivity, the evaluation of facial proportions could be objectively performed. The discussion is about how ideal patterns can be defined, within a theme that experiences important changes with the evolution of society.[44]

In a recent study, Orce-Romero et al.[45] investigated the common characteristics which influenced esthetical perception in different populations around the world. This study was based on the analysis of the smile of 500 celebrities exposed on Time magazine. They found that upper lip vertical height, smile width, upper central incisors exposure, dental symmetry and intra-dental proportions are the most influential factors in defining a smile as pleasant, corroborating the findings of other authors who found an evolution on the esthetical criteria of professionals and laypeople.[3,25,25,52] Four of these factors are characteristics related to microesthetics and, if well managed by the orthodontist and his team of colleagues of related specialties, are determinant to achieve the esthetical excellence of the smile.

It is important to note that there is a wide range of combinations of smile characteristics that make it more or less pleasant, specially when the entire face of the patient is included in the observation. Kokich Jr, Kiyak and Shapiro[35] observed that people, when seeing a smiling face, look first and for a longer period of time to other areas of the face before they look at the teeth. For this reason, microesthetics must be considered within a context: other variables related to the smile (miniesthetics) and to the face (macroesthetics) must be in harmony with the proportions and dimensions in the dental arches.

WIDTH AND HEIGHT OF CROWNS

There is a variation on dental dimensions that can be considered as normal or desirable, specially when considering that there are individuals with different facial patterns. Some works show that the dimensions of anterior teeth can be defined within a limited range. The height of the central incisor varies from 10.4 to 11.2 mm while its width varies from 8.73 to 9.3 mm, and, usually, these references are used in prosthetic reconstructions, when no other parameters are available.[37,54,55]

The most important is the correlation of these dimensions, i.e., the dental proportions.[4,20,50] Two proportions must be considered: the relation between height and width of each tooth, and the relation of height and width among the teeth. In these cases, we will always be referring to the real dimension of the teeth, i.e., the clinical crown dimensions of anterior teeth.

A classic study that investigated dental proportions was that by Gillen et al[20] who found the following proportions of width among the upper anterior teeth: a) lateral incisors have 78% of the width of the central incisor (lateral incisor = central incisor x 0.78); b) lateral incisor has 87% of the width of the canine (lateral incisor = canine x 0.87); c) canine has 90% of the width of the central incisor (canine = central incisor x 0.90), as shown in Figure 2.

The studies by Sterrett et al.[58] demonstrated that the relation between width and height of central and lateral incisors and canines is practically the same in both genders. Females tend to have slightly wider teeth in comparison to males, being: central incisors 86% and 85%, lateral incisors 79% and 76%, and canines 81% and 76%, respectively. The most recent research available found the proportion between height and width of upper anterior teeth ranging from 75 to 80% in central incisors, from 66 to 70% in lateral incisors, and from 80 to 85% in canines, without statistical difference between men and women.[45]

Most authors define the height/width ratio of 0.80 for the upper central incisor (which represents the key tooth to esthetical composition of the smile) as a standard to be used in Prosthesis, Periodontics and Orthodontics.[50,55,58] Therefore, on establishing ideal widths, based on intact teeth, it is suggested to use the proportion of 80 ± 5%

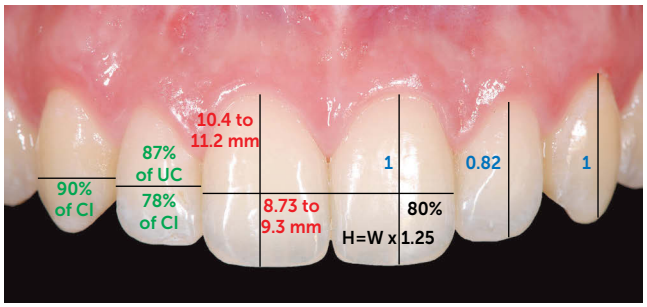


Figure 2 - Real proportions and dimensions of teeth with four approaches: variations on the dimensions of height and width of the central incisor (red), height/width proportion of the central incisor (black), relations of width between anterior teeth (green) and relations of height of anterior teeth (blue).

© 2013 Dental Press Journal of Orthodontics

to define the ideal height, relating it to the facial pattern and to the individual's natural dental proportions (Fig 2).

The relation of proportion between the crown heights of anterior teeth proposed by Gillen et al.[20] is widely used. It suggests that the height of the clinical crown of the upper lateral incisor must be 82% of the height of the crowns of the central incisor and canine. Therefore, canines and upper central incisors would have the same anatomical crown height. (Fig 2). This study was used to justify the bonding of orthodontic brackets at the same height for canines and upper central incisors, during placement of the orthodontic appliance.

In the decision making process, these proportions must be considered in two clinical situations. The first one is when interproximal wear is used to obtain space in the dental arch, or to close black spaces when the contact point is brought closer to the alveolar bone crest, which shall be discussed in a specific topic later on. The second situation in which the height x width relation is essential occurs when the patient has loss of dental volume, compromising the height of the crown, when there is incisal wear by attrition or abrasion, or compromising the width of the crown due to cavities or unsatisfactory restorations. The recovery of these proportions must be defined during treatment planning, and it would be a priority for the definition of transverse and vertical corrections of the dental arches.[30,57] When loss of dimensions of the upper anterior teeth is detected, the first treatment step must be to provide spaces for these dimensions to be restored within the ideal proportionality, using extractions, distalizations or maxillary expansions, even when surgical assistance is necessary (Fig 3).

Another practical way to use dental proportions to establish the width of anterior teeth is by fixed measures, based on averages of tooth size.[14] In this case, database of tooth sizes of different populations are used, which generates formulas for the dental widths to relate to each other, specially for anterior teeth. Figure 4 shows a proposal of a mathematical formula used to define the size of a tooth based on the size of other teeth. In this case, the letter Y represents the width of the upper central incisor and the letter X, the width of the lower central incisor.[14,15] The width of the upper lateral incisor would be the width of the upper central incisor minus 2 mm, and the width of the upper canine would be the width of the central minus 1 mm. Based on the width of the lower central incisor, the width of the upper central incisor would be defined by adding 3 mm, while the width of the lower central incisor would be defined by adding 0.5 mm, and the width of the lower canine by adding 1 mm.

Contrary to golden proportions and based on measures of dental dimensions and of harmonious proportions derived from observations on the population, as those previously described, Chu[14,15] developed an instrument to measure proportionality. This proportionality gauge (commercialized by Hu-Friedy®) does not need mathematical calculations and uses a formula that was predetermined by its creator, for dental proportions that are visually available in a color scale that must be considered by the professional. In other words, for each tooth width marked by the colors on the horizontal rod of the measurer, it would be necessary that the height of the crown were equivalent to the same color available on the vertical rod, this would define the best proportion (Fig 5).

CROWN VIRTUAL WIDTHS

Real width and height are data based on direct measurements carried out on the teeth (anthropometric measures), i.e., their absolute dimensions. It is recommended to consider the virtual dimensions which are, effectively, what is perceived by people – the esthetics that really matters.

The perception of dental dimension different from reality is a physical, better yet, optical phenomenon. When we take a shower with a green soap, we evidently do not become green, because there is no pigment in the soap, but rather an optical phenomenon, due to the arrangement of the crystals of the soap that reflect only part of the light spectrum, where the green color is. We only see what is reflected to our retina; the part of light that focuses an object and is deflected in another direction, or absorbed, escapes our visual perception. Therefore, the flat surfaces are completely perceived by the reflection of light that focuses in 90º on them — it is what we effectively clearly see, the virtual dimensions of the teeth. The shades represent the curved surfaces where the light is deviated in another direction, because it is deflected.[40]

The dimension of the virtual width of the teeth follows its position, the shape of the dental arch and the anatomy of each tooth. The central incisors, for being closer to the observer, at the front of the dental arch, are privileged by the parallax effect, attracting the perception of the human eye.[10] Starting with the concept of central incisor predominance, the perception of the other teeth in the anterior region begins to follow the golden proportion.

© 2013 Dental Press Journal of Orthodontics

Figure 3 - Orthodontic-surgical treatment of Class II division 1 malocclusion, with two surgical times. **A, B, C, D**) Transverse maxillary atresia, with narrow and disproportionate anterior teeth. **E**) Surgically assisted maxillary expansion with Hyrax, maintained for 8 months. **F**) Transpalatal bar with dental anchorage. **G**) Definition of spaces and bracket removal referring to Restorative Dentistry. **H**) Rebonding of brackets after restorations, under completion. **I**) Immediate result after Orthodontics. **J, K, L**) Results of occlusion after prosthodontics had been finished. **M, N**) Comparison of the smile, before and after. **O**) Lateral view of the final smile. **P, Q**) Repercussion on facial esthetics, before and after.

© 2013 Dental Press Journal of Orthodontics

Figure 4 - Formulas to achieve the best relation between the widths of anterior teeth, emphasized by Chu,[14,15] enabling definition of the width of a tooth based on the dimension of another. In the left hemiarch, example of application of the formulas of correlation between the dental widths.

Figure 5 - Class II division 1 patient, right subdivision with excessive overbite. **A, B, C**) Initial case, upper arch with atresia and asymmetric extrusion of anterior teeth. **D, E, F**) Dynaflex® appliance, for action similar to the Class II intermaxillary rubber bands. **G, H, I**) Correction of gingival contour, intruding the right upper central incisor. **J, K, L**) Immediate result after Orthodontics, central incisors with asymmetric dimensions. **M, N, O**) Verification of height and width proportions with Chu's gauge,[15] showing that the teeth should be dimensioned by the red marking, as the left central incisor.

© 2013 Dental Press Journal of Orthodontics

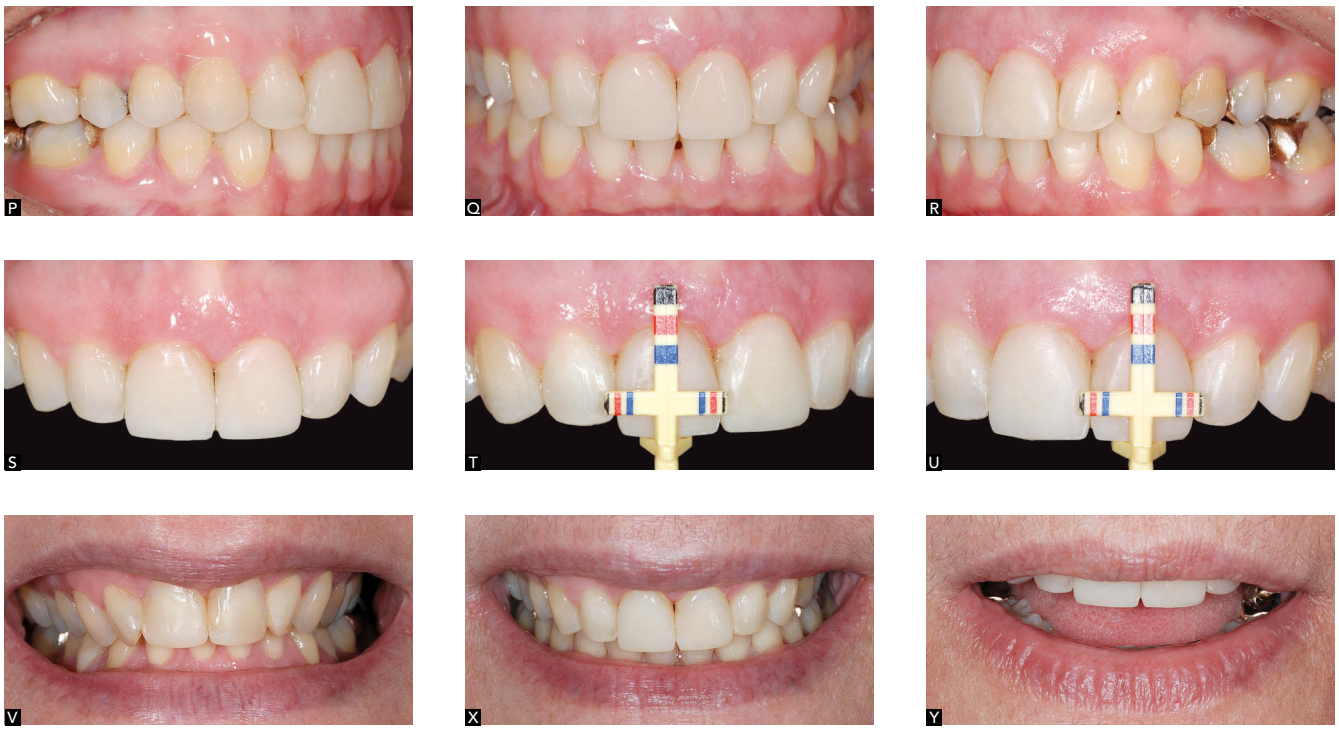


Figure 5 (continuation) - P, Q, R) Restorations in provisional resin, serving as mock-up for the patient to give his opinion and also guide the prosthodontist. S, T, U) Verification of the symmetry and proportions achieved. V) Smile before treatment, wide buccal corridor. X, Y) Smile and speech after Orthodontics and provisional restorations.

Also known as divine proportion, the golden proportion rises from an algebraic constant denoted by the greek letter ϕ (phi), with approximate value of 1.618, and it is used in arts, since Antiquity, by sculptors and painters. It defines the size proportion between structures or parts, directly related to harmony. This proportion was verified in human beings, related to the size of phalanges and to growth, and introduced in Dentistry by Lombardi,[36] when it began to be used as a parameter for the evaluation of smile amplitude measure and of the visible portion of the teeth. The distal reduction of the virtual width of the teeth must be similar to this constant. By this parameter, the lateral incisors must appear proportionally smaller (62%) in relation to the central incisors. Similarly, the proportion of canine appearance in relation to the lateral incisors must be 62% smaller and coincident with the appearance proportion of the premolar, and so on (Fig 6).

The upper central incisor and the canine have approximate real dimensions, but the virtual width of the canine, due to its convex anatomy and position on the dental arch curvature, represents only 33% of the virtual width of the central incisor. This tooth is privileged by its wide flat surface, reflecting most of the light that focuses on its clinical crown. A tool that is widely used by Dental Prosthesis is the generation of optical illusion, for example, when the central and lateral incisors have approximate sizes: the professional builds different anatomical contours on the restoration or on the porcelain crown, totally flat on the central incisor, increasing its virtual width, and with marked curvature on the distal face of the lateral incisor, hiding its real dimension.[2,12,19,37]

The possibility of working with optics, modifying the virtual width of the teeth, can be verified in two situations. The first one is related to the torque effects on the posterior teeth, and influences on the buccal

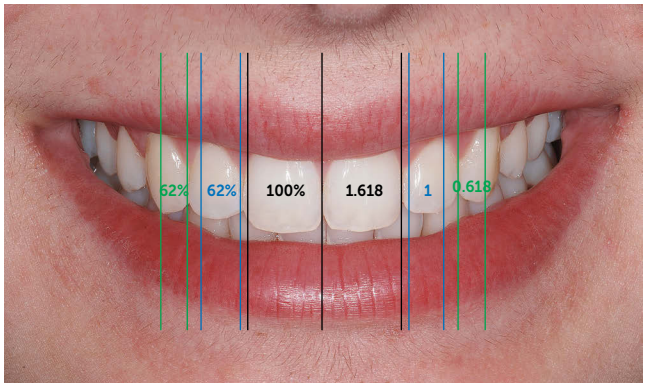


Figure 6 - Virtual width of the teeth, taking the golden proportion as parameter. There is a reduction in the perception of the size of teeth from the central incisors on due to the smaller flat area available to reflect light. The conformation of the arches, dental alignment and shape of the teeth define the amount of flat surface on which the light will focus and, thus, the beauty and naturality of the smile.

© 2013 Dental Press Journal of Orthodontics

corridor and on the smile amplitude. In expanded arches, due to the buccal torque of the crowns of posterior teeth, the teeth seem to be larger or in greater amount in the oral cavity.[8] On the other hand, in contracted arches, due to the excessive lingual torque of the crowns of posterior teeth, the teeth seem to be smaller, with little expression in the smile, and wide and dark buccal corridors. In these cases, the contraction or expansion of the dental arches, at the expense of coronary movement, and the definition of the correct implantation of teeth on their bone base may significantly change the esthetical perception of size and number of teeth in the smile. It is clear that the best buccal corridor and the best amplitude of the smile are established with adequate torques on canines and posterior teeth (Fig 7).[9,47]

The other way to work the virtual width to achieve the best esthetics is related to correct dental alignment, specially when the dental arch shape is respected, setting the teeth with well positioned contact points in the buccolingual direction, without rotations. Otherwise, mesially rotated teeth tend to expose more the clinical crown to the light, making the real width larger. This might generate the illusion of a lateral incisor or canine with dimensions that are larger than or equivalent to the central incisor. A distal rotation hides the buccal surface, creating the appearance of microdontia.

Figure 7 - Patient whose complaint was related to teeth with disproportionate sizes. **A, B, C**) Very wide buccal corridor due to transverse atresia of the dental arches, hiding the posterior teeth in the shade of the canines. **D, E, F**) Placement of teeth in the bone bases, with dentoalveolar expansion, resulting in normal buccal corridor and pleasant smile. **G, H**) Smiling face before and after Orthodontics and teeth bleaching. Note the aspect of larger teeth, now with proportional dimensions, with no need for restorations.

© 2013 Dental Press Journal of Orthodontics

In this case, when the professional is concerned about placing the teeth well implanted into the bone base, there is anatomical integrity and the contact points are correctly established, which automatically generates the best optical response to light propagation. The orthodontist must achieve the expression of what naturally occurs when a normal occlusion is exposed in different situations of speech and smile.[1,10,50] Figure 8 shows the behavior of light, considering the normality in dental alignment and in the arch shape, with maximum reflection of light in the anterior areas and a progressive increase of light deflection in the distal direction, which does not return to the observer's retina.

However, there are situations in which the professional might have to intervene in a different manner, specially when there are limitations for teeth positioning in the bone base, which is common in cases of transverse skeletal asymmetry. We oftentimes face asymmetric mandibular growth, which generates mandibular laterognathism, displacing the entire lower bone base to one side, a situation defined as prevalent in the population, according to Duthie et al.[17] Many times, this happens due to late expression of growth, a nightmare in orthodontic clinic that can lead cases that were under clinical control to orthognathic surgery. In less dramatic cases, asymmetry may be disguised, which compromises the ideal position of the teeth in the bone base. In these cases, the teeth in the upper arch have their crowns buccally tipped, following the mandibular laterognathism. At the same time, the teeth on the same side of the mandible are lingually tipped.[42] Specially in the upper arch, this buccal tipping is biologically recommended because of its thinner gingival tissue, specially in the upper canines and first premolars regions.[43] In the case of misaligned bone bases, should the ideal torques be established, the canine root would be moved against the thin buccal bone plate, significantly reducing the thickness of the periodontium and increasing the risk of periodontal recession. Even if not immediate, periodontal recession may occur in the long-term due to canine positioning and volume, since it is the tooth that is most susceptible to trauma caused by toothbrushing.[61]

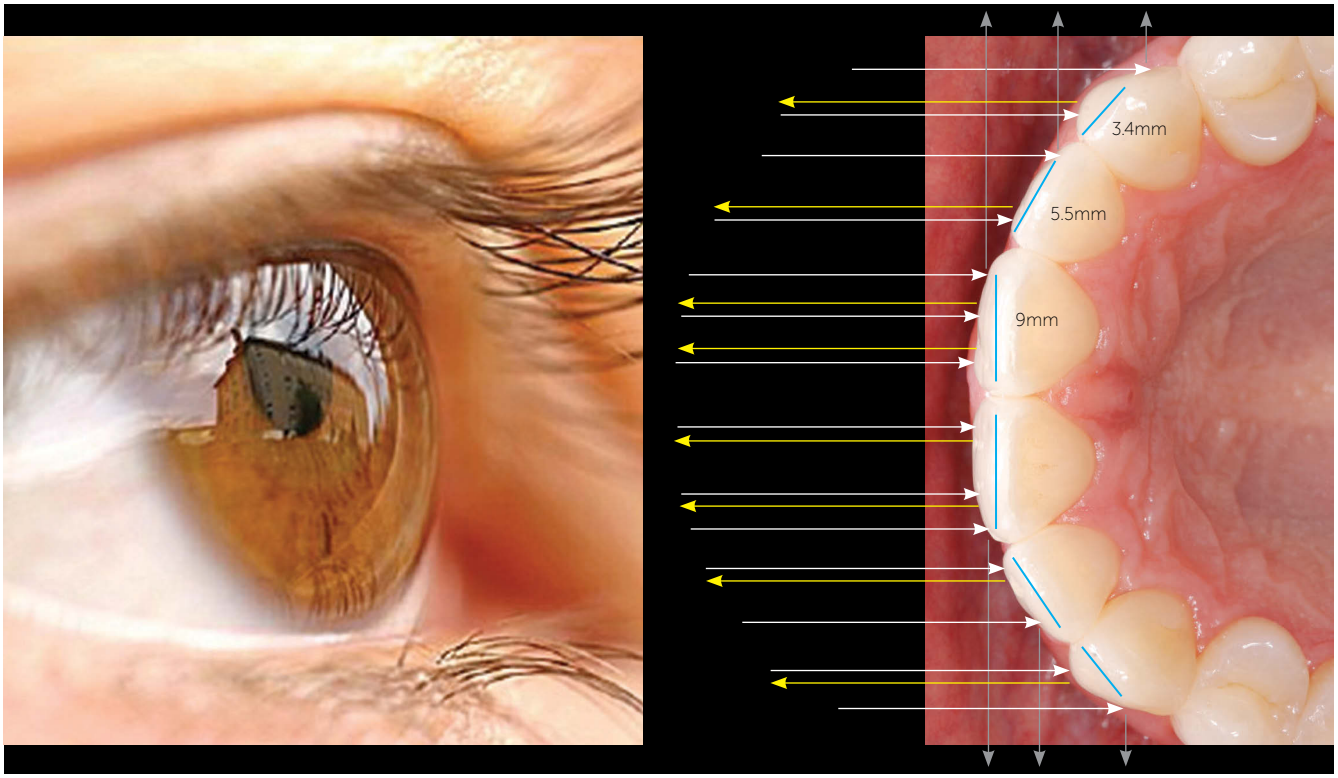


Figure 8 - Virtual width. Behavior of light focusing on anterior teeth (white arrows). Phenomenon that defines the virtual width, in which the central incisors, with larger flat area (blue line), reflect nearly all the light (yellow arrows); while on the canine, with a little more than ⅓ of the area that generates reflection of light, the deflection of light (gray arrows) predominates, which is explained by its position in the arch and convex anatomy.

© 2013 Dental Press Journal of Orthodontics

According to Karring et al[24] even in teeth not orthodontically moved, a periodontuim with no alveolar bone is often found, by dehiscence or fenestration; therefore, a solid periodontal evaluation is recommended before inserting thick rectangular wires.[8,9]

In order to reverse the esthetical impairment of a canine buccal crown torque, procedures that lead to optical illusion can be used, an esthetical disguise that is essential in cases of orthodontically compensated skeletal asymmetry (Fig 9). The base of the procedure is an ameloplasty that hides the distal part of the buccal surface of the buccally tipped canine. It is necessary to divide the buccal surface into two and wear out the distal part of the crown with finishing burs, accentuating the curvature in the crown anatomy until there is no reflection of light and it is in the shade, due to light deflection. After one half of the buccal

Figure 9 - Patient, whose mother had mandibular asymmetry, underwent orthodontic-surgical treatment. **A, B, C**) Transverse maxillary atresia, with crowding and deviation of the midlines. **D, E, F**) Orthodontic treatment with arch of midline correction. **G**) Tomographic slice, top view of the maxilla, showing minimum thickness of alveolar bone in the canine buccal surface. **H**) Final photograph of the treatment, with evident inappropriate torque of tooth #13, because buccal root movement was avoided due to periodontal risk. **I**) Ameloplasty on the distal half of the buccal surface of tooth #13, reducing reflection of light (arrows), with effect of optical illusion, reducing the virtual width of this tooth. **J, K, L**) Final result of the occlusion. Smile before (**M**) and after treatment (**N**), torque of tooth #13 was compensated. **O**) Smile after ameloplasty, virtually reducing tooth #13 due to the smaller flat area exposed to light.

© 2013 Dental Press Journal of Orthodontics

Figure 9 (continuation) - Smile before (**P**) and after treatment (**Q**). **R**) Tomography obtained after treatment, showing the different torques on the upper canines, adequate to mandibular asymmetry.

surface of the canine has been "hidden", polishing with abrasive rubbers is performed and the use of sodium fluoride at 0.05% is prescribed for daily mouthwash.

VIRTUAL HEIGHT OF CROWNS

A reasoning similar to the optical explanation that defines the virtual width must be applied to the virtual height. In other words, there is an alteration on the amount of light reflected over the patient's clinical crown, a difference between real and virtual height. (Fig 10) This difference is directly related to the torque of the upper anterior teeth that deflect most of the light emitted on the clinical crowns: upwards, when torque is excessive; or downwards, when the crowns are retroclined. A similar effect occurs when the occlusal plane is too posteriorly inclined or too flat.[53]

The correction or control of anterior teeth torques defines the success in obtaining the best expression of the dimensions of the dental crowns, when exposed to light.[47] Special attention must be given to torque control in cases in which there will be great retraction of anterior teeth, quite common in Class II division 1 patients, treated with upper first premolars extractions. Third order bend should be emphasized in the retraction arches or high torque brackets should be used at this stage.

Cephalometry is traditionally used for evaluation of torques in anterior teeth and, based on these data and on the treatment strategy, the orthodontic mechanics is defined, with greater or minor concerns over root control. As long as it is correctly obtained, the procedure of reading the light generated by the flash of the camera used for intraoral photograph is also employed. According to Masioli,[38] the correct position for frontal intraoral photograph is with the center of the photograph coinciding with the intersection of the mid sagittal plane with the occlusal plane. In order to obtain natural head position, the camera lens must be directed perpendicularly to the coronal plane of the patient's head and parallel to the Camper's plane whereas the focus must be established between the upper central incisor and the canine (Fig 11).

When the incisors present ideal torques, in natural head position, the flash is reflected to the maximum in the middle of the clinical crowns of these teeth. The flash cervically displaced indicates that the incisors have insufficient lingual root torque (Fig 12B), while the light displaced to the incisal edge indicates upper incisors with excessive lingual root torque. This perception and the routine of photographing the evolution of treatment, not only enhances professional learning, but avoids excessive exposure of the patient to radiation.

Considering this information, patients with Class II division 2 or Angle Class I malocclusion, who have labial musculature with accentuated tonus and usually present excessive overbite and retroclination of upper incisors, are specially esthetically benefited when the anterior teeth

© 2013 Dental Press Journal of Orthodontics

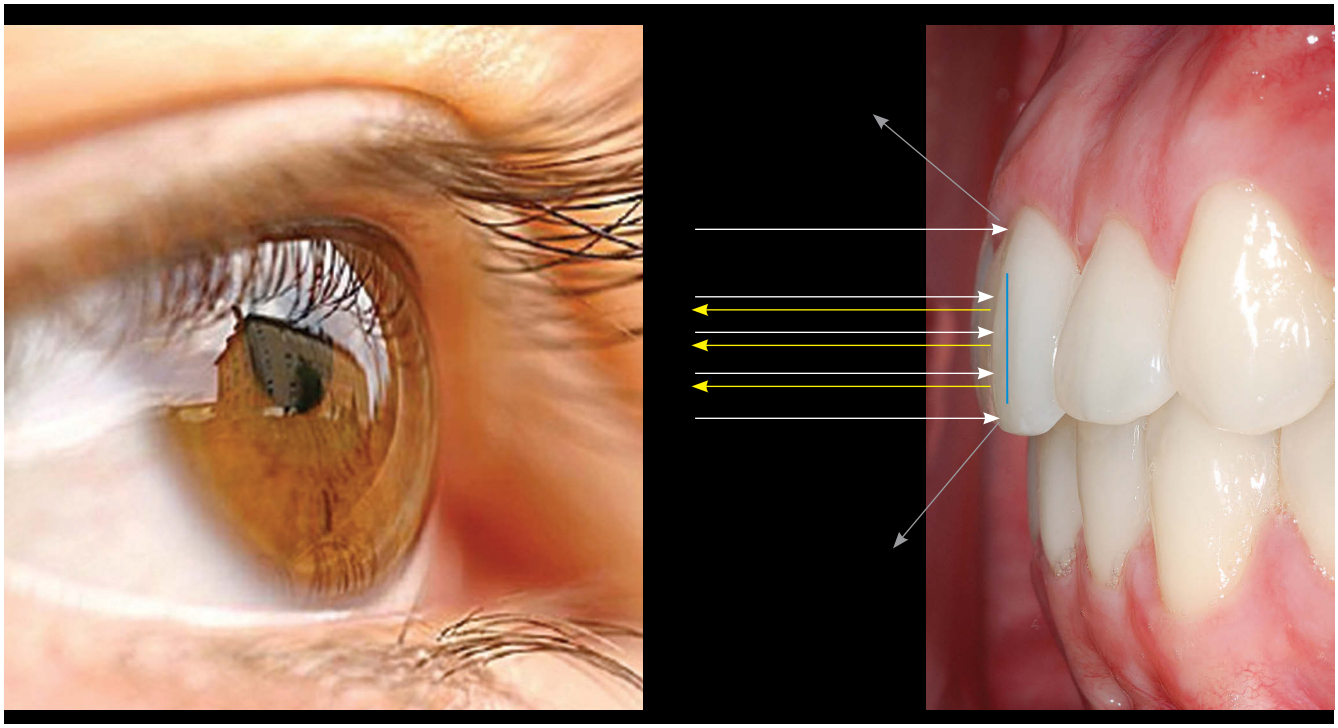


Figure 10 - Virtual height. Behavior of light focusing on anterior teeth (white arrows). Phenomenon that defines the virtual height: if the tooth is with adequate torque, the flat surface of the tooth is large and is at the center of the crown (blue line), reflecting most of the light that focuses (white and yellow arrows). The cervical and the incisal borders generate deflection of light (gray arrows).

are positioned at their correct tipping in the bone base. This finding can be seen in Figure 12 which reveals that during correction of malocclusion, significant improvements occurred in the torques of anterior teeth, which was easily perceived by the area in the crown where there was flash light reflected, migrating from the cervical to the middle of the upper incisor crowns.

Moreover, dental double protrusions are examples of how the appearance of the size of anterior teeth can be improved by orthodontic treatment. Figure 13 presents an adult female patient with excessive incisor proclination, but with a pleasant facial profile. In order to avoid extractions and, specially, the loss of lip support, it was decided to correct the excessive anterior teeth torques with the minimum retraction of these teeth. The patient was treated with controlled tipping, with movements lingually performed in the incisor crowns and maintenance of root apices in position. This way, all necessary spaces were obtained with generous interproximal wear on the posterior teeth, associated with temporary anchorage devices. Thus, an increase in the virtual height of these teeth was obtained with expanded reflection of light, since their buccal surfaces were buccally inclined, exposing a larger flat area of the clinical crowns to light, which is more pleasant and natural. [12,26,36]

Figure 11 - Frontal intraoral photograph. Note that the lens are directed towards the central incisors, perpendicular to the coronal plane of the patient's head. The lens must also be parallel to Camper's plane (tragus – wing of the nose), defined as the natural postural plane, different from the occlusal plane, which may vary with treatment and may influence the expression of dental torques.

© 2013 Dental Press Journal of Orthodontics

Figure 12 - Angle Class I malocclusion with cephalometric characteristics of Class II division 2, hypertonic musculature. **A, B, C**) Retroclined and crowded anterior teeth (note flash light "burst" on the cervical of the central incisors). **D, E, F**) Retraction of upper anterior teeth, with maximum torque control. **G, H, I**) Finished case, flash "burst" in the middle of the crown of central incisors, indicating ideal torques and occlusal plane parallel to Camper's plane. **J**) Smile before Orthodontics. **K, L**) Smile after Orthodontics. **M**) Lingual inclination of the incisor crowns prior to Orthodontics. **N, O**) Torque correction, increasing the virtual height of teeth. **P, Q**) Smiling face, before and after Orthodontics, revealing greater amplitude of the smile after treatment.

© 2013 Dental Press Journal of Orthodontics

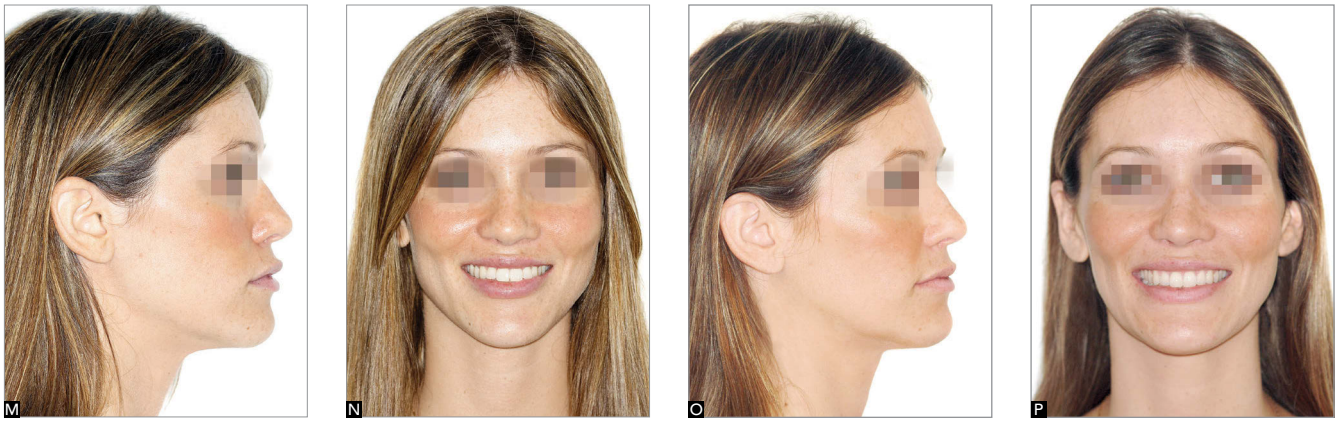


Figure 13 - Patient with Class I malocclusion, in good initial intercuspation. **A, B, C**) Dental double protrusion, with proclination of incisors revealed by the flash "burst" on the incisal surface of the upper central incisor. Large posterior teeth. **D**) Mini-implant on the palate, used as anchorage for retraction. **E, F**) After generous interdental wear on posterior teeth, the incisors were retracted, and the shape of the arches was maintained. **G, H, I**) Results after Orthodontics, with the "burst" of light in the middle of the crown of incisors. **J, K, L**) More pleasant smile as a result of torque correction and teeth positioned in the bone bases. **M, N**) Facial profile and smile before treatment, indicating minimum retraction of the lips. **O, P**) Face in profile and smile by the end of the treatment, enhancing the patient's beauty.

© 2013 Dental Press Journal of Orthodontics

DOMINANCE OF CENTRAL INCISORS

A concept that has been strongly settled in oral prosthetic rehabilitation, specially advocated by Kina and Bruguera,[25] states that the central incisors must be dominant in the smile in order to provide unity, strength, joviality and sensuality. In a dental composition, the dominance of central incisors is considered natural. Previous studies show that human perception is deviated to the upper central incisors and, when their dominance on the face is increased or emphasized, people are considered as younger and more attractive.[25,54]

The studies carried out by King et al[27] showed the preference of dentists, orthodontists and laypeople for the incisal edge of the lateral incisors always being above the incisal plane, on average 0.5 mm, not exceeding 1 mm. This is the pattern used in Orthodontics, with the contour of the incisal edges of the upper anterior teeth following the curvature of the lower lip on the smile.[32,49,62]

Some authors[25,26] of the Dental Prosthesis field work with greater distances and, therefore, the smile curvature becomes more accentuated. The search for joviality based on dental dimensions has generated some excess, but the orthodontist cannot ignore the trends and convictions of other specialties in Dentistry. With some judgment, and after discussing the theme with the patient and the oral rehabilitation colleague, good results can be obtained with the use of porcelain veneers (Fig 14).

Another procedure employed by Dental Prosthesis, and discussed in the previous special article, is the recommendation of increasing the flat surface area on the morphology of the prosthetic anatomy of the central incisors, expanding the reflection of light and contributing to the dominance of central incisors on the facial dynamic.[1,19,36,55]

HEIGHT OF CONTACT POINTS

There are some procedures that can really make a difference on the results of treated cases. Smile symmetry and amplitude were already discussed in this article and must be associated with the sensation of depth and naturality when placing the contact points.

The golden ratio is applied to the height of the contact points of the anterior teeth.[41,50,52] The contact point between central incisors must correspond to 50% of the height of the crown of these teeth, and must gradually distally reduce, turning into 40% of this height at the contact point between central and lateral incisors, and 30% of this height at the contact point between lateral incisor and canine. According to Kina and Bruguera,[25] a hypothetical line connecting the ends of the anterior contact points must be parallel to the horizontal lines of the face and to the edge of the lower lip in order to establish a cohesive and harmonious unity of the smile (Fig 15). These lines and proportions were also used in the determination of the "six horizontal smile lines", emphasized by Câmara[11] and widely used for smile analysis.

There are three ways to achieve this proportion:

1) Prosthetic increase — selective for the height of the crowns of anterior teeth: as it has been previously mentioned, the procedures of Restorative Dentistry and, specially, the porcelain veneers are some of the options that have been increasingly used and resistant to time.[2,26]

2) Gingivectomy including the papilla (Fig 16) — the correction of the gingival contour and the ideal height/width proportion of the teeth must be conciliated so as to intervene in the height of the interdental papilla. In this case, the intervention emphasizes the existence of more than 5 mm of distance between the alveolar bone crest and the contact point, a condition that is established to avoid the opening of black spaces in the interdental spaces.[59]

3) Ameloplasty, performed in two ways — increasing the contact area by interdental wear, or reducing the contact area of the incisal edges, altering the incisal spaces.[52] The interdental embrasures form interdental angles which, according to Magne and Belser,[37] are shaped as an inverted "V", narrower between the central incisors, asymmetric between central and lateral and large between lateral incisor and canine (Fig 17).

When the shape of the interincisal angles are changed by ameloplasty, the professional must also consider if it is desirable to change the shape of the teeth, making them rounder, with wider interincisal angle spaces (Fig 18). Women can be specially benefited with this procedure, while marked angles are masculine characteristics that are desired by the evaluators.[4] The patient must be consulted before this procedure is performed, and the simulation of the future shape of the teeth, drawn with a black dermographic pen, is recommended.

TEETH / PERIODONTIUM RELATION

The discovery of the importance that "pink esthetics" has on the results of dental treatments is not recent, and the definition of normality has nearly established

© 2013 Dental Press Journal of Orthodontics

Figure 14 - Class III patient with anterior open bite, referred to orthodontic-surgical treatment. **A, B, C**) Initial intraoral photographs, revealing loss of height of central incisors, probably caused by chemical erosion. **D, E, F**) Occlusion established after surgical procedure with maxillary advancement. **G, H, I**) Result after Orthodontics, in which satisfactory occlusion can be noted, but with incisal curve almost flat. **J, K, L**) Final result of the patient's microesthetics, with dominance of the central established by means of porcelain veneers. **M**) Smile after Orthodontics, and before the veneers. **N, O**) Repercussion on miniesthetics (smile), after veneers on teeth #11 and #21: a younger smile.

© 2013 Dental Press Journal of Orthodontics

Figure 14 (continuation) - P, Q, R) Macroesthetics (smiling face), sequence of events (left to right): before treatment, after Orthodontics, after veneers.

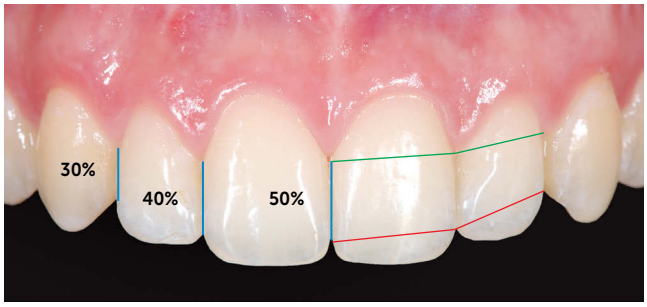


Figure 15 - Ideal heights of contact points. Between the central incisors, it must be half of the height of the crown of these teeth, decreasing distally, at each contact, always in relation to the central incisor. Guiding lines connecting the apices of the papillae (red) and the lower ends of the contact points (green), emphasized by Câmara.[11]

a consensus among professionals that deal with esthetics.[1,11,12,13,26,28,34,48,51,61,63] There is an integration between the factors that determine microesthetics, so that when ideal dental proportions and dimensions are established, the relations between the heights of the crowns of upper anterior teeth also define the adequate gingival contour. Furthermore, the problems tend to be correlated, and the solution becomes the intervention on the position of teeth and dental anatomy, alteration of the anatomy of the periodontium or both procedures.

Gingival contour

Kokich, Nappen and Shapiro[28] established the parameters that must be sought to obtain gingival contour, with the gingival margin of canines and upper central incisors at the same level, and the margin of upper lateral incisors 1 mm below those. (Fig 17) The margin of the lateral at the same height of the central is considered acceptable, provided that, in prosthetic procedures, color and shade effects are established to reduce the virtual height of lateral incisors.[13,40]

Evidently, the gingival contour must be considered as esthetically important if there is gingival exposure at smiling, specially when the smile line is high.[57]

When the gingival contour is asymmetric, with difference in the height/width proportion, three situations, with distinct possibilities of performance, must be considered, as described below.

1) If the teeth are higid and the incisal edges are correctly leveled: there is a difference in height between the clinical and anatomical crowns of the tooth, usually related to the excess of gingival tissue. In this case, by means of a periodontal probe,it is noticeable that the gingival sulcus is deep or that he periodontal biological space is excessive. This happens when the keratinized gingiva is thick and did not migrate apically, which defines a partial eruption of the tooth; or when there was gingival hyperplasia, which is very common for orthodontic treatment, specially for patients with poor oral hygiene.[33,61]

In these cases, the patient must be referred to a periodontist for augmentation of the clinical crown of anterior teeth, performed by means of gingivectomy. Depending on the width of the keratinized gingiva area, a gingival flap associated with bone recontouring might be necessary.[28] The amount of periodontal

Figure 16 - Adolescent patient, with impacted canine and lateral incisors, without space. **A, B, C**) Maxilla with atresia, leading to right posterior crossbite, upper midline deviated to the right. **D, E, F**) After the lateral incisor had been forcefully extruded, ameloplasty was performed on the incisal surface in addition to cervically rebonding the bracket, allowing greater extrusion and correction of the gingival contour. **G, H, I**) Result obtained after Orthodontics, with satisfactory occlusion, but with difference in the height of the contact points and gingival contour of the left upper central incisors. **J, K, L**) Results after gingivectomy, including the papilla between teeth #21 and #22, to redimension the crown of tooth #21 and the contact point. **M**) Smile before Orthodontics. **N**) Smile after Orthodontics. **O**) Smile harmony after gingivectomy.

© 2013 Dental Press Journal of Orthodontics

Figure 16 (continuation) - Smile before (**P**) and after orthodontic treatment (**Q**). R) Smile harmony after gingivectomy.

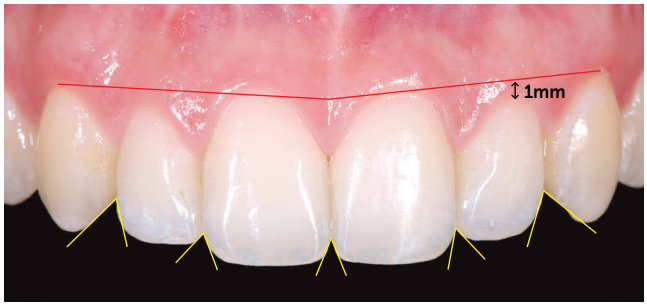


Figure 17 - Gingival contour and spaces. The red line shows the gingival contour, with lateral incisor 1 mm below the apical limit of the contour of the central incisor and the canine. In yellow, the conformation in inverted "V" in the interdental spaces, defined as: narrow between central incisors, asymmetric between central and lateral, and large between the lateral incisor and canine.

tissue that will be removed corresponds to what is enough to establish the best height/width proportion, along with the best gingival contour relation. In higid teeth, the exposure of the entire anatomical crown is recommended.

It is worth noting that, after surgery, the tooth seems to be greater in height in comparison to what it will actually be after three months,which is the period necessary for the operated gingiva to recover and for the gingival sulcus to be restored, reducing the crown height in nearly 2 mm. Patients with gingival smile are specially benefited by this procedure.

2)If the teeth are not higid: there usually is asymmetric wear of the incisal edges, associated with compensatory extrusion of these teeth, together with the entire periodontium of the compromised tooth. In these cases, the leveling of cementoenamel junctions must be carried out with individualized intrusion movements.[30,34] The appliance must be placed in compliance with the need for gingival contour correction, and not the leveling of incisal edges.[62] It is very important to emphasize that the intruded tooth needs to be retained for, at least, six months in its position, waiting for the turnover of the periodontal ligament, when the stretched collagen and elastic fibers are rearranged, reducing the risk of relapse. The importance of Orthodontics for the solution of periodontal and prosthetic problems was clearly exposed in the systematic review published by Gkantidis, Christou and Topouzelis.[21]

Esthetic restorative procedures will be necessary to establish the relation of incisal edges and dental proportions by means of composite or provisional resin during orthodontic finishing. It is also important to consider that there might be accumulation of gingival tissue with the intrusion of the tooth, which will indicate that a gingivectomy procedure should be performed at least three months before the definitive prosthetic work is performed.[63]

3) If there is a bone defect: usually associated with a history of periodontal disease or localized gum recession, making the gingival edge of a tooth to move apically. In this case, slow dental extrusion is indicated,

© 2013 Dental Press Journal of Orthodontics

Figure 18 - Angle Class II division 2 malocclusion. **A, B, C**) Retroclined upper central incisors and overbite, characteristics of malocclusion. **D, E, F, G**) Treated case, with good arch relationship, the aspect of fused teeth on the upper central incisors calls our attention because of the very large contact point. **H, I**) After ameloplasty, which increased the incisal spaces, resulting in reduction in the height of the contact points between the central incisors, and their progressive distal decrease. **J, M**) Smile before treatment. **K, L, N, O**) Smile after Orthodontics and ameloplasty, resulting in rounder incisal edges and larger spaces.

© 2013 Dental Press Journal of Orthodontics

followed by wear of the incisal edge.[21] In order to use the root of the extruded tooth, the limit of extrusion is the minimum crown/root relation (1:1). The tooth can be slowly extruded above this limit, with its extraction previously planned and with the aim of achieving alveolar bone and/or gingival soft tissue gain for posterior placement of implant.[30,57] Current scientific evidence reveals that additional studies are warranted so as to obtain predictability of periodontal response for correction of bone defects through orthodontic movement.[46]

One of the greatest concerns about gingival contour is with regard to implants and facial growth. It is known that the end of growth, which was believed to be at 16 years of age for girls and 18 years for boys, in fact does not happen. There is a late growth, with sudden changes, which is especially important for young adults between 17 and 23 years of age, that must be considered.[5] The consequences of vertical growth for gingival contour are known. Unlike the teeth, the implants do not follow the displacement of maxillary bones, producing important asymmetry on gingival and incisal contours (Fig 19). In these cases, the esthetic concern is even greater because implant substitution, of which gingiva migrates apically as time goes by, is not a simple procedure, and may generate a bone defect that is difficult to solve. The decision on placing implants in the anterior region must consider the height of the patient's smile line and, in particular, estimate the vertical facial growth.[60]

Mishandling orthodontic treatment may cause potential gingival defects when there is buccal root movement, especially in critical areas or in patients with thin periodontal biotype.[43] On average orthodontic treatments, periodontal recession and alveolar bone loss are minimum (0.03 mm and 0.13 mm, respectively), as showed in the systematic review published by Bollen et al.[6]

Zenith

The gingival zenith is the highest point of the gingival contour curvature, and may vary significantly in anterior teeth.[62] Sarver[50] presents as norm that the ideal position of the apex of the gingival contour of the lateral incisor would be in the center of the crowns, along the long axis of the tooth; while it is distally displaced on the central incisor and canine.

In recent research, Chu et al.[13] quantified the position of the gingival zenith of upper anterior teeth in a periodontally healthy population: 1 mm distal to the line that divides the middle of the crown, following the long axis of the tooth, on the upper central incisor; 0.4 mm distal to the line that divides the middle of the crown, following the long axis of the lateral incisor; and at the center of the line that represents the long axis of the upper canine (Fig 20).

The zenith can be orthodontically defined by the position of the bracket bonded to the upper anterior teeth or second-order bends on orthodontic wires, also known as artistic bends that define the mesiodistal tippings of these teeth. On the other hand, if we consider the mesiodistal angulation patterns which are used for the anterior teeth, the greatest tipping is established for the lateral incisors and canines which have the zenith less distally displaced if compared to the central incisor. The limit of what is esthetically pleasant for zenith deviations, in relation to the center of the upper central incisor, seems to be 2 mm, coinciding with a mesial tipping of 10 degrees from the long axis of these teeth.[22]

Prosthetically, the volume of the crown may contribute to the apical displacement of the gingival margin, and the coloration or shade in the cervical region of the tooth may generate the optical illusion of the most apical part of the gingival contour of each tooth — which is not simple, specially due to the need for a refined interaction between the technician in prosthesis and the prosthodontist.[37]

Definitely, the zenith represents an intrinsic characteristic of the periodontium and, therefore, can be more easily modified by periodontal surgery, with clinical crown augmentation; or recovering, in cases of periodontal recession. The stability of the position defined by the periodontist depends on respecting the periodontal biological space and the architecture of the alveolar bone crest which can be defined by bone recontouring.[18] Chu[15] emphasizes the use of the proportionality gauge developed by him for this purpose, using the vertical point, which defines 3 mm of interval between the colors of the two segments that compose the end of the instrument to guide the professional on establishing the alveolar bone limit in the cervical area of periodontally modified teeth (Fig 5).

Maximum symmetry on the placement of the zenith is recommended, specially on the upper central incisors due to the proximity established between them as well as to the facial midline.[25]

© 2013 Dental Press Journal of Orthodontics

Figure 19 - Patient with agenesis of upper lateral incisor, who decided for dental implant. **A, B, C**) Initial photographs, showing the mesialization of permanent upper canines and the prolonged retention of deciduous canines. **D, E, F**) Orthodontic correction opening spaces by distalization of canines for placement of osseointegrated implants and crowns, at 20 years of age. **G, H, I**) 26-year-old patient: note that the levels of gingival and incisal contour of the implants rose at least 1 mm. **J, K, L**) Sequence of photographs of the smile in different moments: before treatment, soon after Orthodontics with implants, and 6 years after implant placement, with canines quite marked by the infraocclusion of lateral incisors.

© 2013 Dental Press Journal of Orthodontics

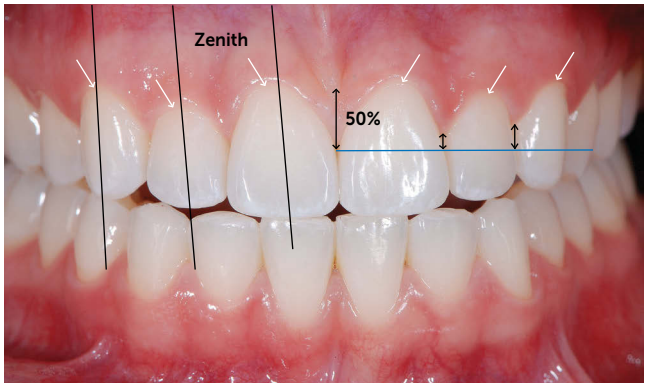


Figure 20 - Zenith and gingival papillae. Arrangement of the zenith defined by the inclinations of the long axis of the upper anterior teeth: in the middle of the canine, 0.5 mm distal to the lateral incisor; and 1 'mm distal to the central incisors (white arrows). Papilla between the central incisors filling the space until half of the height of the crowns of these teeth and gradually reducing, in height, to distal.

Height of the papilla / black spaces

The gingival papilla must apically fill from the interdental space to the contact point, being extended to half of the height of the upper central incisor, and following a position that is gradually more apical from the midline on, conferring a natural and beautiful aspect to the smile (Fig 20).

When the distance between the roots is shorter than 0.3 mm, it affects the presence of the proximal bone and, therefore, is usually accompanied by the absence of the interdental papillae On the other hand, greater interradicular spaces, as in the diastema, are usually associated with short and flattened papillae.

Tarnow, Magner and Fletcher[59] showed that the interdental papilla is present in 98% of the cases in which the cervical limit of the interdental contact is located up to 5 mm from the alveolar bone crest. When the distance from the contact point to the bone crest is of 6 mm, there is nearly 50% of chance of black space; and with 7 mm of distance, the presence of interdental papilla filling the space is found in only 27% of the cases. Therefore, it is possible to predict the appearance of black interdental spaces, which are especially common in patients with triangular teeth, when severe crowding is corrected or when there is bone loss by periodontitis.

Orthodontics has used the procedure of interdental wear for the closure of these spaces, changing the dental shape and, thus, approximating the contact point of teeth and the alveolar bone crest.[33,53,61] This procedure, extremely common among orthodontists, may lead to other undesirable esthetic consequences. Interdental wear changes two determinants of esthetics: 1) height/width proportion of the crowns, possibly generating excessively narrow teeth, and 2) increase in the height of the contact point, breaking the golden ratio of the smooth reduction in the distal direction.

A good guide to define the correct attitude towards interdental black spaces is, in ascending order of procedure:

1) Interproximal wear until the width of the incisor is not smaller than 80% of its width, in which case 75% is acceptable for naturally elongated teeth and faces.

2) Restorations or porcelain veneers changing the dental anatomy up to the limit of proportions in height of the contact points.

3) Periodontal surgery with graft to increase the height of the papilla, which is left as a last resource due to the fact that the prognosis is not always favorable.

The case presented in Figure 21 shows the closure of the pathological diastema in a periodontally compromised patient, followed by wear up the limit of the dental proportions, and finishing with veneers that closed the interdental black spaces.

PROPORTIONS BETWEEN DENTAL ARCHES (BOLTON DISCREPANCY)

A special part of this article was reserved to discuss a fundamental and specific procedure of Orthodontics, which is the analysis of Bolton discrepancy.[7] Additionally, it aimed at discussing the clinical development of this problem of high prevalence in the population, equally distributed in both genders and in different ethnicity and types of malocclusion.[23]

Although it is seen as a mathematical calculation for orthodontic planning that aims at establishing a better relation of the mesiodistal dimensions between the upper and lower arches, the discrepancy of dental volume must be carefully considered. Attenuating this difference is fundamental to establish satisfactory dental intercuspation, but, on the other hand, the problem can also be aggravated by wrong professional decisions. The fact that the measurements taken in models to define dental volume discrepancy show poor reliability deserves attention, with regard to measurement errors in cases of crowding over 3mm.[56]

© 2013 Dental Press Journal of Orthodontics

Figure 21 - Patient with history of aggressive periodontitis which was periodontally treated and controlled. **A, B, C**) Initial malocclusion, with dental loss, pathological tooth migration and multiple diastema. **D, E, F**) Ongoing orthodontic treatment, with interdental wear at the limit of the height x width proportion, for closure of black spaces, within the best dental proportion. Posterior teeth still in provisional, with precarious anatomy. **J, M**) Smile before orthodontic treatment. **K, L, N, O**) Smile after perio-ortho-prosthetic integrated treatment, in several amplitudes and approaches.

© 2013 Dental Press Journal of Orthodontics

Dental volume addition was described in the first part of this article, with space opening performed to restore dental width (Fig 3). Most of the times, the professional decides to reduce dental volume in one of the arches by means of interdental wear or atypical extractions.

Decisions on incisors extractions should be previously tested by physical or virtual set-up, because the calculations do not contemplate the buccolingual thickness of the incisal edges. Moreover, small differences may be disguised by differentiated torques and variations of overbite.[29] The orthodontist may cause a large Bolton discrepancy when extraction of a lower incisor is planned (usually recommended to treat lower anterior crowding) and not previously tested. In extreme cases, a new malocclusion would be created by the orthodontist, which would result in a contracted lower arch, canines without contact and accentuated overjet and overbite.

The attenuation of the Bolton discrepancy by means of wear also needs to be considered, because, in cases in which the dimensions of upper incisors are at the limit of the height/width dental proportion or present square-shaped crowns, the wear is quite limited, for it causes dangerous root proximity and quite extensive contact points in the cervico-incisal height.[29] The Bolton discrepancy is an important and decisive finding for orthodontic treatment and, beyond numbers, it presents clinical unfolding. Because it is a mathematical estimate, its clinical implications must be considered. Some logical rules can be used to guide the orthodontist's conduct, showing the problem and solving it as the treatment evolves.

Clinically, the best treatment option should privilege molar intercuspation as the first step of treatment. After the distobuccal cusp of the upper first molar is occluded between the lower first and the second molars, the spaces are closed backwards, and some situations may appear:

1) If the relation is canine Class II after premolars have been distalized and occluded: it shows upper posterior excess, and it can be solved with interproximal wear on the mesial surface of the first molar; mesial and distal of premolars; and on the distal surface of upper canines.

2) If the relation is canine Class III after premolars have been distalized and occluded: it shows lower posterior excess, and it can be solved with interpoximal wear on the mesial surface of the first molar; mesial and distal of premolars; and on the distal of lower canines.

3) If overjet or anterior crossbite persists after premolars have been distalized and occluded, and after canine occlusion has been defined: it shows lower anterior excess, and it can be solved with interproximal wear on the mesial surface of the canines and on the mesial and distal surface of lower incisors.

4) If overjet persists after premolars have been distalized and occluded, and after canine occlusion has been defined: it shows upper anterior excess, and it can be solved with interproximal wear on the mesial surface of canines and on the mesial and distal surfaces of upper incisors — respecting the ideal symmetry and proportions. In this case, the lack of lower anterior dental volume must be verified and the need for incisor clinical crown augmentation must be considered.

Clinical conditions may present a blend of these possibilities of solution, and the excess may also be by quadrants, with asymmetry between the right and left sides. A careful analysis of the relation of the inclined planes of the teeth in the clinical evaluation, as well as in the analysis of models, can determine if there is significant Bolton discrepancy, without the necessity of applying any formulas, as shown in Figure 22.

CONCLUSIONS

Microesthetics comprises treatment approaches that are more directly related to Orthodontics and other dental specialties that deal with esthetics. Mastering it must be part of the foundations on which a dentist's fine practice is based. The challenge is to use all the parameters available, those emphasized by the different specialties of Dentistry, and apply these concepts in each treated case. It is not a single detail that defines excellence, but the sum of many of them. This article aimed at describing the ideal dental proportions and dimensions, and their interaction with the periodontium, which shall be considered by the orthodontist for treatment finishing. Many of these aspects are out of the spectrum of changes that the orthodontic appliance could provide and totally dependent on the intervention of periodontists and prosthetists. Therefore, it is necessary to gather concepts and define patterns that must be followed by the team of professionals in order to avoid wasting time with unnecessary or contradictory procedures.

© 2013 Dental Press Journal of Orthodontics

Figure 22 - Orthodontic retreatment case; previous treatment finishing was not adequate, because the proportions between the arches was not observed. **A**, **B**, **C**) Right lower crowding and Class III canine relationship on the left denote bilateral posterior lower excess, whereas Class II canine relationship on the right and the insufficient overjet reveal anterior lower excess. **D**, **E**, **F**) Case being treated with interproximal wear from molar to molar (do not use bands). **G**, **H**, **I**) Orthodontics final result, with satisfactory intercuspation and overbite. **J**, **K**, **L**) Smile and incisor relation before Orthodontics. **M**, **N**, **O**) Final smile and correction of overbite and overjet.

© 2013 Dental Press Journal of Orthodontics

On the clinical tables of cases approved by the American Board of Orthodontics (ABO) and by the Brazilian Board of Orthodontics (BBO), which are presented in meetings, is the phrase: "All cases orthodontically treated have some defects, and the cases herein exposed represent the effort of the professionals to achieve the certification of excellence." This means that the complete excellence in all treated cases should always be sought, even if it is utopian. If all cases are prepared as if they were presented to the BBO exam, many of them would certainly not achieve the excellence degree for many reasons, but there would be an orthodontist who is much better in his clinical performance, ready to achieve the certification of excellence.

Microesthetics must not be seen in isolation, but as the key to achieve a pleasant smile (miniesthetics) and a harmonious face (macroesthetics). The greatest concern must always be the patient, with his desires not only granted, but overcome by the professional. Our concerns and actions are measured in millimeters, but can make all the difference to people's quality of life. To raise one's self-esteem by means of integrated dental treatment could be considered an objective, that may be referred to as "hyper-esthetics".

ACKNOWLEDGEMENTS

The authors would like to thank and honor Vincent G. Kokich who represented not only the search for excellence in Orthodontics, with his brilliant articles and lectures, but mainly the critical thinking and the search for the best scientific evidence that must guide the decisions that we need to make every day in our clinics. Special acknowledgements to Telma Martins de Araújo, Lícia Pacheco Teixeira and Gabriela Cassaro de Castro for the precious help on the elaboration of this work.

REFERENCES

1. Adolfi D. Natural esthetics. Chicago: Quintessence; 2003.
2. Adolfi D. Functional, esthetic, and morphologic adjustment procedures for anterior teeth. Quintessence Dent Technol. 2009;32:153-68.
3. Al-Johany SS, Alqahtani AS, Alqahtani FY, Alzahrani AH. Evaluation of different esthetic smile criteria. Int J Prosthodont. 2011;24(1):64-70.
4. Anderson KM, Behrents RG, McKinney T, Buschang PH. Tooth shape preferences in an esthetic smile. Am J Orthod Dentofacial Orthop. 2005;128(4):458-65.
5. Behrents RG. Growth in aging craniofacial skeleton. Monograph 17 - Craniofacial Growth Series, Center for Human Growth and Development. Ann Arbor, Michigan: The University of Michigan; 1985.
6. Bollen AM, Cunha-Cruz J, Bakko DW, Huang GJ, Hujoel PP. The effects of orthodontic therapy on periodontal health: a systematic review of controlled evidence. J Am Dent Assoc. 2008;139(4):413-22.
7. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod. 1958;28(3):113-30.
8. Brandão RCB, Brandão LBC. Ajuste oclusal na Ortodontia: por que, quando e como? Rev Dental Press Ortod Ortop Facial. 2008;13(3):124-56.
9. Brandão RCB. Entrevista com Roberto Carlos Bodart Brandão. Rev Dental Press Ortod Ortop Facial. 2009;14(6):19-41.
10. Câmara CALP. Estética em Ortodontia: diagramas de referências estéticas dentárias (DRED) e Faciais (DREF). Rev Dental Press Ortod Ortop Facial. 2006;11(6):130-56.
11. Câmara CALP. Estética em Ortodontia: seis linhas horizontais do sorriso. Dental Press J Orthod. 2010;15(1):118-31.
12. Chiche GJ, Pinault A. Estética em próteses fixas anteriores. 1a ed. São Paulo: Ed Santos; 1996.
13. Chu SJ, Tan JH-P, Stappert, CFJ, Tarnow, DP. Gingival zenith positions and levels of the maxillary anterior dentition. J Esthet Restor Dent. 2009;21(2):113-20.
14. Chu SJ. Range and mean distribution frequency of individual tooth width of the maxillary anterior dentition. Pract Proced Aesthet Dent. 2007;19(4):209-15.
15. Chu SJ. A biometric approach to predictable treatment of clinical crown discrepancies. Pract Proced Aesthet Dent. 2007;19(7):401-9.
16. Dürer A. The art of measurement. San Francisco: Alan Wofsy Fine Arts; 1981.
17. Duthie J, Bharwani D, Tallents RH, Bellohusen R, Fishman L. A longitudinal study of normal asymmetric mandibular growth and its relationship to skeletal maturation. Am J Orthod Dentofacial Orthop. 2007;132(2):179-84.

© 2013 Dental Press Journal of Orthodontics

18. Fletcher P. Biologic rationale of esthetic crown lengthening using innovative proportion gauges. Int J Periodontics Restorative Dent. 2011;31:523-32.
19. Fradeani M. Esthetic analysis: a systematic approach to prosthetic treatment. Chicago: Quintessence Books; 2004.
20. Gillen RJ, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont. 1994;7(5):410-7.
21. Gkantidis N, Christou P, Topouzelis N. The orthodontic-periodontic interrelationship in integrated treatment challenges: a systematic review. J Oral Rehabil. 2010;37(5):377-90.
22. Janson G, Branco NC, Fernandes TM, Sathler R, Garib D, Lauris JR. Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness. Angle Orthod. 2011;81(1):153-61.
23. Johe RS, Steinhart T, Sado N, Greenberg B, Jinge S. Intermaxillary tooth-size discrepancies indifferent sexes, malocclusion groups, and ethnicities. Am J Orthod Dentofacial Orthop. 2010;138(5):599-607.
24. Karring T, Nyman S, Thilander B, Magnusson I. Bone regeneration in orthodontically produced alveolar bone dehiscences. J Periodontal Res. 1982;17(3):309-15.
25. Kina S, Bruguera A. Invisível: restaurações estéticas cerâmicas. 1a ed. Maringá: Dental Press; 2007.
26. Kina S, Romanini JC, Harmonia. Rev Dental Press Estét. 2007;4(2):67-88.
27. King KL, Evans CA, Viana G, BeGole E, Obrez A. Preferences for vertical position of the maxillary lateral incisors. World J Orthod. 2008;9(2): 147-54.
28. Kokich VG, Nappen DL, Shapiro PA. Gingival contour and clinical crown length: their effect on the esthetic appearance of maxillary anterior teeth. Am J Orthod. 1984;86(2):89-94.
29. Kokich VG, Shapiro PA. Lower incisor extraction in orthodontic treatment. Angle Orthod. 1984;54(2):139-53.
30. Kokich VG, Spear FM. Guidelines for managing the orthodontic-restorative patient. Semin Orthod. 1997;3(1):3-20.
31. Kokich VG, Spear FM. Interdisciplinary management of anterior guidance: a case report. Adv Esthet Inter Dent. 2007;3(3):2-6.
32. Kokich VG. Esthetics and anterior tooth position: an orthodontic perspective. Part I: crown length. J Esthet Dent. 1993;5(1):19-23.
33. Kokich VG. Esthetics: the Orthodontic-Periodontic restorative conection. Semin Orthod. 1996;2(1):21-30.
34. Kokich VG. Excellence in finishing: modifications for the perio-restorative patient. Semin Orthod 2003;9(3):184-203.
35. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11:311-24.
36. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. J Prosthet Dent. 1973;29(4):358-82.
37. Magne P, Belser U. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago: Quintessence; 2001.
38. Masioli M. Fotografia odontológica. 2a ed. Porto Alegre: Artmed; 2010.
39. Mattos C, Santana RA. Quantitative evaluation of the spacial displacement of the gingival zenith in the maxillary anterior dentition. J Periodont. 2008;79(10):1880-5.
40. Mayekar SM. Shades of color: illusion or reality? Dent Clin North Am. 2001;45(1):155-72.
41. Morley J, Eubank J. Macro esthetic elements of smile design. J Am Dent Assoc. 2001;132(1):39-45.
42. Mucha JN. As limitações do tratamento ortodôntico não-cirúrgico. In: Medeiros PJ, Medeiros PP. Cirurgia ortognática para ortodontista. São Paulo: Ed. Santos; 2004. p. 29-56.
43. Müller HP, Eger T. Masticatory mucosa and periodontal phenotype: a review. Int J Periodontics Restorative Dent. 2002;22(2):172-83.
44. Naini FB, Moss JP, Gill DS. The enigma of facial beauty: esthetics, proportions, deformity, and controversy. Am J Orthod Dentofacial Orthop. 2006;130(3):277-82.
45. Orce-Romero A, Iglesias-Linares A, Cantillo-Galindo M, Yañez-Vico RM, Mendoza-Mendoza A, Solano-Reina E. Do the smiles of the world's most influential individuals have common parameters? J Oral Rehabil. 2013;40(3):159-70.
46. Rotundo R, Nieri M, Iachetti G, Mervelt J, Cairo F, Baccetti T, Franchi L, Prato GP. Orthodontic treatment of periodontal defects. A systematic review. Prog Orthod. 2010;11(1):41-4.
47. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 2. Smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop. 2003;124(2):116-27.
48. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification and its impact on orthodontic diagnosis and treatment planning. In: The art of smile: integrating Prosthodontics, Orthodontics, Periodontics, Dental Technology and Plastic Surgery. Chicago: Quintessence; 2005. p. 99-139.
49. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001;120(2):98-111.
50. Sarver DM. Principles of cosmetic dentistry in orthodontics: Part 1. Shape and proportionality of anterior teeth. Am J Orthod Dentofacial Orthop. 2004;126(6):749-53.
51. Sarver DM. Soft-tissue-based diagnosis and treatment planning. Clin Impress. 2005;14(1):21-6.
52. Sarver DM. Enameloplasty and esthetic finishing in orthodontics: identification and treatment of microesthetic features in Orthodontics. Part 1. J Esthet Restor Dent. 2011;23(5):296-302.
53. Sarver DM. Enameloplasty and esthetic finishing in orthodontics: differential diagnosis of incisor proclination - the importance of appropriate visualization and records Part 2. J Esthet Restor Dent. 2011;23(5):303-13.
54. Schillinburg HT, Kaplan MJ, Grace CS. Tooth dimensions. A comparative study. J South Calif Dent Assoc. 1972;40(9):830-9.
55. Schillinburg HT. Fundamentals of fixed prosthodontics. 3a ed. Chicago: Quintessence; 1997.
56. Shellhart WC, Lange DW, Kluemper GT, Hicks, EP, Kaplan AL. Reliability of the Bolton tooth-size analysis when applied to crowded dentitions. Angle Orthod. 1995;65(5):327-34.
57. Spear FM, Kokich, VG. A multidisciplinary approach to esthetic dentistry. Dent Clin North Am. 2007;51(2):487-505.
58. Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol. 1999;26(3):153-57.
59. Tarnow DP, Magner AW, Fletcher P. The effect of distance from the contact point to the crest bone of the presence or absence of the interproximal dental papilla. J Periodontol. 1992;68:995-6.
60. Thilander B. Orthodontic space closure versus implant placement in subjects with missing teeth. J Oral Rehabil. 2008;35 Suppl 1:64-71.
61. Zachrisson BU. Orthodontics and periodontics. In: Lindhe J, Karring T, Lang NP. Clinical Periodontology and Implant Dentistry. 3rd ed. Copenhagen: Blackwell Munksgaard; 1997. p. 741-93.
62. Zachrisson BU. Esthetic factors involved in anterior tooth display and the smile: vertical dimension. J Clin Orthod. 1998;32(7):432-45.
63. Zanetti GR, Brandão RCB, Zanetti LSS, Castro GC, Borges Filho FF. Integração orto-perio-prótese para correção de assimetria gengival: relato de caso. Rev Dental Press Estét. 2008;5(4):104-15.

© 2013 Dental Press Journal of Orthodontics

— *Dental Press Journal of Orthodontics* publishes original scientific research, significant reviews, case reports, brief communications and other materials related to orthodontics and facial orthopedics.

— *Dental Press Journal of Orthodontics* uses the Publications Management System, an online system for submission and evaluation of manuscripts. To submit manuscripts, please visit:
www.dentalpressjournals.com.br

— Please send all other correspondence to:
Dental Press International
Av. Dr. Luiz Teixeira Mendes, 2.712 - Zona 5
ZIP CODE: 87.015-001, Maringá/PR, Brazil
Phone. (55 044) 3031-9818
E-mail: artigos@dentalpress.com.br

— The statements and opinions expressed by the author(s) do not necessarily reflect those of the editor(s) or publisher, who do not assume any responsibility for said statements and opinions. Neither the editor(s) nor the publisher guarantee or endorse any product or service advertised in this publication or any claims made by their respective manufacturers. Each reader must determine whether or not to act on the information contained in this publication. The Journal and its sponsors are not liable for any damage arising from the publication of erroneous information.

— To be submitted, all manuscripts must be original and not published or submitted for publication elsewhere. Manuscripts are assessed by the editor and consultants and are subject to editorial review. Authors should follow the guidelines below.

— All articles must be written in English.

— Before submitting the full version of the article, if authors wish to enquire whether their paper might be suitable for consideration by Dental Press Journal of Orthodontics, they may use our online presubmission enquiry service. Presubmissions are not compulsory and there is no warranty of acceptance of the paper for publication. All presubmission enquiries must include a structured abstract. Editors will not discuss about a negative response to a presubmission enquiry, but authors who have received such a response may nevertheless formally submit the paper if they wish.

GUIDELINES FOR SUBMISSION OF MANUSCRIPTS

— Manuscripts must be submitted via www.dentalpressjournals.com.br. Articles must be organized as described below.

1. Authors

— The number of authors is unlimited; however, articles with more than four authors must inform the participation of each one of them in the study.

2. Title page

— Must comprise the title, abstract and keywords.

— Don't include information about the authors (e.g., authors' full names, academic degrees, institutional affiliations and administrative positions). They should be included only in the specific fields of the site for article submission. Thus, this information will not be available to reviewers.

3. Abstract

— Preference is given to structured abstracts with 250 words or less.

— The structured abstracts must contain the following sections: INTRODUCTION, outlining the objectives of the study; METHODS, describing how the study was conducted; RESULTS, describing the primary results; and CONCLUSIONS, reporting the authors' conclusions based on the results, as well as the clinical implications.

— Abstracts must be accompanied by 3 to 5 keywords, or descriptors, which must comply with MeSH (www.nlm.nih.gov/mesh).

4. Text

— The text must be organized in the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, References and Figure legends.

— Texts must contain no more than 4,000 words, including captions, abstract and references.

— Figures and tables must be submitted in separate files (see below).

— Insert the Figure legends also in the text document to help with the article layout.

5. Figures

— Digital images must be in JPG or TIF, CMYK or grayscale, at least 7 cm wide and 300 dpi resolution.

— Images must be submitted in separate files.

— In the event that a given illustration has been published previously, the legend must give full credit to the original source.

— The author(s) must ascertain that all figures are cited.

© 2013 Dental Press Journal of Orthodontics

6. Charts and cephalometric tracings

— Files containing the original versions of graphs and tracings must be submitted.
— It is not recommended that such graphs and tracings be submitted only in bitmap image format (non-editable).
— Drawings may be improved or redrawn by the journal's production department at the criterion of the Editorial Board.
— Graphics must be cited in the text as Figures.

7. Tables

— Tables must be self-explanatory and should supplement, not duplicate the text.
— Must be numbered with Arabic numerals in the order they are mentioned in the text.
— A brief title must be provided for each table.
— In the event that a table has been published previously, a footnote must be included giving credit to the original source.
— Tables must be submitted as text files (Word or Excel, for example) and not in graphic format (non-editable image).

8. Ethics committees

— Articles must, where appropriate, refer to opinions of the Ethics Committees.

9. Required statements

All manuscripts must be accompanied with the following statements, to be filled at the time of submission of the article:

— **Assignment of Copyright**
Transferring all copyright of the manuscript for Dental Press International if it is published.

— **Conflict of Interest**
If there is any commercial interest of the authors in the research subject of the paper, it must be informed.

— **Human and Animals Rights Protection**
If applicable, inform the implementation of the recommendations of international protection entities and the Helsinki Declaration, respecting the ethical standards of the responsible committee on human /animal experimentation.

— **Permission to use copyrighted images**
Original illustrations or tables, or modified from copyrighted material must be accompanied by permission to be used, given by the owners of those rights and the original author (and the legend must give proper credit to the source).

— **Informed Consent**
Patients have a right to privacy that should not be violated without informed consent.

10. References

— All articles cited in the text must appear in the reference list.
— All listed references must be cited in the text.
— For the convenience of readers, references must be cited in the text by their numbers only.
— References must be identified in the text by superscript Arabic numerals and numbered in the order they are mentioned in the text.
— Journal title abbreviations must comply with the standards of the "Index Medicus" and "Index to Dental Literature" publications.
— Authors are responsible for reference accuracy, which must include all information necessary for their identification.
— References must be listed at the end of the text and conform to the Vancouver Standards (http://www.nlm.nih.gov/bsd/uniform_requirements.html).
— The following examples should be used:

Articles with one to six authors
Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol. 1999 Mar;26(3):153-7.

Articles with more than six authors
De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res. 2005 Feb;84(2):118-32.

Book chapter
Higuchi K. Osseointegration and orthodontics. In: Branemark PI, editor. The osseointegration book: from calvarium to calcaneus. 1. Osseointegration. Berlin: Quintessence Books; 2005. p. 251-69.

Book chapter with editor
Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wieczorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper
Kuhn RJ. Force values and rate of distal movement of the mandibular first permanent molar. [Thesis]. Indianapolis: Indiana University; 1959.

Digital format
Oliveira DD, Oliveira BF, Soares RV. Alveolar corticotomies in orthodontics: Indications and effects on tooth movement. Dental Press J Orthod. 2010 Jul-Aug;15(4):144-57. [Access 2008 Jun 12]. Available from: www.scielo.br/pdf/dpjo/v15n4/en_19.pdf.

© 2013 Dental Press Journal of Orthodontics

1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (http://www.who.int/ictrp/network/en/index.html), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
- Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;
- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

3. Dental Press Journal of Orthodontics - Statement and Notice

DENTAL PRESS JOURNAL OF ORTHODONTICS endorses the policies for clinical trial registration enforced by the World Health Organization - WHO (http://www.who.int/ictrp/en/) and the International Committee of Medical Journal Editors - ICMJE (# http://www.wame.org/wamestmt.htm#trialreg and http://www.icmje.org/clin_trialup.htm), recognizing the importance of these initiatives for the registration and international dissemination of information on international clinical trials on an open access basis. Thus, following the guidelines laid down by BIREME / PAHO / WHO for indexing journals in LILACS and SciELO, DENTAL PRESS JOURNAL OF ORTHODONTICS will only accept for publication articles on clinical research that have received an identification number from one of the Clinical Trial Registers, validated according to the criteria established by WHO and ICMJE, whose addresses are available at the ICMJE website http://www.icmje.org/faq.pdf. The identification number must be informed at the end of the abstract.

Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

David Normando, CD, MS, Dr
Editor-in-chief, Dental Press Journal of Orthodontics
ISSN 2176-9451
E-mail: davidnor@amazon.com.br

© 2013 Dental Press Journal of Orthodontics