

Dental Press Journal of

ORTHODONTICS

Volume 15, Number 1, January / February 2010



Transparency
for better smile



ORTHOMETRIC
Orthodontic Solutions

www.orthometric.com.br
orthometric@orthometric.com.br

The most complete archwires line
FLEXYNiTi

Ceramic Brackets
ICERAM
Orthodontic Brackets

The best stainless steel archwires
Orthometric SS

Dental Press Journal of
ORTHODONTICS

v. 15, no. 1

January/February 2010

ISSN 2176-9451

Dental Press J. Orthod.	Maringá	v. 15	no. 1	p. 1-160	Jan./Feb. 2010
-------------------------	---------	-------	-------	----------	----------------

EDITOR-IN-CHIEF		Orthodontics			
Jorge Faber	Brasília - DF	Adriano de Castro	UCB - DF	Ricardo Machado Cruz	UNIP - DF
		Ana Carla R. Nahás Scocate	UNICID - SP	Ricardo Moresca	UFPR - PR
ASSOCIATE EDITOR		Ana Maria Bolognese	UFRJ - RJ	Robert W. Farinazzo Vitral	UFJF - MG
Telma Martins de Araujo	UFBA - BA	Antônio C. O. Ruellas	UFRJ - RJ	Roberto Rocha	UFSC - SC
		Ary dos Santos-Pinto	FOAR/UNESP - SP	Rodrigo Hermont Cançado	Uningá - PR
ASSISTANT EDITOR		Bruno D'Aurea Furquim	PRIVATE PRACTICE - PR	Sávio R. Lemos Prado	UFPA - PA
(online only articles)		Carla D'Agostini Derech	UFSC - SC	Weber José da Silva Ursi	FOSJC/UNESP - SP
Daniela Gamba Garib	HRAC/FOB-USP - SP	Carla Karina S. Carvalho	ABO - DF	Wellington Pacheco	PUC - MG
		Carlos A. Estevanel Tavares	ABO - RS	Dentofacial Orthopedics	
ASSISTANT EDITOR		Carlos H. Guimarães Jr.	ABO - DF	Dayse Urias	PRIVATE PRACTICE - PR
(Evidence-based Dentistry)		Carlos Martins Coelho	UFMA - MA	Kurt Faltin Jr.	UNIP - SP
David Normando	UFPA - PA	Eduardo C. Almada Santos	FOA/UNESP - SP	Orthognathic Surgery	
		Eduardo Silveira Ferreira	UFRGS - RS	Eduardo Sant'Ana	FOB/USP - SP
PUBLISHER		Enio Tonani Mazzeiro	PUC - MG	Laudimar Alves de Oliveira	UNIP - DF
Laurindo Z. Furquim	UEM - PR	Flávia R. G. Artese	UERJ - RJ	Liogi Iwaki Filho	UEM - PR
		Guilherme Janson	FOB/USP - SP	Waldemar Daudt Polido	ABO/RS - RS
EDITORIAL SCIENTIFIC BOARD		Haroldo R. Albuquerque Jr.	UNIFOR - CE	Dentistics	
Adilson Luiz Ramos	UEM - PR	Hugo Cesar P. M. Caracas	UNB - DF	Maria Fidela L. Navarro	FOB/USP - SP
Daniilo Furquim Siqueira	UNICID - SP	José F. C. Henriques	FOB/USP - SP	TMJ Disorder	
Maria F. Martins-Ortiz Consolaro	ACOPEM - SP	José Nelson Mucha	UFF - RJ	Carlos dos Reis P. Araújo	FOB/USP - SP
		José Renato Prietsch	UFRGS - RS	José Luiz Villaça Avoglio	CTA - SP
EDITORIAL REVIEW BOARD		José Vinicius B. Maciel	PUCPR - PR	Paulo César Conti	FOB/USP - SP
Adriana C. da Silveira		Júlio de Araújo Gurgel	FOB/USP - SP	Phonodontology	
Univ. of Illinois / Chicago - USA		Karina Maria S. de Freitas	Uningá - PR	Esther M. G. Bianchini	CEFAC/FCMSC - SP
Björn U. Zachrisson		Leniana Santos Neves	UFVJM - MG	Implantology	
Univ. of Oslo / Oslo - Noruega		Leopoldino C. Filho	HRAC/USP - SP	Carlos E. Francischone	FOB/USP - SP
Clarice Nishio		Luciane M. de Menezes	PUC-RS - RS	Oral Biology and Pathology	
Université de Montreal		Luiz G. Gandini Jr.	FOAR/UNESP - SP	Alberto Consolaro	FOB/USP - SP
Jesús Fernández Sánchez		Luiz Sérgio Carreiro	UEL - PR	Edvaldo Antonio R. Rosa	PUC - PR
Univ. of Madrid / Madri - Espanha		Marcelo Bichat P. de Arruda	UFMS - MS	Victor Elias Arana-Chavez	USP - SP
José Antônio Bósio		Márcio R. de Almeida	UNIMEP - SP	Periodontics	
Marquette Univ. / Milwaukee - USA		Marco Antônio Almeida	UERJ - RJ	Maurício G. Araújo	UEM - PR
Júlia Harfin		Marcos Alan V. Bittencourt	UFBA - BA	Prothesis	
Univ. of Maimonides / Buenos Aires - Argentina		Maria C. Thomé Pacheco	UFES - ES	Marco Antonio Bottino	UNESP - SP
Larry White		Marília Teixeira Costa	UFG - GO	Radiology	
AAO / Dallas - USA		Marinho Del Santo Jr.	BioLogique - SP	Rejane Faria Ribeiro-Rotta	UFG - GO
Marcos Augusto Lenza		Mônica T. de Souza Araújo	UFRJ - RJ	SCIENTIFIC CO-WORKERS	
Univ. of Nebraska - USA		Orlando M. Tanaka	PUC-PR - PR	Adriana C. P. Sant'Ana	FOB/USP - SP
Maristela Sayuri Inoue Arai		Oswaldo V. Vilella	UFF - RJ	Ana Carla J. Pereira	UNICOR - MG
Tokyo Medical and Dental University		Patrícia Medeiros Berto	PRIVATE PRACTICE - DF	Luiz Roberto Capella	CRO - SP
Roberto Justus		Pedro Paulo Gondim	UFPE - PE	Mário Taba Jr.	FORP - USP
Univ. Tecn. do México / Cid. do Méx. - México		Renata C. F. R. de Castro	FOB/USP - SP		

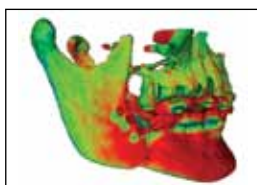
Dental Press Journal of Orthodontics (ISSN 2176-9451) continues the **Revista Dental Press de Ortodontia e Ortopedia Facial** (ISSN 1415-5419)

DENTAL PRESS JOURNAL OF ORTHODONTICS (ISSN 2176-9451) is a bimonthly publication of Dental Press International.

Av. Euclides da Cunha, 1.718 - Zona 5 - ZIP CODE: 87.015-180 - Maringá / PR - Phone/Fax: (0xx44) 3031-9818 - www.dentalpress.com.br - artigos@dentalpress.com.br.

DIRECTOR: Teresa R. D'Aurea Furquim - INFORMATION ANALYST: Carlos Alexandre Venancio - DESKTOP PUBLISHING: Fernando Truculo Evangelista - Gildásio Oliveira Reis Júnior - Tatiane Comochena - REVIEW / COPYDESK: Ronis Furquim Siqueira - IMAGE PROCESSING: Andrés Sebastián - LIBRARY: Jessica Angélica Ribeiro - NORMALIZATION: Marlene G. Curty - DATABASE: Adriana Azevedo Vasconcelos - Cléber Augusto Rafael - E-COMMERCE: Soraia Pelloi - ARTICLES SUBMISSION: Simone Lima Rafael Lopes - COURSES AND EVENTS: Ana Claudia da Silva - Rachel Furquim Scattolin - INTERNET: Carlos E. Lima Saugo - FINANCIAL DEPARTMENT: Márcia Cristina Nogueira Plonkóski Maranha - Roseli Martins - COMMERCIAL DEPARTMENT: Roseneide Martins Garcia - SECRETARY: Luana Gouveia - PRINTING: Gráfica Regente - Maringá / PR.

Dental Press Journal of Orthodontics v.1, n.1 (set./out. 1996) - . - Maringá : Dental Press International, 1996 - Bimonthly. ISSN 2176-9451 1. Orthodontics - Periodicals. I. Dental Press International CDD 617.643005	Indexing: IBICT - CCN Databases: LILACS - 1998 BBO - 1998 National Library of Medicine - 1999 SciELO - 2005
---	---



- 5 Editorial**
- 11 Events Calendar**
- 12 News**
- 13 What's new in Dentistry**
- 16 Orthodontic Insight**
- 25 Interview**

Online Only Articles

- 45** *Assessment of mandibular advancement surgery with 3D CBCT models superimposition*
Alexandre Trindade Simões da Motta, Felipe de Assis Ribeiro Carvalho, Lúcia Helena Soares Cevidanes, Marco Antonio de Oliveira Almeida
- 49** *Methodology standardization for measuring buccal and lingual alveolar bone plates using Cone Beam Computed Tomography*
Marcos Cezar Ferreira, Daniela Gamba Garib, Flávio Cotrim-Ferreira

Original Articles

- 53** *Laboratorial study of loops closure time and degree of cuspid's tipping, during the retraction phase, using segmented arch mechanics*
Gilberto Kauling Bisol, Roberto Rocha
- 65** *Reproducibility of natural head position in profile photographs in children aged 8 to 12 years old, with and without an auxiliary cephalostat*
Adriana Likes Pereira, Luciana Manzotti De-Marchi, Paula Cabrini Scheibel, Adilson Luiz Ramos
- 74** *Analysis of bone maturation in patients 13 to 20 years old by means of wrist radiographies*
Yasmine Bitencourt Emílio Mendes, Juliana Roderjan Bergmann, Marina Fonseca Pellissari, Sérgio Paulo Hilgenberg, Ulisses Coelho



- 80** *The influence of the methodologic variables on the shear bond strength*
 Marcel Marchiori Farret, Tatiana Siqueira Gonçalves,
 Eduardo Martinelli S. de Lima, Luciane Macedo de Menezes,
 Hugo Matsuo S. Oshima, Renata Kochenborger, Maria Perpétua Mota Freitas



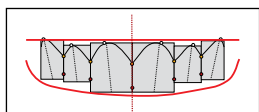
- 89** *Comparison of the occlusal outcomes and the treatment time of Class II malocclusion with the Pendulum appliance and with extraction of two maxillary premolars*
 Célia Regina Maio Pinzan-Vercelino, Arnaldo Pinzan, Guilherme Janson,
 Renato Rodrigues de Almeida, José Fernando Castanha Henriques,
 Marcos Roberto de Freitas



- 101** *A PowerPoint-based guide to assist in choosing the suitable statistical test*
 David Normando, Leo Tjäderhane, Cátia Cardoso Abdo Quintão



- 107** *Clinical and polysomnographical assessment of Obstructive Sleep Apnea Syndrome treatment with BRD appliance*
 Cibele Dal-Fabbro, Cauby Maia Chaves Junior,
 Lia Rita Azeredo Bittencourt, Sergio Tufik



- 118** *Esthetics in Orthodontics: Six horizontal smile lines*
 Carlos Alexandre Câmara



- 132** **BBO Case Report**
Angle Class II, Division 2, malocclusion with deep overbite
 Paulo Renato Carvalho Ribeiro



- 144** **Special Article**
Anticipated Benefit: a new protocol for orthognathic surgery treatment that eliminates the need for conventional orthodontic preparation
 Jorge Faber

- 158** **Information for authors**

Adversities stimulating advances

The economic crisis is over. At least that's what we observe when analyzing different indexes, that is, industry, Bovespa activity, and unemployment. The course and submission of the crisis have instilled a feeling that we would only sporadically experience: we have really been living in a great country. And at this time it is not the country of the future, but the present one. We have found that several of our recognized weaknesses, were, in fact, our greatest force. This is what this editorial refers to: how adversities stimulate advances.

We have been facing a banking system vaccinated through the years of hyperinflation and other economic problems. There has been a need for several regulations in order to control social problems caused by the uncontrolled rise of prices. It was precisely this high immunity, considered by many as a disproportional and damaging intervention of the State on economy, which had prevented us from the bank negative exposure that other countries had faced during the world economic crisis.

Our health system—widely criticized and, indeed, yet so destitute—has an abundance of positive examples for developed countries. The assistance we provide to people with HIV is an international model of excellence. Generic drugs have made medical treatment more accessible to the entire population. In addition, we have the largest world public system of oral health, although still not the best. The specialized dental clinics (CEOs) freely offer specialized treatments to several Brazilian cities. The small town known as 'Brejo da Madre de Deus', located in the arid and remote interior of Pernambuco state, is proud of displaying an outdoor at the entrance of the city with the following headlines: 'first Brazilian city to offer Orthodontics through the Unique National Health System'.

Dental Press Journal of Orthodontics is itself an example of how adversities have become a

fuel for advancement. At the time this magazine was launched, its modest aim was to be a vehicle for knowledge dissemination for many Brazilian orthodontists who were not able to read in English. All articles of the initial editions were legal translations of papers published in international journals, and their distribution was free for specialists in Orthodontics. The seriousness of their purpose, the correct actions, and the quality of the people involved in this project have made the embryo to turn into an important publication for the orthodontic community. While the magazine was being developed, it encouraged Brazilian researchers to present their study, as well as it contributed to the improvement of Orthodontics in Brazil, which is currently among the world's most productive ones.

Paradoxically, the development of the Journal led it to a reverse path from its origin. It was originally born to translate articles written by foreign authors to Brazilian readers, but it is from this edition on to be officially published in English in order to provide foreign readers with information produced in Brazil. In addition, studies carried out in other countries will be more intensely published.

This modification will not eliminate the Portuguese version, since our original mission will not be forgotten. Two magazines with the same content will be edited: the official one in English, and the other in Portuguese.

The examples above are fruits of meritocratic environment prevalence. They show that the pressures caused by selection make us think, innovate and develop. I wish you to have a pleasant reading. A better future is only built with information.

Jorge Faber
editor-in-chief
faber@dentalpress.com.br

all the information.
one scan.



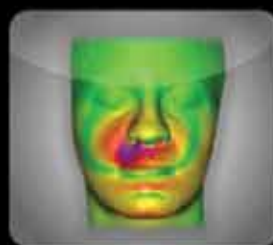
3D Computerized Assessment, **COMPASS** is a new Internet based service to help better diagnose and treatment plan orthodontic cases.

Using the latest software, **COMPASS** derives 3D models and 2D radiographs from DICOM images. Experienced Orthodontists and Radiologists then assess these DICOM images to produce a thorough Report.

CT scans can help locate impacted teeth, TAD placement sites, TMJ pathologies and internal derangement, assess transpalatal suture for RME and volumetrically assess the airway. Furthermore, **Orthognathic Surgery can be planned and the soft tissue response simulated to achieve the best occlusal, esqueletal and facial results.** Guides can than be prototyped to transport accurate virtual simulations into the operating room.

Using the **COMPASS** Protocol the clinician will not only have a detailed report but will also save precious time required to render images and perform cephalometric measurements. **A quantitative diagnosis is reached when accurate 3D measurements are compared to known cephalometric standards corrected by a proprietary algorithm.** These reports are animated with videos and screen shots of the most relevant Images found on the exam. **Fully interactive reports are also available through free viewer.**

COMPASS has over 2000 satisfied customers since 2007.



To learn more about us please visit our website.

www.compass3d.com.br

download the **free viewer** on our site

Partners Image Centers

Please contact us if your city does not yet have a Compass partner: **www.compass3d.com.br | (31) 3221-7095**





Excellence in Orthodontics

Created in 1999, the Excellence in Orthodontics is the 1st program in Latin America focused exclusively to specialized professionals, who are willing to develop both their technique skills and orthodontic philosophy. The faculty reunites the best PhD Professors in Brazil.

Faculty:

ADEMIR ROBERTO BRUNETO
ADILSON LUIZ RAMOS
ALBERTO CONSOLARO
ARY DOS SANTOS PINTO
BEATRIZ FRANÇA
CARLO MARASSI
CARLOS ALEXANDRE CÂMARA
CARLOS COELHO MARTINS
CELESTINO NOBREGA
EDUARDO PRADO DE SOUZA
EDUARDO SANT'ANA
GLÉCIO VAZ CAMPOS
GUILHERME DE ARAÚJO ALMEIDA
GUILHERME JANSON

HENRIQUE MASCARENHAS VILLELA
HIDEO SUZUKI
HUGO JOSÉ TREVISI
JORGE FABER
JOSÉ FERNANDO CASTANHA HENRIQUES
JOSÉ MONDELLI
JOSÉ NELSON MUCHA
JOSÉ RINO NETO
JULIA HARFIN
JÚLIO DE ARAÚJO GURGEL
JURANDIR BARBOSA
KURT FALTIN JÚNIOR
LAURINDO ZANCO FURQUIM
LEOPOLDINO CAPELOZZA FILHO

LUIZ GONZAGA GANDINI JR.
MARCOS JANSON
MARDEN OLIVEIRA BASTOS
MAURÍCIO GUIMARÃES ARAÚJO
MESSIAS RODRIGUES
MIKE BUENO
OMAR GABRIEL DA SILVA FILHO
PAULO CÉSAR CONTI
REGINALDO CÉSAR ZANELATO
ROBERTO MACOTO SUGUIMOTO
ROLF MARÇON FALTIN
TELMA MARTINS ARAÚJO
WEBER JOSÉ DA SILVA URSI





ImagingPlus™

• Ceph Tracing

• Treatment Simulation

• 3D

• Letter System

3D skeletal rendering



2D photo



Facial Photo Wrap

Face your patient.

Stunning Visualization • Instant Ceph/Pan
• 3D Analysis • Easy Data Processing

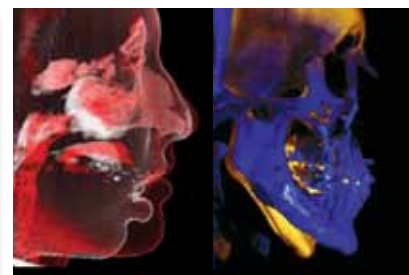
Introducing 2D Facial Photo Wrap, a brand new feature included in Dolphin 3D. Import a 2D photo of your patient and Dolphin 3D guides you through simple steps to overlay it on the facial surface of the patient's CBCT, CT or MRI 3D scan. No additional devices or add-ons are needed. This, plus all the other rich and sophisticated features of Dolphin 3D is why practitioners worldwide are choosing Dolphin. Go ahead: add a face to your patient! To learn more, visit www.renovatio3.com.br or contact us at comercial@renovatio3.com.br, fone: +55 11 3286-0300.



3D airway volume analysis



Panoramic projection

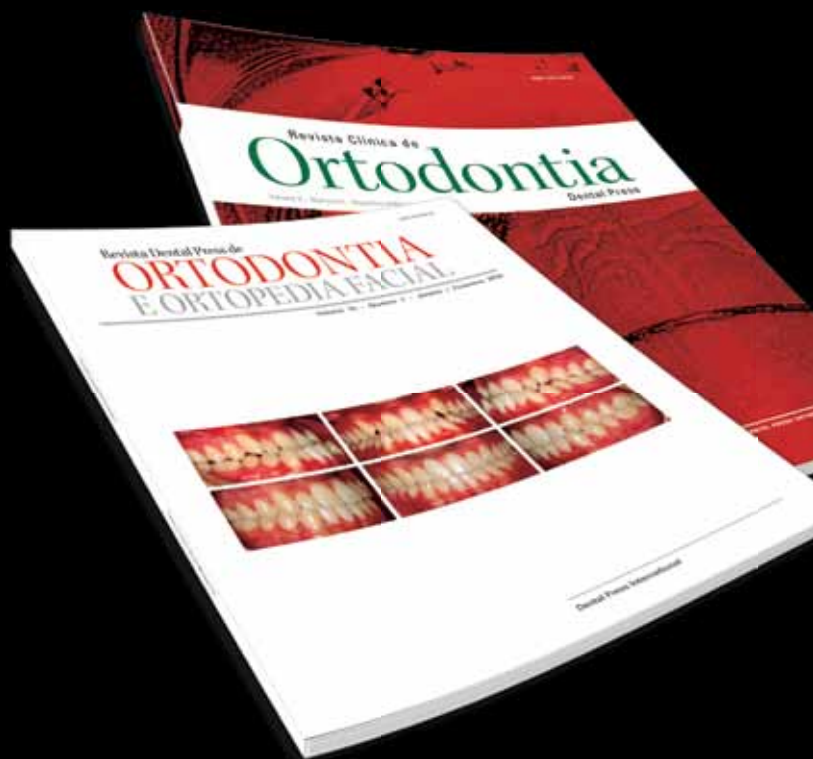


3D pre/post operative superimpositions



You can bring home the entire collection of the
Dental Press Journal of Orthodontics published
from 1996 to 2008!

73 issues
10.540 pages
16.029 images
4.728 infographics



www.dentalcompras.com.br

Coming soon to your clinic



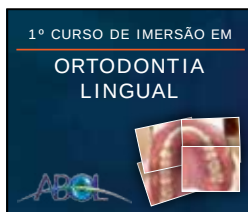
The Dental Press Journal of Periodontology and Implantology and the Dental Press Journal of Aesthetics are directed to the dentistry profession, intended for the publication of research articles, case and techniques reports, significant revisions, brief communications and updates, each in its specific area.

www.dentalpress.com.br



International Interdisciplinary Meeting

Date: 26th and 27th February, 2010
Place: Belo Horizonte / MG / Brazil
Information: (31) 3287-3267
contato@cgcursos.com.br



1st Immersion Course on Lingual Orthodontics - ABOL

Date: 1st to 5th March, 2010 (1st module)
12th to 16th April, 2010 (2nd module)
Place: Belo Horizonte / MG / Brazil
Information: (11) 3816-1096
(11) 3812-9110
cursolingual.abol@succeedtour.com.br



Brazilian Straight-Wire Congress

Date: 12th and 13th March, 2010
Place: Campinas / SP / Brazil
Information: (11) 4586-8133



4th Paulista Congress of Specialists in Orthodontics/Dentofacial Orthopedics - ABOR

Date: 15th to 17th April, 2010
Place: APCD - São Paulo / SP / Brazil
Information: (11) 2031-2300 / (11) 2037-0623
www.aborsp.com.br / crpromocoes@hipernet.com.br



XI International Meeting on Orthodontics of Paranaense Association of Orthodontics and Dentofacial Orthopedics - APRO

Date: 16th and 17th April, 2010
Place: Curitiba / PR / Brazil
Information: (41) 3223-7893
www.aporto.org.br / secretaria@aporto.org.br



'Erty Systems' - Orthodontics / TMD / Occlusion

Date: 20th to 22nd May, 2010
Place: São Paulo / SP / Brazil
Information: (61) 3248-0859



Orthodontics from the age of 8 to 80 - well-being and quality of life

Date: 11th and 12th June, 2010
Place: Brasília / DF / Brazil
Information: www.abordf.com.br

BBO Graduation, 2009

The Brazilian Board of Orthodontics and Facial Orthopedics (BBO) is an entity established as an initiative of the Brazilian Association of Orthodontics and Dentofacial Orthopedics (ABOR) which aims at promoting excellence to clinical specialty. The purpose of BBO is to encourage professional self-evaluation, as well as to offer a certification of excellence by applying specific tests to the specialists whose clinical studies have quality. On October 9th, 2009, during the 7th ABOR Congress it was held, in Brasília, the Graduation Ceremony of those who had succeeded in the last exam carried out on 26th, 27th, and 28th, March, 2009.



From left to right: upper column - José Valladares Neto (GO), Silvio Rosan Oliveira (SP), Ivan Tadeu Pinheiro da Silva (GO); down column - Guilherme de Araujo Almeida (MG), Merian Lucena de Moura (RN) and Heitel Cabral Filho (RN).

Clinical Forum of the ABOR 7th Congress

During the 7th Congress of the Brazilian Association of Orthodontics and Dentofacial Orthopedics (ABOR), held in Brasília from 8th to 11th, October, 2009, several specialized Brazilian courses sent clinical cases treated by students under the orientation of their professors, in order to apply for the Clinical Forum. The documentation presented was in accordance with the recommendations of the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO), available at www.bbo.org.br. The examination board, composed of BBO directors, awarded the following specialization courses: 1st place – Universidade Federal da Bahia; 2nd place – Universidade Estadual de São Paulo / Ribeirão Preto; 3rd place – Universidade Estadual do Rio de Janeiro.



From left to right: Keiji Moriyama (speaker from Japan), Samara Bezerra (student at UFBA), Hugo Caracas (scientific director of the ABOR 7th Congress), Flávia Artese (director of CDBBO), Daniela Feu Rosa Kroef de Souza (student at UERJ), Ricardo Machado Cruz (President of the 7th ABOR Congress), Eric Liou (speaker from Taiwan), Nelson Mucha (BBO President) and Patrícia Ferreira Amato (student at USP/RP).

Three-dimensional face morphometry

Márcio de Menezes*, Chiarella Sforza**

Facial anthropometry plays a key role in clinical assessments, providing an accurate diagnosis for different syndromes. Clinicians working with the head and face (maxillo-facial, plastic and aesthetic surgeons; orthodontists and prosthodontists) are the mostly interested in this three-dimensional information, being able to estimate the normal and abnormal growth, planning and evaluating surgical or orthodontic treatment, plastic surgeries and anthropometric studies.^{1,6}

Currently, classic direct anthropometry is being replaced with various three-dimensional image (3D) analyzers, and the knowledge and application of this technology is essential for clinicians to analyze the information for planning and evaluating medical procedures and treatments.

Facial landmarks (previously marked on the face of the subject) represent the link between conventional and digital anthropometry⁷: conventional anthropometry identifies soft-tissue landmarks, and places some instrument (calipers, protractors) over them. Fundamentally, digital anthropometry collects a set of digital landmarks from the soft-tissue surface, and uses their spatial x, y, z coordinates as end-points for calculations based on Euclidean geometry: linear distances and angles. Together with these classic measurements, mathematics and geometrics allow the assessment of more complex characteristics from the same set of landmarks used by conventional anthropometry: estimations of volumes and surfaces, analyses of symmetry, and detailed assessments of shape.^{2-5,8}

THREE-DIMENSIONAL MORPHOMETRY METHODS

Two main groups of instruments can be used for soft-tissue three-dimensional facial anthropometry: contact instruments (electromagnetic and electromechanical digitizers, ultrasound probes) and optical/non contact instruments (laser scanners, optoelectronic instruments, stereophotogrammetry, Moiré topography). All these instruments are not invasive and do not provoke pain or discomfort to the subjects. But both

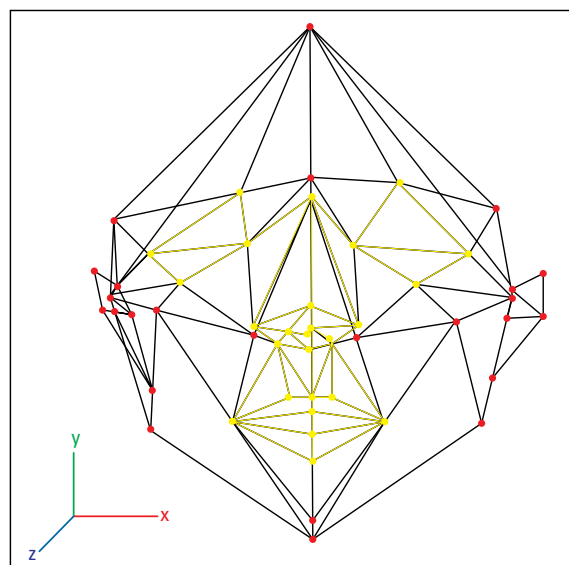


FIGURE 1 - Landmarks digitized by the electromagnetic three-dimensional tablet.

* Postgraduate student, Department of Human Morphology, University of Milan, Milano, Italy.

** Professor, Department of Human Morphology, University of Milan, Milano, Italy.

categories of instruments have advantages and limitations, which should be considered according to the investigated problem and the human resources.

An ideal method for the quantitative evaluation of the patients should combine:

- non-invasive;
- low-cost;
- a fast (simple data collection technique that provides three-dimensional digital data of the facial morphology);
- possibility to create a digital database;
- possibility to use computerized techniques for visualization, simulation and quantitative assessment of the treatment.

CONTACT INSTRUMENTS

Ultrasound probes, electromagnetic and electromechanic digitizers are among the most used contact instruments. The ultrasound method is widely used for prenatal, intrauterine imaging and diagnosis, and three-dimensional reconstructions of fetal face are becoming a current clinical practice. However its application for postnatal facial morphometry is limited and it's being used just to evaluate the facial soft tissue thickness. Electromagnetic and electromechanic digitizers provide the three-dimensional coordinates of landmarks that are previously marked on the face of the subject, which directly correspond to anatomical and anthropometric structures. The facial landmarks are digitized one by one using a stylus connected to the digitizer.^{2,4,7}

Ultrasound probes use acoustic waves in the Megahertz frequency domain, while electromagnetic and electromechanic digitizers are based on electromagnetic waves. The main limitations of the instruments are the reduction of information obtained, and the data acquisition time, which is extremely long when compared to optical methods. Indeed, movements of facial muscles (in particular around mouth and eyes), as well as global head movements, may occur during digitization

producing errors. The acquisition of only single, selected landmarks impedes to produce life-like facial models (Fig 1).

OPTICAL INSTRUMENTS

The optical instruments need no physical contact with the skin, thus eliminating the risk of cutaneous compression, and of potential injuries during measurements.

The instruments of this category are laser scanners and stereophotogrammetric systems. Laser scanners illuminate the face with a laser light source, and digital cameras capture the reflected light; the depth information is obtained by triangulation geometry.

Stereophotogrammetry uses a light source (either patterned or conventional) to illuminate the face, and two or more synchronized cameras record images from different points of view. A previous calibration, made with objects with known geometric characteristics, supplies the mathematical information to obtain a stereoscopic reconstruction of the face. The system can record also facial texture, and combines the three-dimensional information with an accurate reproduction of all facial characteristics (Fig 2, A and B).

Some methods using photogrammetric practices are also available for facial measurement as the Photomodeler system (Eos Systems Inc. Vancouver, British Columbia). This system uses similar techniques from stereoscopic images. Conventional pictures obtained from different angles are analyzed by a dedicated software, and the information is employed to work out the 3D measurements and geometric reconstructions of the face (Fig 3). In a recent study,¹ this system showed able to assess the coordinates of facial landmarks with satisfactory precision and can be used to obtain reliable facial measurements, identifying the major anthropometric landmarks. The method is relatively fast and inexpensive equipment is needed; thus it is simple for those in private practice, researchers, or other practitioners to use¹.

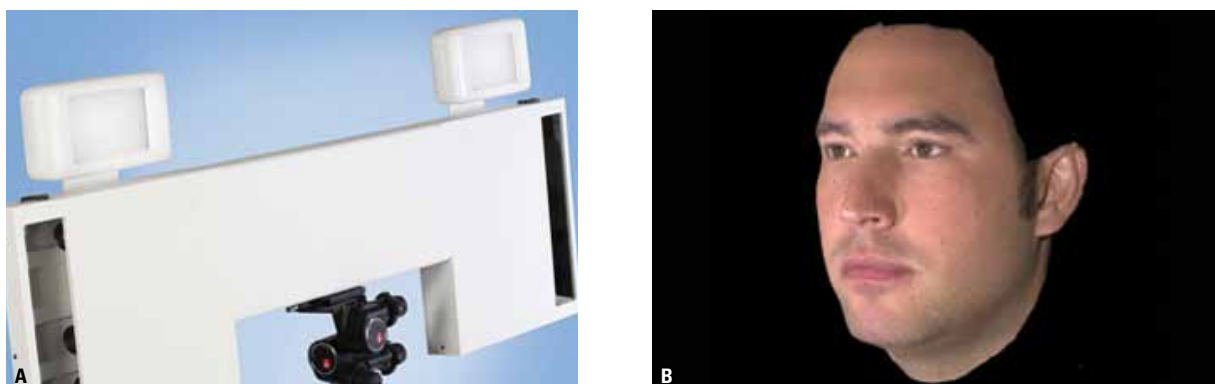


FIGURE 2 - **A)** Vectra-3D system, CanfieldScientific, Inc., Fairfield, NJ, USA. **B)** Facial image obtained with stereophotogrammetry system.



FIGURE 3 - Photogrammetry system (Photomodeler).

Different methods for 3D analysis are being developed and studied, but in general the elevated costs restrict the use in clinical practice.

REFERENCES

1. de Menezes M, Rosati R, Allievi C, Sforza C. A photographic system for the three-dimensional study of facial morphology. *Angle Orthod.* 2009 Nov;79(6):1070-7.
2. Ferrario VF, Sforza C, Poggio CE, Cova M, Tartaglia G. Preliminary evaluation of an electromagnetic three-dimensional digitizer in facial anthropometry. *Cleft Palate Craniofac J.* 1998 Jan;35(1):9-15.
3. Hajeer MY, Ayoub AF, Millett DT. Three-dimensional assessment of facial soft-tissue asymmetry before and after orthognathic surgery. *Br J Oral Maxillofac Surg.* 2004 Oct;42(5):396-404.
4. Ozsoy U, Demirel BM, Yildirim FB, Tosun O, Sarikcioglu L. Method selection in craniofacial measurements: advantages and disadvantages of 3D digitization method. *J Craniomaxillofac Surg.* 2009 Jul;37(5):285-90.
5. Plooi JM, Swennen GR, Rangel FA, Maal TJ, Schutyser FA, Bronkhorst EM, Kuijpers-Jagtman AM, Bergé SJ. Evaluation of reproducibility and reliability of 3D soft tissue analysis using 3D stereophotogrammetry. *Int J Oral Maxillofac Surg.* 2009 Mar;38(3):267-73.
6. Rosati R, Dellavia C, Colombo A, de Menezes M, Sforza C. Nasal base symmetry: a three dimensional anthropometric study. *Minerva Stomatol.* 2009 Jul-Aug;58(7-8):347-57.
7. Sforza C, Ferrario VF. Soft-tissue facial anthropometry in three dimensions: from anatomical landmarks to digital morphology in research, clinics and forensic anthropology. *J Anthropol Sci.* 2006;84:97-124.
8. Shaner DJ, Peterson AE, Beattie OB, Bamforth JS. Assessment of soft tissue facial asymmetry in medically normal and syndrome-affected individuals by analysis of landmarks and measurements. *Am J Med Genet.* 2000 Jul;93(2):143-54.

Contact address

Márcio de Menezes
Praça Cônego Joaquim Alves 79
CEP: 14.300-000 – Batatais / SP
E-mail: marcio.demenezes@unimi.it

Sources of controversies over analgesics prescribed after activation of orthodontic appliances

Acetylsalicylic acid or acetaminophen?

Alberto Consolaro*, Vanessa Bernardini Maldonado**,
Milton Santamaria Júnior***, Maria Fernanda M-O. Consolaro****

The wide range of available drugs raises questions about the desirable and undesirable effects on orthodontic movement. Could medications such as non-steroidal anti-inflammatory drugs (NSAIDs)—ASA, acetaminophen, diclofenac, ibuprofen, indomethacin and celecoxib—, corticosteroids and bisphosphonates have any impact on bone metabolism to the extent of interfering with orthodontic movement?^{23,18}

When administered to control pain and discomfort after activation of the orthodontic appliance, what would be the influence of ASA and acetaminophen on tooth movement and the root resorption associated with it? To help in clarifying this question, Maldonado³⁴ and his team set out to quantitatively determine the influence of ASA and acetaminophen on induced tooth movement and on root resorption by means of optical microscopy. In another study they described the history and action mechanisms of these two medications.¹⁴

However, when analyzing the literature on the subject, it appears that no work repeated the same experimental model of any other work. The appliance used to move a tooth, the

force applied, the dosage and duration of drug use, route of administration, the experimental animal, the teeth that were moved, the types of tissue section and tooth movement assessment as well as many other details differ from study to study, thus precluding comparisons. Without comparisons and without relevant discussions grounded and based on relevant literature it becomes difficult to draw inferences for clinical applications.

Fundamentals and assumptions

Orthodontic movements occur by the application of continued and controlled mechanical forces on the tooth pushing it against the bone, resulting in areas of pressure and tension in the periodontal ligament. The sort of bone remodeling that promotes tooth movement is the result of cellular stress and occasionally inflammation involving clast cells, osteoblasts, osteocytes, cementoblasts and fibroblasts. Mediators—such as various cytokines, growth factors and arachidonic acid products such as prostaglandins and leukotrienes—participate in the process as interaction molecules between cells.^{11,13,16}

* Full Professor of Pathology at FOB-USP and at FORP-USP Postgraduate courses.

** Master's degree from FORP-USP and private clinic in Ribeirão Preto.

*** Doctor of Orthodontics and Professor of postgraduate studies in Orthodontics at the University of Araras.

**** Doctor and Professor of Orthodontics at the postgraduate course of Oral Biology at USC.

Kinins primarily induce pain in free nerve endings and prostaglandins potentiate the effect of kinins, which after 5 to 6 hours no longer produce desirable effects. This potentiation of kinin effects by prostaglandins also occurs in microcirculation vessels increasing vascular permeability. The action mechanism of NSAIDs and acetaminophen has been proven by specific studies conducted on the subject.^{1,4,6,7,8,10,15,19,20,21,26,30,31,35,39,42,45,46,53}

Apparently, drug prescription after activation of the orthodontic appliance poses a paradox: *If, on the one hand, they suppress the patient's pain and discomfort with analgesics that reduce the level of prostaglandins, could it be that, on the other hand, they reduce the effectiveness of cellular stress and inflammation as a mechanism of bone resorption and induced tooth movement?*

Based on reports found in the literature and the behavior of orthodontic clinical cases within the framework advanced by Maldonado³⁴ the authors developed the following hypothesis:

Could the prescription of ASA or acetaminophen have no effect on the biological reactions related to effective orthodontic movement and the frequency and severity of root resorption associated with it? Could the occasional and random administration of such drugs or longer periods of administration produce different effects?

Studies that focused on shorter periods of use of these drugs have been criticized^{3,56} for ignoring the option of longer administration periods. As proposed by Maldonado,³⁴ could the results of the experimental group undergoing the long and short-term administration of acetaminophen and acetylsalicylic acid help in answering how the short and long-term administration of these drugs influence orthodontic movement? In the view of Jerome et al,²⁵ anti-inflammatory medication might even offer protection against root resorption during

orthodontic movement.

It is a fact that prostaglandins induce cellular, tissue and vascular alterations but there is no evidence of inhibition of orthodontic tooth movement by painkillers and NSAIDs.⁵⁶ Bone resorption induced by tooth movement is not mediated solely by prostaglandins^{9,58} but by a pool of mediators such as leukotrienes, cyclic adenosine monophosphate (cAMP),^{16,58} collagenase and many others,²⁹ which are generated by forces applied to periodontal tissues.

The molecular life of prostaglandins consists of only a few seconds. Occasional, randomly administered doses over short periods of time lead to a transient reduction of prostaglandins but are enough to reduce the pain and discomfort after the activation of orthodontic appliances. It is only the long-term reduction of prostaglandins after the administration of regular and repeated doses that would be able to reduce the edema effect and the efficiency of the inflammatory cells, known as anti-inflammatory effect, widely used in postoperative surgical periods.^{12,13}

Inconsistencies in the literature and possible explanations

The literature on the effects of drugs during induced tooth movement is still lacking standardized methodology in all its aspects. Results are often very diverse and inconsistent and cause confusing interpretation. The literature on the subject often demonstrates inexperience with the experimental model and the animal used. Thus, veritable "literature trends" arise whereby one study cites the other without checking basic methodological details. The main variables involved in the lack of consistency between the results reported in the literature are described below.

1. Medication inconsistencies

The doses of ASA or acetaminophen and the

administration periods used in the various studies about induced tooth movement differ widely:

- Wong et al⁵⁷ (1992): 65mg of acetylsalicylic acid for 28 days.
- Kehoe et al²⁷ (1996): 200mg of acetaminophen for 11 days.
- Roche et al⁴⁷ (1997): 1,000mg de acetaminophen for 21 days.
- Sari et al⁵⁰ (2004): 500mg of acetylsalicylic acid for 2 days.
- Arias et al² (2006): 100mg of acetylsalicylic acid and 200mg of acetaminophen for 10 days.
- Salmassian et al⁴⁸ (2009): 600mg of acetaminophen for 7 days.
- Stabile et al⁵² (2009): 200mg de acetaminophen for 2 days.

These differences led two groups of researchers to review the matter: Walker and Buring⁵⁶ and Bartzela et al.³ In a systematic review of Bartzela et al³ on induced tooth movement and the use of NSAIDs, including acetaminophen, the authors found 49 articles. The selection criteria were experimental design, magnitude of force and medication. The authors criticized the results of studies using NSAIDs in induced tooth movement concluding that most of these studies evaluated short-term experiments underestimating the effects of prolonged drug administration.

A similar review was conducted in 2001 by Walker and Buring⁵⁶ with conclusions similar to those reached by Bartzela et al³ in 2009. The authors emphasized that there is no evidence nor any reasonable grounds to account for a complete inhibition of induced tooth movement either with short or long-term drug administration. They justified their conclusions based on the concept that prostaglandins are not the only modulators of bone resorption. Furthermore, based on previous studies, they claim that the exact amount of force necessary to create tooth movement has not been

standardized, and conclude that animal studies have been limited and short-term.

2. Inconsistencies regarding animals used and teeth moved

Methods using induced tooth movement accompanied by drug administration are numerous in the literature, but the choice of experimental model insofar as the orthodontic appliance and the animals are concerned is fraught with inconsistencies. Rabbits,⁴⁷ cats,⁹ pigs^{27,57} and rats^{2,17,32,33,36,37,38,40,41,49,52,54,55,59} have been used.

The teeth used for induced tooth movement are yet another variable that influences the wide variety of results achieved by such studies. Compared with human incisors rodent incisors are quite different in their morphology. Moreover, their odontogenesis is continuous. For example:

- Wong et al⁵⁷ (1992) used guinea pig incisors.
- Kehoe et al²⁷ (1996) studied guinea pig incisors.
- Roche et al⁴⁷ (1997) investigated rabbit molars.
- Sari et al⁵⁰ (2004) experimented using human gingival fluid.
- Arias et al² (2006) used the upper incisors of rats.
- Salmassian et al⁴⁸ (2009) measured the painful effects of fixed orthodontic appliances in humans.
- Stabile et al⁵² (2009) investigated rat incisors.

Research in animals is justified because it is numerically more representative than evaluation in humans. The microscopic analysis of induced tooth movement in humans is limited since it requires extraction, which ruptures periodontal ligament fibers. As a result, part of the tissue that should be examined remains attached to the alveolar bone thereby precluding the analysis of the ensuing changes.⁵

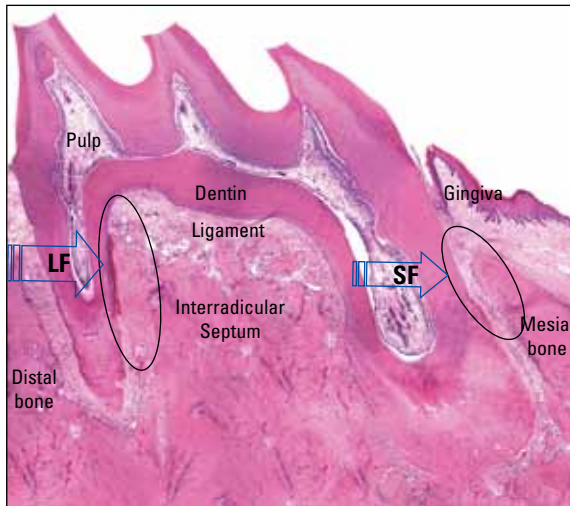


FIGURE 1 - By observing the longitudinal section of a murine first molar one can compare the similarities between a murine tooth and a human molar. In the experimental model proposed by Heller and Nanda²² the forces applied to the mesial root are considered light (LF) due to its volume and size. The small dimensions of the distobuccal root imply strong forces (SF) with greater action exerted on the periodontal ligament, which is consequently extensively hyalinized (red area in the larger circle).

The model of induced tooth movement in rats is universally accepted due to the fact that it is more ethical and can be extrapolated to humans, considering the favorable root morphology of rodents, the size of their molars (Figs 1, 2 and 3) and their anatomical peculiarities, although their metabolism is twice as high as that of humans.^{12,43,51}

3. Inconsistencies regarding the design of the experimental orthodontic appliance

Many different appliance designs are employed to obtain experimental tooth movement and these designs influence the results, regardless of whether or not associated with drug use.

- V-shaped appliances are intended to separate the incisors,^{2,52} which in rodents undergo continuous root formation.
- When placed between the first and second molars elastomers exert a not so efficient or continuous force, which tends to dissipate swiftly, as it acts on two teeth,



FIGURE 2 - By observing the cross-section of a murine first molar one can compare the similarities between this murine tooth and a human molar and its reactions with greater histomorphometric accuracy—in the face of light forces (small arrow) and intense forces (large arrow)—such as the hyaline areas in the periodontal ligament (circles) and the attendant dental resorption. In these cross-sections one can observe all five roots of the murine first molar and adjacent bone.

instead of just one. Moreover, the force is further absorbed by a considerable deflection of the bony ridges and septa of two teeth, and not just one.^{40,55}

- When expansion screws are placed between the first molars they cause upper first molar proclination.^{23,24} Transverse coil springs for molar proclination²⁸ work both on the teeth and on the palatal sutures, and it is not possible to determine with any degree of reliability the extent

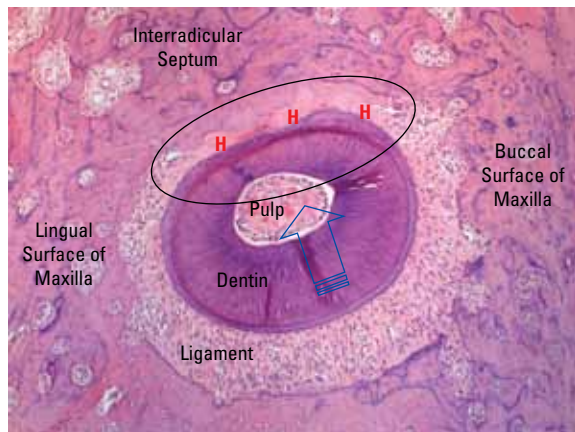


FIGURE 3 - By magnifying a cross-section of a murine first molar root one can measure its reactions with histomorphometric accuracy in the face of the forces (arrow) applied, such as the hyaline areas (H) in the periodontal ligament (circle) and related bone and tooth resorption when these are present.

of such occurrences. The bone plate of the rat is very thin and does not allow a standardized use of these springs.

- The use of coil springs interposed between incisors and molars in order to move molars mesially is currently widespread enabling the quantification and standardization of forces deployed in the experimental model, thereby imparting greater credibility to the extrapolation of results.^{17,36,37,38,41,49,54,59} This model was designed by Heller and Nanda²² and perfected by Martins-Ortiz³⁶ (Figs 1, 2 and 3).

4. Inconsistencies regarding the intensity and distribution of forces

Perhaps the most decisive factors influencing the differences and diversities of the results regarding this matter do not concern only the experimental appliance but especially the intensity and distribution of forces applied to achieve tooth movement:

- Wong et al⁵⁷ (1992) moved guinea pig

incisors with a V-shaped appliance using a force of 8cN.

- Kehoe et al²⁷ (1996) moved guinea pig incisors using a V-shaped appliance and applied forces up to 25cN.
- Roche et al⁴⁷ (1997) moved rabbit molars mesially using springs interposed to the incisors by applying forces up to 100cN.
- Sari et al⁵⁰ (2004) moved human canines distally applying forces up to 120cN.
- Arias et al² (2006) separated the upper incisors of rodents using a V-shaped appliance and a force of 35cN.
- Salmassian et al⁴⁸ (2009) did not standardize force intensity.
- Stabile et al⁵² (2009) moved the upper incisors of rats with a V-shaped appliance using a force of 30cN.

These significant discrepancies could also be found in the data reported in 2004 after a systematic review of Ren.⁴⁴ In 20% of the studies on induced tooth movement the forces applied were lower than 20cN; 27% of the studies used elastomers of unknown forces; 37% applied forces ranging from 20 to 50cN and 12% used forces ranging from 50 to 100cN.

5. Inconsistencies regarding result interpretation and measurement

The criteria for interpreting and measuring the effects of applied forces on cells and tissues, of associated root resorption and the influence of drugs on periodontal tissues represent another variable limiting the extrapolation of the clinical results previously reported in the literature.

For example, in research on induced tooth movement areas of hyalinization in the periodontal ligament mean that the forces applied were effective in light of a microscopic analysis of experimental results. The results found by Bohl et al⁵ about the extent of hyalinization areas after experimental tooth movement are

rather inadequate in the literature due to:

- Wide variation among the methods.
- Variability in size and time as regards the emergence of hyaline areas.
- Considerable type and intensity differences in terms of force application.

In 2007, Fracalossi¹⁷ revealed that, under microscopic analysis, the differences may also occur in the cross-section plane of the moved teeth. Cross-sections allowed a better assessment of tissue effects making it easy to visualize the roots in a single, parallel plane¹⁷ (Figs 1, 2 and 3).

Acetylsalicylic acid or acetaminophen?

In the work of Maldonado,³⁴ the comparative results between the short and long-term administration of acetylsalicylic acid and acetaminophen were obtained using the model created by Heller and Nanda²² and later modified by Martin-Ortiz³⁶ since it allows for force and movement type standardization. The first molars of young rats are very similar in morphology to that of humans and their formation is not continuous as is the case with rat incisors.

Result reproducibility was based on the measurement of two important parameters, namely, the occurrence of hyaline areas (Figs 1, 2 and 3) and the presence of root resorption. Hyaline areas indicate that there was vascular compression and areas of hypoxia that determine cell migration and necrosis. In other words, this means that the force was active in the first hours and days of the experiment. The areas of root resorption in turn indicate cell mobilization, especially of clast cells, indicating that the forces continued to operate even several days after the force had been applied and the teeth moved.

The dosage administered in the Maldonado³⁴ investigation was based on the dosage recommended for humans taking into account that the rat's metabolism is twice that of humans.

For the relief of human pain, these drugs—acetylsalicylic acid and acetaminophen—are prescribed and patients recommended to swallow them whenever the need arises, i.e., administration follows a random pattern in time. Thus, the administration of these drugs for short periods attempted to simulate this situation of randomness and contingency. However, certain patients endowed with higher sensitivity to pain can take them several times over a period of just a few days. Long-term administration was meant to simulate this situation.

In this study, a histomorphometric analysis was performed of the effects of induced tooth movement in rats (200g) with springs interposed between the upper molars and the incisors and a force of 75cN associated with 25mg of ASA and 25mg of acetaminophen (short-term administration/2 days, and long-term/9 days). When compared with the control, the authors found no statistically significant differences in percentage means of hyaline areas in the periodontal ligament. Tissue reactions in the experimental groups were similar to those in the control group.

Root resorption was also assessed by the quantitative histomorphometric method and no statistically significant differences were found in the percentage means of the areas of root resorption between the acetylsalicylic acid group and the acetaminophen group compared with the control group, in the time periods used for evaluation.

The same findings were observed when comparing the experimental acetylsalicylic acid group with the acetaminophen group in terms of the percentage of hyaline areas found. In the authors' opinion, no statistically significant difference was found in the means of the hyaline areas between the experimental groups at 5, 7 and 9 days. The microscopic effects were similar in the experimental groups.

A comparison between the acetylsalicylic

acid group and the acetaminophen group (short and long term), in light of the percentage means of root resorption areas found no statistical difference in the time periods under evaluation.

The findings were difficult to be compared directly with those of other authors as the experimental model in almost all respects differed significantly.

In this experimental model results can be more safely and directly extrapolated to humans using the measurements and analysis conducted by the authors. In particular, this is due to the fact that this experimental model allows the observation and measurement—on the same tooth—of the tissue and cellular effects brought about by light and heavy forces, both without drugs and under their influence. Such precautions were suggested by Bartzela et al,³ Walker and Buring.⁵⁶

Final considerations

The results of the study carried out by Maldonado³⁴ indicated that acetylsalicylic acid and acetaminophen did not interfere in the cell and tissue phenomena caused by induced tooth movement or in the degree and frequency of

the attendant root resorption. This corroborates the finding of Walker and Buring⁵⁶ that prostaglandins—the main targets of acetylsalicylic acid and acetaminophen—are not the only local mediators of bone resorption. These drugs act as modulators of prostaglandin production to control pain and discomfort rather than inhibiting total prostaglandin synthesis in the cellular stress and inflammation region, while other mediators of bone resorption continued to operate normally in the periodontal tissues.

When prescribing an analgesic to relieve the patient's pain and discomfort after activation of orthodontic appliances—always in writing and using the prescription pad—the choice should take into account the patient's history with side effects and the possibility of drug hypersensitivity. If any of these situations is characterized, the choice between ASA and acetaminophen depends on the accessibility or cost of the drug, at the discretion of the professional and/or the patient. The results show no influence on the effectiveness of orthodontic movement and frequency of root resorption associated with both ASA and acetaminophen.

REFERENCES

1. Abramson SB, Weissmann G. The mechanism of action of nonsteroidal anti-inflammatory drugs. *Arthritis Rheum.* 1989; 32:1-9.
2. Arias OR, Marquez-Orozco MC. Aspirin, acetaminophen, and ibuprofen: Their effects on orthodontic tooth movement. *Am J Orthod Dentofacial Orthop.* 2006 Sep;130(3):364-70.
3. Bartzela T, Türp JC, Motschall E, Maltha JC. Medication effects on the rate of orthodontic tooth movement: a systematic literature review. *Am J Orthod Dentofacial Orthop.* 2009 Jan;135(1):16-26.
4. Bianchi M, Panerai AE. The dose-related effects of paracetamol on hyperalgesia and nociception in the rat. *British Journal of Pharmacol.* 1996;117:130-32.
5. von Böhl M, Kuijpers-Jagtman AM. Hyalinization during orthodontic tooth movement: a systematic review on tissue reactions. *Eur J Orthod.* 2009 Feb;31(1):30-6.
6. de Carlos F, Cobo J, Díaz-Esnal B, Arguelles J, Vijande M, Costales M. Orthodontic tooth movement after inhibition of cyclooxygenase-2. *Am J Orthod Dentofacial Orthop.* 2006 Mar;129(3):402-6.
7. de Carlos F, Cobo J, Perillan C, Garcia MA, Arguelles J, Vijande M, Costales M. Orthodontic tooth movement after different coxib therapies. *Eur J Orthod.* 2007 Dec;29(6):596-9.
8. Chandrasekharan NV, Dai H, Roos KL, Evanson NK, Tomsik J, Elton TS, Simmons DL. COX-3, a cyclooxygenase 1 variant inhibited by acetaminophen and other analgesic/antipyretic drugs: cloning, structure, and expression. *Proc Natl Acad Sci USA.* 2002 Oct;99(21):13926-31.
9. Chumbley AB, Tuncay OC. The effect of indomethacin (an aspirin-like drug) on the rate of orthodontic tooth movement. *Am J Orthod.* 1986 Apr;89(4):312-4.
10. Clissold SP. Acetaminophen and phenacetin. *Drugs.* 1986; 32:46-59.
11. Consolaro A. Reabsorções dentárias nas especialidades clínicas. 2ª ed. Maringá: Dental Press; 2005.
12. Consolaro A. Analgésicos e antiinflamatórios na movimentação dentária induzida: metodologia e interpretação. Você sabe o que é extrapolação cefalométrica? *Rev Dental Press Ortod Ortop Facial.* 2007 maio/jun;12(3):19-23.
13. Consolaro A. Inflamação e reparo. 1ª ed. Maringá: Dental Press; 2009.
14. Consolaro A, Maldonado VB, Santamaria Jr, M Consolaro MFMO. Ácido acetilsalicílico ou acetaminofeno? Qual o medicamento para aliviar a dor e o desconforto após a ativação dos aparelhos ortodônticos? *Rev Clin Ortodon Dental Press.* 2009 dez;2010 jan;8(6):106-10.
15. Courade JP, Caussade F, Martin K, Besse D, Delchambre C, Hanoun N, Hamon M, Eschaliere A, Cloarec A. Effects of acetaminophen on monoaminergic systems in the rat central nervous system. *Naunyn Schmiedeberg Arch Pharmacol.* 2001 Dec;364(6):534-7.
16. Davidovitch Z, Shanfeld J. Cyclic AMP level in alveolar bone of orthodontically treated cats. *Arch Oral Biol.* 1975 Sep; 20(9):567-74.
17. Fracalossi ACC. Análise da movimentação dentária induzida em ratos. Influências do alendronato nas reabsorções dentárias, estudo comparativo em cortes transversais e longitudinais e avaliação microscópica em diferentes períodos de observação. [Dissertação]. Bauru (SP): Universidade de São Paulo; 2007.
18. Gameiro GH, Pereira-Neto JS, Magnani MB, Nouer DF. The influence of drugs and systemic factors on orthodontic tooth movement. *J Clin Orthod.* 2007 Feb;41(2):73-8.
19. Giunta D, Keller J, Nielsen FF, Melsen B. Influence of indomethacin on bone turnover related to orthodontic tooth movement in miniature pigs. *Am J Orthod Dentofacial Orthop.* 1995 Oct;108(4):361-6.
20. Goodman A. As bases farmacológicas da terapêutica. 10ª ed. New York: Mc Graw-Hill; 2003. p. 517-50.
21. Graf P, Glatt M, Brune K. Acidic nonsteroid anti-inflammatory drugs accumulating in inflamed tissue. *Experientia.* 1975 Aug 15;31(8):951-3.
22. Heller IJ, Nanda R. Effect of metabolic of periodontal fibers on orthodontic tooth movement. *Am J Orthod.* 1979 Mar;75(3):239-58.
23. Igarashi K, Mitani H, Adachi H, Shinoda H. Anchorage and retentive effects of a bisphosphonate (AHBuBP) on tooth movements in rats. *Am J Orthod Dentofacial Orthop.* 1994 Sep;106(3):279-89.
24. Igarashi K, Adachi H, Mitani H, Shinoda H. Inhibitory effect of the topical administration of a bisphosphonate (risedronate) on root resorption incident to orthodontic tooth movement in rats. *J Dent Res.* 1996 Sep;75(9):1644-9.
25. Jerome J, Brunson T, Takeoka G, Foster C, Moon HB, Grageda E, Zeichner-David M. Celebrex offers a small protection from root resorption associated with orthodontic movement. *J Calif Dent Assoc.* 2005 Dec;33(12):951-9.
26. Jones M, Chan C. The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two aligning archwires. *Am J Orthod Dentofacial Orthop.* 1992;102:373-81.
27. Kehoe MJ, Cohen SM, Zarrinnia K, Cowan A. The effect of acetaminophen, ibuprofen and misoprostol on prostaglandin E2 synthesis and the degree and rate of orthodontic tooth movement. *Angle Orthod.* 1996;66(5):339-49.
28. Iwase M, Kim KJ, Kobayashi Y, Itoh M, Itoh T. A novel bisphosphonate inhibits inflammatory bone resorption in rat osteolysis model with continuous infusion of polyethylene particles. *J Orthop Res.* 2002 May;20(3):499-505.
29. King GJ, Collier J. A bone resorptive agent extracted from orthodontically-treated tissues of the rat. *Angle Orthod.* 1986 Oct;56(4):299-308.
30. Krishnan V. Orthodontic pain: from causes to management - a review. *Eur J Orthod.* 2007 Apr;29(2):170-9.
31. Law SLS, Southard KA, Law AS, Logan HL, Jakobsen JR. An evolution of preoperative ibuprofen for treatment of pain associated with orthodontic separator placement. *Am J Orthod Dentofacial Orthop.* 2000 Dec;118(6):629-35.
32. Leiker BJ, Nanda RS, Currier GF, Howes RI, Sinha PK. The effects of exogenous prostaglandins on orthodontic tooth movement in rats. *Am J Orthod Dentofacial Orthop.* 1995 Oct;108(4):380-8.
33. Macapanpan LC et al. Early tissue changes following tooth movement in rats. *Angle Orthod.* 1954;24(2):79-95.
34. Maldonado VB. Efeitos microscópicos do ácido acetilsalicílico (aspirina) e do acetaminofeno (tylenol) na movimentação dentária induzida e nas reabsorções radiculares associadas. [Dissertação] Ribeirão Preto (SP): Universidade de São Paulo; 2009.
35. Marshall PJ, Kulmacz RJ, Lands WE. Constraints on prostaglandins biosynthesis in tissues. *J Biol Chem.* 1987 Mar 15;262(8):3510-7.
36. Martins-Ortiz MF. Influência dos bisfosfonatos na movimentação dentária induzida, na frequência e nas dimensões das reabsorções radiculares associadas. [tese]. Bauru (SP): Universidade de São Paulo; 2004.
37. Mazzeiro ET. Bisfosfonato e movimentação dentária induzida: avaliação microscópica de seus efeitos. [Tese]. Bauru (SP): Universidade de São Paulo; 1999.
38. Mohammed AH, Tatakis DN, Dziak R. Leukotrienes in orthodontic tooth movement. *Am J Orthod.* 1989 Mar;95(3):232-37.
39. Ngan P, Kess B, Wilson S. Perception of discomfort by patients undergoing orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1989 Jul;96(1):47-53.
40. Ohkawa S. Effects of orthodontic forces and anti-inflammatory drugs on the mechanical strength of the periodontium in the rat mandibular first molar. *Am J Orthod.* 1982 Jun;81(6):498-502.
41. Pereira AAC. Avaliação microscópica da influência de anticoncepcional e gravidez na movimentação dentária induzida, em especial nos fenômenos da reabsorção dentária. [dissertação]. Bauru (SP): Universidade de São Paulo; 1995.
42. Polat O, Karaman AI. Pain control during fixed appliance therapy. *Angle Orthod.* 2005;75:214-9.

43. Porter G. The norway rat (*Rattus norvegicus*). In: Lanne-Petter, W. et al. The UFAW handbook on the care and management of laboratory animals. 3rd ed. London: Livingstone; 1967. p. 353-90.
44. Ren Y, Maltha JC, Jagtman-Kuijpers AM. The rat as a model for orthodontic tooth movement - a critical review and a proposed solution. *Eur J Orthod*. 2004;26:483-490.
45. Rodan GA, Martin TJ. Role of osteoblasts in hormonal control of bone resorption: a hypothesis. *Calcif Tissue Int*. 1981;33(4):349-51.
46. Rodan GA, Yeh CK, Thompson DT. Prostaglandin and bone. In: Norton LA, Burstone CJ. The biology of tooth movement. Boca Raton: CRC Press; 1989. Chapter 16:263-7.
47. Roche JJ, Cisneros GJ, Acs G. The effect of acetaminophen on tooth movement in rabbits. *Angle Orthod*. 1997;67(3):231-6.
48. Salmassian R, Oesterle LJ, Shellhart WC, Newman SM. Comparison of the efficacy of ibuprofen and acetaminophen in controlling pain after orthodontic tooth movement. *Am J Orthod Dentofacial Orthop*. 2009 Apr;135(4):516-21.
49. Santamaria MJR. Biologia da movimentação dentária induzida e das reabsorções radiculares associadas. Influência do gênero e dos bisfosfonatos. [tese]. Bauru (SP): Universidade de São Paulo; 2009.
50. Sari E, Olmez H, Gürton AU. Comparison of some effects of acetylsalicylic acid and rofecoxib during orthodontic tooth movement. *Am J Orthod Dentofacial Orthop*. 2004 Mar;125(3):310-5.
51. Schour I, Massler M. The teeth. In: Farris EJ, Griffith JQ. The rat in laboratory investigation. 2nd ed. New York: Hafner; 1963.6:104-65.
52. Stabile AC, Stuari MB, Leite-Panissi CR, Rocha MJ. Effects of short-term acetaminophen and celecoxib treatment on orthodontic tooth movement and neuronal activation in rat. *Brain Res Bull*. 2009 Aug 14;79(6):396-401.
53. Swierkosz TA, Jordan L, McBride M, McGough K, Devlin J, Botting RM. Actions of paracetamol on cyclooxygenases in tissue and cell homogenates of mouse and rabbit. *Med Sci Monit*. 2002 Dec;8(12):BR496-503.
54. Vasconcelos MHF et al. A histological study of tooth movement in rats under contraceptive use. In: Davidovitch Z, Mah J. Biological mechanisms of tooth eruption, resorption and replacement by implants. Alabama: Harvard Society for the Advancement of Orthodontics; 1998.
55. Waldo CM, Rothblatt JM. Histologic response to tooth movement in the laboratory rat: procedure and preliminary observations. *J Dent Res*. 1954 Aug;33(4):481-6.
56. Walker JB, Buring SM. NSAID impairment of orthodontic tooth movement. *Ann Pharmacother*. 2001 Jan;35(1):113-5.
57. Wong A, Reynolds EC, West VC. The effect of acetylsalicylic acid on orthodontic tooth movement in the guinea pig. *Am J Orthod Dentofacial Orthop*. 1992 Oct;102(4):360-5.
58. Yamasaki K. The role of cyclic AMP, calcium and prostaglandins in the induction of osteoclastic bone resorption associated with experimental tooth movement. *J Dent Res*. 1983 Aug;62(8):877-81.
59. Zhou D, Hughes B, King GJ. Histomorphometric and biochemical study of osteoclasts at orthodontic compression sites in the rat during indomethacin inhibition. *Arch Oral Biol*. 1997 Oct/Nov;42(10-11):717-26.

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

James Leonard Vaden

- Graduated in Dentistry, College of Dentistry, Tennessee.
- Doctor and Master in Orthodontics, University of Tennessee.
- Graduated in History, Vanderbilt University.
- Professor of the Graduation Program in Orthodontics, University of Tennessee.
- Clinical Associated Professor at the University of Michigan in Ann Arbor, from 1991 to 2000.
- Former Chairman and current Director of the American Board of Orthodontists.
- Associate Director of the Tweed Study Course in Tucson Arizona.
- Treasurer of the Tweed Foundation.
- Editor of the Tweed Loop Journal.



It was with great honor and pleasure that I accepted the invitation to coordinate this interview with Dr. Vaden, for whom I have a deep admiration, especially for his work as a clinician and educator. His clinic life started in 1972 in his office in Cookeville, TN, where, he has been attending children and adults. Over the years, he has been trying to pass his orthodontic experience through more than 120 articles published, as either an author or co-author of 10 chapters of textbooks, in addition to more than 200 lectures carried out in several countries, including Brazil, where he has been five times. He is married to Dr. Beverly Hedgepeth and has a daughter, Meg, a lawyer in New York. He and Beverly live in a farm in the area of Buck Mountain, Vanderbilt, TN, where he raises Angus cattle. In his spare time, he works the land with a John Deere tractor that he had repaired by himself.

Along with well known professors we could prepare questions that express the brilliant opinions of our interviewer on several topics related to contemporary Orthodontics. Have a nice reading!

Estelio Zen

We have seen in your presentations the beautiful esthetic results of the patients' faces with treatment plans involving dental extractions. However, many orthodontists seem to ignore the possibility of improved facial aesthetics through extractions. What are the reasons that you point to the strength of these professionals to accept more extractions? Nelson Mucha

I wish I knew the answer to Dr. Mucha's question. I've wondered the same thing many, many

times. I don't know why many who practice orthodontics don't have a better understanding of the relationship of facial esthetics and the treatment plan. Each patient should be treatment planned so that the optimum in facial esthetics is achieved. Some say that facial esthetics is an "individual thing" and I constantly hear the phrase "beauty is in the eye of the beholder". If one looks at the subject of facial esthetics from a historical perspective, this is not true. There are standards and guidelines for facial esthetics. Perhaps the



FIGURE 1 - Michelangelo.



FIGURE 2 - Leonardo Da Vinci.

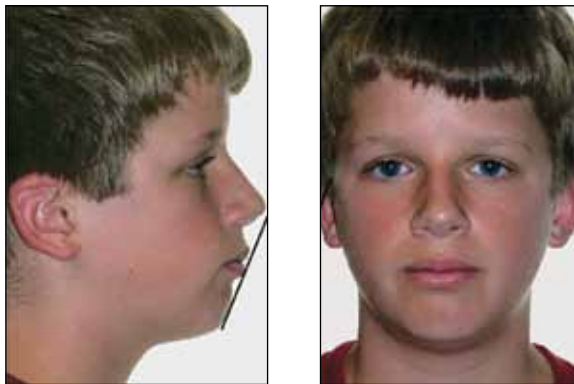


FIGURE 3 - Bialveolar protrusion correction.

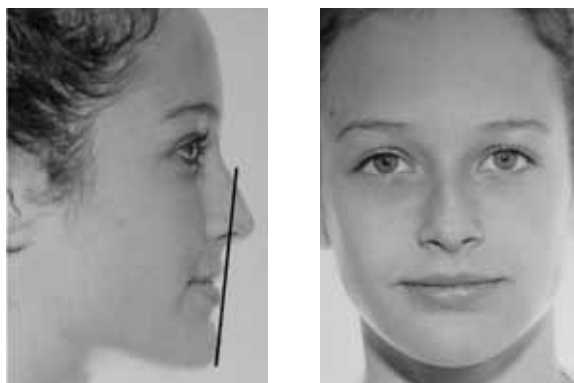


FIGURE 4 - Maintenance of labial balance.



simplest guide that exists was given to us by the Renaissance artists, Michelangelo and DaVinci. These artists used the profile line to determine balance and symmetry of the lower facial profile (Figs 1 and 2). The profile line is a simple tool

that is constructed by drawing a line from the soft tissue chin that touches the most prominent lip and that extends upward past the nose. A good relationship of the profile line to the nose is to bisect the anterior 1/3 of the nose. If the profile

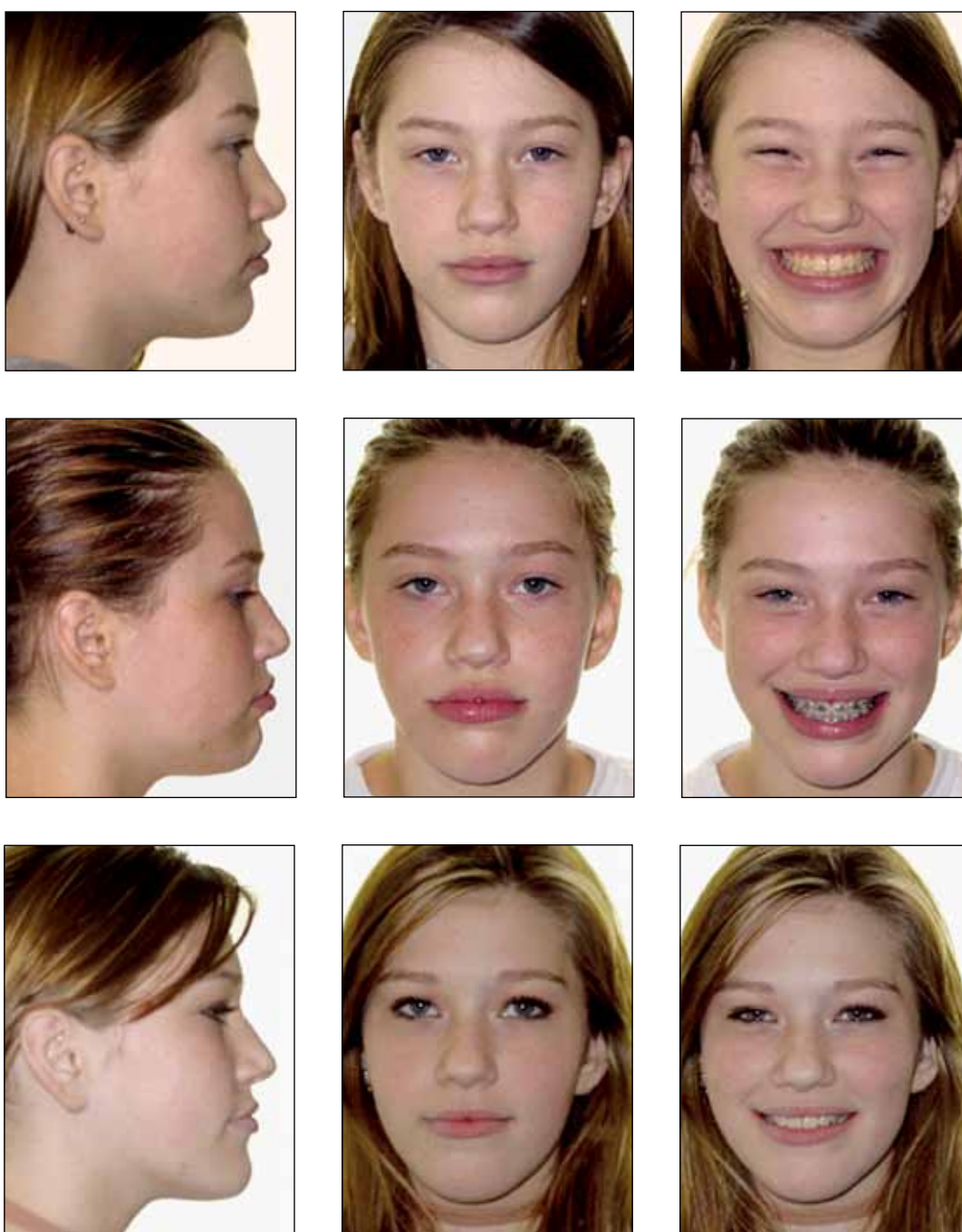


FIGURE 5 - The patient began treatment without extractions and profile worsened. The treatment plan was changed to extractions and back to the original profile.

line is outside the nose, the patient has a bialveolar protrusion (Fig 3). Reducing the protrusions moves the profile line into the nose. If the profile line is too far “into” the nose, the face is too “concave” (Fig 4). Treatment must not move the profile line further into the nose. I use this simple tool in my treatment plan for every patient. If the patient has a balanced and proportioned face prior to orthodontic treatment, I want to maintain that balance and proportion. If the patient

has a bialveolar protrusion—if the lips are too far forward—I want to reduce that protrusion. To reduce a protrusion for most patients requires extractions. Patient MH had a reasonably balanced face but was started without the removal of teeth even though there was crowding of the teeth. Protruding the teeth to gain alignment created an unsightly protrusion. The treatment plan was altered, extractions were done, treatment was completed and facial esthetics recovered (Fig 5).



FIGURE 6 - This patient was treated without premolar extraction. Facial balance was preserved.



FIGURE 7 - Extractions were used to improve facial balance. Note the proportions of the face at age 42.

Dr. Mucha asks the question of why most orthodontists don't seem to realize the impact of extractions and the fact that extractions can greatly improve facial balance, harmony and proportion for many patients. My feeling is that orthodontics, as a specialty, has gotten so appliance driven that concern for facial esthetics has "gone by the wayside". Some "orthodontists" are, in many

instances, placing appliances and using the same series of preformed archwires on every patient to simply align the teeth. The specialty is becoming a specialty of tooth alignment. If we as a specialty don't go back to our roots and our training and become less "appliance driven", we are going to face some serious problems in the future. It's not about extracting teeth or not extracting, it's about doing what's right for the patient's face. If the patient doesn't require extractions for post-treatment facial balance, harmony and beauty, no extractions should be done (Fig 6). If extractions will improve the balance and harmony of the patient's face (Fig 7), the specialty must use this very valuable tool.

With the large supply of "magical treatments, smart archwires, aligners, self ligating brackets", among others, which arguments do you use as a teacher to your students to maintain high standards for diagnosis, planning and accomplishment of appropriate orthodontic treatments with the need for individualized bends in archwires? Nelson Mucha

Orthodontic education has a great responsibility to teach students the fundamentals that are involved in a careful and methodical system of treatment planning and force system application. Once the treatment plan is reached, the appliances must be placed appropriately and treatment conducted accordingly. It is imperative that students understand that there are no magic appliances and no magic archwires. The patient must be treated by a skillfully trained orthodontist, not by an appliance. Many programs that teach graduate orthodontic students stress fundamentals. These programs have leadership that understands and appreciates the fundamentals. They also have part-time clinical faculty who understand the fundamentals. There are some programs, however, that have faculty who are appliance driven and who have no concept of the fundamentals of orthodontics. The student who trains in this type of program, therefore, has no understanding of treatment planning and of treatment. It is

not the fault of the student. Our specialty must come to grips with this problem. This is not to say, however, that those programs that stress the fundamentals have graduates who adhere to what they are taught during their training program. Some well trained graduates simply take a couple of the commercial courses that tout the amount of money one can make if they see “x” number of patients in a day with that company’s “magic” appliance. These students buy into this commercialism and join the ranks of tooth alignment specialists. This is disheartening to the people who taught them, but we always think they will return to what they were taught when they see that the “quick and easy” doesn’t always work. The primary argument we use at my university is “Look at the face. Do what is right for the face and for the long-term stability of your treatment result.” We keep repeating this fact. It’s heartening that some students listen and practice accordingly. Others who haven’t practiced accordingly have realized their error, have reevaluated their practices and have started treating their patients more appropriately. I can assure you that it’s a hard problem in today’s climate of “everything works and nothing matters”. Those of us in orthodontic education have to keep our hope that our students are listening and learning and that, even if they “stray” for a while, will come back to the fundamentals in order to render appropriate treatment for their patients.

In your article published in World Journal of Orthodontics (v. 6, no. 2, p. 115-124, 2005), you stated that the patient who has a diminished anterior facial height and excess posterior facial height must be treated with a different diagnosis and treatment plan. What diagnostic and treatment plan “schemes” must be used? Adilson Tomazinho

The “low angle” patient has short anterior facial height and excessive posterior facial height. As a general rule, this patient has a profile line to nose relationship that is either “correct” or the profile line might even be too far into the

nose. One has to carefully treatment plan these patients to preserve facial balance (refer to Fig 6) and yet give them a dentition that is esthetic and stable over the long term (Fig 8). In most instances the treatment plan will involve the preservation of mandibular incisor position. The low angle patient does not benefit from uprighting mandibular incisors; in fact, it can be harmful to facial esthetics. Therefore, most of these patients need to be treatment planned so that mandibular incisors are left in their pretreatment positions (Fig 9). This does not mean, however, that one can ameliorate crowding or level the curve of Spee by proclining mandibular incisors. If the patient has significant crowding, teeth must be extracted, but it’s normally the mandibular second premolars. Crowding is eliminated for these patients and the space that remains must be closed by mesial movement of the mandibular posterior teeth so that mandibular incisor position is protected. The records of the following patient illustrate this concept (Fig 10). In some instances, if there is not significant mandibular crowding, the curve of Spee can be leveled with an approach that utilizes a headgear to the mandibular arch along with early removal of mandibular third molars. This allows one to level the mandibular arch without flaring mandibular incisors. Quite honestly, the treatment of these patients revolves around how one can manage the mandibular arch—if there is a deep curve of Spee and/or if there is crowding. The mandibular incisor cannot be flared to correct these two problems. The case report that follows illustrates this concept. The patient was treated by leveling the curve of Spee and eliminates the crowding with third molar extraction and the use of a mandibular J-hook headgear (Fig 11).

Conventional orthodontic treatment of the patient who has excessive anterior facial height with open bite is difficult. Many times, it is necessary to make surgical-orthodontic treatment. What nonsurgical orthodontic treatment options can give to the patient



FIGURE 8 - An esthetic, stable dentition.

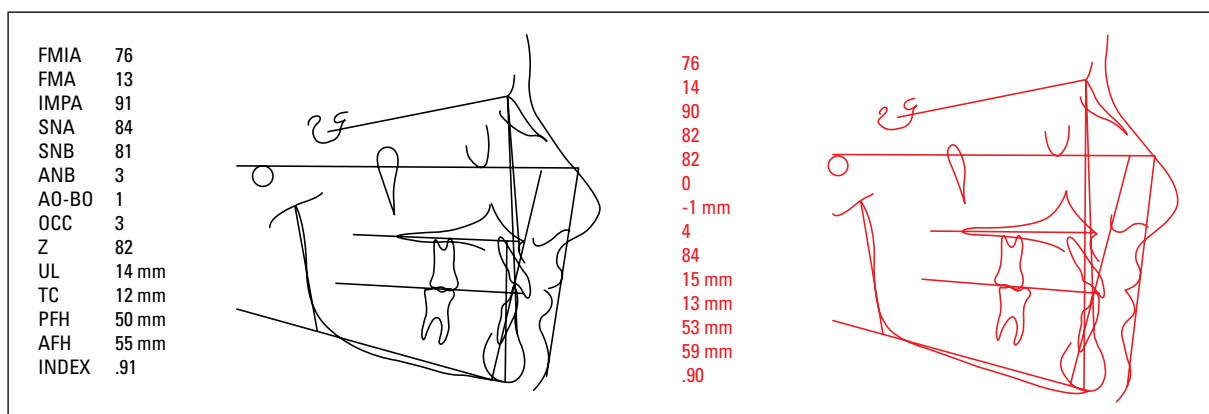


FIGURE 9 - Pretreatment and posttreatment tracings: Note maintenance of the mandibular incisor positions.



FIGURE 10A - Pretreatment and posttreatment facial photographs: Note maintenance of facial balance.

acceptable facial balance and a good functional occlusion? Adilson Tomazinho

The Class II high angle patient, particularly one who also presents with an anterior open bite, is difficult to treat without surgical intervention. There are treatment planning approaches, however, that the orthodontist can use to treat these patients.

I preface my answer by saying that in most instances the patient might receive a better facial esthetic result if surgical orthodontics is done. However, this doesn't mean that the teeth will not fit together properly and that the patient won't have a functional occlusion that lasts and that is stable—along with reasonable balance and harmony of the

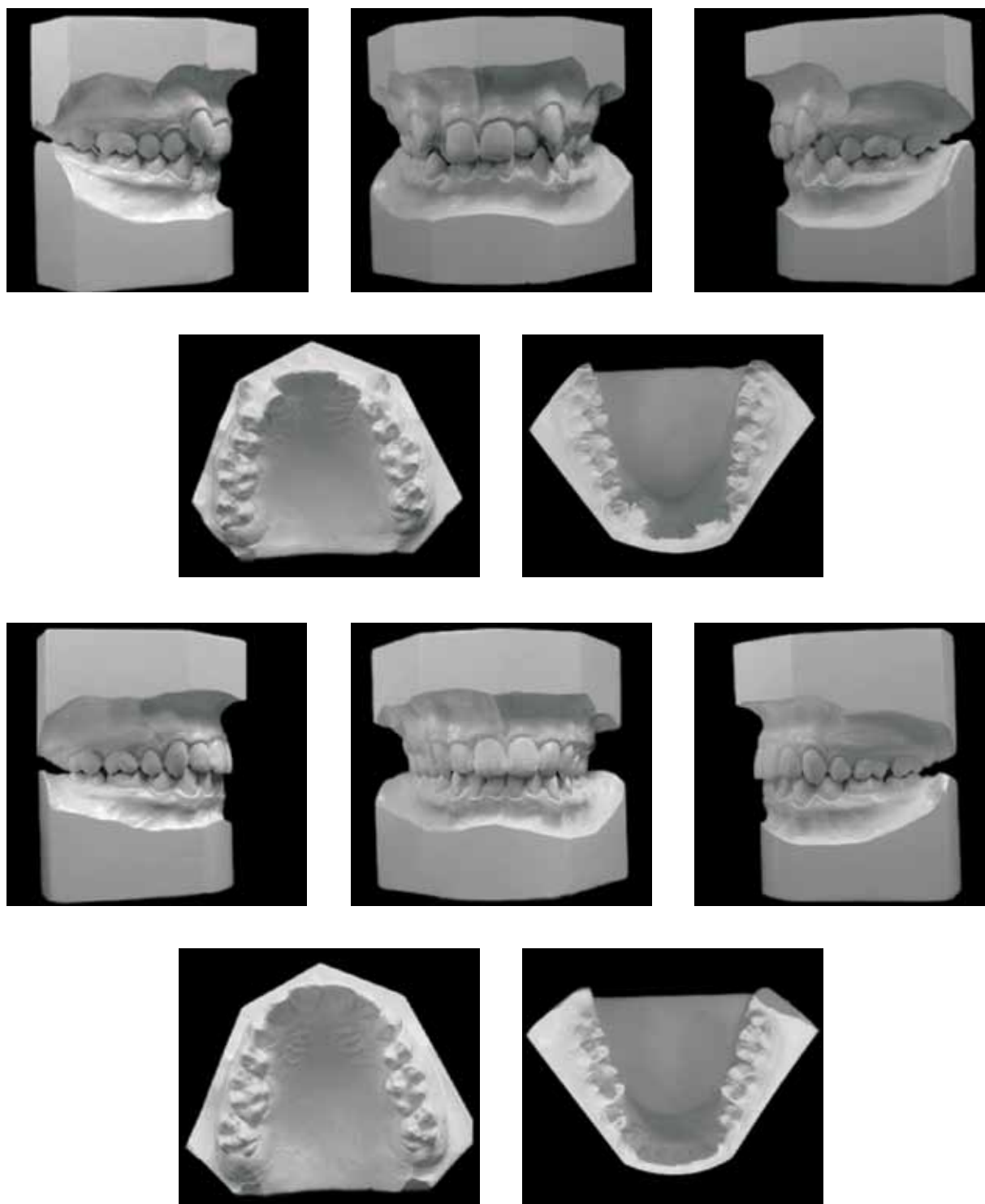


FIGURE 10B - Pretreatment and posttreatment casts: the dental relationship has been corrected. Arch form has been preserved.



FIGURE 10C - Pretreatment and posttreatment panoramic and cephalometric radiographs.

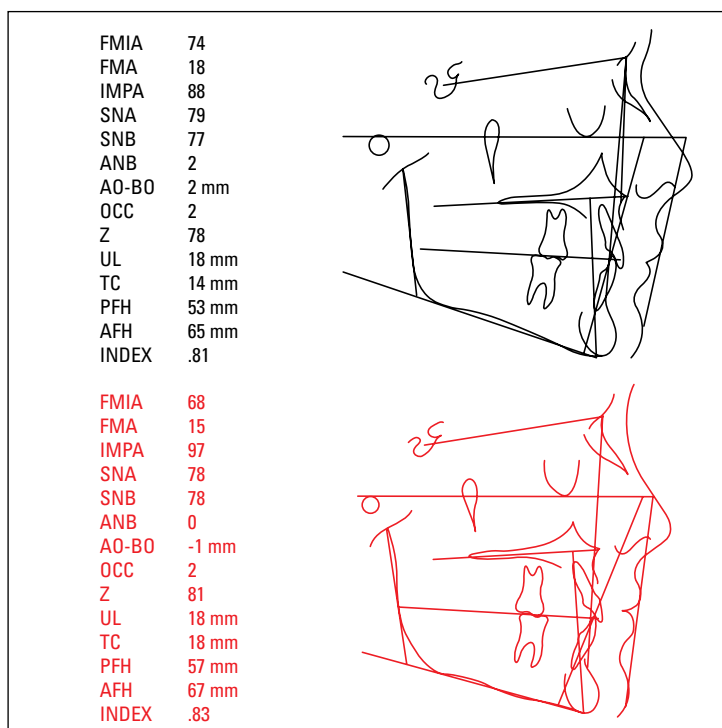


FIGURE 10D - Pretreatment and posttreatment cephalometric tracings.

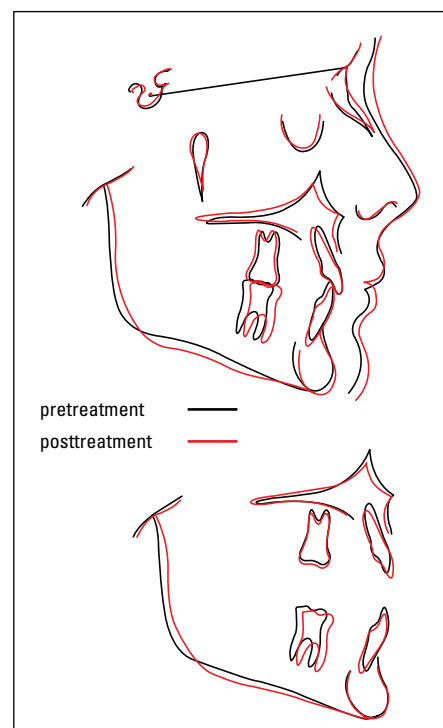


FIGURE 10E - Superimpositions.



FIGURE 11A - Pretreatment and posttreatment facial photographs.

lower face. There are several guidelines that must be followed if these patients are to be successfully treated with orthodontics only:

- Guideline #1: The mandibular incisors must be more than upright over basal bone. The higher the mandibular plane angle, the more the incisors must be upright (Fig 12).

- Guideline #2: Vertical dimension must be controlled. The clinician has to carefully control the extrusion of the mandibular and maxillary molars. If patients are growing, there is going to be normal growth and development of these teeth. However, no excessive extrusion in the posterior areas can occur. If it does occur, the patient's facial esthetics will be severely compromised (Fig 13).

- Guideline #3: There must be no expansion of the dentition. When the treatment plan is devised, the nonsurgically treated high angle patient might need more teeth removed than one would ordinarily surmise. In other words, one has to have space to a) eliminate crowding, b) upright the mandibular incisors over basal bone, c) level the curve of Spee, and d) correct the Class II dental relationship. In order to accomplish all of these goals, a lot of space is required, particularly for the high angle patient.

These guidelines are critical. The following case report illustrates many of these concepts.

As one examines the malocclusion, it should be apparent that the crowding and protrusion must be corrected by the removal of the maxillary and mandibular first premolars. Because of the high mandibular plain angle, mandibular incisors must be upright and the maxillary anterior teeth must be retracted and intruded. If these things are accomplished, there will not be space to correct the posterior occlusion. In order to achieve a satisfactory Class I occlusion, more space is required. The treatment plan, therefore, required that the patient be reevaluated after all premolar extraction space is closed. At this juncture, the maxillary first molars and mandibular third molars were removed. The removal of the mandibular third molars facilitated anchorage preparation and vertical control of the mandibular arch. The removal of the maxillary first molars provided space for further retraction of the maxillary anterior dentition and mesial movement of the maxillary second molars into a Class I interdigitation with the mandibular first molars. Maxillary third molars were used as substitutes for the maxillary second molars (Fig 14).

This type of treatment takes an additional eight to ten months in most instances, and it must be reiterated that facial esthetics is compromised somewhat from what could be achieved with a

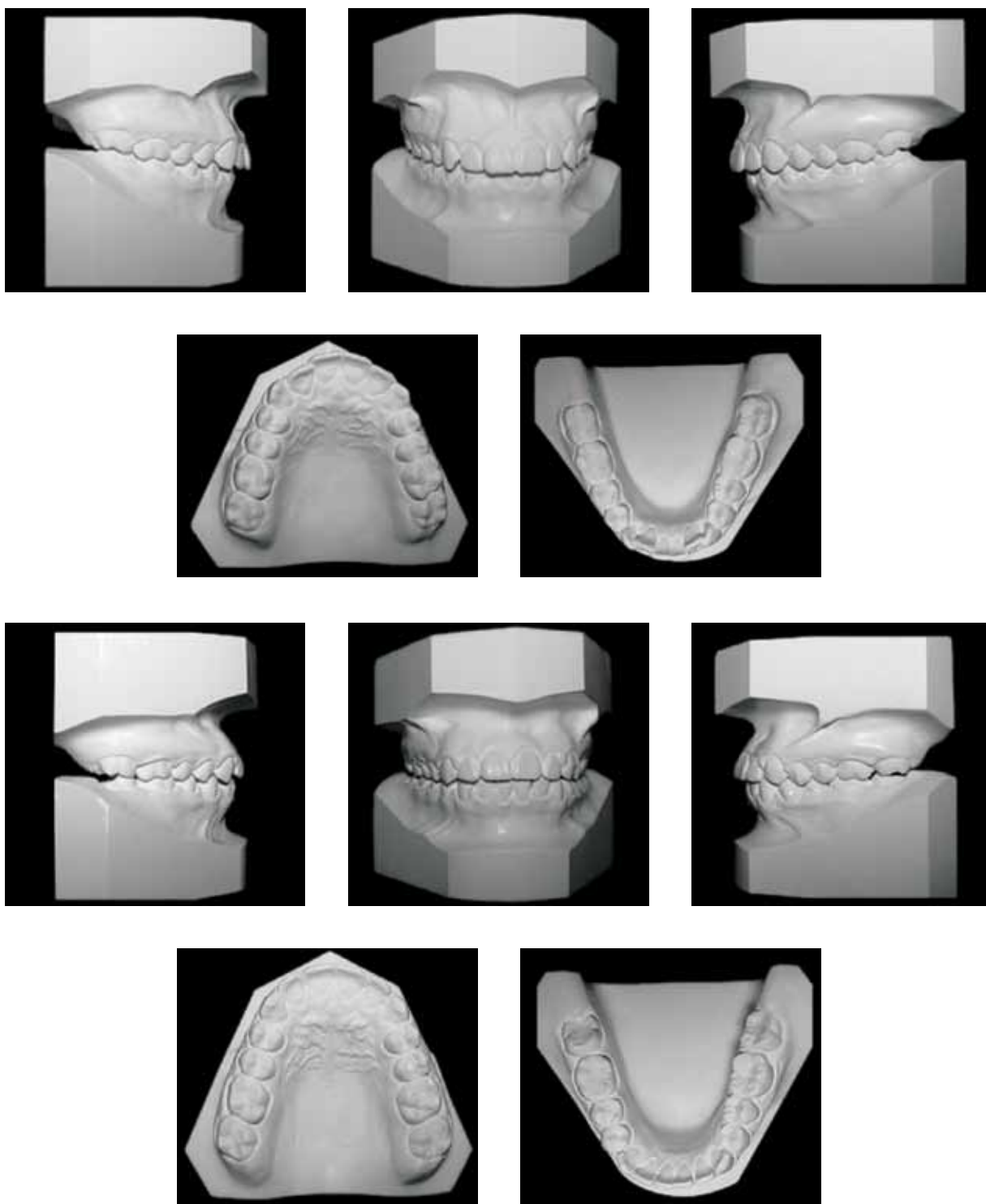


FIGURE 11B - Pretreatment and posttreatment casts.

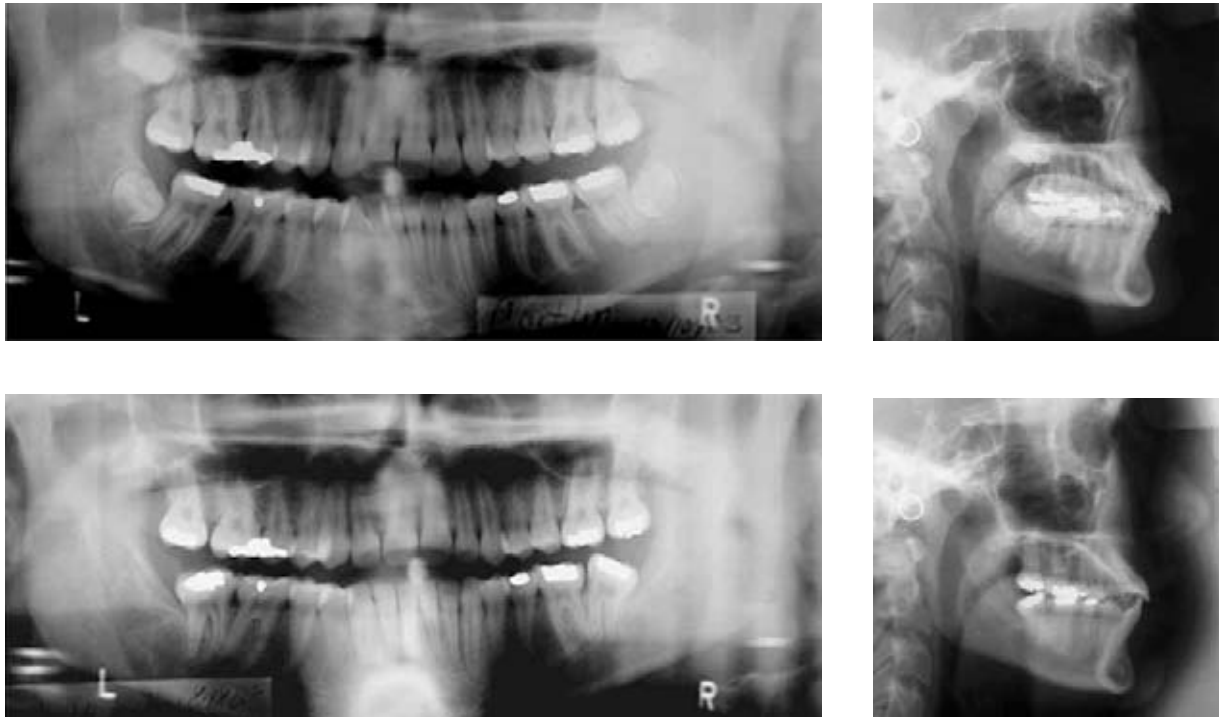


FIGURE 11C - Pretreatment and posttreatment panoramic and cephalometric radiographs. Observe the control of the mandibular arch.

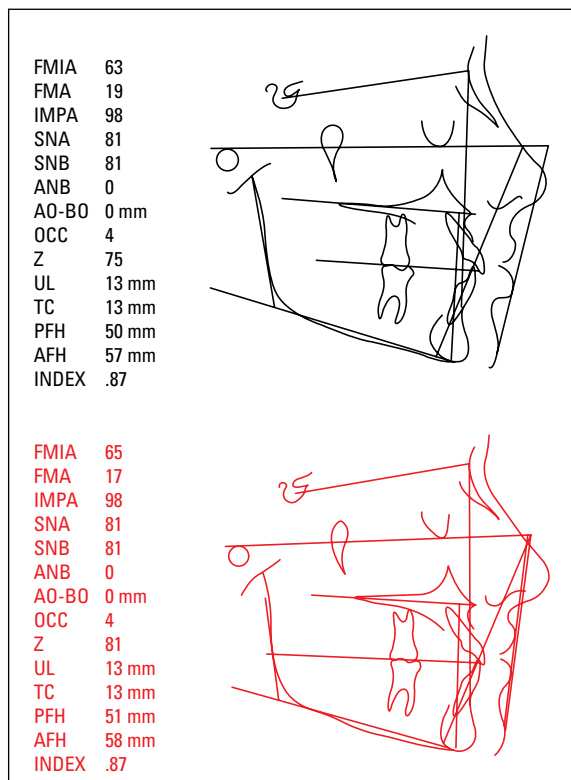


FIGURE 11D - Pretreatment and posttreatment cephalometric tracings.

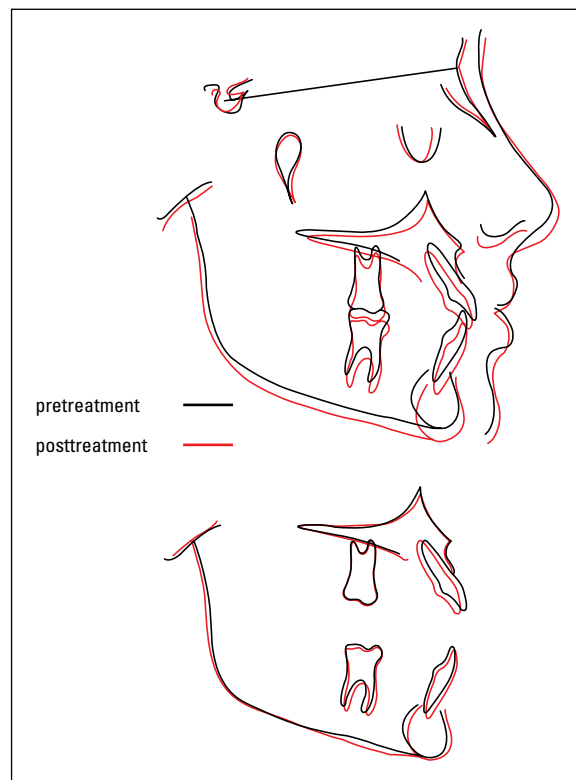


FIGURE 11E - Superimpositions.

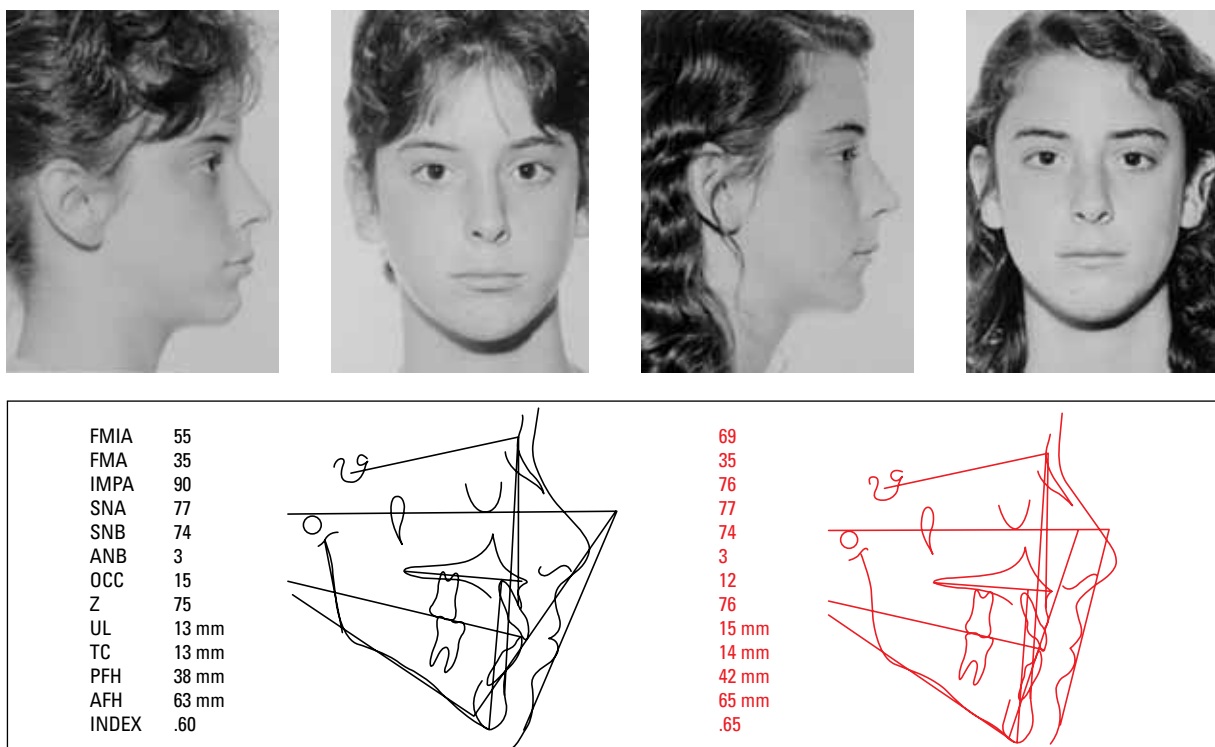


FIGURE 12 - Pretreatment and posttreatment facial photographs and cephalometric tracings. The FMA dictated that mandibular incisors be uprighted to preserve facial balance.

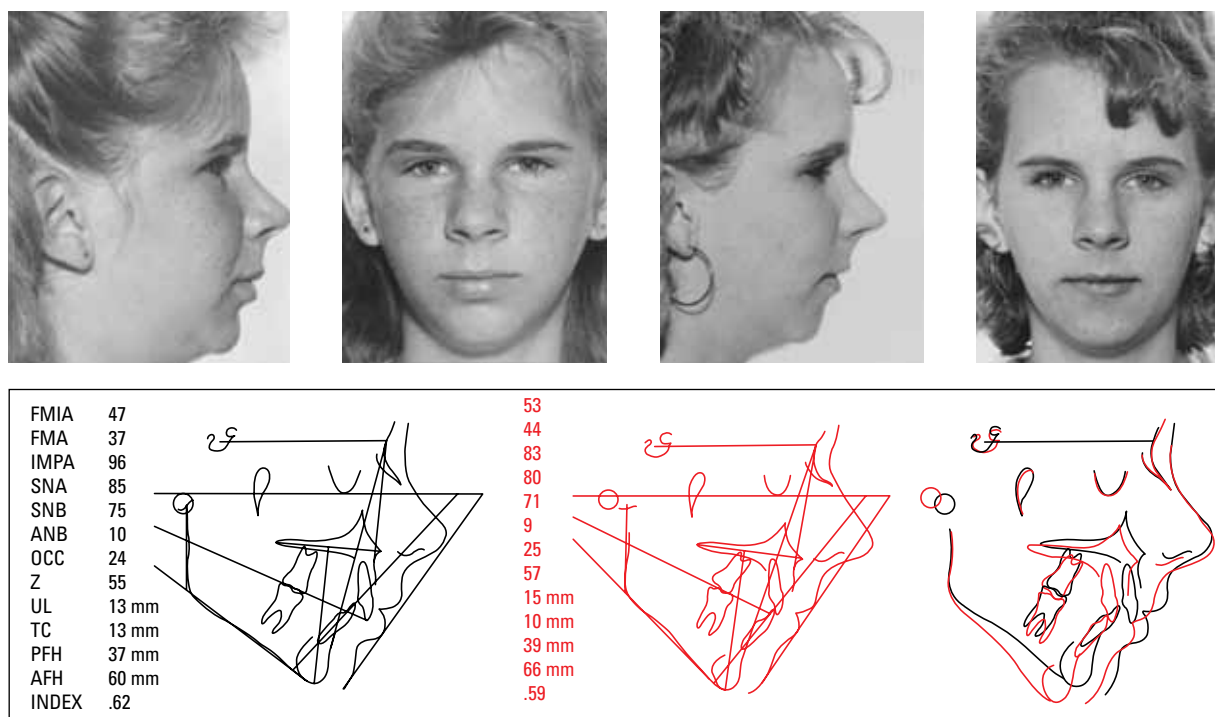


FIGURE 13 - Pretreatment and posttreatment facial photographs, superimpositions and cephalometric tracings. The FMA was opened due to molar extrusion. The facial contours and balance suffered.



FIGURE 14A - Pretreatment and posttreatment facial photographs. Facial balance, though “perfect”, is significantly improved.

surgical orthodontic approach. The patient will, however, if treatment planned properly, have an acceptable esthetic result as well as a functional, stable and healthy dentition. This type of treatment plan, though a bit unusual, is required for the severe high angle, Class II malocclusion who declines the surgical option. If this type of patient has a malocclusion that is compromised by an anterior open bite, the same principles apply, but one might use temporary anchorage devices or mini-screws to intrude the maxillary posterior segments. Additionally, tongue posture problems must be eliminated. The bottom line is that the clinician must use every tool at his/her disposal in order to carefully and methodically correct a “surgical” malocclusion without surgery.

What your opinion about the use of mini-implant and miniplate as anchorage in Orthodontics? Adilson Tomazinho

Many case reports have been presented in the literature that show the successful use of mini-screws and miniplates as anchorage units. I think the specialty has accepted the fact that these devices are quite good adjuncts to treatment mechanics for selected patients. One problem, however, is that I have seen miniscrews used to

attempt to change an extraction treatment plan into a nonextraction plan by enmass distalization of the entire maxillary arch. I think that the use of these types of devices in an attempt to drastically alter treatment plans is a mistake. In other words, YES, use them when they can improve the treatment result or make treatment possible, but don't use them indiscriminately to do things that shouldn't be done.

Up until 15 or 20 years ago, the Tweed-Merrifield Technique and its followers were criticized for: utilizing heavy forces, extracting too many teeth and flattening the profile. Nowadays, there is much more approval, even in the American Association of Orthodontists (AAO). We know that you and Dr. Jack Dale played an important role in this transition. Did the Tweed-Merrifield Philosophy change or did the general thought change? Hiroshi Maruo

Those of us who use the standard edgewise appliance, and have used it for years, are in a small minority of practicing orthodontists. We will always be a minority in orthodontics because of: 1) the nature of the people who practice the specialty, and 2) the influence that the supply

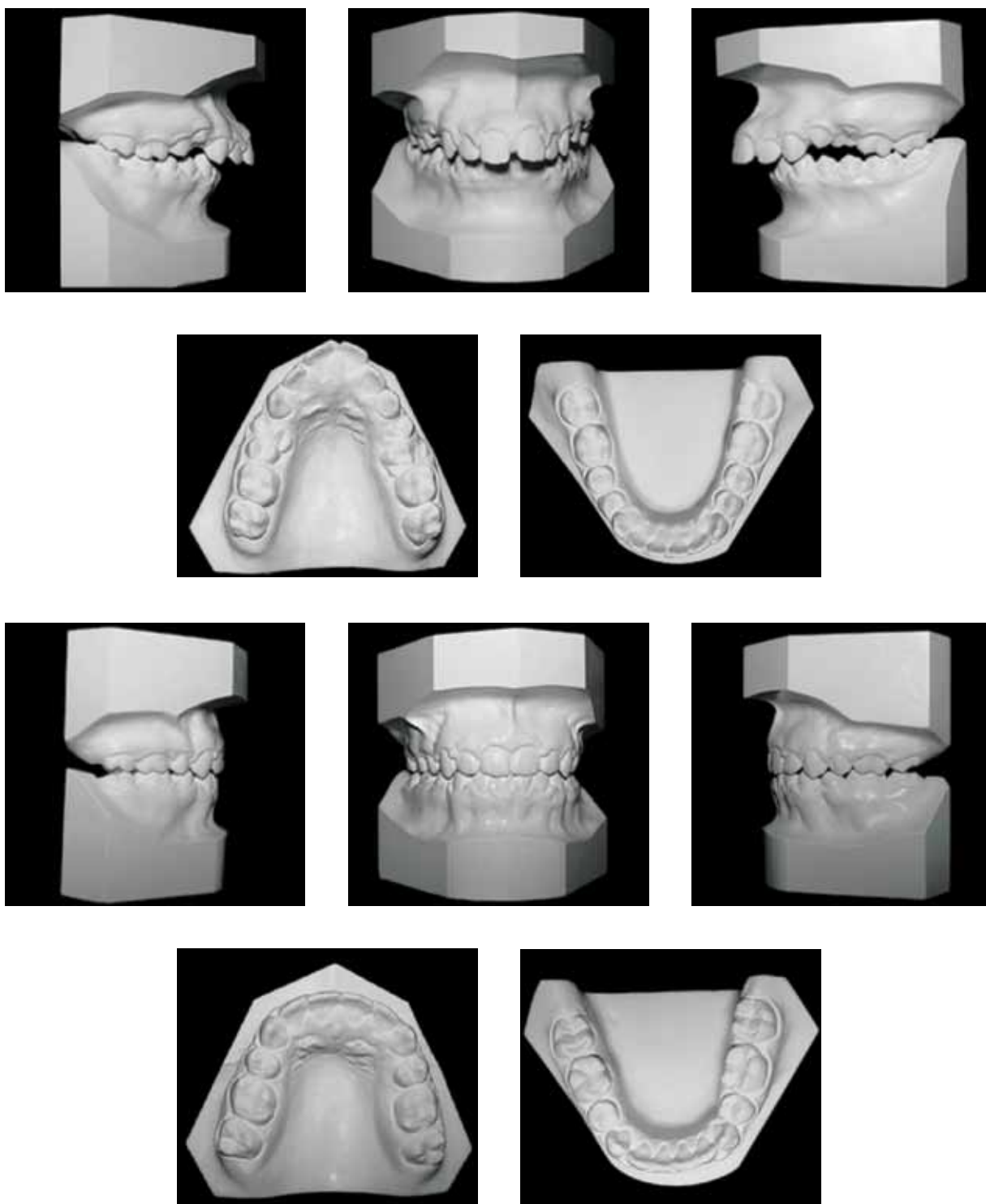


FIGURE 14B - Pretreatment and posttreatment casts: The second molars have been substituted for first; third molars for second molars.

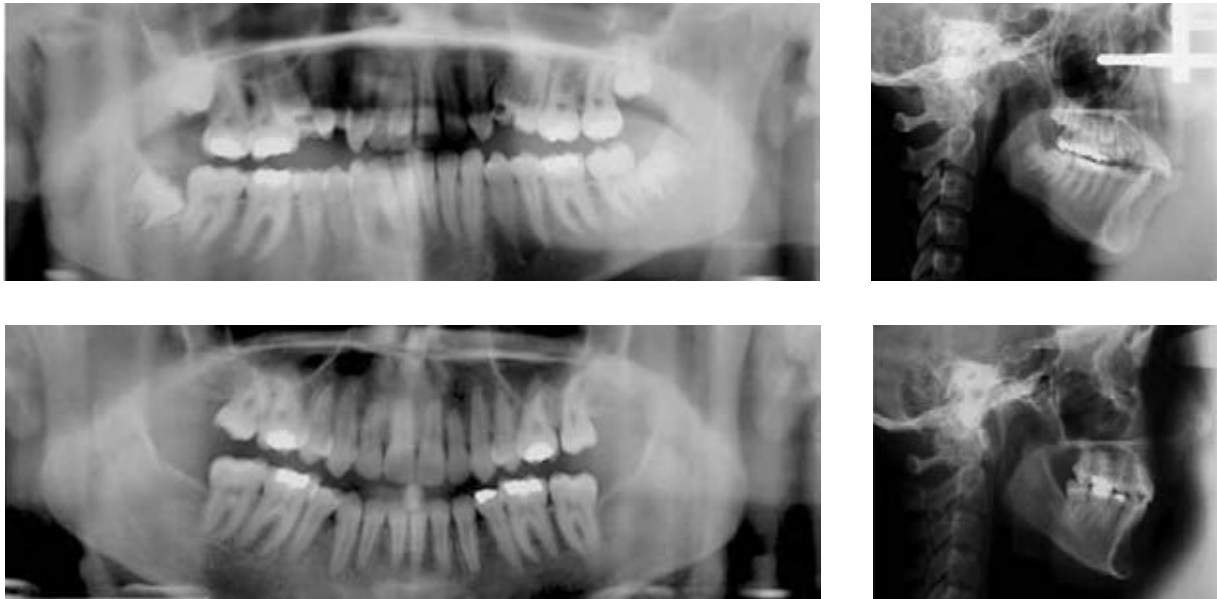


FIGURE 14C - Pretreatment and posttreatment panoramic and cephalometric radiographs.

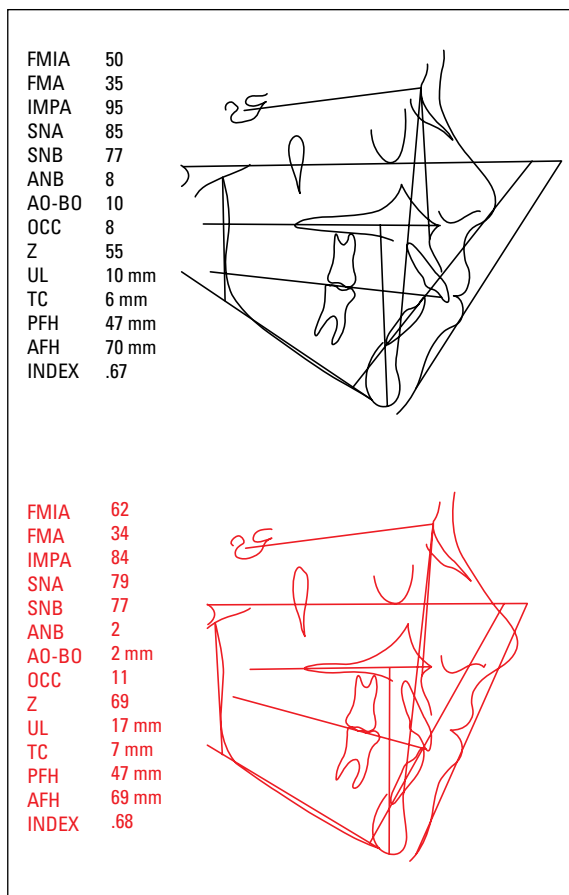


FIGURE 14D - Pretreatment and posttreatment tracings: The profile line to nose relations has been altered.

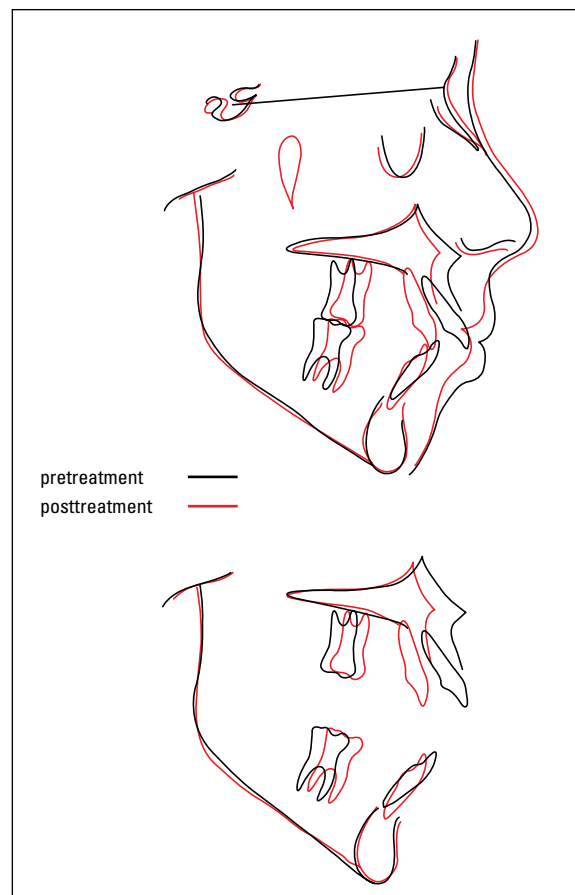


FIGURE 14E - Superimpositions.

companies have upon the specialty. It's much more profitable for the supply company to sell a preadjusted self ligating bracket than it is to sell a standard nonprescription bracket. Think about the amount of money that's at stake! This is why the supply companies tout the magic appliances. It's a money driven system. I don't know if the way that I treat patients, or that Jack Dale or Herb Klontz treats patients, is more accepted now than it was. I think it has always been accepted and we've always been looked upon to provide some fundamentals to the orthodontic specialty. Without fundamentals, nothing is successful. You can treat a patient with any appliance as long as you adhere to the fundamentals of treatment planning and of force systems. One doesn't have to use a standard edgewise appliance with the Tweed-Merrifield force system to achieve an esthetic, healthy, functional and stable result. If this result is to be achieved, however, one must adhere to fundamentals of treatment planning within the dimensions of the dentition concept and use a carefully controlled force system. Because the specialty gradually drifted away from these things, many now realize how important they are. Hence, the "revival" of requests for information from Jack Dale, Herb Klontz, etc. We have found that the Tweed Study Course is more popular than ever. In fact, in 2009 we had to have three courses because of demand. More than 30 of the 60 American Universities now send all of their students to Tucson to take the Tweed Study Course. The reason this is done is because the people in charge of these programs realize that the fundamentals are important. They understand that in the two week study course the student is absolutely saturated with fundamentals of diagnosis, treatment planning, and archwire manipulation. The successful orthodontist must know these things. We feel that the student who learns them, no matter what appliance he/she uses, will be a better clinician.

One of the most cited critique to the Tweed-Merrifield mechanics is the using of High-Pull

Headgear with "J" hooks. With the temporary anchorage devices (mini-implants) arrival, is it possible to integrally apply Tweed-Merrifield mechanics without the headgear?

Hiroshi Maruo

The application of forces with miniscrews instead of a headgear might work in certain instances—particularly in adult treatment. Adults are not growing. Miniscrews can be used very successfully in adult treatment to preserve anchorage, to intrude incisors, etc. In the growing patient, however, there is no substitute for the benefit of anchorage preparation and Class II elastics. Those of us who use this system firmly believe that it allows the patient's genetic potential for a spatial change in the relationship of the maxilla to the mandible to favorably express itself. Implants cannot allow this relationship to express itself because there is no constant Class II elastic force. Therefore, the use of Class II elastics, anterior vertical elastics and headgear are fundamental. It would be very difficult to use miniscrews instead of the highpull headgear to apply the proper force system. The headgear can be varied from maxillary arch to mandibular arch, from maxillary canines to hooks placed between the maxillary central and lateral incisors. Forces applied from miniscrews cannot be used with such variation. One would have to use six or eight implant sites to achieve the same thing one can achieve with a J-hook highpull headgear. It just doesn't seem practical. It is putting the patient through a lot of unnecessary trauma and implant placement. The headgear is much safer and much more reliable. Therefore, as I see it, the J-hook headgear is here to stay; miniscrews are also here to stay, but should be used only when indicated. The versatility of the two is not comparable. The J-hook headgear wins the versatility contest.

The Tweed-Merrifield mechanics is quite suitable for the treatment of Class II malocclusions in "long face" patients (high FMA angle). Among the many cases treated by Dr. Vaden, the Class II treatments in "short face"

patients (low FMA angle) are very impressive. Considering the Tweed-Merrifield mechanics, which are the differences in the Class II treatment between "short face" and "long face" patients? Hiroshi Maruo

"Short face" patients must be treated by leaving mandibular incisors in their pretreatment positions. They cannot be pushed forward to ameliorate crowding or to level the curve of Spee. Long face patients must have overly upright mandibular incisors and the subsequent retraction of maxillary incisors. The vertical control of the maxillary and mandibular molars is much more critical in long face patients than in short face patients. If molars are not controlled in the long face patient, the chin will rotate down and back and the face is irreparably harmed (Fig 15). While molar vertical exclusion in the short face patient is, or might be beneficial, it's extremely hard to accomplish with any degree of stability. It's almost not fair that the patient on whom you want no vertical extrusion will get it quickly and it does irreparable damage, while the short face patient cannot seem to sustain any kind of vertical molar extrusion because of the musculature. Constrictive, intrusive forces

must be used on long face patients. It is not so critical to use them on short face patients.

In your opinion, are there any change in the fundamental principles of orthodontics due to the advancement of new technologies? Ana Maria Bolognese

Ana Maria's question is very interesting. My answer is an unequivocal "NO" – FUNDAMENTALS DO NOT CHANGE. Appliances might change, treatment mechanics might change, but fundamentals don't change. The fundamentals of achieving esthetics, health, function, stability and treatment in harmony with growth have been with us since the day of Kingsley and Angle. These things have been debated and people have tried to change them to suit their individual treatment planning, force systems or whims, but these changes haven't lasted. Fundamentals will stay with us. It's important to know, appreciate, and understand the fundamentals in order to use any type of orthodontic appliance and force system. If you deviate from fundamentals, you will compromise the esthetics, health, function, stability and treatment and harmony with growth.

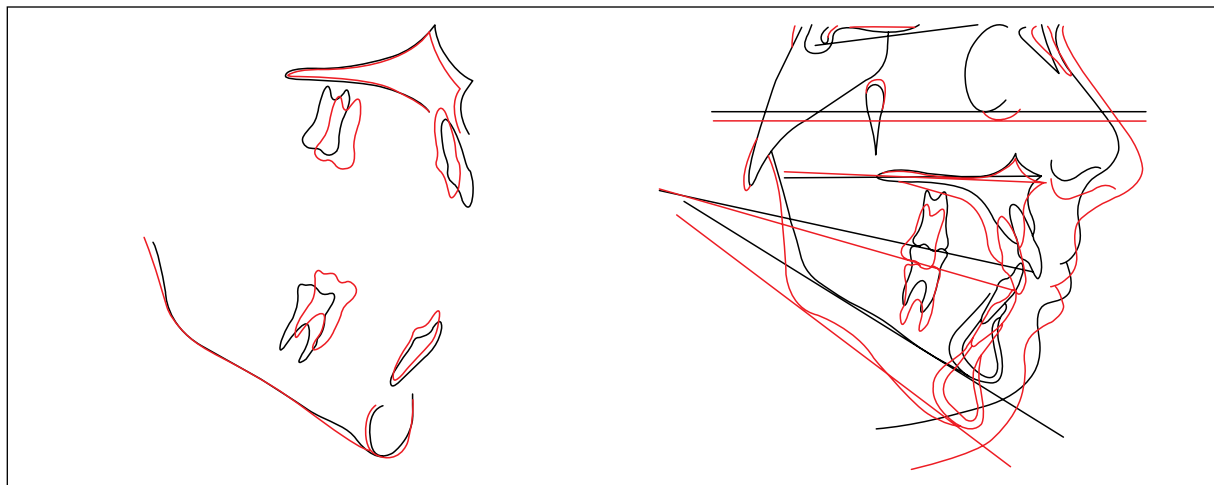


FIGURE 15 - Molar extrusion yields a "down and back" mandibular rotation.

It is undeniable the efficiency of the Tweed-Merrifield philosophy in the mechanics of anchorage preparation and control of facial growth. Is there any indication to associate absolute skeletal anchorage in patients where growth has already ceased? Ana Maria Bolognese

There is absolute skeletal anchorage with the use of miniscrews. The Koreans and Japanese have perfected this approach. An excellent case report that I use as a “standard” for this type of treatment was published in the American Journal of Orthodontics DentoFacial Orthopedics by J M Chae². My prediction is that miniscrew anchorage will be the tool that the serious orthodontist uses to help with the correction of the severe adult malocclusion I think most orthodontists will probably not use these devices in most growing patients because there are so many other things that will offer more versatility of application. For the patient who has no growth potential, however, the miniscrew skeletal anchorage system has many advantages because vertical and horizontal control of the dentition is made so much easier.

How do you see the future of Orthodontics? Estelio Zen

My answer is simple: I’m very worried about the future of Orthodontics. It seems that the influence of the supply houses and the desire of many in the specialty to see how many patients can be run through an office in a day and how much money could be made is going to destroy the quality of orthodontic care. If this trend does not reverse itself, we then become a specialty that is doing nothing but aligning teeth. There is a difference between an orthodontist and a tooth alignment specialist. If we, as a specialty, do nothing but align teeth; if we do not create or maintain good faces; if we do not give our patients a treatment result that is stable in the long term without permanent retention; if our result is not healthy and functional the specialty will become extinct. The general dentist in any country in the world can stick some brackets on the teeth, use some

magic wire and align the teeth. We as a specialty must come back to the realization that we have an obligation to each patient to give the patient the very best that orthodontics has to offer. Now I refer to an editorial written by Lysle Johnston,¹ in the World Journal of Orthodontics, entitled “When Everything Works and Nothing Matters”. Unless we begin to realize that things do matter, our long term survival is in jeopardy. On a positive note, there are some glimmers of hope. Many clinicians are becoming disenchanted with the magic appliances. There seems to be a resurgence in the fundamentals of treatment planning and of archwire manipulation. The Tweed Study Course has never been more popular than it is today. I have met many young people who are doing a very good job in their practices. They are interested in quality and not quantity. So, even though the pendulum has swung too far toward appliance driven treatment, it seems to be swinging back toward treatment planning with a concern for facial esthetics and long-term stability. Many of the young people we see are limiting their practice to the number of patients they can comfortably see and are limiting their staff size so that the overhead expenses are compatible with their income. One of the big problems that all students now have to solve is debt. Student debt forces many young orthodontists to do things they know they shouldn’t be doing. If we could get a handle on student debt, I think the pendulum would swing back toward the center even faster. So, there is doom and gloom, but there are very, very good indications that the patients of the next generation of orthodontists will be better served than they are now being served.

What message you give to the Brazilian orthodontists for getting the certification of the Brazilian Board of Orthodontics and Facial Orthopedics - BBO? Estelio Zen

Board certification, if done for the right reason, is a tremendous learning experience. The orthodontist who is board certified makes himself/herself look at the work that he/she is

rendering to the patients who seek care. Self examination is a good thing. Peer examination is a good thing. If your work is evaluated and accepted by your peers, then you are doing standard of care treatment for your patients. It becomes a proven fact that you're a better orthodontist if you examine yourself and if you allow your peers to examine you. It's got to make you better. Board certification is something the specialist must do for himself/herself. It's not something you do for "notoriety." Board certification is going to be one of the things that saves the specialty of orthodontics. I encourage all Brazilian orthodontists to examine themselves and let their peers examine their work. This is a giant step toward standard of care. It will definitely help every orthodontist be better than if he/she had not entered the certification process. It makes the specialty better and greatly benefits the patients we all serve. There is no down-side to becoming board certified - whether you live in France, Japan, Australia, the United States of America or Brazil!

REFERENCES

1. Johnston Jr. LE. When everything works and nothing matters. *World J Orthod.* 2002 Summer;2:92-3.
2. Chae JM. A new protocol of Tweed Merrifield directional force technology with microimplant anchorage. *Am J Orthod Dentofacial Orthop.* 2006 Jul;130(1):100-9.

Adilson Thomazinho

- PhD at the College of Dentistry, Ribeirão Preto / USP (FORP-USP).
- Coordinator of the Specialization Course in Orthodontics (FORP-USP).

Ana Maria Bolognese

- PhD in Orthodontics at Northwestern University.
- Doctorate in Dentistry, Federal University of Rio de Janeiro (UFRJ).
- Master in Orthodontics, UFRJ.
- Specialist in Radiology, UFRJ.
- Former Director and Chairman of the Brazilian Board of Orthodontics and Facial Orthopedics.
- Withholder of Prof. Édimo José Soares Martins Commendation.

Estelio Zen

- Post-graduated in Orthodontics, Federal University of Rio de Janeiro (UFRJ).
- Master in Orthodontics, UFRJ.
- Former director and chairman of the Brazilian Board of Orthodontics and Facial Orthopedics.
- Withholder of Édimo José Soares Martins Commendation.
- Associate and director of BBO.

Hiroshi Maruo

- PhD in Orthodontics, State University of Campinas / Piracicaba.
- Master in Orthodontics, Unicamp / Piracicaba.
- Specialist in Dental Prosthesis, Unicamp / Piracicaba.
- Graduated by the Brazilian Board of Orthodontics and Facial Orthopedics.

José Nelson Mucha

- Doctor of Dentistry, Federal University of Rio de Janeiro (UFRJ).
- Master in Dentistry, UFRJ.
- Specialist in Radiology, UFRJ.
- Former director and chairman of the Brazilian Board of Orthodontics and Facial Orthopedics.
- Withholder of Édimo José Soares Martins Commendation.

Contact address

James L. Vaden, D.D.S., M.S., P.C.
308 East 1st Street, Coolville, TN 38501.
USA

Assessment of mandibular advancement surgery with 3D CBCT models superimposition

Alexandre Trindade Simões da Motta**, Felipe de Assis Ribeiro Carvalho***, Lúcia Helena Soares Cevidanes****, Marco Antonio de Oliveira Almeida*****

Abstract

Objectives: To assess surgery and short-term post-surgery changes in the position of the condyles, rami and chin after mandibular advancement. **Methods:** Pre-surgery (T1), 1 week post-surgery (T2), and 6 weeks post-surgery (T3) CBCT scans were acquired for 20 retrognathic patients with short or normal face height. Three-dimensional models were built and superimposed through a fully automated voxel-wise method using the cranial base of the pre-surgery scan as reference. Anatomic regions of interest were selected and analyzed separately. Within-subject surface distances between T1-T2, T2-T3, T1-T3 were computed. Color-coded maps and semi-transparent display of overlaid structures allowed the evaluation of displacement directions. **Results:** After an antero-inferior chin displacement with surgery in all cases (>4 mm in 87.5%), 25% of the patients showed some kind of posterior movement (<3 mm), and 69% showed an antero-superior movement after splint removal. Comparing T1-T3, an antero-inferior (87.5% of the cases) or only inferior (12.5%) displacement was observed (>4 mm in 80%). Considering all directions of displacement, the surface distance differences for the condyles and rami were small: 77.5% of the condyles moved <2 mm with surgery (T1-T2), and 90% moved <2 mm in the short-term (T2-T3) and in the total evaluation (T1-T3), while the rami showed a <3 mm change with surgery in 72.5% of the cases, and a <2 mm change in 87.5% (T2-T3) and in 82% (T1-T3). **Conclusions:** Expected displacements with surgery were observed and post-surgery changes suggested a short-term adaptive response toward recovery of condyle and ramus displacements. The changes on the chin following splint removal suggested an acceptable adaptation, but with considerable individual variability.

Keyword: Cone-Beam Computed Tomography. Image processing. Computer-assisted surgery. Computer simulation. Orthodontics. Oral surgery.

Editor's abstract

It seems that changes occur in condylar position after bilateral sagittal split ramus osteotomy

(BSSO) to advance the mandible,⁴ and both rotation and transverse displacement of the condyles related to ramus surgery have been described.¹

* Access www.dentalpress.com.br/journal to read the full article.

** DDS, MS, PhD; Professor, Department of Orthodontics, Fluminense Federal University (UFF/Niterói, RJ, Brazil); Visiting Scholar, University of North Carolina at Chapel Hill (UNC).

*** DDS, MS; PhD Student, Department of Orthodontics, State University of Rio de Janeiro (UERJ), Visiting Scholar (UNC).

**** DDS, MS, PhD; Professor, Department of Orthodontics (UNC/Chapel Hill).

***** DDS, MS, PhD; Professor and Chair, Department of Orthodontics (UERJ), Post-doctoral Fellow (UNC).

Otherwise, the extent to which mandibular structures rotations/displacements and bone remodeling/resorption contribute to posttreatment instability are poorly understood at present. Previous studies based in standardized norms and bidimensional (2D) representation of 3D changes could not answer many questions related to factors influencing treatment response and skeletal remodeling.³ Investigations using cone-beam computed tomography (CBCT)⁵ in Orthodontics and Oral-Maxillofacial Surgery have shown that this new tool can improve the identification of different patterns of rami and condyles positioning after orthognathic surgery.² The purpose of this study was to evaluate the displacements at the chin, condyles and rami between presurgery, postsurgery, and splint removal through 3D models superimposition.

Twenty patients presenting skeletal Class II and consecutively treated at the Dentofacial Deformities Program at the School of Dentistry, University of North Carolina (UNC), were recruited for this study, and underwent orthodontic treatment and had mandibular advancement surgery by means of a bilateral sagittal split osteotomy (BSSO). The scans were taken one week before surgery (T1), one week after surgery (T2), to assess changes with the surgical procedure, and six weeks after surgery (T3), immediately after splint removal to assess short-term adaptive changes. Image segmentation of the anatomic structures of interest and the 3D graphic rendering were done by using the InsightSNAP software (<http://www.itksnap.org/>). The pre-surgery and post-surgery models were registered based on the cranial base, since this structure is not altered by surgery. A fully automated voxel-wise rigid registration method was used through the Imagine free software (<http://www.ia.unc.edu/dev/download/>). The software compares both images using the intensity of grayscale for each voxel of the region, so that the pre-surgical cranial base (T1) was used as ref-

erence for the superimposition of post-surgery models (T2 and T3). To control the cropping for a quantitative analysis of regions of interest such as the condyles, the posterior border of the rami and chin, the 3D models at different time points of each patient were combined also with the *Imagine* tool. Each region of interest of each phase was prepared for pair comparisons, and was then analyzed separately with MeshValmet (<http://www.ia.unc.edu/dev/download/>), where measurements of the surface distances between two different time points within the same subject allowed quantification of rami, condyles and chin displacements that accompanied mandibular surgery. The visualization of the directions of displacement was done through color maps and semitransparencies methods (Fig 1). Descriptive statistics was done and illustrated in graphics of direction and amount of displacement for each anatomic region.

In this short-term observation 25% of the patients showed some posterior movement at the chin after splint removal. These few cases showed less than 3 mm displacements between T2-T3, and when compared to superimpositions T1-T2 and T1-T3 a high similarity in the color maps (area and intensity of red surfaces corresponding to mandibular advancement) could be visually observed, as well as in the difference between solid white and transparent red in the semi-transparencies (Fig 2). Rami and condyles displacements were considered clinically relevant, even so were concentrated under 3 mm and 2 mm, respectively, and chin position was kept stable. Actually, the results suggest that an important recovery tendency toward preoperative positions occurred after splint was removed and mandibular function resumed. Otherwise, some cases showed a larger displacement in the proximal segment that could be maintained even after a long-term follow-up. Since condylar displacements concentrated under 2 mm, clinical effects are questionable and long-term

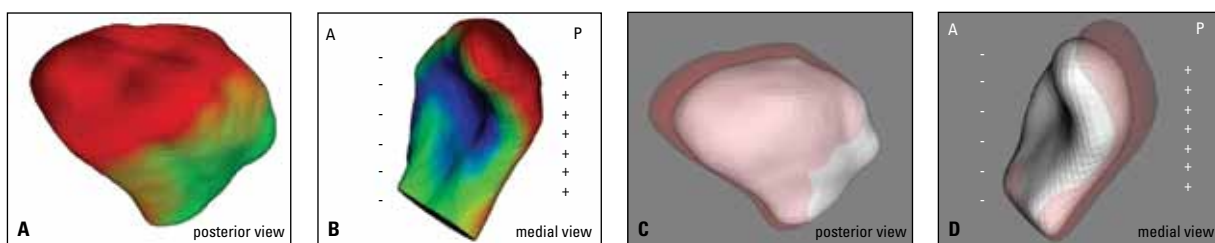


FIGURE 1 - Visualization of a right condyle displacement between T1 and T2. **A, B)** Color coded maps indicate outward displacements in red and inward displacements in blue. **C, D)** Semi-transparencies with T1 in solid white and T2 in transparent red (A = anterior, P = posterior).

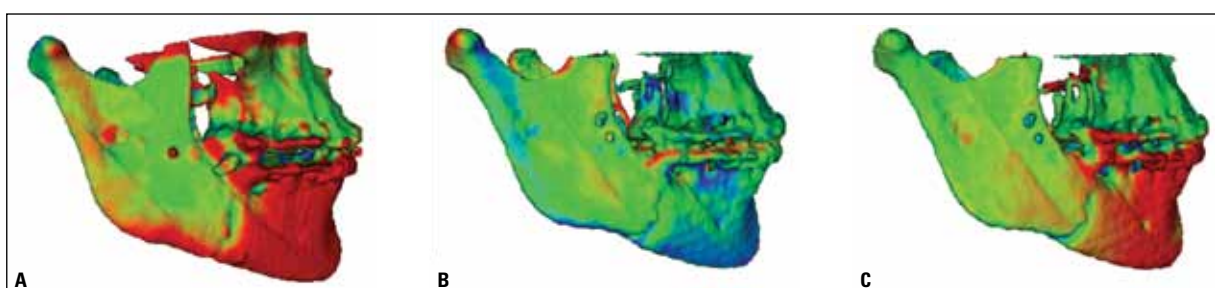


FIGURE 2 - Superimpositions between pre-surgery to immediately post-surgery with splint in place (**A**), immediately post-surgery to splint removal (**B**), and pre-surgery to splint removal (**C**). Some posterior (inward) movement of the chin is noted in B, shown by the blue color code. It can also be noted by the comparison between different area and density of red surfaces representing the anterior (outward) displacement in A and C. Still, the resultant superimposition in C shows an acceptable maxillomandibular relation at splint removal, considered a short-term stability. The right ramus shows a slight lateral movement in A (outward), a recovery tendency in B (inward), and green surfaces in C confirming the adaptive response.

follow-ups are needed to show if changes were small enough to allow adaptive remodeling without side effects. Condyles latero-posterior and rami latero-posterior-inferior changes between T1-T2 could result from pressure during the BSSO, fragment sliding and rigid fixation, followed by medio-anterior and medio-anterior-superior displacements between T2-T3 as a recovery toward initial positions due to muscular stretch.

Important displacements with surgery were observed in the rami and condyles, but changes at splint removal suggested an adaptive response toward recovery of pre-surgery positions, especially the medio-lateral movement of the rami. The changes on the chin after six weeks suggested an overall acceptable adaptation, but with considerable individual variability.

Questions

1. Which are the advantages and benefits of cone beam computed tomography as a study methodology in Orthodontics?

Some advantages have been described in the literature and could be also noted during this experiment. Primarily, advantages of CBCT over radiographic projections can be mentioned, acquiring a complete image set of all the craniofacial complex with only one scan, without superimposed or distorted structures. Also, differently from 2D radiographic projection acquisitions which require head positioning standardization, tomographic slices can be obtained without such standards as the whole 3D craniofacial complex is captured. A favorable spatial resolution and tooth/bone contrast recommend this method for Dentistry needs. Depending on the equipment, radiation

dose can be comparable to a complete periapical exam, and is considerably smaller than reported doses for conventional CT.

Overall CBCT applications can be divided in: (1) Analysis of tomographic slices, allowing navigation through them using any software running DICOM files; (2) Radiographic emulation using commercial softwares, generating lateral and frontal cephalometric, panoramic or submentovertex images; (3) Study of 3D rapid reconstructions or volume segmentations generated from commercial or public software; (4) 3D cephalometry, calculating measurements from landmarks established on tomographic slices or on 3D model surfaces; (5) Facial analysis, using soft tissue segmentation on 3D models or linking 3D camera photography and volume rendering; (6) 3D superimposition, using the methodology from this study, thoroughly described in our paper in press.⁶

Cone-beam CT images allow clinical observation of: impacted teeth and ectopic eruption; pathologies among radicular spaces; third molars proximity to noble structures such as the alveolar inferior nerve; alveolar bone width and height; arch size and form for orthodontic movement; condylar findings, i.e. anatomic asymmetries; determination of ideal microimplant sites, etc. Preliminary studies have suggested CBCT applications in analysis of the dentition, building of virtual dental casts without impressions and planning with virtual set-up.

2. Are there limitations associated to tridimensional image manipulation?

Working with 3D images on research purposes can be difficult and challenging, especially regarding the generation of accurate volumetric reconstructions that should include all the anatomic regions of orthodontic and surgical interest. Mandibular condyles, for example, are really hard to segment because of its anatomic shape and bone density, thus requiring specific procedures, more manual and less automatic, to determine reliable

surfaces. Some maxillary surfaces can be also difficult to reconstruct, especially those around the sinuses, because of its thin trabecular bone. Rapid reconstructions generated from the available commercial softwares (VRT, volume rendering technique) are precise enough for visualization purposes, and can also allow 3D measuring based on landmarks established on tomographic slices. Otherwise, the current methodology requires the segmentation of virtual models with 3D surfaces (SSD, shaded surface display) that allow superimposition and quantification of displacements throughout different time-points, so voxels of the tomographic image should be "filled out", i.e., the tomographic slices are actually built into volumetric images. Besides the drawbacks, the use of three-dimensional images can represent a step forward in Orthodontics, where many studies carried out before with 2D methods will be revalidated through more complete and complex observations, highlighting important information never seen due to methodological limitations.

REFERENCES

1. Becktor JP, Rebellato J, Becktor KB, Isaksson S, Vickers PD, Keller EE. Transverse displacement of the proximal segment after bilateral sagittal osteotomy. *J Oral Maxillofac Surg.* 2002 Apr;60(4):395-403.
2. Cevidanes LH, Bailey LJ, Tucker GR Jr, Styner MA, Mol A, Phillips CL, Proffit WR, Turvey T. Superimposition of 3D cone-beam CT models of orthognathic surgery patients. *Dentomaxillofac Radiol.* 2005 Nov;34(6):369-75.
3. Harrell WE Jr, Hatcher DC, Bolt RL. In search of anatomic truth: 3-dimensional digital modeling and the future of Orthodontics. *Am J Orthod Dentofacial Orthop.* 2002 Sep;122(3):325-30.
4. Harris MD, Van Sickels JE, Alder M. Factors influencing condylar position after the bilateral sagittal split osteotomy fixed with bicortical screws. *J Oral Maxillofac Surg.* 1999 Jun;57(6):650-4.
5. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. *Eur Radiol.* 1998;8(9):1558-64.
6. Motta AT, Carvalho FR, Oliveira A, Cevidanes LHS, Almeida MA. Superposição automatizada de modelos tomográficos tridimensionais em cirurgia ortognática. *Dental Press J Orthod* (in press).

Contact address

Alexandre Trindade Simões da Motta
Av. das Américas, 3500 - Bloco 7/sala 220 – Ed. Hong Kong 3000
CEP: 22.640-102 – Barra da Tijuca – Rio de Janeiro/RJ
E-mail: alemotta@rjnet.com.br

Standardization of a method for measuring buccal and lingual bone plates using Cone Beam Computed Tomography

Marcos Cezar Ferreira**, Daniela Gamba Garib***, Flávio Cotrim-Ferreira****

Abstract

Introduction: The thickness of the buccal and lingual bone plates constitutes one of the limiting factors of the orthodontic movement. The imaging technology has permitted the evaluation of this anatomical region, by means of cone beam computed tomography.

Objectives: To detailed describe and standardize a method for measuring the buccal and lingual bone plate thickness in CBCT images. **Methods:** Digital standardization of face image should constitute the first step before the selection of CBCT slices. Two axial sections of each jaw were used for measuring the thickness of buccal and lingual bone plates. The cemento-enamel junction of the first permanent molars was used as a reference, both in the upper and lower arches. **Results:** Axial sections parallel to the palatine plane were recommended for quantitative evaluation of the alveolar bone plate in the maxilla. In the mandibular arch, the axial sections should be parallel to the functional occlusal plane.

Conclusion: The method described shows reproducibility for evaluating the periodontal effects of tooth movement for clinical or research purposes, permitting the comparison between pre and posttreatment images.

Keywords: Tomography. Spiral Cone Beam Computed Tomography. Diagnosis. Alveolar process.

Editor's abstract

Cone beam computed tomography (CBCT) permits the evaluation of tooth movement repercussion on the buccal and lingual alveolar bone plates.^{1,2} For research purposes, it is

necessary to detailed standardize a method for quantitative analyses of these alveolar regions in CBCT, which constitutes the main purpose of this study.

The steps of the methodology were adjusted

* Access www.dentalpress.com.br/journal to read the full article.

** Specialist – Student at the graduate program in Orthodontics (Master's) - UNICID; Faculty, Specialization Course in Orthodontics IOM/UNIG (RJ); Faculty, Specialization Course in Orthodontics ABO/ Niterói (RJ); Coordenador, Dept. of Orthodontics, General Policlinic, Rio de Janeiro.

*** Clinician – Doctorate Faculty, Craniofacial Rehabilitation Hospital / University of São Paulo (USP-Bauru).

**** Clinician – Associate Faculty, Orthodontics, Universidade Cidade de São Paulo - UNICID, Brazil.

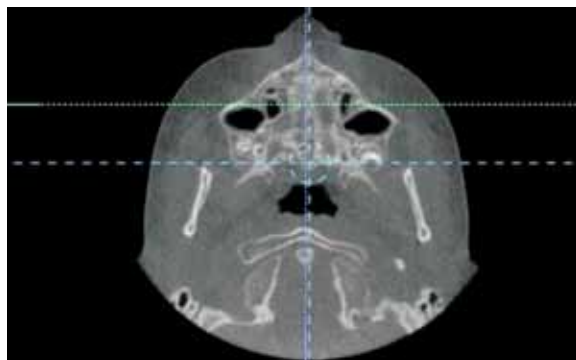


FIGURE 1 - Standardization of the axial section, making the bispinal line coincide with the vertical reference line.

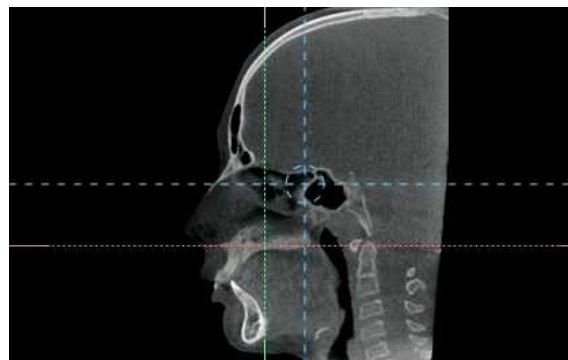


FIGURE 2 - Sagittal section, making the bispinal line coincide with the horizontal reference line.

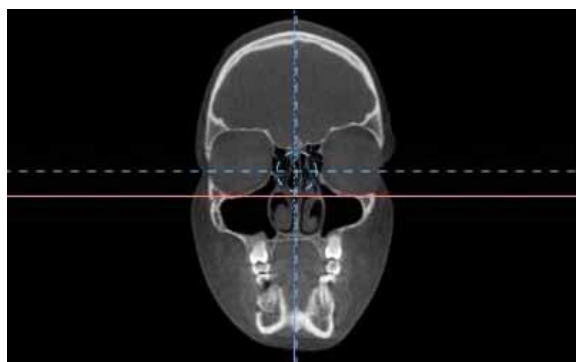


FIGURE 3 - Coronal section, making the infraorbital line coincide with the horizontal reference line (in pink).

for the i-CAT scanner (www.imagingsciences.com) and Nemscan software (Madrid, Spain, www.nemotec.org) or Dolphin 3D software (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA). During image acquisition, the “field of view” should include the entire face, with a voxel dimension of 0.3 or 0.4 mm. Before image selection for measurement, the image of the head should be standardized in all the three planes. Using Nemonscan software, the reference to standardize the axial and sagittal images was the palatal plane (ANS-PNS), making it to coincide with the vertical and horizontal planes, respectively (Figs 1 and 2). The reference used to standardize the frontal plane was the infra-orbital line coincident with the horizontal plane (Fig 3). Using Dolphin

software, the standardization of head position is performed in 3D images and it is possible to use the Frankfurt plane as a horizontal reference in the right and left lateral view and to use the infra-orbital plane in the frontal view.

The next step consisted of the selection of two axial sections of each jaw. For the maxilla, an axial section passing at the level of cemento-enamel junction of the distovestibular region of the right maxillary first molar was selected. From this reference axial section, two axial sections passing 3 and 6 mm apically to the cemento-enamel junction were selected, where the measurements of buccal and lingual bone plates can be performed. In this way, the axial sections of maxilla are parallel to the palatal plane (ANS-PNS) using Nemscan software, or parallel to the Frankfurt plane using Dolphin software. For the mandible, axial sections parallel to the functional occlusion plane was selected. In this way, using Nemscan software, the image of the head was repositioned, rotating it backward in the magnitude equivalent to the angle between the palatal plane (ANS-PNS) and the functional occlusal plane (measurement obtained in the CBCT reformatted image of the lateral cephalogram). Then, an axial section passing through the cemento-enamel junction of the distovestibular region of the right mandibular first molar was selected. From this reference axial section, two

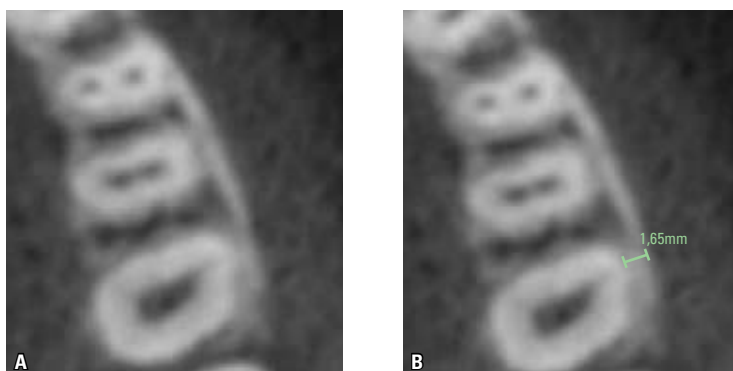


FIGURE 4 - Image zoomed in to facilitate measurement in **A** and with the measurement already executed in **B**.

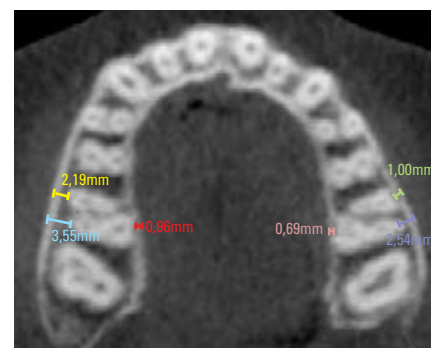


FIGURE 5 - Measurements taken using the software, indicating the thickness (in mm) of the buccal and palatal bone plates.

axial sections passing 4 and 8 mm apically to the cemento-enamel junction were selected for bone plate measurements. When the measurements are performed using Dolphin software, the selection of the axial sections of mandible should consider the angle between Frankfurt plane and occlusal plane, instead of PP.OP. The measurements are performed in amplified images in order to improve the visualization (Fig 4). The measurements of buccal bone plate are performed from the buccal limit of root contour to the buccal

surface of the cortical plate, perpendicularly to the dental arch (Fig 5). The measurements of the lingual bone plate are performed from the lingual limit of the roots to the lingual surface of the cortical plate (Fig 5).

Using this method, a reproducible numerical evaluation can be performed by comparing pre and posttreatment exams. This methodology permits to evaluate the effects of buccal and lingual tooth moment, as well as to rationalize on the biological limits of tooth movement.

REFERENCES

1. Fuhrmann RAW. Three-dimensional evaluation of periodontal remodeling during orthodontic treatment. *Semin Orthod.* 2002;8(1):17-22.
2. Garib DG, Raymundo R Jr, Raymundo MV, Raymundo DV, Ferreira SN. Tomografia computadorizada de feixe cônico (Cone beam): entendendo este novo método de diagnóstico por imagem com promissora aplicabilidade na Ortodontia. *Rev Dental Press Ortod Ortop Facial.* 2007 mar/abr;12(2):139-56.

Questions

1. What is the importance of evaluating the effects of tooth movement on the buccal and lingual bone plates?

The thickness of the alveolar bone defines the limits of orthodontic movement, and to challenge these boundaries can lead to iatrogenic collateral effects for the periodontal tissues. The most critical tooth movements include dental arch expansions and incisor retraction. Such movements can decentralize teeth from the envelop of the alveolar bone causing bone dehiscence, fenestration and gingival recession, depending on the initial morphology of the periodontal bone, as well as on the amount of tooth movement. Classic Orthodontics considered the amount of crowding, the mandibular incisor position and the growth pattern as the tripod which determined the diagnosis and treatment planning. The contemporary Orthodontics included the facial/smile esthetics in the list. The future Orthodontics may add the initial anatomy of the periodontal bone to these four factors.

2. What is the importance of the CBCT for this purpose?

Due to the high definition and sensitivity of spiral and cone-beam CT, the images can show

bone dehiscences and fenestrations. Previously to CT advent, efforts to define the impact of tooth movement on the buccal and lingual bone plates were concentrated in experiments in animals or using conventional radiographs. Currently, many are the CT studies on the morphology of the buccal and lingual bone plates previously to orthodontic treatment and on the repercussions of tooth movement on the alveolar bone. These evidences can change usual treatment planning, pointing the limits of therapeutic options in Orthodontics. Additionally, the morphology of buccal bone plate can tell the orthodontist which patient can or cannot be treated with expansionist mechanics.

3. Comment some examples of the applicability of this methodology to research purposes.

The applications of this methodology should answer if it is reasonable to move teeth to a region of atrophic alveolar bone. CBCT will elucidate the acceptable amount of dental compensation or decompensation in skeletal Class II and Class III patterns. The periodontal effects of mandibular anterior repositioning appliances on the lower incisors can also be evaluated by means of this methodology.

Contact address

Marcos Cezar Ferreira
Rua Malibú, 260 apto 205/Bloco I – Barra da Tijuca
CEP: 22.793-295 – Rio de Janeiro / RJ
E-mail: drmarcos_iom@yahoo.com.br

Laboratorial study of the cuspid's retraction timing and tipping effects during space closure, using the segmented arch technique

Gilberto Kauling Bisol*, Roberto Rocha**

Abstract

Objective: Evaluate the cuspid's retraction time and tipping effects, after submitting it to three different orthodontic retraction loops: the "T" loop, the "boot" loop, and the "tear drop" loop. **Methods:** It was used the following orthodontic wires: Morelli 0.019 x 0.025-in stainless steel, 3M Unitek 0.019 x 0.025-in stainless steel andOrmco 0.019 x 0.025-in beta-titanium (TMA™). The resulting sample from the combination of these variables was submitted to a test developed on a typodont simulator used specifically for this purpose. **Results:** As the closure timing concerns, it was verified that a slower closure and therefore, a smaller releasing force system was achieved by the "T" loop design and by employing the beta-titanium alloy on its construction. As to the tipping effects generated by the retraction device, the "tear drop" loop caused greater tipping effects than the other loops evaluated. The "T" loop, on the other hand, showed itself statistically related to the lowest tipping numerical values. However, when the 3M Unitek stainless steel wire was used to produce the device, all of the types of loops evaluated were considered statistically similar. **Conclusion:** Regardless of the loop design, the ones built out of beta-titanium alloy kept them statistically related to the lowest tipping numerical values observed for the retracted dental element.

Keywords: Orthodontics. Segmented arch. Orthodontic space closure.

* Certification in Orthodontics and Facial Orthopedics, UFSC.

** Master of Science in Orthodontics, UFRJ. PhD in Orthodontics, UFRJ. Assistant Professor, School of Dentistry, UFSC.

INTRODUCTION AND LITERATURE REVIEW

During the orthodontic treatment it is expected that an optimal force used to promote dental movement provides a satisfactory result in a reasonable period of time, with minimum damage to the adjacent structures and minimal discomfort to the patient.^{1,10,17,21,27,29} It seems to exist a wide range of force values that produces a maximum amount of movement of the dental element,²⁷ without undesirable movement of the anchorage unit.^{10,12,13,21}

Several devices can be used to obtain dental movement.^{2,3,6,12,18,22-25,27,28} One can choose between a sliding mechanics along continuous orthodontic arches and frictionless mechanics, where segmented arches with orthodontic loops can be used.^{10,28} However, in both cases, it is not possible to eliminate the rotational and tipping components from teeth, due to the fact that the accessories of the orthodontic device are positioned some millimeters labial to the tooth axis and a few millimeters occlusal to the center of resistance of the teeth.¹⁰

Some physical concepts need to be revised so that one can understand the relationship between the forces and the dental movement.^{14,15,20,26} Each object or body has a point where it can be balanced perfectly, which is known as center of gravity of the object. However, the teeth have an additional complication. They are surrounded by periodontal structures that involve the root, but not the crown. Then, another point has been used: the center of resistance. It is important to point out that the position of the center of resistance varies with the root length and the alveolar bone height as well.^{20,26} Generally, the tooth can move in three ways: translation or body movement; pure rotation movement, where the tooth will rotate around its center of resistance, and combined translation-rotation movement.^{13,14,20,26}

The authors defined the moment of force as the magnitude of force multiplied by the perpendicular distance to the action line of that force

to the center of resistance of the tooth.^{14,15,20,26} If the line of action of an applied force does not pass through the center of resistance of the dental element, the force will produce some rotation on that tooth. This rotation potential is called moment. The orthodontist creates a binary of forces in the bonded device, which will oppose to the moment produced by the force acting on the dental element, so that the forces act directly on the center of resistance of the tooth.²⁶ The dental movement is determined by the ratio between the binary moment (M) used to control the position of the root and the force (F) used on the crown to move the tooth. The more heavy is the force, greater is the moment of the binary (on the accessory) needed to maintain the desired rotation.²⁰ In a M/F ratio of 5:1, an uncontrolled tipping occurs; with a M/F ratio of 8:1, a controlled tipping occurs; in a M/F ratio of 10:1, translation occurs; in a M/F ratio of 12:1, root movement occurs.^{8,13,20,26,28}

Several authors discussed the optimal properties of devices used for dental movement.^{2,8,9,17} Among the respective properties are:

1. It should generate appropriate levels of force, a low load/deflection ratio^{2,16,20,23,25} and a high M/F ratio, in order to reach the desired dental movement. Gable or antitipping bends can be incorporated to the devices in order to increase the level of moment produced.^{7,8,17,24,28} This reflects an increase of the M/F ratio; differential moments can still be generated, changing the positioning of the devices.^{3,12,28}

2. It should be capable to submit to a reasonable range of activation/deactivation, liberating relatively continuous forces and moments.

3. It should be sufficiently small to adapt comfortably in the available intra-oral space.

In addition, the properties of the devices can be changed with modifications in the thickness, shape, amount of wire used, and rate of activation according to the modulus of elasticity of the wire by thermal treatment.¹⁷

In order to reach these objectives, several devices with different configuration have been introduced in the literature.^{3,7,12,16,18,23,24,25,28,30} The results provided by these different devices can be linked to relevant factors of the orthodontic treatment, i.e., the time needed for accomplishment of the dental movement, as well as tipping effect on the dental element. Another factor to be taken in consideration is the type of wire used to build the orthodontic device. There are several types of wire available in the market,^{3,8,9,11,12,16,18,19,29,30} which possess different features and mechanical properties.

The current work aimed to evaluate the retraction rate and the degree of tipping suffered

by the moved dental element using three different types of orthodontic retraction springs: the “T” loop, the “L” loop, and the “tear-drop” loop. For making these springs different materials were used: two commercially available stainless-steel wires, and one commercially available beta-titanium wire (TMA™).

MATERIAL AND METHODS

In the present study, three types of loops, the “T” loop, the “L” loop, and the “tear-drop” loop, conformed in stainless steel wires (Morelli, Sorocaba, SP, Brazil and 3M Unitek, Saint Paul, MN, USA) and one beta-titanium wire (TMA™, Ormco, Orange, CA, USA) were evaluated.

TABLE 1 - Description of the sample groups.

GROUP	DRAWING OF THE LOOP	WIRE TYPE	COMMERCIAL MARK
A	“T” loop	Stainless Steel	Morelli
B	Tear-drop	Stainless Steel	Morelli
C	“L”	Stainless Steel	Morelli
D	“T” loop	Beta-titanium (TMA™)	Ormco
E	Tear-drop	Beta-titanium (TMA™)	Ormco
F	“L”	Beta-titanium (TMA™)	Ormco
G	“T” loop	Stainless Steel	3M Unitek
H	Tear-drop	Stainless Steel	3M Unitek
I	“L”	Stainless Steel	3M Unitek



FIGURE 1 - Typodont model used for evaluation: simulation of exodontia of 44 (set-up of right lower arch).



FIGURE 2 - Anchorage unit stabilized with gypsum (coated with clear nail varnish).



FIGURE 3 - Metallic teeth with the respective accessories positioned.

A partial typodont assembly simulating a right lower arch was made for the experiment. The created model simulated the exodontia of the element 44 (Fig 1). The elements 47, 46 and 45 were fixed with dental gypsum and represented the posterior anchorage (Fig 2). Teeth # 47, 46, 45, and 43 received Edgewise standard 0.022 x 0.030-in slot brackets. Element 43 received a vertical segment of wire, welded orthogonally to the slot to serve as a reference for reading tipping suffered by this tooth during the proposed movement (Fig 3).

Three types of loop were conformed to each wire (all wires were 0.019 x 0.025-in), yielding nine different evaluation groups (Table 1). To help in the making of the arch segments with loops, it was used a chart where was drawn the outline of the arch segment and a template with the drawing of the loops (Figs 4 and 5). Fifteen samples were

made for each group (135 arch segments evaluated) (Fig 6).

Then, each of the arch segments was tested, according to the following sequence:

1. The arch segment was tied to the assembly with 0.010-in stainless steel ties (Fig 7).

2. This condition was recorded with photographs (T1). The mannequin was stabilized in this moment by means of a support with screws. Then, the distance between the anterior border of the support to the most anterior portion of the photo camera lens was standardized: i.e. 12.4 mm, so that both elements were parallel to each other, from a upper view (Fig 8). The lens opening was adjusted to "32" and the shutter speed was "90". Two gridlines demarcated in the base of the articulator were used to standardize the framing of the photographs.

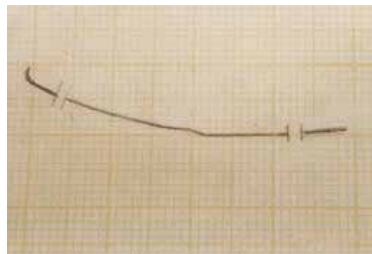


FIGURE 4 - Chart used to make the archwires segments.

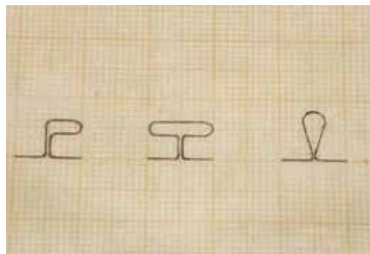


FIGURE 5 - Template used to make the loops.

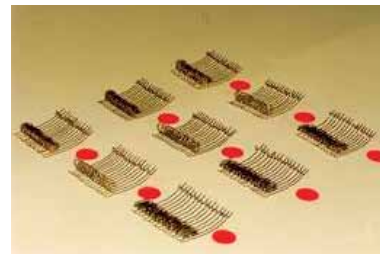


FIGURE 6 - Sample used in this work (n = 135 archwires).



FIGURE 7 - Archwire being fixed to the assembly with steel tie.

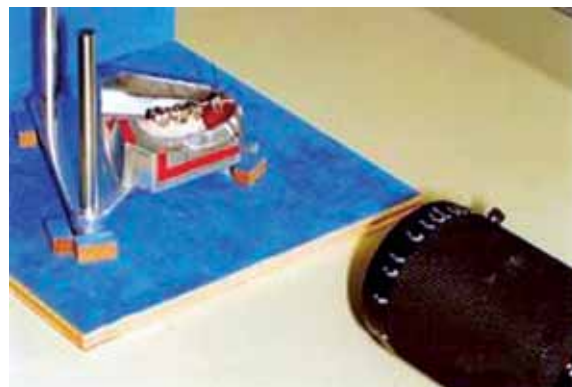


FIGURE 8 - View of the assembly in place for photographic recording.



FIGURE 9 - Activation of the loop with a tieback with double tie in the omega loop. The amount of the activation was controlled with a divider.

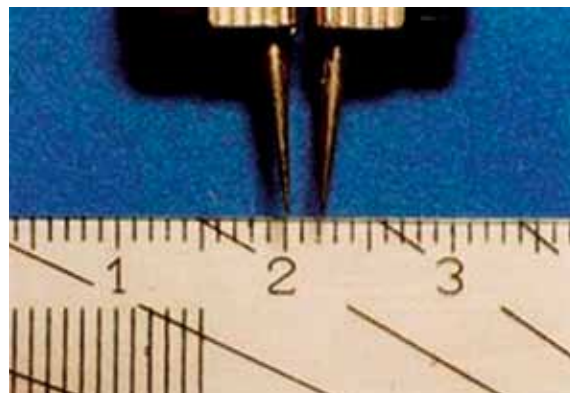


FIGURE 10 - Measurement of the amount of activation with divider and scale: 2 mm of activation.

3. The spring was activated by means of a tie-back, promoting the movement of the distal segment to that direction. The spring was opened until an opening of 2 mm was achieved, checked by means of a divider (Figs 9 and 10).

4. The articulator was then immersed in a recipient with warm water (50°C), in order to allow the deactivation of the spring.

5. Immediately after the immersion, the chronometer was started. The time (in seconds) required for complete deactivation of the spring was recorded by visual inspection.

6. The articulator was positioned again in the support so that a new photo was obtained (T2).

7. It was necessary that the cuspid has assumed repeatedly the same initial position to the procedure could be considered reproducible for each one of the arch segments. This was achieved with a segment of 0.0215 x 0.0275-in ideal arch, used as a guide for repositioning of the cuspid after the evaluation of each arch.

8. The assembly was immersed in cold water to evaluate a new arch.

In order to avoid that possible alteration of the characteristics of the wax after successive evaluations could interfere in the fidelity of the results, the evaluation was accomplished in the following manner: the nine combinations were divided in 3

TABLE 2 - Sequence of evaluation of the devices.

	1 ST TYPE OF LOOP EVALUATED	2 ND TYPE OF LOOP EVALUATED	3 RD TYPE OF LOOP EVALUATED
Morelli wire loops (new wax)	"T"	"L"	"Tear-drop"
Ormco wire loops (1st change of wax)	"L"	"Tear-drop"	"T"
3M Unitek wire loops (2nd change of wax)	"Tear-drop"	"T"	"L"

groups, separated by the type of wire. The wax was replaced for each type of wire. In addition, the arrangement of type of the loop to be evaluated was changed, according to sequence described in Table 2.

Having the photographic recordings of the initial (T1) and the final (T2) conditions of the assembly, a tracing paper was placed over these pictures. The long axis of the cuspid was traced, and the line was extended until contact the grid-line demarcated in the base of the articulator,

from which the upper margin was traced. Then, the angle formed between these two lines was measured for all arches evaluated, for both the initial (T1) and the final (T2) conditions. The difference between these two values could be calculated, and the angular variation presented by the cuspid with the closure of the loop was obtained. Another variant recorded was the time required for the deactivation of the loop.

The results were recorded in individual forms for data collection, and ultimately submitted to statistical analysis using non-parametric comparison tests (Kruskal-Wallis). The conditions tested were the loop design (independent of the type of wire) for the three groups, the type of wire (independent of the loop design) for the three groups, and finally the interaction between the loop design and the type of wire for the nine groups.

RESULTS AND DISCUSSION

To help the analysis and discussion of the results, two issues were addressed, according with two evaluated variables: the time for closure of the loop and the degree of tipping suffered by the tooth. Inside each topic, it was evaluated the effects of the different types of wires (independent of the drawing of the loop), the effects of the different loop types (independent of the wire type) and the effects of the interaction between loop type and wire type, on the variant in question. When interaction was verified, post analysis was performed, to investigate whether the effect occurred due to the loop, to the wire, or both.

Time of closing of the loop

The time observed for closing of the loop was recorded in seconds. In an attempt to guide the discussion of this topic on which device exerted a larger or minor force on the tooth to be moved, it was taken into account that less time for closing of the loop is related to a higher force released by the loop. Conversely, the smaller the force, the more is the time required for closing of the loop.

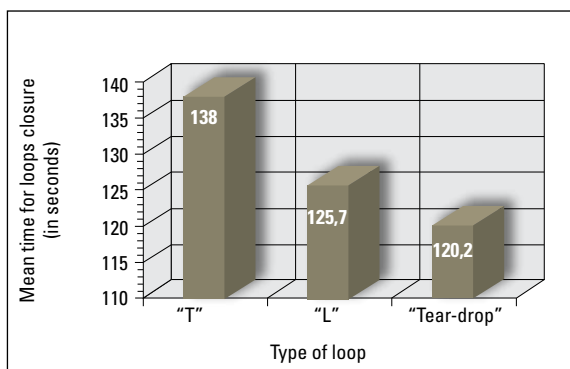
Burstone³ reported that the optimal force for dental movement is that capable to produce a fast movement with minimal discomfort and damage to the tissues, using continuous and slight forces. Hixon et al¹⁰ stated that the fast tooth movement generated when using light forces seems to be a result of tipping movement that produces great pressure on the alveolar crest.

All recordings obtained in this work were subjected to statistical analysis. Two segments presented values for this variable that were characterized as outliers from all appraised arch segments. These values were excluded from the analysis. (Specimen # 14, Group H; Specimen # 1, Group F). The analysis was subsequently performed for the interaction between loop type and wire type for the variant "time of closing of the loop". The interaction was not statistically significant. On the other hand, the variables wire type and loop type were significantly different when analyzed independently:

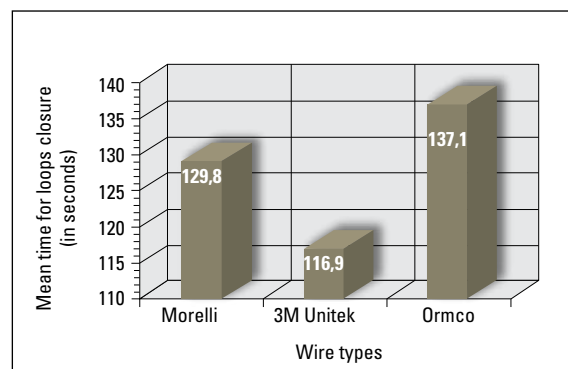
Relationship of the loop type with the variant "time of closing of the loop"

According with the values of Graph 1, it was observed that the "T" loop took more time to accomplish the tooth movement, therefore exerting a smaller force on the cuspid than the other loops. In spite of the "L" loop exerted less force than the "tear-drop" loop, the difference was not statistically significant.

The good performance of the "T" loop was previously reported by Burstone and Koenig.⁵ They stated that this loop uses a great amount of wire for its construction, especially cervically. This loop configuration with great amount of wire arranged horizontally at the cervical, even when is built with stainless steel wire, yields a significant decrease of the load/deflection ratio. This was also observed more recently by Shimizu et al.²³ The authors concluded that the "T" loop is capable to generate relatively low load/deflexion rates, and more consistent magnitudes of force during the



GRAPH 1 - Mean time (in seconds, y-axis) for deactivation of loops with different drawings (x-axis).



GRAPH 2 - Mean time (in seconds, y-axis) for deactivation of different commercially available loops (Morelli and 3M Unitek: stainless steel; Ormco: beta-titanium; x-axis).

deactivation as a result. Souza et al²⁵ also supported the use of "T" loops by orthodontists; as well as several authors did previously.^{3,28}

Relationship of the wire type with the variable "time of closing of the loop"

In 1979, Burstone and Goldberg⁹ introduced to the market a beta-titanium alloy, considered as the newest material in the orthodontic profession.

Since then, this alloy became an option for the orthodontist, with characteristics that surpassed other alloys, such as: capacity of application of light forces, continuous deactivation of the force with time, higher precision in the application of a force and the capacity of application of larger activations, associated to an extended "working time" of the device. In 1980, the importance of this alloy was advocated due to its great potential in orthodontics.⁴ The main reason is that in an orthodontic device, the maximum elastic flexion increases with the accumulated force/modulus of elasticity ratio of the material. Beta-titanium alloys possess one of the highest values for this ratio (about 1.8

times higher than that of stainless steel), while maintains good formability.

The importance ascribed to beta-titanium alloys by these authors was confirmed in the present work. According with the values of Graph 2, the stainless steel devices accomplished the dental movement more quickly than beta-titanium alloy devices. This was reported earlier by Stagers and Germane,²⁸ that found that the load/deflexion ratio can be changed by differences in wire composition. TMATM loops have low modulus of elasticity, and a lower load/deflexion ratio than stainless steel loops. This was also reported earlier by Boshart et al² that found that there was a change in the rigidity of coil springs with different compositions. Menghi, Planert and Melsen¹⁸ also compared systems of force liberated by beta-titanium and stainless steel devices, and found a conclusion similar to our study: beta-titanium devices released 40% of the force provided by identical stainless steel loops. Beta-titanium alloy loops are preferable in comparison to stainless steel loops due to their higher activation range and consistent

liberation of forces.

It could be concluded from our results that the beta-titanium alloy devices exerted less force on the cuspid than the others. This is a clinical information that is extremely important. Manhartsberger, Morton and Burstone¹⁶ reported that orthodontic extraction therapy is common in adult patients. In these cases, where bone loss is a complication, they suggest the use of beta-titanium alloys for loops. These alloys reduce the magnitude of the forces applied to the teeth and yield a lower load/deflection ratio (allowing the making of an arch with smaller rigidity). Another factor to be considered with the use of less rigid wires, according to the authors, is the potential of increasing the amount of activation of the loop. Burstone³ stressed out that a beta-titanium alloy for making loops for closing of spaces is more easy to handle, allows for a simplification in the drawing of the loop and has a low load/deflection ratio. This means that it can release optimal levels of force, which are dissipated slowly, with great amounts of activations. The clinical relevance of this issue is that with great activations, an error of 1 mm during activation is not as significant as the same error in a more rigid device.

The lack of statistical relationship between stainless steel arches remains unclear. Further investigation is required about the proportions of alloy's components in manufacturing process. In spite of this limitation, beta-titanium alloy arches exerted less force on the tooth, supporting the findings of Kapila and Sachdeva.¹¹ Also in this work, commercially available beta-titanium wires, known as TMA™, presented lower elasticity modulus than stainless steel and chromium-cobalt wires, and approximately the double of the presented by nickel-titanium wires. Therefore, beta-titanium alloy wires can be deflected without permanent deformation (about two times) than stainless steel wires, have higher formability than nickel-titanium wires, and allow that loops can be incorporated to the wire. According to the same authors, its only

disadvantage is the high level of friction presented when it is in contact with the bracket.

However, it is proper to stress out here that a low load/deflection ratio is not necessarily advantageous for the dental movement in all stages of the orthodontic treatment. According to Yang, Kim and Kim,³⁰ low rigidity nickel-titanium wires are recommended in the early stages of the treatment, beta-titanium wires are recommended in the intermediary stages due to their moderate rigidity, and high-rigidity arches are more appropriate for the final stages. Therefore, the relevance of alloys with high load/deflection ratio cannot be omitted by the results presented by our study, as showed by the stainless steel wires throughout the orthodontic therapy.

Degree of tipping of the cuspid

The variation in tipping of the cuspid after its movement can be attributed to the fact that the point of application of forces (bracket) is placed far from the center of resistance of the element in a cervico-occlusal direction. This generates a moment in the tooth to be moved, tipping it.

Despite it is not the objective of the present discussion, it is also convenient to highlight that the point of application of forces of the evaluated devices on the tooth is far from its center of resistance in the labial-lingual direction, which is responsible for the tendency of rotation of the tooth during the movement.

Hixon et al¹⁰ reported the difficulty in eliminating the rotational and tipping components presented by the element to be retracted, due to the distance of the center of resistance to the point of force application. In our work, the control of the variation in the angulation of the cuspid could be attributed to the M/F ratio of the devices used. According to Smith and Burstone,²⁶ the aim is to create a binary of forces in the accessory bonded to the tooth, opposing the moment produced by the force that acts on the tooth. The type of movement of a tooth is determined by the ratio between the

magnitude of the binary (M) and the force (F) applied on the bracket. Kuhlberg and Priebe¹³ mentioned that a small value in this ratio (about 7/1) provides a movement of controlled tipping; a ratio of approximately 10/1 is capable to promote translation of the tooth. Higher values (about 12/1) can cause movement of the root apex while the crown of this element remains stable.

Regarding the issue “degree of tipping of the cuspid”, the presence of a outlier was verified (Specimen # 15, Group F). This value was eliminated to not compromise the final result of the analysis. The analysis revealed that the interaction between the loop type and the wire type with the variable “degree of tipping of the cuspid” was statistically significant. The unfolding of the results was the following:

Relationship of the loop type with the variable “degree of tipping of the cuspid”

In function of the post analysis, the loop types were evaluated for each type of wire, separately, according to the Graph 3.

Staggers and Germane²⁸ stated that the drawing of the retraction spring influences the load/deflection ratio. In a general way, according to the Graph 3, the teardrop loop promoted greater tipping of the tooth than the other evaluated loops. On the other hand, the “T” loops presented, within each wire type, statistical correlation to the smallest variation values in angulation presented by the cuspid after its retraction. The exception was the third evaluated type of wire that did not presented statistically significant differences.

The variation in the angulation of the cuspid can be attributed to the M/F ratio of the devices: a higher magnitude force provided by the teardrop loop yields a low M/F ratio. Then, one could expect that “T” loops are capable to yield smaller magnitudes of force and, consequently, provide a higher M/F ratio, tipping less the tooth to be moved.

Burstone and Koenig⁵ suggested that to in-

crease the M/F ratio of a loop during activation the length of the loop in an apical direction should be raised. Another manner is to increase the amount of wire used in the terminal segment of the loop, which decreases the load/deflection ratio. According with the same authors, this can be achieved by using the “T” loop. However, according with our results, even a “T” loop seemed to be unable to avoid tipping of the cuspid during the movement. This undesirable effect can be minimized by the incorporation of compensatory folds in these loops (gable bends), in order to promote a greater root movement.

Manhartsberger, Morton and Burstone¹⁶ reported that introducing angulations in the loop could increase the M/F ratio of a device.

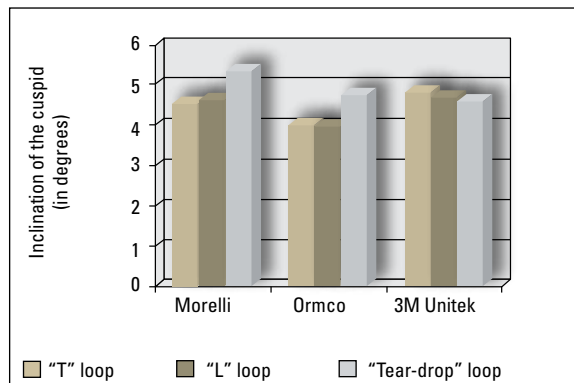
Staggers and Germane²⁸ showed that, even for a “T” loop, it is very difficult to get a 10:1 M/F ratio, required to obtain translation movement, without making gable bends. The incorporation of this type of bends was also suggested by Burstone,³ Chen, Markham and Katona,⁷ Faukner et al,⁸ Shimizu et al,²³ and Souza et al,²⁵ among others.

It would be interesting, in a next study, to use a method similar to the present work including gable bends in the tested loop, for evaluation of the advantages from these bends.

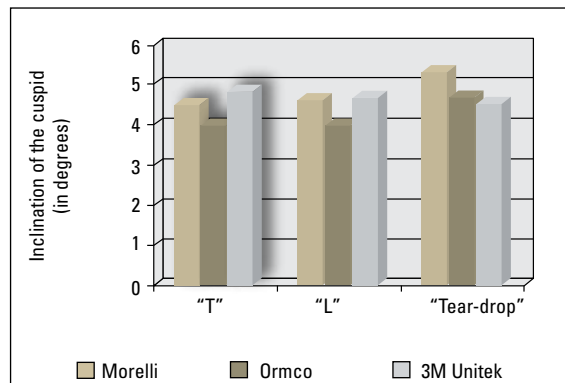
Relationship of the type of wire with the variable “degree of tipping of the cuspid”

Investigating the influence of different resources available to the orthodontist for obtaining a device that could yield a suitable M/F ratio, it was aimed to evaluate the influence of the alloy's type used for fabricating the loop on the tipping presented by the cuspid after retraction. Regarding this topic, due to the unfolding of the results, the wires of different composition were evaluated separately for each type of loop, according to the Graph 4.

It was observed that, in a general way, the beta-titanium alloy loops were statistically related, in all the 3 groups, to the smallest values of variation



GRAPH 3 - Inclination of the cuspid after retraction (in degrees, y-axis) for different drawings, according to each type of wire (x-axis).



GRAPH 4 - Inclination of the cuspid after retraction (in degrees, y-axis) for different commercially available archwires (Ormco: beta-titanium; 3M Unitek and Morelli: stainless steel), for each loop drawing (x-axis).

in angulation presented by the cuspid after retraction, when compared to the stainless steel loops evaluated in this study.

In spite of Staggers and Germane²⁸ have affirmed that the M/F ratio is not influenced by the composition of the wire used, it could be expected that the use of more resilient wires provides smaller magnitudes of force. According to Shimizu et al,²³ devices capable to generate relatively low load/deflection ratios, provide more consistent magnitudes of force during deactivation as a result; yielding high moment/force (M/F) ratios, and ultimately more root movement.

The combination of materials with lower modulus of elasticity and rigidity, associated to a loop drawing capable to decrease the load/deflection ratio of the assembly, can produce devices that promote a slower closing of the loop after its activation and a retraction with lighter, biologically more compatible forces. Thus, smaller magnitudes of force can act in the M/F ratio increasing its values and, consequently, decreasing tipping effects generated by the forces of dental movement. These forces do not act directly on the center of

resistance of the teeth submitted to the orthodontic treatment.

However, this study showed that even the combination of a loop drawing capable to promote a lower load/deflection ratio with more resilient wires was unable to isolate tipping effect suffered by the moved tooth. Nevertheless, it is likely that additional resources should be used seeking this objective, such as the incorporation of bending in these devices.

Another important issue to be considered for discussion is that the high tipping values recorded at the end of the retraction procedure maybe are due to the fact that it has not awaited sufficient time so that the evaluated devices could release all its potential of root movement. Staggers and Germane²⁸ reported that since the M/F ratio increases as the loop is deactivated, the loop should not be reactivated so frequently. According to the authors, repeated reactivations do not allow that the loops reach a sufficiently high M/F ratio to promote a translation movement of the tooth. It would of interest that this fact was taken in consideration in the case of further investigation.

CONCLUSION

According to the results obtained in this work, it could be concluded that:

Time of closing of the loops

There was no interaction between the type of wire and loops for this variable. However, when considered independently, the differences were significant:

- Loop type: the "T" loop take more time to deactivate than the others.
- Wire type: the beta-titanium alloy loop takes more time to deactivate than the others.

Degree of tipping of the cuspid

In this case, it was observed an interaction between the type of the loop and wire. The post analysis revealed was accomplished as following:

Loop type

The "teardrop" loops promoted greater dental tipping than the others evaluated. On the other hand, the "T" loops showed statistical correlation to the smallest tipping values. However,

when 3M Unitek stainless steel wires were used to make the loops, the 3 types did not present statistical difference for this variant.

Wire type

The beta-titanium alloy loops were statistically correlated to the smallest tipping values observed for the moved tooth, regardless of the loop drawing used.

Therefore, the combination of a material with lower modulus of elasticity and rigidity (beta-titanium) associated to a loop drawing that uses greater amount of wire (such as "T" loops) produces a device that generates a relatively lower load/deflection ratio. As a consequence, this provides lighter and consistent force magnitudes during deactivation, increasing the moment/force ratio, providing greater root movement.

Submitted: August 2008
Revised and accepted: August 2009

REFERENCES

- Boester CH, Johnston LE. A clinical investigation of the concepts of differential and optimal force in canine retraction. *Angle Orthod.* 1974 Apr;44(2):113-9.
- Boshart BF, Currier GF, Nanda RS, Duncanson MG Jr. Load-deflection rate measurements of activated open and closed coil springs. *Angle Orthod.* 1990 Spring;60(1):27-32; discussion 33-4.
- Burstone CJ. The segmented arch approach to space closure. *Am J Orthod.* 1982 Nov;82(5):361-78.
- Burstone CJ, Goldberg AJ. Beta-titanium: a new orthodontic alloy. *Am J Orthod.* 1980 Feb;77(2):121-32.
- Burstone CJ, Koenig HA. Optimizing anterior and canine retraction. *Am J Orthod.* 1976 Jul;70(1):1-19.
- Chaconas SJ, Caupito AA, Miyashita K. Force distribution comparisons of various retraction archwires. *Angle Orthod.* 1989 Spring;59(1):25-30.
- Chen J, Markham DL, Katona TR. Effects of T-loop geometry on its forces and moments. *Angle Orthod.* 2000 Feb;70(1):48-51.
- Faulkner MG, Lipsett AW, el-Rayes K, Habersack DL. On the use of vertical loops in retraction systems. *Am J Orthod Dentofacial Orthop.* 1991 Apr;99(4):328-36.
- Goldberg J, Burstone CJ. An evaluation of beta-titanium alloys for use in orthodontic appliances. *J Dent Res.* 1979 Feb;58(2):593-99.
- Hixon EH, Atikian H, Callow GE, McDonald HW, Tacy RJ. Optimal force, differential force, and anchorage. *Am J Orthod.* 1969 May;55(5):437-57.
- Kapila S, Sachdeva R. Mechanical properties and clinical applications of orthodontic wires. *Am J Orthod Dentofacial Orthop.* 1989 Aug;96(2):100-9.
- Kuhlberg AJ, Burstone CJ. T-loop position and anchorage control. *Am J Orthod Dentofacial Orthop.* 1997 Jul;112(1):12-8.
- Kuhlberg AJ, Priebe DN. Space closure and anchorage control. *Semin Orthod.* 2001 Mar;7(1):42-9.
- Kusy RP, Tulloch JF. Analysis of moment/force ratios in the mechanics of tooth movement. *Am J Orthod Dentofacial Orthop.* 1986 Aug;90(2):127-31.
- Lindauer SJ. The basics of orthodontic mechanics. *Semin Orthod.* 2001 Mar;7(1):2-15.
- Manhartsberger C, Morton JY, Burstone CJ. Space closure in adult patients using the segmented arch technique. *Angle Orthod.* 1989 Fall;59(3):205-10.
- Mendes AM, Baggio PE, Bolognese AM. Fechamento de espaços. *Rev SBO.* 1992; 2(1):11-9.
- Menghi C, Planert J, Melsen B. 3-D experimental identification of force systems from orthodontic loops activated for first order corrections. *Angle Orthod.* 1999 Feb;69(1):49-57.
- Muraviev SE, Ospanova GB, Shlyakhova MY. Estimation of force produced by nickel-titanium superelastic archwires at large deflections. *Am J Orthod Dentofacial Orthop.* 2001 Jun;119(6):604-9.
- Oliveira EJ. *Biomecânica básica para ortodontistas.* Belo Horizonte: Ed. UFMG; 2000.
- Quinn RS, Yoshikawa DK. A reassessment of force magnitude in orthodontics. *Am J Orthod.* 1985 Sep;88(3):252-60.
- Rosenstein SW, Jacobson BN. Class I extraction procedures and the edgewise mechanism. *Am J Orthod.* 1970 May;57(5):465-75.
- Shimizu RH, Sakima T, Pinto AS, Shimizu IA. Desempenho biomecânico da alça em "T" construída com fio de aço-inoxidável, durante o fechamento de espaços no tratamento ortodôntico. *R Dental Press Ortodon Ortop Facial.* 2002 nov/dez;7(6):49-61.
- Siatkowski RE. Continuous arch wire closing loop design, optimization, and verification. Part II. *Am J Orthod Dentofacial Orthop.* 1997 Nov;112(5):487-95.
- Souza RS, Pinto AS, Shimizu RH, Sakima MT, Gandini Jr LG. Avaliação do sistema de forças gerado pela alça T de retração pré-ativada segundo o padrão UNESP – Araraquara. *R Dental Press Ortodon Ortop Facial.* 2003 set/out;8(5):113-22.
- Smith RJ, Burstone CJ. Mechanics of tooth movement. *Am J Orthod.* 1984 Apr;85(4):294-307.
- Smith R, Storey E. The importance of force in Orthodontics. *Aust Dent J.* 1952 Dec;56(6):291-304.
- Staggers JA, Germane N. Clinical considerations in the use of retraction mechanics. *J Clin Orthod.* 1991 Jun;25(6):364-9.
- von Fraunhofer JA, Bonds PW, Johnson BE. Force generation by orthodontic coil springs. *Angle Orthod.* 1993 Summer;63(2):145-8.
- Yang WS, Kim BH, Kim YH. A study of the regional load deflection rate of multiloop edgewise-arch wire. *Angle Orthod.* 2001 Apr;71(2):103-9.

Contact address

Gilberto Kauling Bisol
Rua Francisco Goulart, 278, ap. 26.
CEP: 88.306-600 – Florianópolis/SC
E-mail: gibakb@terra.com.br

Reproducibility of natural head position in profile photographs of children aged 8 to 12 years with and without the aid of a cephalostat

Adriana Likes Pereira*, Luciana Manzotti De-Marchi**, Paula Cabrini Scheibel***, Adilson Luiz Ramos****

Abstract

Objectives: The present study assessed the reproducibility of the natural head position (NHP) in children. **Methods:** Twenty-five children (12 females and 13 males) aged 8 to 12 years (patients at the School of Dentistry of the Universidade Estadual de Maringá PR, Brazil) were photographed. Photographs were taken in the NHP using a digital camera with and without the aid of a cephalostat. A vertical line (VL) was used as reference for the measurements. The photographs were taken again after a 15-day interval using the same protocol. Reproducibility of the NHP between both photograph sessions was evaluated using an angular measurement between the reference vertical line and a profile line passing through the soft pogonion and the upper lip point. **Results and Conclusion:** Although positional variations have suggested that patients in this age group should receive additional orientation on NHP photographs, there were no significant differences in the NHP within a 15-day interval with or without the aid of a cephalostat. The NHP proved to be a method with good reproducibility in children.

Keywords: Natural head position. True vertical line. Orthodontics. Children.

INTRODUCTION

The natural head position (NHP) is considered the most appropriate reference for orthodontic diagnoses and the planning of treatment. The NHP is a standardized, reproducible position, with the head in an upright posture and eyes focused on a point in the distance at eye level such that the visual axis is horizontal.¹⁹

There are two methods for obtaining the NHP. In the first method, the patient's head is orientated to his or her NHP and a mark or plumb line is used as a reference point in radiographs or photographs. In the second method, known as the Estimated Natural Head Position (ENHP), a conventional cephalogram or profile photograph is taken and then rotated to the

* Specialist in Dentistry, Universidade Estadual de Maringá.

** Specialist in Orthodontics and Master's Student in Integrated Dentistry, Universidade Estadual de Maringá.

*** Specialist in Orthodontics, Centro Universitário de Maringá/Dental Press and Master's Student in Integrated Dentistry, Universidade Estadual de Maringá.

**** Adjunct Professor, Department of Dentistry and Coordinator of Postgraduate Program in Dentistry, Universidade Estadual de Maringá.

patient's NHP under the judgment of an experienced specialist, if necessary.^{14,19}

A number of studies have found evaluations of the NHP required in photographs and lateral radiographs to be reasonably stable.^{20,26,27} However, few studies have investigated the reproducibility of these imaging methods using a similar methodology, especially regarding photographs of children.^{4,11,12,13,22,24}

According to Moorrees,¹⁹ orthodontists have disregarded the statement Downs made in 1956 that discrepancies between cephalometric facial typing and photographic facial typing disappear when a correction is made for persons in whom the Frankfurt plane does not correspond to the true horizontal line observed in the NHP. As the inclination of intracranial reference lines varies significantly, these lines may also be used as variables in cephalometric analyses. The advantage of recording the NHP resides in the fact that an either horizontal or vertical extra-cranial reference line can be used.^{9,17}

One of the aims of orthodontic treatment is to improve the patient's profile and not merely correct numbers based on intracranial lines. Thus, a number of authors stress that facial profile analyses obtained using the NHP should be more reliable, with anterior-posterior corrections consistent with the patient's habitual image; this is especially true for patients who are in the growth phase.^{14,17,19}

The aim of the present study was to evaluate the reproducibility of the natural head position in standard photographs of male and female Brazilian children from 8 to 12 years of age with and without the aid of a cephalostat.

METHODS

Profile photos were taken of twenty-five children (12 females and 13 males) aged 8 to 12 years, patients at the School of Dentistry of the Universidade Estadual de Maringá (PR, Brazil). Parents/guardians authorized the participation

of their children by signing terms of informed consent. All procedures were carried out in compliance with the principles established in Resolution n° 196/96 of Brazilian National Health Council. The study received approval from the ethics committee of the Universidade Estadual de Maringá.

A digital camera (Nikon Coolpix 4500) was used in manual mode, with aperture value F 4.2 and speed adjustment 1/60, normal quality and flash positioned 90 cm from the patient. The camera was attached to a tripod (Vivitar/VPT-15) with its height adjusted such that the center of the lens was aligned with the sub nasal point of the patient. An auxiliary light source was set up in a box (32 cm³) on a metal support (132 cm in height). The box was lined with aluminum foil on the sides, black TNT fabric on the posterior portion and a white TNT fabric on the anterior portion. A 100-watt incandescent light bulb (GE) was installed in the box, positioned 68 cm from the patient.

The portable cephalostat was specifically confected for this study and consisted of a metal structure with an acrylic part to which the ear rods were attached. These structures were adjustable in the horizontal and vertical directions for the correct adaptation to the patient's ears. An adjustable device on the anterior portion of the structure parallel to floor contained a red cotton string (0.5 mm thick), which was attached to a plumb. This string was used as the vertical reference line (VL).

A mirror (83 x 100 cm) was positioned 90 cm from the floor and 190 cm from the patient to assist in maintaining posture, allowing the patient to look into his/her own eyes while the photograph was being taken. As a background for the photographs, a light box (61 x 82 cm) with four fluorescent bulbs (Phillips do Brasil – SP, Brazil), covered with white TNT fabric was placed 70 cm from the patient. Figure 1 illustrates the arrangement of the equipment used

for the photography.

The NHP was obtained following the method proposed by Solow and Tallgren²⁷ adapted to photographs with and without the aid of a cephalostat. The patient was instructed to stand in front of the mirror with his/her feet a short distance apart, back straight and looking into his/her eyes in the mirror. There was no direct influence from the operator regarding posture during the instructions and photography. The operator was limited to giving the instructions orally.

Once the patient remained stable in the NHP, the ear rods were inserted with light skin contact. At this time, the first photograph was taken (T1 with cephalostat). Next, the ear rods were removed and the patient was again instructed not to move, maintain his/her feet a short distance apart, with back straight and looking into his/her eyes in the mirror while the second photograph was taken (T1 without cephalostat). New photographs were taken after 15 days of all the children in the sample using these same procedures (T2 with and without cephalostat).

The digital photographs were unaltered, stored and printed. The angle between the VL (vertical reference line) and soft tissue line Ls – Pog' (upper lip – tegumentar pogonium) was manually measured by a single operator (Fig 2).

To evaluate the error of method, the described angle was measured again on all photographs by the same evaluator after a period of ten days. There were no statistically significant differences between first and second measurements, as determined by the paired Student's t-test. The mean value between these values was used for statistical purposes. The Shapiro-Wilk revealed that these data exhibited normal distribution.

STATISTICAL ANALYSIS

The Shapiro-Wilk and Kolmogorov-Smirnov tests demonstrated that the variables did not exhibit normal distribution. Therefore, non-parametric tests were applied, with the level of significance set at 5%. Wilcoxon's test was used to compare the first (T1) and second (T2)

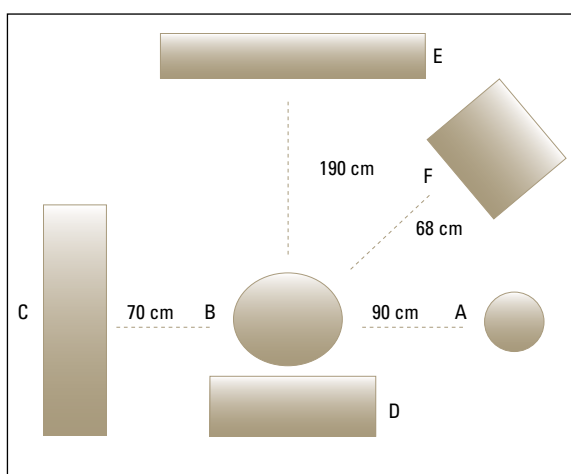


FIGURE 1 - Equipment disposition as used in this study (A – photograph camera; B- patient; C – negatoscopy; D – cephalostat; E – mirror; F – auxiliary light spot).



FIGURE 2 - Ls-Pog' . LV angle used in this study.

means of the measurements with and without the cephalostat. The Mann-Whitney test was used to compare absolute angular differences between T1 and T2 with and without the cephalostat. The Kruskal-Wallis test was used to compare all groups.

RESULTS

Table 1 displays the results of the measurements made with and without the cephalostat and with a 15-day interval between the photo sessions. Wilcoxon's test revealed no statistically significant differences between the angle values in T1 and T2 when the photos taken with the cephalostat ($p = 0.484$) or without the cephalostat ($p = 0.425$). Table 2 displays the absolute angular differences between T1 and T2 for the photos taken with and without the cephalostat. The Mann-Whitney test revealed no statistically significant differences between the absolute angles on the images obtained with and without the cephalostat ($p = 0.313$). The Kruskal-Wallis test revealed no statistically significant differences between T1 and T2 values with and without the cephalostat (comp = 0.998).

DISCUSSION

The importance of the reproducibility of the NHP is justified by the fact that facial analysis is essential to orthodontic diagnoses.¹ According to Moorrees,¹⁹ little attention has been given in orthodontic publications regarding the appropriate facial orientation during photographic recording. In some cases, patients with malocclusion Class II are documented before treatment with the head tilted down and after treatment with the head tilted up in order to highlight the correction of mandible retrognathia.

The Frankfurt horizontal plane (parallel to soil) is the most commonly used reference for positioning patients during photographic or radiographic records, as recommended by

Burstone.⁵ However, according to Viazis²⁸ and subsequently confirmed by Arnett and Bergman,¹ people do not assume this posture in their day-to-day life. Viazis²⁹ states that a variation of as much as 4° could be tolerated in the records based on the NHP. This margin was found in most cases in the present study. Lin and Arild¹⁵

TABLE 1 - Comparisons (Wilcoxon test) between T1 and T2 angular measurements (Ls-Pog'.LV) from photographs taken with and without the aid of a cephalostat.

PATIENT	WITH CEPHALOSTAT		WITHOUT CEPHALOSTAT	
	T1 (degrees)	T2 (degrees)	T1 (degrees)	T2 (degrees)
1	24	22.75	21	26.25
2	20	18.75	19.25	21.25
3	21.5	16.25	18.5	17.5
4	11.5	8.5	9	5
5	21.25	7	17	18.5
6	11	21.5	17.5	21
7	21.75	14.25	21.75	15.5
8	26.5	23.25	22.75	22
9	21	23.25	23.25	20.75
10	15.75	22.25	15.25	19
11	19	19	19.25	23.5
12	17.5	19.5	21	21
13	20.5	25.25	22.25	26.25
14	18.25	20.25	18	20.5
15	22	23	25.5	23
16	20.75	17	17.5	18
17	30.5	33	32.5	32.25
18	18.25	19	14.25	16.75
19	30	32.5	30	28.5
20	18.5	12.75	18.25	12.75
21	15.75	16.5	19.75	18
22	15	21	14	13.5
23	28	27.75	22.75	23.5
24	13	12.5	20.5	17.75
25	28.25	32	31	27.25
X	20.38	20.35	20.47	20.37
d.p.	5.15	6.45	5.12	5.42
p	0.808 ns		0.898 ns	

ns = not statistically significant.

found a large variation in the NHP of children between six and nine years of age assessed longitudinally. Few studies have evaluated children in orthodontic treatment.⁹ Angular variations tend to decrease in adult patients.²¹

Arnett and Bergman² prefer the NHP in facial analysis, stating that it does not exhibit the

same variation as intercranial points. This lesser variation has been confirmed by a number of authors.^{6,7,9,15,17} Thus, the NHP has been a preferred reference position for assessing facial morphology, as it is the position individuals naturally assume. Arnett et al³ detailed the analysis of soft tissues based on the philosophy of “Facial Keys”, which reinforces the need for the use of the NHP.

Although the NHP is recognized in the literature as a reliable position, different methods for obtaining this position are cited.^{7,8,18,20,28,29} There are few studies on profile photographs, which hinders the discussion of what method is best for obtaining the NHP. The use of the mirror promotes better reproducibility regarding this position when compared with images obtained without the aid of a mirror.^{8,14} There are divergences regarding the need for the use of a cephalostat, especially when recording the NHP in children. Cooke and Wei⁸ analyzed the use of the ear rods of the cephalostat and found no significant influence regarding the obtainment of the NHP.

The present study found that the NHP is a method with good reproducibility, corroborating previous studies.^{7,8,21} It was also confirmed that the NHP can be safely used in profile photography involving children. As there was no increase in accuracy when obtaining the NHP with the assistance of the cephalostat, this device seems unnecessary. Moreover, the children reported discomfort caused by the ear rods.

In 1971, Solow and Tallgren²⁷ found a standard deviation of 2.48° in the natural position when using the self-balance method, while the standard deviation with the aid of the mirror was 1.43°. A mirror was used in the present study and the standard deviation was 1.67° without the aid of the cephalostat and 3.26° with the cephalostat.

Another situation that caused discomfort in the patients was the presence of the string representing the true vertical line (VL), which was

TABLE 2 - Comparison (Mann-Whitney test) between T1 and T2 angular variation from photographs taken with and without the aid of a cephalostat.

PATIENT	WITH CEPHALOSTAT	WITHOUT CEPHALOSTAT
	DIF	DIF
1	1.25	5.25
2	1.25	2
3	5.25	1
4	3	4
5	14.25	1.5
6	10.5	3.5
7	7.5	6.25
8	3.25	0.75
9	2.25	2.5
10	6.5	3.75
11	0	4.25
12	2	0
13	4.75	4
14	2	2.5
15	1	2.5
16	3.75	0.5
17	2.5	0.25
18	0.75	2.5
19	2.5	1.5
20	5.75	5.5
21	0.75	1.75
22	6	0.5
23	0.25	0.75
24	0.5	2.75
25	3.75	3.75
X	3.65	2.54
d.p.	3.26	1.67
P		0.313 ns

ns = not statistically significant.

located in front of the patient. This suggests that it would be better to position the line simulating the VL alongside rather than in front of the patient in order to avoid this possible nuisance when photographing children. Another alternative would be to attach the string to the light box.

While there were cases in which the NHP did not vary with the use of cephalostat (Fig 3), there were also cases in which the mean values were different between the two photo sessions (initial and after 15 days) (Fig 4). A similar situation occurred when the photographs were taken without the use of the cephalostat, with some cases exhibiting no significant differences between photo sessions (Fig 5) and others exhibiting considerable variation (Fig 6). In most cases, however, the measures exhibited little variability in the photographs with and without the cephalostat (Fig 7).

Foster et al,¹⁰ Ludström and Ludström¹⁷ and Rino Neto et al²⁵ all report that slight differences in the recording of the natural head position is a smaller problem than the variation in intracranial reference lines. However, clinicians should assess whether the photography was really carried out with the patient in the NHP prior to performing the facial analysis. According to Reche et al,²³ the analysis of the facial profile using standardized photographs is valid and reliable for orthodontic documentation.

Based on the protocol of the present study, the researcher did not interfere in the positioning of the patient, as the intention of the study was to observe the reproducibility of the NHP in children. However, it should be noted that, in everyday practice, there is a need for trained technicians to record the photographs in the NHP. The cases in Figures 4B and 6B clearly show that



FIGURE 3 - Photographs taken from the same patient positioned in a cephalostat (A – first photograph; B – after 15 days). No angle variation was observed.

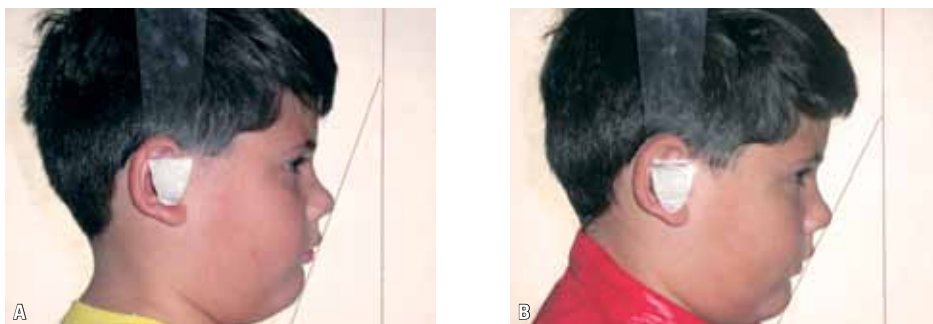


FIGURE 4 - Photographs taken from the same patient positioned in a cephalostat (A – first photograph; B – after 15 days). Obvious postural variation was observed.

the patients were in incorrect positions, requiring a new supervised photograph record. Thus, there should be technicians trained in obtaining photos in the NHP at centers for orthodontic exams, as suggested by Rino Neto et al.²⁵ Thus, the proposal made by Lundström et al.¹⁶ regarding the natural head position (NHP) is confirmed, as previously suggested by Moorrees and Kean.²⁰ This position

is also reinforced by Halazonetis,¹³ who stresses the need for the calibration of technicians, since more or less prognathous facial types could be positioned wrongly. It would therefore be ideal to take repeated photos in order to certify that the patient is in the NHP. This procedure has become more feasible with the popularization and routine use of digital cameras.



FIGURE 5 - Photographs taken from the same patient without the aid of a cephalostat (A – first photograph; B – after 15 days). No postural variation was observed.



FIGURE 6 - Photographs taken from the same patient without the aid of a cephalostat (A – first photograph; B – after 15 days). Obvious postural variation was observed.

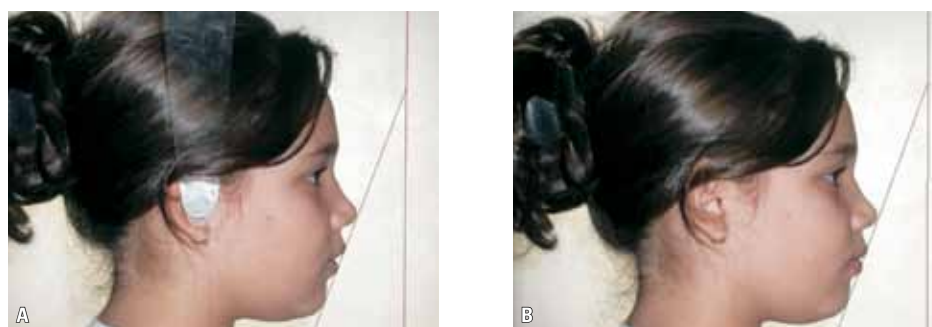


FIGURE 7 - Photographs taken from the same patient at the same day (T1). No angle variation was observed (A – with cephalostat; B – without cephalostat).

CONCLUSION

Although positional variations have suggested that patients in this age group should receive additional orientation on NHP photographs, there were

no significant differences in the NHP within a 15-day interval with or without the aid of a cephalostat in the present study. Thus, the NHP proved to be a method with good reproducibility in children.

Submitted: January 2007
Revised and accepted: September 2009

REFERENCES

1. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. *Am J Orthod Dentofacial Orthop.* 1993 Apr;103(4):299-312.
2. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part II. *Am J Orthod Dentofacial Orthop.* 1993 May;103(5):395-411.
3. Arnett GW, Jelic JS, Kim J, Cummings DR, Beress A, Worley CM Jr, Chung B, Bergman R. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. *Am J Orthod Dentofacial Orthop.* 1999 Sep;116(3):239-53.
4. Bister D, Edler RJ, Tom BD, Prevost AT. Natural head posture – considerations of reproducibility. *Eur J Orthod.* 2002 Oct;24(5):457-70.
5. Burstone CJ. The integumental profile. *Am J Orthod Dentofacial Orthop.* 1958 Jan;44(1):1-25.
6. Chen CM, Lai S, Tseng YC, Lee KT. Simple technique to achieve a natural head position for cephalography. *Br J Oral Maxillofac Surg.* 2008 Dec;46(8):677-8.
7. Cooke MS. Five-year reproducibility of natural head posture: a longitudinal study. *Am J Orthod Dentofacial Orthop.* 1990 Jun;97(6):489-94.
8. Cooke MS, Wei SH. A summary five factor cephalometric analysis based on natural head posture and the true horizontal. *Am J Orthod Dentofacial Orthop.* 1988 Mar;93(3):213-23.
9. Ferrario VF, Sforza C, Germanò D, Dalloca LL, Miani A Jr. Head posture and cephalometric analyses: an integrated photographic/radiographic technique. *Am J Orthod Dentofacial Orthop.* 1994 Sep;106(3):257-64.
10. Foster TD, Howat AP, Naish PJ. Variation in cephalometric reference lines. *Br J Orthod.* 1981 Oct;8(4):183-7.
11. Freire-Maia BAV, Pereira MFSM, Paiva JB, Rino Neto J. Avaliação cefalométrica radiográfica da posição craniofacial de pacientes orientados em posição natural da cabeça pré e pós-expansão rápida da maxila. *Rev Dental Press Ortod Ortop Facial.* 2005 mar/abr;10(2):96-109.
12. Goldreich HN et al. Considerações sobre os erros em cefalometria. *Rev Dent Press Ortod Ortop Maxilar.* 1998 jan/fev;3(1):81-90.
13. Halazonetis DJ. Estimated natural head position and facial morphology. *Am J Orthod Dentofacial Orthop.* 2002 Apr;121(4):364-8.
14. Jiang J, Xu T, Lin J. The relationship between estimated and registered natural head position. *Angle Orthod.* 2007 Nov;77(6):1019-24.
15. Lin XP, Arild S. Longitudinal study of the stability and reproducibility of natural head position in adolescents with different facial types over time. *Shanghai Kou Qiang Yi Xue.* 2005 Jun;14(3):238-42.
16. Lundström A, Forsberg CM, Westergren H, Lundström F. A comparison between estimated and registered natural head posture. *Eur J Orthod.* 1991 Feb;13(1):59-64.
17. Lundström A, Lundström F. The Frankfort horizontal as a basis for cephalometric analysis. *Am J Orthod Dentofacial Orthop.* 1995 May;107(5):537-40.
18. Marcotte MR. Head posture and dentofacial proportions. *Angle Orthod.* 1981 Jul;51(3):208-13.
19. Moorrees CF. A. Natural head position - a revival. *Am J Orthod Dentofacial Orthop.* 1994 May;105(5):512-3.
20. Moorrees CF, Kean MR. Natural head position: a basic consideration in the interpretation of cephalometric radiographs. *Am J Phys Anthropol.* 1958 Jun;16(2):213-34.

21. Nouri M, Mir M, Akbarzadeh A, Marami A. Three-year reproducibility of natural head position: a longitudinal study. *J Dent.* 2006;3(4):178-86.
22. Peng L, Cooke MS. Fifteen-year reproducibility of natural head posture: a longitudinal study. *Am J Orthod Dentofacial Orthop.* 1999 Jul;116(1):82-5.
23. Reche R, Colombo VI, Verona J, Moresca CA, Moro A. Análise do perfil facial em fotografias padronizadas. *Rev Dental Press Ortod Ortop Facial.* 2002 jan/fev;7(1):37-45.
24. Rino Neto J, Paiva JB, Freire-Maia BAV, Miasiro Jr H, Attizzani MF, Crivello Jr. O. Avaliação da reprodutibilidade da posição natural da cabeça: estudo radiográfico. *Ortodontia.* 2002 out/dez;35(4):55-68.
25. Rino Neto J, Freire-Maia BAV, Paiva JB. Método de registro da posição natural da cabeça para obtenção da radiografia cefalométrica lateral – considerações e importância do método no diagnóstico ortodôntico-cirúrgico. *Rev Dental Press Ortod Ortop Facial.* 2003 maio/jun;8(3):61-71.
26. Siersbaek-Nielsen S, Solow B. Intra- and interexaminer variability in head posture recorded by dental auxiliaries. *Am J Orthod.* 1982 Jul;82(1):50-7.
27. Solow B, Tallgren A. A natural head position in standing subjects. *Acta Odontol Scand.* 1971 Nov;29(5):591-607.
28. Viazis AD. A cephalometric analysis based on natural head position. *J Clin Orthod.* 1991 Mar;25(3):172-81.
29. Viazis AD. Posição natural da cabeça. In: Viazis AD. *Atlas de Ortodontia: princípios e aplicações clínicas.* São Paulo: Ed. Santos; 1996. p. 41-3.

Contact address

Adriana Likes Pereira
Rua Brasil 1667
CEP: 87.302230 – Centro Campo / PR
E-mail: dra.adrilikes@lojafactor.com.br

Analysis of skeletal maturation in patients aged 13 to 20 years by means of hand wrist radiographs

Yasmine Bitencourt Emílio Mendes*, Juliana Roderjan Bergmann**, Marina Fonseca Pellissari**, Sérgio Paulo Hilgenberg***, Ulisses Coelho****

Abstract

Objectives: Evaluate an alternative and simplified radiographic method that will enable implantologists and orthodontists to keep track of bone growth completion as well as differences between genders in a sample of individuals from 13 to 20 years of age. **Methods:** A hand wrist radiograph was acquired with the use of occlusal radiographic film to assess the maturation of the radius bone. One hundred and sixty patients of both genders were divided into groups of 10 individuals. The radiographs were examined by five raters using applicable rating standards, all specialists in orthodontics. **Results:** The results showed that there was a positive correlation between the chronological age of the patients and their biological age, whereas female bone maturation occurs earlier than in males. **Conclusion:** This method can determine the stage of maturation of the radius bone, allowing an affordable means of diagnosis and rapid determination of bone age for correct installation of an implant and/or orthodontic appliance.

Keywords: Maturity. Tooth movement. Dental implant.

INTRODUCTION

Understanding the events of craniofacial growth is of paramount importance in dental practice.¹⁰ Knowing the patient's exact stage of maturity and the period of occurrence of the pubertal growth spurt (PGS) may influence not only diagnosis and prognosis, but also the development of a treatment plan.²⁴ Thus, this knowledge is considered convenient for orthodontic treatments that

require the use of devices influenced by the stage of maturation of the craniofacial complex.²⁸ This growth stage also helps in preparing the treatment plan, especially in defining surgical procedures.¹⁵

It was recognized long ago that the chronological age of an individual does not necessarily coincide with their maturational age. A person's skeletal development may be delayed or advanced in various degrees of divergence from their actual

* Master's candidate in Dentistry; area of concentration Restorative Dentistry, Universidade Estadual de Ponta Grossa (UEPG).

** Surgeon Dentists.

*** Master of Dentistry; area of concentration Integrated Clinical Practice – UEPG. Postgraduate student specializing in Orthodontics - (UEPG).

**** Adjunct Professor of Orthodontics - UEPG. Orthodontics Specialist from Universidade de São Paulo (USP-Bauru); Master and Doctor of Orthodontics from Unesp - Araraquara/SP.

current chronological age.⁹ Therefore, chronological age is not always a good parameter for the correct evaluation of the body's maturation stage because, for example, the PGS does not occur at the same time in all individuals.²⁰ Biological age is more reliable since it is reported as the body's development towards maturity, which encompasses anatomical changes, dental and skeletal maturation, development of secondary sexual characteristics, hormonal function and enzyme activity, even if those mechanisms are influenced by genetic factors, socio-economic, environmental, nutritional and gender-related conditions.⁴

According to Rigertz and Eklöf,⁸ Caffey (1961) consider that the ideal method for assessing skeletal maturity should include a study of the whole skeleton. However, these authors⁸ affirm that due to practical and economic reasons this is not only impossible but also incompatible with the efforts to reduce exposure to radiation. The difficulties in finding a procedure that combines a simple and accurate definition of normal variations with reasonable statistical confidence have surfaced in the design of different methods.^{1,3,5,8,19,27}

In contemporary Orthodontics, early correction of various types of malocclusion is rendered easier when it is possible to take advantage of the moments of maximum increment in an individual's facial and overall growth occurring during the PGS.²¹ A patient's growth stage, therefore, proves essential in establishing accurate diagnoses and reliable prognoses.²¹ The stage of bone development can be estimated by means of hand wrist radiographs and through skeletal maturation as visualized in lateral cephalometric radiographs of the cervical vertebrae.²¹

Orthodontic treatment should be performed preferably in very young patients or during their PGS, as it is during this period that facial structures respond more efficiently to the stimuli provided by orthodontic mechanics.²³ Moreover, cases that are treated in later stages do not usually undergo significant skeletal changes as a result

of treatment, with the exception of surgical interventions in the bone bases.²³

The hand wrist has been widely studied and used as an area that helps to determine bone maturation with scientifically proven efficacy. Furthermore, it is a complementary exam that can be easily obtained with an X-ray and used for diagnosis and orthodontic treatment planning.^{12,27} Several investigations have shown that these areas represent the overall maturity of the skeleton and thus are suitable for such evaluation.¹² Similarly, other specialties require knowledge of skeletal maturation, especially Implantology since the aesthetic and functional success of an implant is associated with complete bone maturation.¹³

Therefore, considering the importance of PGS, this study aims to establish an affordable radiographic methodology that will allow dental professionals to assess skeletal maturation and monitor craniofacial growth and the alveolar process, focusing on adolescents aged 13 to 20 years. Additionally, it also seeks to establish the best time for dental implant placement and the most convenient moment to begin orthodontic treatment in this age group.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of the Universidade Estadual de Ponta Grossa - COEP – UEPG, Protocol No. 03569/06, Opinion No. 16/2006.

Hand wrist radiographs were performed with the use of occlusal films on 80 male patients and 80 female patients 13 to 20 years of age, further divided into 10 subjects for each age group totaling 8 groups for each gender. The radiographs allowed an assessment of the degree of maturation and the fusion of the epiphysis with the diaphysis of the radius bone.

The technique consisted of an occlusal film positioned under the wrist, with the palm facing down. With an exposure time of 0.8 seconds, a

40 cm cone was positioned perpendicular to the position of the hand and the film, and the radiographs were acquired. The films were processed using the time and temperature method and, after complete drying and identification, were stored for evaluation.

The evaluation was performed by five specialists in Orthodontics using applicable rating standards, who observed and scored (Fig 1) the stage of maturation of the radius bone. When the epiphysis and diaphysis of the radius bone were either smaller or equal in width, a zero score was assigned; a score of 1 was given when the epiphysis was larger than the diaphysis; a score of 2 when the epiphysis was starting to merge with the diaphysis; a score of 3 when the epiphysis and diaphysis were bound together by a slight radiolucent line; and a score of 4 to indicate the complete and final maturation of bone growth, with no significant difference between epiphysis and diaphysis.

The results obtained by each rater were analyzed by Kappa statistics to establish the Kappa coefficient of agreement. The non-parametric Mann-Whitney test was performed to see if both genders had the same distribution of results. The Spearman correlation test was used to assess the correlation between chronological age and the relative gender scores.

RESULTS

A statistical analysis of the data showed that the average level of inter-rater agreement was considered good ($\kappa = 0.66$) (Table 1).

The nonparametric Mann-Whitney test yielded a p value of 0.0011, which shows a statistically significant difference between groups due to the fact that the distribution of scores occurred differently in females, with men showing faster results.

The Spearman correlation test showed a value of $p < 0.001$ for both females and males, i.e., scores increased with age (Table 2).

Whereas there was good inter-rater agreement and a statistically significant difference between males and females, and considering that as chronological age advances, the scores will also increase, the next step consisted in evaluating—for both genders—at what age stage 4 (complete fusion of the epiphysis with the diaphysis of the radius bone) occurred significantly. For this the authors used the median values for each age considering the analysis of all raters. The occurrence of stage 4 is significant in females aged 16 years and in males aged 18 years (Graphs 1, 2).

DISCUSSION

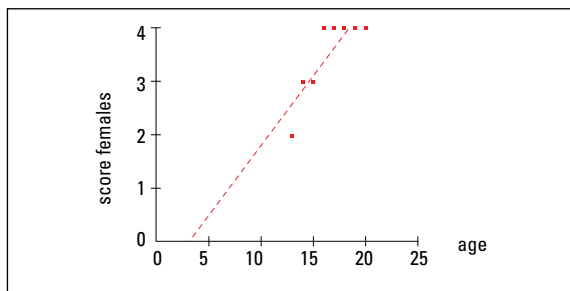
The planning and clinical conduct for rehabilitation of patients with partial anodontia, especially

SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 4
				
The epiphysis and diaphysis of the radius bone are equal or smaller in width	The epiphysis is larger than the diaphysis of the radius bone	The epiphysis is starting to merge with the diaphysis of the radius	A slight radiolucent line appears between the epiphysis and diaphysis of the radius bone	The complete maturation and final bone growth are indicated with no significant difference between the epiphysis and diaphysis

FIGURE 1 - Kappa inter-rater agreement coefficient.

TABLE 1 - Kappa inter-rater agreement coefficient.

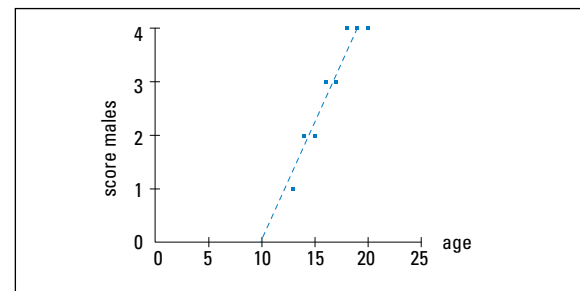
RATER	KAPPA VALUE
rater 1 x rater 2	0.63
rater 1 x rater 3	0.71
rater 1 x rater 4	0.66
rater 1 x rater 5	0.66
Mean Kappa value	0.66



GRAPH 1 - Graphical representation of the relationship between chronological age and female scores.

TABLE 2 - Representation of the Spearman correlation test results for males and females.

	FEMALES	MALES
Spearman coefficient(rs)	0.7314	0.8599
p-value	< 0.001	< 0.001



GRAPH 2 - Graphical representation of the relationship between chronological age and male scores.

multiple partial anodontia, is hampered by the decision of when to start treatment and what techniques to adopt.¹³ Thus, as the patient is born with missing teeth, prosthetic rehabilitation should be undertaken as soon as the patient's development is complete.

The patient's bone development can be tracked in various ways, but the use of hand wrist radiographs can provide information on the patient's growth and maturity, which are clinically important in the application of dentofacial diagnosis and orthopedic therapy,^{10,11,14} and more recently, the installation of dental implants. Another way to assess skeletal maturation is accomplished through an analysis of the cervical vertebrae in lateral radiographs, which are part of the orthodontic documentation.²⁶ However, it is suggested that professionals exercise caution in considering cervical vertebrae examination as an absolute method to evaluate skeletal maturation in growing patients for as long as professionals have not yet developed enough familiarity with this method.^{1,7} Thus, it

is believed that carpal index is the most reliable resource for bone assessment given the fact that most professionals are very comfortable using the method, which is not only easy to obtain but involves less radiation exposure.

The patient's exact stage of maturation has been the target of research, which has sought to facilitate its assessment, reduce costs and reduce the exposure of patients to ionizing radiation.^{1,5,18,19,24} Silva Filho et al²⁷ evaluated a simplified alternative method consisting of an X-Ray of the metacarpophalangeal joint area of the thumb, using a radiographic periapical film. In this film the presence of the ulnar sesamoid bone can be observed, in a clear indication that PGS onset will occur within a 1-year period, thereby signaling the correct time for the installation of the orthodontic appliance.

In this study, the authors have attempted to find a fast and secure way for dentists to detect, in their own office, the patient's stage of maturation for the placement of a dental implant and assess

the most suitable time to begin orthodontic treatment of patients aged 13 to 20 years. This was achieved by acquiring an X-ray—using occlusal film—of the radius bone region, which indicates the end of the alveolar bone growth. It should be underscored that in establishing the bone age diagnosis of a patient who will undergo a dental implant surgery, the exclusion of the carpal and metacarpal bones does not significantly influence bone age determination.²⁷ Moreover, this method readily addresses a clinical issue while ensuring less patient exposure to radiation.²⁵

A literature review has revealed a growing concern by orthodontists to establish parallels between a patient's chronological and biological ages.^{9,15} As can be observed in this study, there is a positive correlation between biological age and chronological age, i.e., in this sample, chronological age progressed in tandem with biological age.

Regarding gender differences in terms of bone maturation, the results endorse other studies^{6,16,19,22} which concluded that all events and stages of skeleton growth occur earlier in female than in male individuals.

In this study, most women's readiness to undergo dental implant installation or orthodontic treatment depended on the time of maturation, on their chronological age (16 years) and on complete ossification (score 4) of the radius bone, while most men were able to undergo the same

procedure only at 18 years of age. However, we must consider that some of the individuals—although being the same age—had not completed their growth. Thus, this finding should not be generalized, requiring the mandatory implementation of radiographic examination in all patients who are subjected to such treatment. Nevertheless, the method used in this study has proven an effective alternative to address routine clinical issues related to skeletal maturation.

CONCLUSION

Based on the results and the methodology employed, the authors have concluded that:

1) The method is effective in predicting the skeletal age of the patient. Furthermore, it consists of a practical, quick and accessible method that can assist in the planning of dental implants and orthodontic treatment.

2) There are individual differences for each group, indicating that each individual—regardless of their chronological age—may have a different biological bone age.

Submitted: February 2007
Revised and accepted: August 2009

REFERENCES

1. Armond MC, Castilho JCM, Moraes LC. Estimativa do surto de crescimento puberal pela avaliação das vértebras cervicais em radiografias cefalométricas laterais. *Ortodontia*. 2001;34(1):51-60.
2. Björk A, Helm S. Prediction of the age of maximum puberal growth in body height. *Angle Orthod*. 1967 Apr;37(2):134-43.
3. Bosco VL, Silva RHH. Relação entre crescimento e erupção dentária. *RG*. 1991;39(3):189-90.
4. Carvalho PL, Ando T, Reis HSM, Pannunzio E. Considerações sobre metodologias de avaliação das idades dental e óssea, em pacientes com idades cronológicas de 3 a 14 anos. *JBP – Rev Ibero Am Odontopediatr Odontol Bebê*. 2005;8(45/46):312-20.
5. Castriota-Scanderbeg A, Sacco MC, Emberti-Gialloreti L, Fraracci L. Skeletal age assessment in children and young adults: comparison between a newly developed sonographic method and conventional methods. *Skeletal Radiol*. 1998 May;27(5):271-7.
6. Chaves AP, Ferreira RI, Araújo TM. Maturação esquelética nas raças branca e negra. *Ortodontia Gaúcha*. 1999 jan/jul;3(1):45-52.
7. Damian MF, Woitichunas FE, Cericato GO, Cechinato F, Moro G, Massochin ME, Castoldi FL. Análise da confiabilidade e da correlação de dois índices de estimativa da maturação esquelética: índice carpal e índice vertebral. *Rev Dent Press Ortod Ortop Facial*. 2006 set/out;11(5):110-20.
8. Eklöf O, Ringertz H. A method for assessment of skeletal maturity. *Ann Radiol*. 1967;10(3-4):330-36.
9. Fishman LS. Chronological versus skeletal age, an evaluation of craniofacial Growth. *Angle Orthod*. 1979;49(3):181-89.
10. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method base on hand-wrist films. *Angle Orthod*. 1982;52(2):88-112.
11. Fishman LS. Maturation patterns and prediction during adolescence. *Angle Orthod*. 1987 Jul;57(3):178-93.
12. Flores-Mir C, Nebbe B, Major PW. Use of skeletal maturation based on hand-wrist radiographic analysis as a predictor of facial growth: a systematic review. *Angle Orthod*. 2004 Feb;74(1):118-24.
13. Francischone CE, Vasconcelos IW. Osseointegração e as próteses unitárias. 1a ed. São Paulo: Artes Médicas; 1998.
14. Franco AA, Santana AH, Santana IS, Melo MFB, Santos Júnior JH. Determinação radiográfica da maturidade esquelética e sua importância no diagnóstico e tratamento ortodôntico. *Ortodontia*. 1996;29(1):53-9.
15. Guzzi BSS, Carvalho LS. Estudo da maturação óssea em pacientes jovens de ambos os sexos através de radiografias de mão e punho. *Ortodontia*. 2000;33(3):49-57.
16. Hägg U, Taranger J. Skeletal stages of the hand and wrist as indicators of the pubertal growth spurt. *Acta Odontol Scand*. 1980;38(3):187-200.
17. Hägg U, Taranger J. Maturation indicators and the pubertal growth spurt. *Am J Orthod*. 1982 Oct;82(4):299-309.
18. Hamui T, Prata C. Estudo do crescimento maxilar e mandibular na fase de aceleração do surto de crescimento puberal. *Rev Dent Press Ortod Ortop Facial*. 2001 jul/ago;6(4):19-31, 2001.
19. Hilgenberg S, Pinto SCS, Pinheiro JC, Jimenez EEO, Coelho U. Comparação entre as idades óssea, dentária e cronológica por meio de método radiográfico simplificado. *Rev Odonto*. 2008 jul/dez;16(32):31-8.
20. Lejarraga H, Guimarey L, Orazi V. Skeletal maturity of the hand and wrist of healthy Argentinian children aged 4-12 years, assessed by the TW II. *Ann Hum Biol*. 1997;24(3):257-61.
21. Martins EG, Simone JL, Reis RRB. Estudo comparativo de dois métodos de avaliação da maturação esquelética utilizando radiografias carpais e telerradiografias em norma lateral. *RG*. 2006;54(4):322-27.
22. Moraes MEL, Medici Filho EM, Moraes LC. Surto de crescimento puberal. Relação entre mineralização dentária, idade cronológica, idade dentária e idade óssea – método radiográfico. *Rev Odontol UNESP*. 1998;27(1):111-29.
23. Moraes, MEL, Morosolli ARC, Moraes LC, Castilho JCM. Comparação dos métodos de Martins & Sakima e de Fishman para avaliação do surto de crescimento puberal. *J Bras Ortodon Ortop Facial*. 2005;10(57):255-62.
24. Prata THC, Moraes Filho E, Moraes LC, Moraes MEL. Estudo do crescimento maxilar e mandibular na fase de aceleração do surto de crescimento puberal. *Rev Dent Press Ortod Ortop Facial*. 2001;6(4):19-31.
25. Santos SCBN, Almeida RR. Estudo comparativo de dois métodos de avaliação da idade esquelética utilizando telerradiografias em norma lateral e radiografias carpais. *Ortodontia*. 1999;3(2):33-45.
26. Schusterchitz T, Haite NF. Estudo comparativo entre a maturação óssea das vértebras cervicais e a região carpal. *Ortodontia*. 2002;35(3):33-41.
27. Silva Filho OG, Sampaio LL, Freitas JAS. Avaliação de um método simplificado para estimar a maturação esquelética. *Ortodontia*. 1992;25(1):21-36.
28. Vieira CL, Oliveira AEF, Ribeiro CCC, Lima AASJ. Relação entre os índices de maturação das vértebras cervicais e os estágios de calcificação dentária. *Rev Dent Press Ortod Ortop Facial*. 2009 mar/abr;14(2):45-53.

Contact address

Yasmine Bitencourt Emilio Mendes
Rua Jaime Rosas, 180 – Jardim Carvalho
CEP: 84.015-600 – Ponta Grossa / PR
E-mail: yasminemendes@hotmail.com

The influence of the methodological variables on the shear bond strength

Marcel Marchiori Farret*, Tatiana Siqueira Gonçalves**, Eduardo Martinelli S. de Lima***, Luciane Macedo de Menezes****, Hugo Matsuo S. Oshima*****, Renata Kochenborger*****, Maria Perpétua Mota Freitas*****

Abstract

Objectives: Evaluate the influence of several methodological variables on the shear bond strength of *in vitro* studies. **Methods:** 105 bovine incisors were sectioned at the cervical level. The coronary portion was included in PVC rings, fulfilled with auto polymerized acrylic resin, with its labial surfaces positioned upward. All the samples were prepared for bonding, cleaned and acid etched on the central area of the crowns. In this area, central incisors' Morelli™ brackets were bonded with Concise™ (3M/Unitek). Three testing groups were established, according to the studied variable: Group 1—storage previous to bonding (a- thymol 0.1%; b- distilled water; c- freezing); Group 2—crosshead speed of the universal testing machine (a- 0.5 mm/min; b- 1.0 mm/min; c- 2.00 mm/min) and Group 3—commercial brand of 37% phosphoric acid (a- 3M/Unitek; b- Acid Gel; c- Attack Tek). The shear bond strength test was performed at the Emic DL2000™ universal testing machine. Data was analyzed through the Student's t test for independent samples. **Results:** In Group 1, the freezing group showed the higher values of shear bond strength when compared to the others, although no statistical difference was observed ($p > 0.05$). For Group 2, the higher the crosshead speed, the lower the shear bond strength, with no statistical difference. In Group 3, the 3M/Unitek brand showed the highest average of shear bond strength in MPa, but also no statistical difference was shown. **Conclusions:** The variable analyzed in this research had not presented enough influence to determine significant differences between the results.

Keywords: Methodological variables. Investigation protocol. Bracket bonding. Shear bond strength.

* DDs, MsD and PhD student in Orthodontics - PUCRS.
** DDs, MsD, PhD student in Orthodontics and Professor - PUCRS.
*** DDs, MsD and PhD in Orthodontics - UFRJ and Professor - PUCRS.
**** DDs, MsD and PhD in Dental Materials - FOP/Unicamp and Professor - PUCRS.
***** DDs - PUCRS and Orthodontist - UPF.
***** DDs, MsD in Orthodontics and PhD in Dental materials - PUCRS.

INTRODUCTION

In the last decades, significant changes signed the new directions in the use of orthodontic materials. Among them, might be highlighted the substitution of bands cemented in all teeth by direct bonding in the enamel. Since then, a great variety of materials have been proposed and a significant amount of scientific researches have been done with the intent of improving the bond strength between orthodontic accessories and dental surface, providing a high bond strength during the orthodontic treatment.

In vitro tests represents a reference to discovery, selection and use of dental materials. In Orthodontics the most common test used to determine the bonding systems efficiency is the shear bond strength test. However, the great variability of the results suggests a deficiency in the standardization of the technique, disturbing the correct interpretation of the results and comparisons with another studies as well. Among the variables able to influence the results, there is the storage solution of the teeth before bonding, the time and the type of the surface acid conditioning, the type of the brackets, the crosshead speed of the testing machine and the duration of the storage after bonding.^{3,8}

Fox, McCabe e Buckley⁸ reviewed 66 manuscripts which evaluated the shear bond strength of orthodontic devices bonded on tooth surface. The authors revealed that there was no consensus about the methodology, showing the necessity of standardization. Therefore, they proposed a protocol to future researches in this area: use surfaces of premolars extracted by orthodontic reasons; use teeth after one month and until six months after extraction, stored in distilled water; after bonding the specimens should be stored at 37°C during 24 h; the debonding should be performed in Instron machines or similars, with a crosshead speed of 0.1 mm/min; ensure the load of debonding in the same direction;

use at least 20 and preferably 30 specimens for each test; to evaluate the adhesive failure in the results; to include in the statistical analysis a prediction related with the clinical performance of the material; to quantify the shear bond strength in Newtons or MegaPascals.

Cal Neto and Miguel³ reviewed the methodologies used for authors of 127 published manuscripts in two international orthodontic journals (American Journal of Orthodontics and Dentofacial Orthopedics e The Angle Orthodontist)—the Table 1 shows the results of the analyses of the manuscripts which used *in vitro* shear bond strength tests.

Storage solution of teeth

Among the storage solutions of bovine and human teeth may we mention: the distilled water, which is the most commonly used; the 0.1% thymol solution—which might both disinfect and conserve the specimens—; 0.5% chloramines solution; physiologic solution; freeze-dry and freeze-wet with immersion on physiologic solution.

Wang and Sheen¹⁹ selected 20 premolars extracted for orthodontic reasons and stored them into water or physiologic solution, to evaluate

TABLE 1 - Variables analyzed by Cal Neto e Miguel.³

VARIABLE	PERCENTAGE OF THE MANUSCRIPTS		
substrate for bonding	human teeth (68%)	bovine teeth (19%)	-
storage solution	distilled water (43%)	thymol 0.1% (28%)	not mentioned (15%)
type of bracket	metallic (80%)	ceramic (8%)	plastic (1.5%)
crosshead speed	5.0 mm/min. (36%)	1.0 mm/min. (35%)	0.5 mm/min. (20%)
adhesive remnant index	ARI (40%)	modified ARI (22%)	another method (22%)

the effects over the shear bond strength with the enamel treatment by fluoride previous bonding. In the same way, Chaconas et al⁴—with the intent of evaluate the bonding of the ceramic brackets on the surface of 140 human third molars—stored the teeth into 0.9% physiologic solution.

Others authors as Sargison, McCabe and Millett,¹⁵ to evaluate the union strength of resins on enamel, immersed human premolars into formalin and, thereafter, kept those teeth immersed on distilled water on refrigerator. Lindemuth and Hagge⁹, with the same aim, used 50 human premolars with storage in water at ambient temperature. Romano et al¹⁴ used 30 teeth which after extraction were stored on plastic recipient with 0.9% physiologic solution being after stored on refrigerator at 4°C.

Feldens et al⁶ aimed to evaluate the shear bond strength of brackets bonded on bovine enamel with Fuji Ortho-LC after blood and saliva contamination and stored teeth in 0.5% thymol solution.

Crosshead speed in testing machine

In the laboratory investigations (*in vitro*) which proposes to evaluate the strength union of orthodontic devices on teeth surfaces the use of universal testing machine or similar is indispensable either for shear or tensile tests.⁸ Among the adjustments that the machine has, there is the crosshead speed during the test, giving to the operator a large amount of options. However, although it is not a well-discussed issue, the standardization of the crosshead speed is very important to comparison between different studies and has been verified great variations in the literature in relation to speed selection.³

Lindemuth and Hagge⁹ evaluated the influence of the crosshead speed over the adhesion strength and failure mode of resins on enamel and dentine. The authors used crosshead speeds of 0.1, 0.5, 1.0, 5.0 and 10.0 mm/min. The results

shown that there was no statistical significant difference among groups with bonding on enamel, however, the bond strength had significant variation when bonding was made on dentine, showing the lowest values with 0.1 and 1.0 mm/min and the highest values with 1 mm/min.

Acid etching

The acid etching of the enamel surface was introduced more than half a century ago² and until nowadays it is essential to perform an efficient and effective bonding. This procedure causes the dissolution of the inorganic component of the enamel matrix, mainly in the interprismatic region, creating micro porosities on the surface, improving the superficial wetting and the penetration of the resin into the enamel. On this way, a mechanical interlock is created between adhesive and tooth.¹³

A commonly fact when the literature is analyzed is the great variation in acid etching pattern used, either for the acid concentration, time of etching or commercial brand used. In the Table 2 may be observed some of those variations on several studies.

Based on the importance of standardization of the tests and the control of the methodological variables to the reliability of the scientific researches, this study aims to evaluate the influence over the shear bond strength of brackets bonded on bovine enamel according to the following variables:

- storage solution of teeth,
- crosshead speed of the testing machine,
- acid etching.

MATERIAL AND METHODS

Selection and inclusion of the teeth

The sample was composed by 105 permanent bovine incisors, with no fractures or caries, obtained from two slaughterhouses. The teeth were extracted and divided into two groups, containing three subgroups each, and the same

TABLE 2 - Storage method, crosshead speed and acid etching used in different studies, showing a great variety in the methodologies applied.

AUTHORS	STORAGE METHOD	CROSSHEAD SPEED	ACID AND COMMERCIAL BRAND
Fox, McCabe, Buckley ⁸	distilled water	0.1 mm/min	-
Wang, Sheen ¹⁹	physiologic solution and water	-	37% phosphoric acid Concise - 3M-Unitek
Chaconas, Caputo, Niu ⁴	0.9% physiologic solution	2 mm/min	37% phosphoric acid 3M-Unitek, Ormco and MacroChem
Sargison, McCabe, Millet ¹⁵	formaline and refrigerate distilled water	10 mm/min	37% phosphoric acid unknown brand
Lindemuth, Hagge ⁹	water	0.1; 0.5; 1.0; 5.0 e 10.0 mm/min	37% Phosphoric acid - Dentsply
Romano et al ¹⁴	0.9% physiologic solution with dry freezing	0.5 mm/min	-
Feldens et al ⁶	0.5% thymol	0.5 mm/min	-
Osterle, Shellhart, Belanger ¹²	cloramine – T (refrigerate)	1 mm/min	37% phosphoric acid 3M Unitek
Flores, Sáez, Barceló ⁷	distilled water	1 mm/min	37% phosphoric acid 3M Unitek and GC (Fuji Ortho)
Surmont et al ¹⁸	0.01% thymol (refrigerate)	0.5 mm/min	37% phosphoric acid 3M Unitek, Lee, AMC, "A"-Co and Kuraray
Meehan, Foley, Mamandras ¹⁰	distilled water	0.5 mm/min	37% phosphoric acid and 10% poly-acrylic acid - 3M-Unitek and GC
Bishara et al ¹	0.1% thymol	0.5 mm/min	37% phosphoric acid and 10% poly-acrylic acid - 3M-Unitek and GC

control subgroup was part of all groups (Table 3). The teeth were segmented around the cervical third of the roots, and only the crown was used for the study. The bonding area was determined on the center of the buccal surface of the teeth. After the crowns were separated from the roots, retentions on the proximal surfaces were created and then each teeth was positioned with its buccal surface over a glass plate to assure that the largest plain enamel surface for bonding was parallel to the ground, and in this position the crown was stabilized with wax and then mounted in self-cured acrylic resin in plastic cylinders of 20 mm X 20 mm. A bubble level was used to assure that the lateral walls of the plastic cylinder were perpendicular to the buccal surface of the teeth (Fig 1), allowing a

standardization on the positioning of the metallic matrix during the test.

The teeth from Group 1 were stored in three different storage solution before bonding, in order to evaluate the effects of the storage on the shear bond strength. The teeth from Group 2 were stored in a 0.1% thymol solution before bonding, and for the shear bond strength test three different velocities of the cell charge were used. The teeth from group 3 were also stored in 0.1% thymol solution and three different commercial brands of 37% phosphoric acid were used for acid etching (Table 3).

Sample preparation

The specimens were cleaned with Vaporetto™ to remove the excess of wax from the inclusion

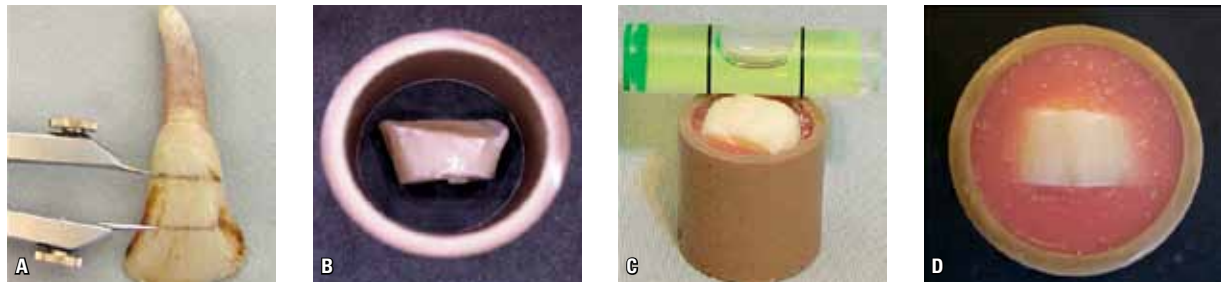


FIGURE 1 - Delimitation of the crown to segmentation (A); Plastic cylinder and crown positioned over the glass plate (B); Analysis of the parallelism between ground, crown and plastic cylinder (C); Specimen ready for bracket bonding (D). Source: Sória et al.¹⁷

process. After the specimens were washed, they were prepared for the bonding procedures as follows:

- Prophylaxis: with rubber cup (changed every each 5 specimens), in a low rotation, using pumice paste during 10 seconds.
- Cleaning: with distilled water during 10 seconds.
- Drying: with air, during 20 seconds, at a 50 mm distance.
- Acid etching: with 37% phosphoric acid during 30 seconds.
- Cleaning: with distilled water during 10 seconds.
- Drying: with air, during 20 seconds, at a 50 mm distance.

Bracket bonding

For the bonding procedure, 105 central incisor brackets (MorelliTM) were used and, after the preparation of the sample, the bonding was done as follow (Fig 2):

- Manipulation of the bonding material (Concise - 3M/Unitek, Sumaré, SP, Brazil), according to the manufacturer's instructions.
- Displaying of the bonding material on the bracket base.
- Positioning of the bracket with a bonding nipper.
- Removal of the adhesive excess with a scaler.

TABLE 3 - Distribution of groups and subgroups.

* All of these subgroups are the same, therefore, it is present in all of the groups and was considered the control subgroup.

TOTAL OF TEETH	GROUPS (N)	(N) - SUBGROUPS
105 bovine teeth	storage method (45 teeth)	(15) - thymol 0.1%*
		(15) - distilled water
		(15) - freezing
	crosshead speed (45 teeth)	(15) - 0.5 mm/min
		(15) - 1.0 mm/min*
		(15) - 2.0 mm/min
	commercial brands of acids (45 teeth)	(15) - 3M/Unitek*
		(15) - Acid Gel
		(15) - Attack Tek

- Awaited the time for the autopolymerization of the bonding material, according to the manufacturer.

Storage after bonding

After bracket bonding, the specimens were stored in a closed recipient with 100% relative humidity at 23°C, during one hour, and then the specimens were immersed in distilled water for 24 hours at 37°C.

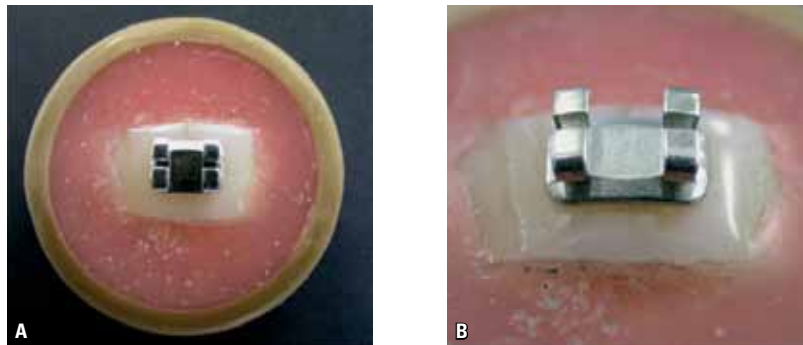


FIGURE 2 - Features of the brackets bonded on the central region of the crown. Superior view (A) and approximated inferior view (B). Source: Archives of PUCRS.

Mechanical essay – Shear bond strength

A chisel-edge plunger was mounted in the movable crosshead, with a 2 mm thick contact area with the bracket. The matrix was positioned on the universal testing machine (Emic DL2000, São José dos Pinhais, PR, Brazil), connected to a computer with the Mtest software, which registers the maximum load at failure in MegaPascal (MPa).

The control subgroup determined in this investigation was: storage in 0.1% thymol solution, acid etching with 37% phosphoric acid from 3M /Unitek and cell charge of 1.0 mm/min, which are more commonly used in the literature nowadays.

Statistics

Data was statistically analyzed using SPSS™ - Statistical Package for Social Sciences 10.0. To compare the groups, student's t test for independent samples was used. Statistical significance was considered for values of $p < 0.05$ (95% confidence interval).

RESULTS

The results obtained through the Student t test showed that there was no statistical significant difference between the means of experimental groups and between experimental groups and control group, in all of variables analyzed (Tables 4, 5 and 6).

DISCUSSION

An ideal sample to be used in shear bond strength tests on enamel must be composed by human central incisors¹². However, due to the difficulty to obtain those teeth, a great number of researchers began to use premolars extracted due to orthodontic reasons. Nevertheless, premolars have a large variation in curvature of the buccal surface which adds one more variable in bracket/enamel interface¹². Some authors argue that the bovine incisors are easily obtained and have a large flat area at the buccal surface; moreover, there is micro structural similarity between human and bovine enamel and, therefore, the bovine teeth have been recommended as a substitute to human tooth in bonding researches.^{3,6,11,14}

Laboratory studies are normally performed with the intent of evaluating new techniques or materials, allowing the clinical use thereafter. Beyond the analysis of the results of the studies, there is also the possibility of comparing the results with others studies already performed. However, the absence of well defined protocols to *in vitro* studies allow the application of different methodologies disturbing the comparison between researches and reducing the scientific value of some studies, preventing the results to be extrapolated to orthodontic clinic.^{3,5,8}

The storage process of teeth and specimens

previously to orthodontic device's bonding could eventually change the characteristics of the enamel surface and, furthermore, could lead to different results in shear tests.^{3,5,8} However, the results of the Group 1 (Table 4) shown that the storage solution of teeth did not significantly influenced the union strength. Those results allow to the investigators to choose the storage solution, without great concern about the difference in results.

Due to the viscoelastic pattern of the bonding materials either the union strength or the adhesive failure mode in the debonding can be changed with the crosshead speed variation.^{3,8} With lower velocity, for instance, the adhesive might show great deformations, the load might be dissipated and, consequently, the adhesive could support greater load. On this basis, there is a tendency to obtain low values of enamel bond strength when is adopted a high crosshead speed.⁹ However, the results of the Group 2 (Table 5) demonstrated that there was no statistically significant differences among the subgroups with different load cell speeds. It might be observed that there was a tendency of reduction in bond strength with the increment in the speed of the testing machine, which suggest that if high values of speed were applied—as 5 or 10 mm/min—possibly would result in mean values with statistical difference between them.

The acid etching with 37% phosphoric acid is essential previously to orthodontic devices' bonding with resin, to obtain more microporosities and mechanical retention between adhesive and tooth surface.^{2,13} Nowadays, there are commercial brands of acids with different compositions which can lead to different etching pattern of enamel. In this study were analyzed the brands 3M/Unitek, AcidGel and Attack Tek. The subgroup 3M/Unitek showed the high shear bond strength among the three subgroups, possibly showing a greater surface conditioning of the surface, however, without

statistical difference in relation of others subgroups (Table 6).

The variables studied in this study obviously are not alone during the *in vitro* tests, therefore, this data does not discard the possibility of the

TABLE 4 - Means, standard deviations, and Student t test for comparison of experimental subgroups between them and with the control subgroup, in the Group 1 (storage solution).

GROUP	N	MEAN (MPA)	STANDARD-DEVIATION	P
control subgroup (thymol)	15	11.50	6.07	0.85
distilled water	15	11.13	4.70	
control subgroup (thymol)	15	11.50	6.07	0.28
freezing	15	13.51	3.75	
distilled water	15	11.13	4.70	0.14
freezing	15	13.51	3.75	

TABLE 5 - Means, standard deviations, and Student t test for comparison of experimental subgroups between them and with control subgroup, in the Group 1 (crosshead speed).

GROUP	N	MEAN (MPA)	STANDARD-DEVIATION	P
control subgroup (1 mm/min)	15	11.50	6.07	0.69
2 mm/min	15	10.69	4.94	
control subgroup (1 mm/min)	15	11.50	6.07	0.68
0.5 mm/min	15	12.31	4.39	
2 mm/min	15	10.69	4.94	0.35
0.5 mm/min	15	12.31	4.39	

TABLE 6 - Means, standard deviations, and Student t test for comparison of experimental subgroups between them and with control subgroup, in the Group 1 (acids).

GROUP	N	MEAN (MPA)	STANDARD-DEVIATION	P
control subgroup (3M/Unitek)	15	11.50	6.07	0.36
attack Tek	15	9.64	4.77	
control subgroup (3M/Unitek)	15	11.50	6.07	0.43
acid gel	15	9.91	4.63	
Attack Tek	15	9.64	4.77	0.87
acid gel	15	9.91	4.63	

inappropriate standardization influence over the final results of researches, so will be necessary another analyses to complete this understanding. Moreover, it is important to highlight that in this study the variables were analyzed independently, inside each group. However, if the groups were compared among themselves involving more than one variable, could be found different results even with statistical significant difference.

CONCLUSION

Based on the results the following conclusions can be draw:

- The storage solution of teeth previously to inclusion and bonding did not influence significantly the shear bond strength.

- There was a tendency of reduction of the shear bond strength with the increase in the crosshead speed, however, without statistical difference among the groups.

- The different commercial brands of acids also did not show statistical significance influence over the shear bond strength.

Submitted: May 2007
Revised and accepted: June 2008

REFERENCES

1. Bishara SE, Olsen ME, Damon P, Jakobsen JR. Evaluation of a new light-cured orthodontic bonding adhesive. *Am J Orthod Dentofacial Orthop.* 1998 Jul;114(1):80-7.
2. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. *J Dent Res.* 1955 Dec;34(6):849-53.
3. Cal Neto JOAP, Miguel JAM. Uma análise dos testes in vitro de força de adesão em Ortodontia. *Rev Dental Press Ortod Ortop Facial.* 2004 jul/ago;9(4):44-51.
4. Chaconas SJ, Caputo AA, Niu GS. Bond strength of ceramic brackets with various bonding systems. *Angle Orthod.* 1991 Spring;61(1):35-42.
5. Eliades T, Brantley WA. The inappropriateness of conventional orthodontic bond strength assessment protocols. *Eur J Orthod.* 2000 Feb;22(1):13-23.
6. Feldens JÁ, Freitas MPM, Lima SEM, Oshima HMS. Resistência ao cisalhamento de "brackets" colados em esmalte bovino contaminado por sangue ou saliva. *Rev Odonto Ciênc.* 2004 abr/maio;19(44):192-96.
7. Flores AR, Sáez EG, Barceló F. Metallic bracket to enamel bonding of photopolymerizable resin-reinforced glass ionomer. *Am J Orthod Dentofacial Orthop.* 1999 Nov;116(5):514-7.
8. Fox NA, McCabe JF, Buckley JG. A critique of bond strength testing in Orthodontics. *Br J Orthod.* 1994 Feb;21(1):33-43.
9. Lindemuth JS, Hagge MS. Effect of universal testing machine crosshead speed on the shear bond strength and bonding failure mode of composite resin to enamel and dentin. *Mil Med.* 2000 Oct;165(10):742-6.
10. Meehan MP, Foley TF, Mamandras AH. A Comparison of the shear bond strengths of two glass ionomer cements. *Am J Orthod Dentofacial Orthop.* 1999 Feb;115(2):125-32.
11. Nakamichi I, Iwaku M, Fusayama T. Bovine teeth as possible substitute in the adhesion test. *J Dent Res.* 1983 Oct;62(10):1076-81.
12. Oesterle LJ, Shellhart WC, Belanger GK. The use of bovine enamel in bonding studies. *Am J Orthod Dentofacial Orthop.* 1998 Nov;114(5):514-9.
13. Owens SE Jr, Miller BH. A comparison of shear bond strengths of three visible light-cured orthodontic adhesives. *Angle Orthod.* 2000 Oct;70(5):352-6.
14. Romano FL, Tavares SW, Ramalli EL, Magnani MBBA, Nouer DF. Análise in vitro da resistência ao cisalhamento de bráquetes metálicos colados em incisivos bovinos e humanos. *Rev Dental Press Ortod Ortop Facial.* 2004 nov/dez;9(6):63-9.
15. Sargison AE, McCabe JF, Millett DT. A laboratory investigation to compare enamel preparation by sandblasting or acid etching prior to bracket bonding. *Br J Orthod.* 1999 Jun;26(2):141-6.
16. Silverman E, Cohen M. Etching versus nonetching. *Am J Orthod Dentofacial Orthop.* 1998 Jul;114(1):80-7.
17. Sória ML, Menezes LM, Oshima HMS, Rizzatto SMD. Resistência de união de braquetes ao esmalte bovino: avaliação de três cimentos de ionômero de vidro. *Rev Dental Press Ortod Ortop Facial.* 2003 nov/dez;8(6):89-98.
18. Surmont P, Dermaut L, Martens L, Moors M. Comparison in shear bond strength of orthodontic brackets between five bonding systems related to different etching times: an in vitro study. *Am J Orthod Dentofacial Orthop.* 1992 May;101(5):414-9.
19. Wang WN, Sheen DH. The effect of pretreatment with fluoride on the tensile strength of orthodontic bonding. *Angle Orthod.* 1991 Spring;61(1):31-4.

Contact address

Marcel Marchiori Farret
Rua Floriano Peixoto 1000/113
CEP: 97.015-370 – Santa Maria / RS
E-mail: marcelfarret@yahoo.com.br

Comparison of the occlusal outcomes and treatment time of Class II malocclusion with the Pendulum appliance and with two maxillary premolar extractions

Célia Regina Maio Pinzan-Vercelino*, Arnaldo Pinzan**, Guilherme Janson***, Renato Rodrigues de Almeida**, José Fernando Castanha Henriques***, Marcos Roberto de Freitas***

Abstract

Objectives: The purpose of this study was to compare the occlusal outcomes and the treatment time of Class II malocclusion with the Pendulum appliance and with two maxillary premolar extractions. **Methods:** For this, 48 Class II malocclusion patients were selected and divided into two groups according to the treatment protocol: group 1 consisted of dental study casts and initial cephalograms of 22 patients treated with the Pendulum appliance, with an initial mean age of 14.44 years and group 2, comprised of dental study casts and initial cephalograms of 26 patients treated with two maxillary premolar extractions and a initial mean age of 13.66 years. The occlusal outcomes were evaluated on dental casts with the PAR occlusal index and the treatment time of each group was calculated by the clinical records. The variables were compared by the t tests. **Results and conclusions:** The results demonstrated that the occlusal outcomes were similar between the groups, however, the two maxillary premolar extractions protocol provided occlusal outcomes in a shorter treatment time than the Pendulum treatment.

Keywords: Class II. Pendulum. Extractions. Distalization.

* Orthodontic graduate student. Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil. Assistant professor. Centro Universitário do Maranhão - UNICEUMA, São Luís - MA, Brazil.

** Associate Professors. Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil.

*** Professors. Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil.

INTRODUCTION

The Class II malocclusion is considered as the most frequent treatment problem in the orthodontic practice.^{6,27} It occurs because of the aesthetic and functional imbalance related to this malocclusion. So the various treatment protocols described in the literature for the Class II malocclusion correction cause an interest in the orthodontic community.

The orthodontic treatment plan decision of Class II malocclusion depends on the characteristics associated with the malocclusion (anteroposterior, transversal and vertical discrepancies), age, patient compliance, psychological implications, stability, financial conditions, treatment time and treatment efficiency degree.^{3,22,23}

Orthodontists, patients and patients' parents are worried about the clinical effectiveness of the orthodontic procedures. They want to obtain the best results in the least amount of time.³ So, when more than one treatment protocol is indicated to treat the same malocclusion, the clinician should also consider the treatment efficiency.³

Treatment of dental Class II malocclusion, without significant skeletal involvement, reduced potential of craniofacial growth and without crowding or cephalometric discrepancy in the mandibular arch, can be performed with maxillary molar distalization or with maxillary premolar extractions.^{14,16}

Among the appliances available to molar distalization, is the Pendulum appliance that was proposed by Hilgers,¹⁶ in 1992. This device was developed to treat the Class II malocclusion non-compliance patients. Studies^{7,8,13} demonstrated the effectiveness of the Pendulum appliance to molar distalization, but with some undesirable effects as distal tipping of the molars, anchorage loss, expressed as mesial movement and tipping of the canines and the premolars, proclination of the incisors and

increase at the lower anterior facial height. According to the authors, this undesirable effects are corrected during the orthodontic fixed appliance that follows molar distalization.^{7,8,13} However, after the distalization phase is indicated the use of the headgear to correct the molar distal tipping and to maintain the molar relationship corrected during the anterior teeth retraction since these teeth are used as anchor units.¹³

The protocol that involves the maxillary premolar extractions to treat the Class II malocclusion has been widely discussed in literature. To indicate the maxillary premolar extractions, the clinician must evaluate the Class II severity, craniofacial growth pattern, age, patient compliance and the facial profile between other factors.⁴ The decision to extract or to not extract may influence the occlusal and facial results, the parents and patients' satisfaction and the treatment duration.^{25,28}

Studies have demonstrated that this protocol produces a better occlusal result than the four premolar extractions protocol¹⁷ and also than the nonextraction protocol.³ Besides, recent studies demonstrated that the treatment time was smaller for the groups initially planned with extractions of two upper premolar.^{3,21}

Evaluating these two protocols to treat the dental Class II, the following considerations were elaborated:

- using the Pendulum appliance, a "space" similar of that obtained with the premolar extraction is created, and this space need to be closed with adequate patient compliance to correct the molar tipping and to retract the anterior teeth without significant anchorage loss. In patients with limited compliance, can this treatment protocol result in a longer treatment time and/or an occlusal unsatisfactory result?
- the protocol that involves the maxillary premolar extractions spend a longer treatment time?

To investigate these considerations, the aim of this study was to compare the occlusal results and the treatment time of the Class II malocclusion treatment with the Pendulum appliance and with two maxillary premolar extractions.

MATERIAL AND METHODS

Material

The sample was retrospectively selected from the files of the orthodontic department at Bauru Dental School in Brazil. The criteria for patient selection included the following: Class II malocclusion, treated with the Pendulum appliance or with maxillary premolar extractions;

treatment finished with fixed edgewise appliances (standard or pre-adjusted—Roth prescription), presence of all permanent teeth up to the first molars and no dental anomalies of number, size and form.

The sample was consisted of the dental study models and the lateral radiographs of 48 patients, divided into two groups, according to the treatment protocol (Table 1).

TABLE 1 - Initial characteristics of the groups.

	GROUP 1 (N = 22) (PENDULUM)	GROUP 2 (N = 26) (EXTRACTIONS)
INITIAL AGE		
Mean	14.44	13.66
Standard deviation	1.85	0.91
Minimum age	11.6	12
Maximum age	17.65	15.08
GENDER DISTRIBUTION		
Male	7	15
Female	15	12
ANTEROPOSTERIOR DISCREPANCY		
Complete Class II	6	26
$\frac{3}{4}$ of Class II	6	0
$\frac{1}{2}$ Class II	6	0
$\frac{1}{4}$ Class II	4	0
TYPES OF CLASS II MALOCCLUSION		
Class II division 1	19	22
Class II division 2	3	4



FIGURE 1 - Pendulum appliance (A – treatment onset; B – after molar distalization).

Orthodontic treatment

Group 1

This group belongs to a sample that was prospectively treated by only two orthodontists. The pendulum appliance was used to correct the Class II malocclusion, with the release of a force of 230-250 g per side, during the average time of 5.85 months (SD = 1.82). The appliance was left in place until an overcorrected Class I molar relationship was achieved. After removal of the Pendulum appliance, a Nance button was used to retain the distalized first molars. Anchorage reinforcement was achieved with a cervical headgear exerting 400-500 g of force per side, with an average wear time of 10-12 hours per day.

After 30 days, pre-adjusted edgewise orthodontic appliance was placed to initiate leveling and alignment. During use of the 0.019 x 0.025-in rectangular arch, sequential retraction of the second premolars followed by the first premolars was initiated with elastic chains and with the aid of cervical headgear worn at night. After retraction of the first premolars, the Nance button was removed for retraction of the anterior teeth. At this stage, besides the cervical headgear, Class II elastics were also used for anchorage reinforcement and to reduce the increased overjet produced by the side effects of the appliance. After retraction of the maxillary anterior teeth, ideal archwires were inserted for the finishing procedures. After removal of the fixed orthodontic appliance, conventional Hawley and 3 x 3 retainers were placed.

Group 2

The group 2 comprised 26 patients treated with two maxillary premolar extractions. All patients were planned with two maxillary premolar extractions at treatment onset (Fig 2).

Orthodontic mechanics included fixed edgewise appliance, with 0.022 x 0.028-in.



FIGURE 2 - Treatment with two maxillary premolar extractions.

The extraoral headgear was used to reinforce anchorage. The orthodontic mechanics followed the conventional sequence: leveling and aligning (usual wire sequence characterized by the use of nitinol alloy wire initially, followed by round stainless steel wires until the 0.019 x 0.025-in), anterior retraction, intercuspation and finishing procedures. Class II elastics were also used to help in maintaining Class II molar relationship. After removal of the fixed orthodontic appliance, conventional Hawley and 3 x 3 retainers were placed.

METHODS

Records

The patients' records were used to determine the initial age, gender, date of treatment onset, date of treatment completion and total treatment time (TT). Also they were used to check the treatment protocols and to confirm that there were no delayed extractions in the groups.

Occlusal results

The PAR²⁴ (Peer Assessment Rating index) index was calculated on the pre (IPAR)

and posttreatment (FPAR) dental study models of each patient, according to the American weightings suggested by De Guzman et al.¹¹

This index was selected due to the proven validity that possesses in quantitatively express a certain occlusal condition, for its reliability and reproducibility of the results, for being elaborated and thoroughly used with the purpose of evaluating the results of the orthodontic treatment and for being objective and easily applicable^{3,11,24}.

Cephalometric evaluation

The lateral cephalograms were traced on acetate paper, and the cephalometric tracings and landmark identifications were performed by a single investigator and then digitized with a Numonics AccuGrid XNT, model A30TL.F digitizer (Numonics Corporation, Montgomeryville, PA). These data were stored on a computer and analyzed with Dentofacial Planner 7.02 (Dentofacial Planner Software, Toronto, Ontario, Canada), which corrected the image magnification factors of the groups, that were 6%, 7.4% and 9.8%, depending on which X-ray machine they had been taken.

Error study

Twenty pairs of dental study models and fifteen randomly selected radiographs were re-measured by the same rater. The casual error was calculated according to Dahlberg's formula ($Se^2 = \Sigma d^2 / 2n$, where Se^2 is the error variance and d is the difference between the 2 determinations of the same variable) and the systematic error with dependent t tests, for $p < 0.05$.

Statistical analysis

Means and standard deviations for each variable were calculated to enable characterization of both groups.

Compatibility of the groups regarding the gender distribution, proportions of Class II

Divisions 1 and 2 malocclusions and the anteroposterior severity of Class II malocclusions were evaluated with chi-square tests.

Independent t test was used to evaluate the compatibility between the initial cephalometric characteristics, the initial age and the occlusal characteristics of the groups at the initial treatment stage (IPAR).

T test was also used to compare the groups regarding occlusal outcomes (FPAR) and treatment time (TT).

Results were considered to be statistically significant for $p < 0.05$.

These analyses were performed with Statistica software (Statistica for Windows version 6.0, Statsoft, Tulsa, Okla, USA).

RESULTS

No statistically significant systematic errors were detected in the occlusal evaluation and the casual errors were within acceptable levels (Dahlberg: 0.52 and p : 0.13). In the cephalometric evaluation, only two statistically significant systematic errors were detected: overbite, $p = 0.025$ and LS-E, $p = 0.045$. The range of casual errors varied from 0.29 to 3.94, with 25 variables below 1 degree or millimeter, 4 below 2 degrees or millimeters and only one variable above this level.

The groups were compatible regarding the gender distribution, the types of Class II malocclusion, the maxillary component, the maxillomandibular relationships, the vertical components, the mandibular dentoalveolar component, the skeletal and soft tissue profile and the initial age (Tables 2, 3 and 4).

The group 2 had greater Class II anteroposterior discrepancy, a more retruded mandible, greater maxillary incisors proclination and protrusion, overjet, molar Class II relationship and malocclusion severity than the group 1 (Tables 2, 3 and 4).

There was no difference between the groups

TABLE 2 - Results of independent t test to evaluate the initial cephalometric compatibility between the groups.

MEASUREMENTS	GROUP 1 (N = 22) (PENDULUM)		GROUP 2 (N = 26) (EXTRACTIONS)		P
	Mean	SD	Mean	SD	
MAXILLARY COMPONENT					
SNA (°)	82.75	3.16	81.17	3.72	0.1254
Co-A (mm)	85.99	5.21	85.92	6.63	0.9691
A-Nperp (mm)	1.31	3.03	-0.63	4.00	0.0680
MANDIBULAR COMPONENT					
SNB (°)	78.08	2.76	76.94	2.61	0.1493
Co-Gn (mm)	108.34	5.21	108.39	6.60	0.9786
Pog-Nperp (mm)	-3.53	4.76	-6.86	6.10	0.0431
MAXILLOMANDIBULAR RELATIONSHIP					
ANB (°)	4.68	1.60	4.23	2.56	0.4778
WITS (mm)	3.39	2.31	4.70	2.20	0.0505
Co-A/Co-Gn (mm)	79.36	2.39	79.28	3.98	0.9287
VERTICAL COMPONENTS					
FMA	24.71	5.41	26.53	4.91	0.2296
SN.GoGn	31.32	6.04	32.57	4.82	0.4284
SN.PP	6.41	3.80	4.94	2.88	0.1343
LAFH	63.61	4.71	64.79	5.40	0.4292
MAXILLARY DENTOALVEOLAR COMPONENT					
U1.PP (°)	108.98	6.44	114.10	8.57	0.0258
U1.NA (°)	19.83	7.79	27.97	9.68	0.0027
U1-NA (mm)	3.44	2.43	7.21	4.10	0.0004
MANDIBULAR DENTOALVEOLAR COMPONENT					
IMPA (°)	94.71	4.72	93.58	5.89	0.4719
L1.NB (°)	26.16	5.22	25.15	6.29	0.5543
L1-NB (mm)	4.93	2.38	4.91	2.43	0.9813
DENTOALVEOLAR RELATIONSHIPS					
overjet (mm)	4.45	1.20	7.62	2.62	0.0000
overbite (mm)	4.88	1.85	4.11	2.74	0.2668
molar relationship (mm)	0.93	0.85	3.80	0.73	0.0000
SKELETAL AND SOFT TISSUE PROFILE					
NAPog (°)	7.04	3.81	6.12	6.46	0.5595
Nasolabial angle (°)	103	13.94	111.51	16.75	0.0647
H-nose (mm)	2.86	3.52	3.56	3.55	0.5046
Ls-E (mm)	18.37	1.62	18.88	2.84	0.4564
Li-E (mm)	14.68	2.16	15.91	2.58	0.0897

in relation to the occlusal results obtained with the different treatment protocols evaluated (Table 4).

The results showed a shorter treatment time to the maxillary premolars extraction group (group 2 - Table 4).

TABLE 3 - Results of chi-square test to evaluate the compatibility of gender distribution, types of Class II malocclusion and the severity of initial molar anteroposterior discrepancy between the groups.

VARIABLES	GROUP 1 (N = 22) (PENDULUM)	GROUP 2 (N = 26) (EX- TRACTIONS)	X ²	P
GENDER DISTRIBUTION				
male	7	14	2.35	0.1253
female	15	12	2.35	0.1253
TYPES OF CLASS II MALOCCLUSION				
Class II division 1	19	22	0.03	0.8642
Class II division 2	3	4	0.03	0.8642
ANTEROPOSTERIOR DISCREPANCY				
Complete Class II	6	26	28.36	0.000
¾ of Class II	6	0	28.36	0.000
½ Class II	6	0	28.36	0.000
¼ of Class II	4	0	28.36	0.000

TABLE 4 - Results of independent t tests between the groups.

VARIABLES	GROUP 1 (N = 22) (PENDULUM)		GROUP 2 (N = 26) (EXTRACTIONS)		P
	Mean	SD	Mean	SD	
Initial age	14.44	1.85	13.66	0.91	0.0626
IPAR	15.91	5.12	24.62	7.58	0.0000
FPAR	4.23	3.74	2.92	3.16	0.1968
TT (months)	45.70	12.18	23.01	6.01	0.0000
Ttrat (years)	3.81	1.01	1.92	0.50	0.0000

DISCUSSION

Methodology

In the cephalometric evaluation, two statistically significant systematic errors (overbite and LS-E) were detected, with differences smaller than 1 mm between the first and the second measurement. Three casual errors (1.PP, 1.NA and nasolabial angle) were also detected, the range of casual errors varied from 0.29 to 3.94, with 25 variables below 1 degree or millimeter, 4 below 2 degrees or millimeters and only one variable above this level. Since the most part of the errors showed a variation smaller than 1 mm and 1 degree between the measurements and considering that the systematic errors occurred in only 2 from the 27 measures (7,4%), the results observed may be considered reliable.

Probably due to the easy reproducibility of the PAR index and the calibration of the author prior to the measurements, in the occlusal evaluation, no statistically significant systematic errors were detected and the casual errors were within acceptable levels.

Compatibility of the groups

The groups initial cephalometric compatibility regarding the maxillary component, the maxillomandibular relationships, the vertical components, the mandibular dentoalveolar component, the skeletal and soft tissue profile (Table 2) reduces the critical to the not randomized studies,⁶ allowing the comparison between the groups.

The groups were similar regarding the gender distribution (Table 3), so this variable not influenced the obtained results related to some kind of sexual dimorphism as skeletal maturation, growth rate or levels of compliance. The female individuals demonstrated in several studies a more precocious maturation time, a more accelerated growth rhythm²⁹ and a greater cooperation during the treatment¹⁰.

The patients with Class II division 2 malocclusion were included in the sample because the groups were compatible regarding the types of Class II malocclusion (Table 3) and also because correction of the dentoalveolar anteroposterior discrepancy is similar in both types.¹⁸ Besides, the larger score of the PAR from a larger overjet in the Class II division 1 subjects would be compensated by the larger overbite and crowding in the Class II division 2 subjects.^{3,17} The anchorage reinforcement would also be similar because of the greater labial crown torque that should be applied to the maxillary incisors to correct their inclination and to retract them in the Class II division 2 subjects. So their inclusion should not have interfered with the results.^{3,17,18}

The groups were also similar regarding the initial age (Table 4). This is an important factor in this evaluation because the results usually have to be more favorable to younger patients. The mandibular growth helps to achieve desired sagittal relationships in the Class II correction.¹⁵ Harris; Dyer and Vaden¹⁵ demonstrated that differential mandibular growth in the Class II adolescents (mean age of 12.5 years) contributed 70% of the total molar correction, with orthodontic tooth movement accounting for the remaining 30%.

Cephalometrically, the differences between the groups at treatment onset in relation to the labially tipped and protruded maxillary incisors (Table 2) were expected, since the Pendulum appliance results in anchorage loss, with proclination of the incisors and increase in overjet,^{7,8,13} so the use of Pendulum appliance is not recommended in cases with large overjet in treatment onset.²⁷

The initial malocclusion severity was not similar among the groups (Tables 2, 3 and 4), because in the group 1 the patients were prospectively treated and no criterion related to the initial malocclusion severity was included

to select the patients. In group 2 all patients showed a complete bilateral Class II malocclusion at treatment onset. The patients of this group already were evaluated in others studies^{3,17} elaborated at Orthodontic Department at Bauru Dental School in Brazil. This way, the groups were not compatible as to the initial malocclusion severity, demonstrated by the cephalometric measurements horizontal overjet and molar relationship, and for the initial values of the PAR index (Tables 2, 3 and 4).

Occlusal results

The final occlusal status was similar between the groups (Table 4). In accordance with Richmond et al,²⁴ when the final PAR value is 5 or less, suggests an almost ideal occlusion. In the two groups, the final PAR were less than 5 (Pendulum: 4.23 and maxillary premolar extractions: 2.92), so to both protocols the cases could be considered well finished.

Treatment time

Treatment time of the Pendulum followed by fixed appliances was longer than to the maxillary premolar extractions (Table 4). The treatment time to group 1 was 45.7 months (3.81 years) while to the group 2 was 23.01 months (1.92 years).

One of the undesirable effects of Pendulum appliance treatment is distal tipping of the molars. Bussick and McNamara⁷ report a molar distal tipping of 10.6°, Ghosh and Nanda¹³ of 8.4°, Byloff and Darendeliler⁸ of 14.5° and Burkhardt; McNamara and Baccetti⁶ of 10°. Incorporating an uprighting bent into the distalizing springs, Byloff et al⁹ reduced molar distal tipping to 6.1°, but the distalization treatment time increased 64.1%.

The molar distal tipping may cause the molar correction relapse, due to the impossibility of the correct force distribution. In addition, anchorage loss of maxillary molars in terms of mesial move-

ment may takes place, since at this stage of treatment these teeth are used as anchor units²⁷ for the subsequent anterior teeth retraction that follows molar distalization. So, in this phase of the treatment, anchorage reinforcement is essential.

In the literature, the Pendulum is considered a minimal-compliance appliance because it does not require patient compliance in wearing removable anchorage reinforcing devices during distalization of the posterior segment. However, the most part of the studies^{7,8,9,13} evaluated only the distalization results, that really do not require patient compliance. But to finish the treatment, is necessary to correct the distal molar tipping and to retract the anterior teeth maintaining the molar relationship. So the patient compliance in wearing the extra-oral headgear and the Class II elastics^{2,7} is essential to well finish the cases.

In Class II therapy with molar distalization, the need for anchorage reinforcement is even greater, because first the molar root must be distalized and after the molar relationship must be maintained to retract the anterior teeth. While in treatment of Class II malocclusions with two maxillary premolar extractions the use of anchorage reinforcement is require only in order to avoid mesial movement of the posterior segment during retraction of the anterior teeth, since the molar position correct is not required. Consequently, the need for anchorage reinforcement with Pendulum appliance therapy is twice as greater and treatment success will be even more dependent on patient compliance.

Besides the necessity of correction and maintain the molar relationship, the increase in anterior crowding, overjet and in upper incisors proclination^{7,8,13} may also had been collaborated to a longer treatment time in group 1.

The first studies published about the Pendulum appliance only described this device^{1,12} and cases reports.^{5,19} The skeletal and dentoalveolar effects exist in a relatively small number,^{2,7,8,9,13}

and the major part of them^{7,8,9,13} evaluated only the distalization phase. Only two studies^{2,6} evaluated the complete treatment, including the Pendulum followed by fixed appliances.

Treatment time of the Pendulum followed by fixed appliances was longer than the previously reported time of 31.6 months.⁶ Probably this occurred because their sample age was 12.3⁶ while in this study it was 14.44 years. It is known that Class II malocclusion correction is easier in younger patients,¹⁵ because of the mandibular growth.

In the literature, there are studies that demonstrated an increase in treatment time related with teeth extractions.^{25,26,28} However, recently studies demonstrated that the Class II treated with extractions showed a greater anteroposterior discrepancy.²⁶ So, a longer treatment time is probably related to the correction of a greater malocclusion severity^{25,26,28} and not with the teeth extractions.

Moreover, in the studies^{25,28} that associated a longer treatment time with the teeth extractions, the malocclusion types were not isolated. So, the results obtained should not be extrapolated to an isolate malocclusion type, since the treatment protocols may include variables that are peculiar to it, distorting the results.³ For example, it is expected that the correction of Class I nonextraction present a shorter treatment time than the Class II nonextraction, since, for the treatment of the Class II, it is necessary first to correct the molar relationship while in Class I it is not required.³

In this study, the group treated with extractions demonstrated a shorter treatment time when compared with the group treated with the Pendulum appliance. This result is in agreement with that obtained by Barros,³ who demonstrated that the Class II malocclusion treatment with two premolar extractions showed a better occlusal success rate, in a shorter treatment time than the nonextraction protocol.

Similar result was observed by Maria,²⁰ who demonstrated a shorter treatment time with a more predictable occlusal result treating the Class II with two premolar extractions than with four premolar extractions. Some years later, the same author,²¹ compared the treatment time of a group treated with two premolars extraction with other treated with delayed extractions and observed a shorter treatment time to the group planned with two maxillary premolar extractions at treatment onset.²¹

It could be argued that the greater initial malocclusion severity (Tables 2, 3 and 4) of group 2 could have contributed to the results obtained. Nevertheless, this is not the case because a greater malocclusion severity would tend to increase treatment difficulty and consequently treatment time, and the opposite occurred. In spite of there was no difference among the occlusal results, the group 2 showed statistically shorter treatment time than group 1 (Table 4).

The variables that influence the treatment time as missed appointments, attachment failures between others²⁵ were not considered in this study, because as well as Barros,³ it was considered that these variables have the same probability of occurrence among the groups because they representing not only the patient compliance, but also the psychosocial and behavioral characteristics of the patients.²⁵ Moreover, the evaluation of the cooperation was not the purpose of this study.

Clinical implications

The decision to extract or not to extract may influence the final occlusal result, a greater or a smaller patient compliance during the therapy and the treatment time.^{3,25,28}

Despite the knowledge and clinical experience are important, the cooperation of the patient has an important role in achieving the desired results.

Justify the treatment plan based only on the

good results obtained in published studies is not sufficient.²⁸ The treatment time also should be considered. Faced with two treatment protocols that promote satisfactory results, the treatment time may be the differential.

In Class II treatment, the treatment time and the occlusal results are related to patient compliance to achieve the correct molar relationship or to maintain the molar relationship during the anterior teeth retraction. Remaining the maxillary molars in their initial positions with the maxillary premolar extractions protocol^{17,18} facility the mechanic and dispend a smaller patient compliance, while the molar relationship correction difficult and spend a longer time to the Class II orthodontic treatment.^{17,18,25,28} Despite the necessity of patient compliance in the two protocols evaluated in this study, the cooperation should be greater in the cases treated with the Pendulum appliance, because of the undesirables effects of molar distal tipping and anterior anchorage loss. In the distalization protocol is necessary to correct the molar position and also to maintain the molar relationship during the anterior teeth retraction, while with maxillary premo-

lar extractions is only necessary to maintain the molar relationship, so less patient compliance in using extraoral appliances and/or Class II elastics was necessary to finish the cases.

Despite the Pendulum appliance had demonstrated a longer treatment time, the cases were considered well finished. So, depending of the malocclusion severity, the patient age and the resistance from parents or the patients themselves to extraction, the Pendulum appliance can be used, but it is essential that the patient and/or his parents knows that are deciding by a treatment that probably will spend a longer time to be concluded.

CONCLUSIONS

The results showed a shorter treatment time to the maxillary premolars extraction group.

There was no difference between the groups in relation to the occlusal outcomes obtained with the different treatment protocols evaluated.

Submitted: November 2005
Revised and accepted: October 2008

REFERENCES

- Almeida RR, Almeida MR, Fuziy A, Henriques JFC. Modificação do aparelho Pendulum/Pend-X. Descrição do aparelho e técnica de construção. *R Dental Press Ortodon Ortop Facial*. 1999 nov/dez;4(6):12-9.
- Angelier F, Almeida RR, Almeida MR, Fuziy A. Dentoalveolar and skeletal changes associated with the Pendulum appliance followed by fixed orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2006 Apr;129(4):520-7.
- Barros, S. E. C. Avaliação do grau de eficiência do tratamento da Classe II realizado sem extrações e com extrações de dois pré-molares superiores Bauru. [dissertação]. Bauru (SP): Universidade de São Paulo; 2004.
- 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 Apr;109(4):393-402.
- Bortolozzo MA, Capelozza Filho L, Ozawa TO, Cavassan AO. Distalização de molares superiores com o Pendulum/Pendex: o aparelho, seu modo de ação, possibilidades e limitações. *R Dental Press Ortodon Ortop Facial*. 2001 jul/ago;6(4):43-50.
- Burkhardt DR, McNamara JA Jr, Baccetti T. Maxillary molar distalization or mandibular enhancement: a cephalometric comparison of comprehensive orthodontic treatment including the pendulum and the Herbst appliances. *Am J Orthod Dentofacial Orthop*. 2003 Feb;123(2):108-16.
- Bussick T, McNamara J. Dentoalveolar and skeletal changes associated with the pendulum appliance. *Am J Orthod Dentofacial Orthop*. 2000 Mar;117(3):333-43.
- Byloff FK, Darendeliler MA. Distal molar movement using the pendulum appliance. Part 1: clinical and radiological evaluation. *Angle Orthod*. 1997;67(4):249-60.
- Byloff FK, Darendeliler MA, Clar E, Darendeliler A. Distal molar movement using the pendulum appliance. Part 2: The effects of maxillary molar root uprighting bends. *Angle Orthod*. 1997;67(4):261-70.
- Cucalon A 3rd, Smith RJ. Relationship between compliance by adolescent orthodontic patients and performance on psychological tests. *Angle Orthod*. 1990 Summer;60(2):107-14.
- DeGuzman L, Bahiraei D, Vig KW, Vig PS, Weyant RJ, O'Brien K. The validation of the Peer Assessment Rating index for malocclusion severity and treatment difficulty. *Am J Orthod Dentofacial Orthop*. 1995 Feb;107(2):172-6.
- Figueiredo CTP, Figueiredo MA, Nobuyasu M. Distalização de molares superiores com o aparelho Pendulum/Pendex. *Rev Ass Paul Cir Dent*. 1999 jan/fev;53(1):27-30.
- Ghosh J, Nanda RS. Evaluation of an intraoral maxillary molar distalization technique. *Am J Orthod Dentofacial Orthop*. 1996 Dec;110(6):639-46.
- Graber TM, Vanarsdall RL. Orthodontics: current principles and techniques. 2nd ed. St. Louis: Mosby; 1994.
- Harris EF, Dyer GS, Vaden JL. Age effects on orthodontic treatment: skeletodental assessments from Johnston analysis. *Am J Orthod Dentofacial Orthop*. 1991 Dec;100(6):531-6.
- Hilgers JJ. The Pendulum appliance for class II non-compliance therapy. *J Clin Orthod*. 1992 Nov;26(11):706-14.
- Janson G, Brambilla AC, Henriques JF, de Freitas MR, Neves LS. Class II treatment success rate in 2 and 4 premolar extraction protocols. *Am J Orthod Dentofacial Orthop*. 2004 Apr;125(4):472-9.
- Janson G, Dainesi EA, Henriques JF, de Freitas MR, de Lima KJ. Class II subdivision treatment success rate with symmetric and asymmetric extraction protocols. *Am J Orthod Dentofacial Orthop*. 2003 Sep;124(3):257-64.
- Macedo DM, Aidar LAA. Uso do Pêndulo de Hilgers: apresentação de um caso clínico. *R Dental Press Ortodon Ortop Facial*. 2001 jan/fev;6(1):63-71.
- 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 Bauru. [dissertação]. Bauru (SP): Universidade de São Paulo; 2003.

21. Maria FRT, Janson G, Freitas MR de, Henriques JFC. Influência da cooperação no planejamento e tempo de tratamento da má oclusão de Classe II. R Dental Press Ortodon Ortop Facial. 2005 mar/abr;10(2):44-53.
22. Petrone J, Fishell J, Berk NW, Kapur R, Sciote J, Weyant RJ. Relationship of malocclusion severity and treatment fee to consumer's expectation of treatment outcome. Am J Orthod Dentofacial Orthop. 2003 Jul;124(1):41-5.
23. Proffit WR, Tulloch JF. Preadolescent Class II problems: treat now or wait? Am J Orthod Dentofacial Orthop. 2002 Jun;121(6):560-2.
24. Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD, Roberts CT, Andrews M. The development of the PAR index (Peer Assessment Rating): reliability and validity. Eur J Orthod. 1992 Apr;14(2):125-39.
25. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop. 1998 Oct;114(4):383-6.
26. Turbill EA, Richmond S, Wright JL. The time-factor in orthodontics: what influences the duration of treatments in national health service practices? Community Dent Oral Epidemiol. 2001 Feb;29(1):62-72.
27. Ursi WJS, Almeida GA. Cooperação mínima utilizando o Pêndulo de Hilgers. R Dental Press Ortodon Ortop Facial. 2002 Mar/Abr;7(2):87-123.
28. Vig PS, Weintraub JA, Brown C, Kowalski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop. 1990 Jan;97(1):45-51.
29. West KS, McNamara JA Jr. Changes in the craniofacial complex from adolescence to midadulthood: a cephalometric study. Am J Orthod Dentofacial Orthop. 1999 May;115(5):521-32.

Contact address

Célia Regina Maio Pinzan Vercelino
Alameda dos Sabiás, 58
CEP: 18.550-000 – Boituva / SP
E-mail: cepinzan@hotmail.com - cepinzan@uol.com.br

A PowerPoint-based guide to assist in choosing the suitable statistical test*

David Normando**, Leo Tjäderhane***, Cátia Cardoso Abdo Quintão****

Abstract

Selecting appropriate methods for statistical analysis may be difficult, especially for the students and others in the early phases of the research career. On the other hand, PowerPoint presentation is a very common tool to researchers and dental students, so a statistical guide based on PowerPoint could narrow the gap between orthodontist and the Biostatistics. This guide provides objective and useful information about several statistical methods using examples related to the dental field. A Power-Point presentation is employed to assist the user to find answers to common questions regarding biostatistics, such as the most appropriate statistical test to compare groups, to make correlations and regressions or to look for casual and systematic errors for a specific method. Assistance to check normal distribution and to choose the most suitable graphics is also presented. This guide* could be even used by reviewers in a quick assessment to check the appropriated statistical methodology into a specific study.

Keywords: Biostatistics (Public Health). Health statistics. Statistics. Statistical databases. Interactive tutorial.

* The tutorial can be downloaded at www.dentalpress.com.br.

** Assistant Professor. Department of Orthodontics, Federal University of Pará- UFPa, Brazil.

*** Professor. Institute of Dentistry, University of Oulu, Oulu, Finland; and Oulu University Hospital, Oulu, Finland.

**** Assistant Professor. Department of Orthodontics, State University of Rio de Janeiro- UERJ, Brazil.

INTRODUCTION

Statistical analysis is a very important tool in the validation of data obtained in a given study, as well as to a reliable extrapolation of these data for a population. Despite clinical decisions are routinely based on results of statistical analysis, it is quite common to find graduate dental students, clinicians and researchers showing a certain lack of understanding on how suitable statistics tests can be obtained. Several steps are important in the statistical analysis, a key point being the choice of the appropriate statistical test. Selecting suitable statistical test would correspond analogically to a correct diagnosis for a clinician. A misunderstanding could lead the researcher to wrong conclusions.

This “gap” between health science researchers and the understanding of mathematics and the statistical methods could justify the disinterest of a considerable part of clinical researchers and graduate students.⁶ The use of a clear comprehensive communication tool, such as presented here, using orthodontic subject examples could bring biostatistics closer to the orthodontics students and researchers. The main goal of this guide is to make statistical analysis more understandable, using dentist’s day to day language and a well-known tool, a visual PowerPoint™ presentation. This guide could be even used by the reviewers in a quick assessment to check if the appropriate statistical methodology has been employed in a specific study. It is, however, important to emphasize that the aim of this quick guide is not to underestimate the role of the biostatistician, nor their search tools, textbooks and statistical softwares.

The choice of a statistical test requires the user to know: 1) the data type (continuous, categorical: ordinal or nominal), 2) how this data is distributed after the completion of its collection (Normal or Free-distribution), and 3) the type of samples (independent or paired). A brief review is presented to introduce or remind the

reader about some basic principles. Some articles in the orthodontic literature are available as reference.^{4,5,7}

Data Types

Basically, data may be classified as quantitative (continuous) or qualitative.⁴ Quantitative data is measured on an interval or ratio scale and measures the data with number, such as tooth size in millimeters or incisor’s inclination evaluated in degrees. After data collection, it is possible to obtain a measure for the central tendency and an estimate of variability. The most commonly used estimate of averageness is the arithmetic mean and the most common estimate of variability is the standard deviation.

Qualitative or categorical data has a limited number of distinct values or categories (discrete variable) that are classified as Ordinal or Nominal. Ordinal data should follow a crescent level of assignment order. The apical root resorption index,¹ measured by an ordinal scale from 0 to 4, is an example of ordinal data. Each increasing score level reflects an increasing severity of apical root resorption. However, it can not be said that someone with a root score resorption 1 (mild resorption) has the half of root resorption of someone with a root score resorption 2 (moderate resorption). One measurement (score) is not a parameter to another. Therefore, this kind of data may be also called non-parametric. The most commonly used estimate of averageness to ordinal data is the median value, the middle observation point where half of values are higher and half are lower.

On the other hand, Nominal data is categorized data where no inherent order to the categories exists: for example, the data can be categorized according to the gender of patients or Angle classification. This type of data, consisting of whole units (discrete variable) is often described in absolute or relative frequency (percentage).

Data Distribution

There are two types of data distribution: Normal and abnormal (also called free-distribution). Normal or Gaussian distribution takes approximately the form of a bell-shaped curve when data is exposed in a curve of distribution. It can be seen that the data cluster around a central point and spread symmetrically around this center point. Many commonly used statistical tests, e.g. Student t-test, are based on parametric assumptions requiring a normal distribution.⁵

When the curve distribution is not a bell-shaped curve, it is called asymmetrical, abnormal or a free-distribution. Tests for abnormally distributed data are called nonparametric. The use of a parametric statistic is more likely to detect a statistically significant difference between samples when the difference is real, but use of a parametric test when the normal distribution is violated is not a correct way to perform analysis.

Before analyzing the differences between the groups, it is necessary to check the distribution of the data. If continuous data is abnormally distributed, it is necessary to choose a nonparametric statistics or to transform data into a normal distribution, applying, for example, a log transformation.⁴

Paired and Unpaired sample

Samples can be easily classified as paired (or dependent) and unpaired (or independent).⁵ A common paired design occurs when a single group of subjects is measured before and after a procedure to examine the effect of some treatment. Independent samples are consisted of different subjects on each group.

THE POWER POINT PRESENTATION

The goal of this tutorial is to produce information on the appropriate statistical test for the analysis of the results. This information will be obtained through a system of questions and replies.

To use this guide, the presentation is opened and "Slide show" mode must be selected. The first slide describes the purpose and limitations of this tutorial. One limitation in this guide is that it currently incorporates mainly statistical tests to studies that examine one variable (UNIVARIATE). The choices regarding the multivariate analysis are limited. Although multivariate analyses are still less frequently used in dental research, their use is increasing. In these cases, consultation with a biostatistician is strongly recommended.

The second slide presents a selection of links that lead the user forward according to the need. There are 5 options (Fig 1):

- 1) I want to assess whether my data show a normal distribution.
- 2) I want to make comparisons between groups.
- 3) I want to make correlation or regression analysis.
- 4) I want to check the replicability of data (systematic error).
- 5) I want to choose the appropriate graphics to my data.

Clicking on the icon with arrow, a link will take the user to successive questions until a response will be obtained. To reach the correct answer, the user has to understand the 3 previously described basic items (data distribution, type of variable and sample classification).

1st option: I want to assess whether my data shows a normal distribution

The first option is the analysis of data distribution. This step is not necessary when using categorical or non-parametric data. To use the parametric test properly, it must be verified if the data is continuous (if the data distribution is a bell-shaped curve) and if the variance (or standard deviation) of the variables examined are similar for each group. Some commonly used statistical tests to check normality of data distribution are pointed out (Fig 2).

2nd option: I want to make comparisons between groups

The second option of the presentation is an indication of the appropriated test for a statistical analysis comparing means. Means difference analysis is the most usual statistical test employed in Orthodontics.² When clicking on the icon, the user will have to answer what type of data—continuous, nominal or ordinal—was obtained (Fig 3). Then, the presentation will ask questions regarding the number of sample groups (Fig 4, A) and if examined groups are paired or not (Fig 4, B).

3rd option: I want to make correlation or regression analysis

The third option describes the statistical test for correlation tests or regression analysis (Fig 1). As well as in step 2 (Comparisons between groups), the user must choose the type of data (Fig 3) to get the answer (Fig 5).

4th option: I want to check the replicability of data (systematic and casual errors)

The error analysis of method is frequent in scientific research. In recent years, about 70% of the articles published in Orthodontics presented some type of error analysis.³ The observation of a systematic error of a method used by a researcher is usually achieved by making double measurements. These double data must show a high level of reproducibility or replicability.

The 4th option of this presentation concerns the review of systematic error. The steps to be performed are similar to the previous ones. After defining that you want to analyze the replicability of the data (Fig 1), the user must define what type of data you have (Fig 3), before the answer will be shown (Fig 6).

5th option: I want to choose the appropriate graphic to the data obtained

Usually the researcher is just focused on graph



FIGURE 1 - Options available at the second slide of the presentation, allowing the user to select the preferred function. To continue, the corresponding button must be clicked.

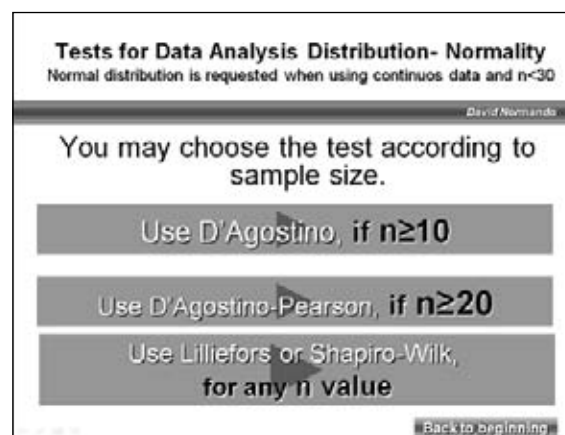


FIGURE 2 - Suggested statistical tests to check normality in the data distribution. The icon "back to beginning" will lead the user to the second slide of the presentation (Fig 1).

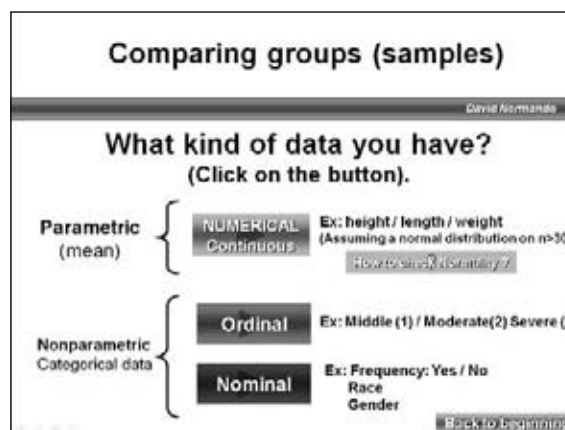


FIGURE 3 - The first step for the selection of statistical test is the description of the type of data. The user must click on one of the options to continue. It should be noted that if continuous data has an abnormal distribution the option "ordinal" (button) should be chosen.

Numerical Data (parametric)
If the distribution is not Normal, skip to "Abnormal"

ABNORMAL

David Normando

How many groups (samples) do you have?

▶ 1

▶ 2

▶ >2

A

Numerical Data (parametric)
If the distribution is not Normal, skip to "Abnormal"

ABNORMAL

David Normando

Are your samples paired or dependent?

No

Yes

Not sure?
Dependent Samples mean:
Before X After
Left Side X Right Side
T1 x T2 x T3

B

FIGURE 4 - **A)** After selecting the type of data, the user must answer how many sample groups are being examined. **B)** After defining the number of groups, the user must answer if the sample is paired or not. The table under the button provides examples to aid in the selection.

Correlation tests or regression analysis to Continuous data
If the distribution is not Normal, skip to "Abnormal"

ABNORMAL

David Normando

Answer: Pearson's Correlation
Simple Linear Regression

Back to beginning

FIGURE 5 - Answer page to suitable statistical test to make correlation or regression analysis of two continuous variables. The box button "abnormal distribution" should be clicked if the data doesn't show a normal distribution.

Replicability or Reproducibility
(Systematic error for numerical data)

ABNORMAL

David Normando

Answer: **Parametric test for dependent data**

2 samples

>2 samples

Note: Intraclass correlation can be used, if you would like to check the association between 2 or more measurements.

For **random or casual error**, you may use **TEM** (technical error measurement):

$$TEM = \sqrt{\sum D^2 / 2n}$$

D = difference between repeated measures
n = number of individuals

Back to beginning

FIGURE 6 - Answer page to the example for the systematic error analysis of cephalometric measurement. The icon "abnormal distribution" should be clicked if the data do not show a normal distribution. Note that statistical tests for paired data can also be used for analysis of the systematic error.

Graph Selection

David Normando

Comparing Independent Samples ▶

Comparing Dependent Samples (paired) ▶

Making Data Correlation or regression ▶

Not sure?
Dependent Samples mean:
Before X After
Left Side X Right Side
T1 x T2 x T3

A

BOX-PLOT - Comparing Groups.
Continuous or Ordinal Data (Score)

David Normando

This chart describes the measure of central tendency (MEAN for continuous data or MEDIAN for Ordinal data), measures of dispersion (Standard deviation for parametric data or interquartile deviation for Ordinal data) and the whiskers (maximum and minimum values).

Control

Treatment

Outlier: an observation that is unusually distant from the rest of the data.

Back

B

FIGURE 7 - Graphic selection. **A)** Selection can be made according to the type of sample and the objective of a given study. **B)** Suggested type of graphic to compare continuous data obtained from independent samples.

presentations of the mean. However, graphics should highlight data dispersion, such as standard deviation or variance to parametric data, or the interquartile range to non-parametric data. The 5th step of this presentation is related to the selection of informative graphs.

The initial steps are the same as shown earlier. After the choice of the option you want to run (Fig 1), the user must choose the type of data that is being evaluated in the study (Fig 3). In case of

continuous or ordinal data, a slide will appear to allow selection between paired or unpaired samples, or if a correlation or regression analysis has been performed (Fig 7, A and B). If the data is nominal, the answer will be directly presented.

Submitted: October 2008
Revised and accepted: November 2008

REFERENCES

1. Levander E, Malmgren O. Evaluation of the risk of root resorption during orthodontic treatment: a study of upper incisors. *Eur J Orthod.* 1988 Feb;10(1):30-8.
2. Lian T, Cuoghi OA. O uso da estatística na Ortodontia. *Rev Dental Press Ortod Ortop Facial.* 2004 Nov/Dez;9(6):97-108.
3. Normando ADC, Quintão, CCA, Almeida, MAO. Análise do emprego do cálculo amostral e do erro do método em pesquisas científicas publicadas na literatura ortodôntica nacional e internacional. *Rev Dental Press Ortod Ortop Facial.* (no prelo).
4. Sheats RD, Pankratz VS. Understanding distributions and data types. *Semin Orthod.* 2002 June;8(2):62-6.
5. Sheats RD, Pankratz VS. Common statistical tests. *Semin Orthod.* 2002 June;8(2):77-86.
6. Torgerson DJ, Miles JN. Simple sample size calculation. *J Eval Clin Pract.* 2007;13(6):952-3.
7. Valladares JVN, Domingues MHMS, Capelloza Filho L. Pesquisa em Ortodontia: bases para a produção e a análise crítica. *Rev Dental Press Ortod Ortop Facial.* 2000 jul/ago;5(4):89-105.

Contact address

Antonio David Corrêa Normando
Rua Boaventura da Silva, 567- 1201
CEP: 66.055-093 – Belém / PA
E-mail: davidnor@amazon.com.br

Clinical and polysomnographic assessment of the BRD Appliance in the treatment of Obstructive Sleep Apnea Syndrome

Cibele Dal-Fabbro*, Cauby Maia Chaves Junior**, Lia Rita Azeredo Bittencourt***, Sergio Tufik****

Abstract

Objectives: This research was designed to perform a clinical and polysomnographic evaluation of the effect of an oral appliance (OA) for the treatment of Obstructive Sleep Apnea Syndrome (OSAS), developed and tested by two Brazilian federal universities. **Methods:** The sample consisted of 50 patients (aged between 18 and 65 years, 33 men and 17 women) with initial polysomnographic diagnoses of mild to moderate OSAS. All patients underwent a new polysomnographic assessment during an entire night (using the OA) approximately six months after the first evaluation. Based on the reduction of apnea and hypopnea index (AHI) obtained with the use of the OA, the patients were divided into good responders (reduction of 50% or more of the AHI, remaining below 10 events/hour) and poor responders (AHI remained greater than or equal to 10 events/hour). **Results and Conclusions:** In 54% of the sample, the AHI decreased to less than five events/hour with the use of the OA; in 38% the reduction in AHI was greater than 50% but remained above the five events/hour; and in 6% of the sample the AHI decreased less than 50%. The good responders accounted for 86% of the studied sample, while the other 14% were poor responders. There were significant improvements in the sleepiness scale, the AHI, the micro-arousals and the minimum oxyhemoglobin saturation with the utilized therapy. A high Body Mass Index seemed to negatively interfere in the performance of the device under study.

Keywords: Obstructive Sleep Apnea. Polysomnography. Respiratory protection devices. Snoring.

* Masters in Oral Rehabilitation-FOB-USP. Doctorate in Medicine and Sleep Biology-UNIFESP.

** Masters and Doctor in Orthodontics-UMESP-UNICAMP. Post-Doctorate in Medicine and Sleep Biology-UNIFESP. Adjunct Professor IV- Orthodontics- Universidade Federal do Ceará-UFC.

*** Doctor - Adjunct Professor of Medicine and Sleep Biology-UNIFESP.

**** Doctor - Lecturer - Full Professor of Medicine and Sleep Biology-UNIFESP.

INTRODUCTION AND LITERATURE REVIEW

Obstructive Sleep Apnea Syndrome (OSAS) is a respiratory disorder related to sleep characterized by repeated partial or complete obstructions of the upper airway during sleep.^{3,4} It is one of the most common clinical entities among sleep disorders, affecting 3 to 5% of the adult population.³⁰

Among the classical clinical findings are heavy snoring, intermittent respiratory pauses during sleep, breathless and recurrent awakenings, non-restorative (fragmented) sleep and excessive daytime sleepiness.^{3,5} Snoring broken by respiratory pauses is a typical account of the companions of these patients.^{5,22} However, snoring can occur in the absence of OSAS, and as such, it is characterized as primary snoring, which affects about 40% of the adult male population.⁵

Precise diagnosis of sleep-disordered breathing is given by means of polysomnography exam (PSG), which permits the quantification of the events reported above and the temporal relationship of the parameters measured during a full night of sleep. The quantification of respiratory events per hour of sleep, given by the apnea-hypopnea index (AHI), confirms the diagnosis and defines the severity of OSAS: mild = between 5 and 15; moderate = between 15 and 30; and severe = above 30 events.³ There are still other parameters that can be altered in these patients and viewed in the polysomnography, such as oxyhemoglobin desaturation, alteration in the percentages of sleep stages, reduced sleep efficiency and sleep fragmentation.^{3,4,7}

The pathophysiology of OSAS appears to be multifactorial, and there are anatomical, functional and neuromuscular factors involved. The soft tissues, adipose tissue, muscles and craniofacial skeleton directly affect the configuration and dimension of the pharynx. In this manner, we frequently observe patients with OSAS with lingual hypotonia, macroglossia, mandibular and/or maxillary retrognathia, micrognathia, ogival palate, transverse maxillary deficiency

and crossbite.^{10,18,22,25,27}

OSAS is commonly associated with cognitive and cardiovascular complications as a result of intermittent hypoxia and sleep fragmentation, which significantly increases the morbidity and mortality of this syndrome.²¹ Recent studies have established that OSAS is an independent risk factor for systemic arterial hypertension (SAH) and contributes to the onset and progression of other cardiovascular diseases.²⁶ The cognitive consequences are principally related to attention, memory and executive function.^{1,13}

Because this syndrome is a chronic and long lasting condition, an effective approach to treatment is mandatory.¹⁵ OSAS treatments consist of clinical and surgical procedures. The choice of the clinical modality of treatment, using positive pressure devices (CPAP, auto-adjusting CPAP, BiPAP) or oral appliances (OA), is directly related to the severity of the disease.

The nasal CPAP ("continuous positive airway pressure") device is considered the gold standard in the treatment of OSAS¹⁴ (Fig 1). It consists of a non-invasive method of continuous positive air pressure application in the airway, generating a continuous airflow that, through a flexible tube, reaches a nasal mask that is adjusted on the face with straps. Thus, a pneumatic cushion is created



FIGURE 1 - CPAP ("continuous positive airway pressure").

in its interior that tends to dislocate the soft palate in the direction of the lingual base and dilate the sectional area of the whole pharynx.¹³ While it is an extremely effective treatment, there are problems with the adhesion of positive pressure devices and their acceptance in the long term.

Oral Appliances (OA) are devices used in the oral cavity during sleep, with the objective to prevent the collapse between the tissues of the oropharynx and the lingual base, i.e., the obstruction of the upper airway.²

OA constitute an effective and well-accepted form of treatment, and they have been an increasing line of treatment of OSAS and snoring for more than 20 years. Today there are more than 80 described types of OA, which specifically fit into the categories of lingual retainers and mandibular repositioners. Only some have been approved by the FDA (Food and Drugs Administration), and there are few controlled studies available. There are different types of OA, differentiated by manufacturing method (prefabricated or made in a laboratory), retention, titration of the mandibular position, anterior vertical opening, freedom of mandibular movement and construction material, among others. The effectiveness of the OA seems to be related to some of these aspects. When the precautions related to these factors are not

observed during the planning of the device, there is a greater probability of side effects, including those related to temporomandibular joint (TMJ) and occlusal alterations, as well as a reduction in adherence to the treatment.²

Treatment with OA is prescribed in patients with primary snoring and mild OSAS, as well as in cases of moderate or severe OSAS in which there was intolerance or refusal of CPAP use, surgical contraindication or the need for a short-term substitute therapy.^{7,17}

The objective of the present study was to evaluate the performance of this new design of OA for OSAS, while attempting also to compare responding and non-responding patients with the use of this mode of treatment.

THE INTRA-ORAL DEVICE

The Brazilian Dental Appliance (BRD) was developed from the experience of orthodontics researchers in the area of sleep medicine at UNIFESP-EPM and UFC who had previously used numerous other devices, mainly North American and Canadian, many of which had important limitations, high costs or a lack of consistent studies endorsing their use in patients with OSAS.

The BRD is an adjustable mandibular repositioning OA (Fig 2, A and B). It is comprised

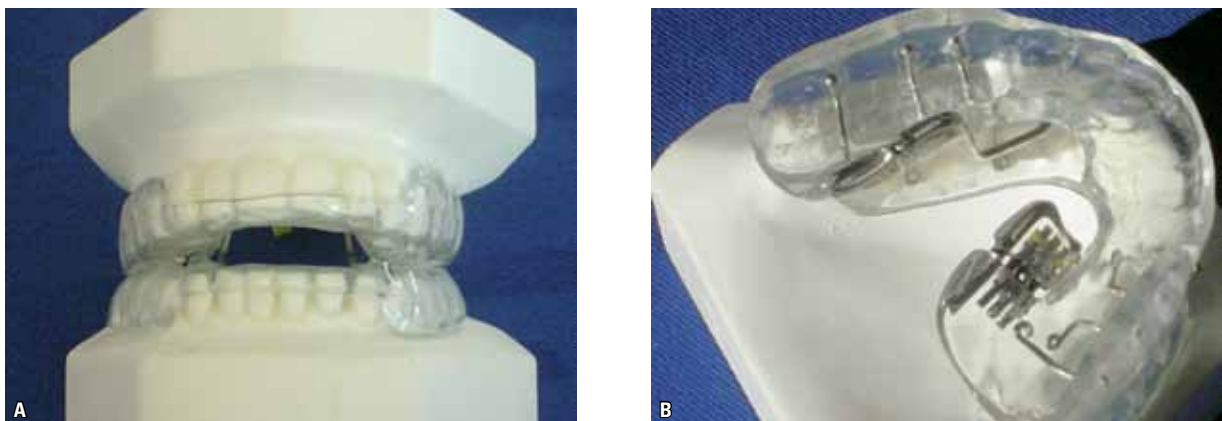


FIGURE 2 - BRD-type OA: **A)** anterior view, **B)** superior view.

of retaining clamps on the posterior teeth and two acrylic support bases (one superior and another inferior) covering all teeth externally and internally (anterior and posterior). It also possesses two independent (one right and another left in the posterior palate region of the superior acrylic base) expansion mechanisms (screws located with their long axle in the anterior-posterior direction). Two independent palate rods (one right and another left) protrude from these expansion mechanisms and are inserted inferiorly into two small tubes located in the anterior portion (distal of the inferior canines) of the inferior acrylic support base. This proposed design allows successive advances in the mandibular position without, however, impeding lateral mandibular movements. That is, with the device in position, even when the jaw is in an anterior position, the patient can make lateral movements and a small buccal opening (Fig 3).

METHODOLOGY

This prospective study included 50 patients with OSAS prescribed for treatment with an OA, following the study design (Fig 4). All the patients had been previously diagnosed by a standardized polysomnography examination in the Department of Psychobiology at UNIFESP (Universidade Federal de São Paulo) and the Universidade Federal do Ceará.

The inclusion criteria consisted of patients with mild and moderate OSAS, aged between 25 and 70 years, with body mass index (BMI) values less than 30 Kg/m² and with at least 10 teeth in each dental arch. Excluded patients were comprised of those who had undergone previous surgeries for OSAS, CPAP users, those currently using any drug that could interfere with the sleep architecture, shift workers and patients with important anatomical alterations in the superior airway, such as deviated septum, turbinate and/or tonsil hypertrophy.

Volunteers who were diagnosed with extensive



FIGURE 3 - BRD in mouth (frontal view).

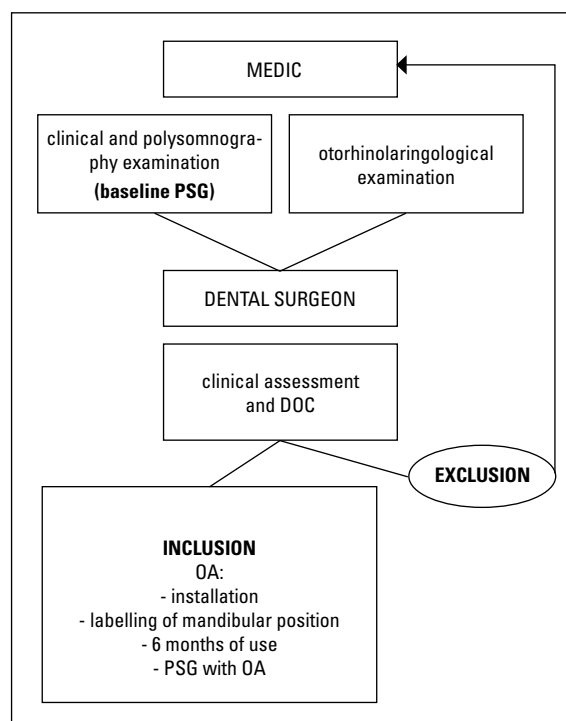


FIGURE 4 - Study design.

periodontal disease, severe temporomandibular joint disorder or dental units with insufficient anatomy for the necessary OA retention were excluded from the study.

Odontological documentation (DOC)

All of the patients underwent a basic orthodontic documentation, consisting of panoramic x-ray, cephalometric analysis, intra and extra-buccal photographs and study models.

Polysomnography (PSG)

All of the patients were subjected to a baseline polysomnography (PSG) for OSAS diagnosis and another one with the device (BRD) in the mandibular position of maximum comfortable protrusion. The average time between the first and the second polysomnographies was six months.

The full night of PSG was performed in a sleep laboratory using a system of 13 channels, which included the electroencephalogram, electrocardiogram, electrooculogram, electromyogram of the submentonian muscles and tibialis anterior, nasal and oral airflow (measured by thermistor and/or nasal cannula), thoracic and abdominal movements, body position (supine) and oxyhemoglobin saturation measured by pulse oximetry.

Clinical and laboratory odontologic procedures

Impressions of the dental arches were made with alginate type II and immediately cast with special plaster type IV. The record of the initial mandibular position was obtained with the "George Gauge"² device and condensation silicone (dense). The plaster models and records were then used for the manufacture of an individualized BRD device. All devices in the study were made of *thermopolymerizable* acrylic, with independent upper and lower parts and retention obtained by interproximal clips placed between all the posterior teeth. The connection between the two arches was made by two expanders positioned at the palate region, just below the cervical region of the superior molars. The purpose of these expanders is to allow the advancement of the mandible to move gradually over 11 mm, in 44 increments of 0.25 mm (Fig 5).



FIGURE 5 - BRD device used in the study.

To obtain the mandibular position of maximum comfortable protrusion, progressive adjustments were made in the expanders of the devices during a period of three to four 4 months, according to the presence of snoring and additional symptoms (drowsiness, fatigue, fragmented or non-restorative sleep).

A limit of 70% of maximum mandibular protrusion was observed.²⁹ At each consultation, the patients were asked about episodes of nasal obstruction and weight change.

Statistical Analysis

The Kolmogorov-Smirnov test for normality was applied and was followed by the paired t-test for comparison between the baseline and OA, in cases when the baseline data displayed a normal distribution, or by the Wilcoxon test when the distribution was not normal.

Subsequently, the patients were divided into two groups: good and poor responders. A patient was considered a good responder when the AHI with the OA was reduced more than 50% from the baseline and was lower than 10 events/hour. The poor responder presented an AHI with the OA of greater than or equal to 10. For this situation, to compare these two groups, we used the Student t-test for independent samples if the distribution was normal or the Mann-Whitney test for non-normal distributions.

RESULTS

The data are presented as means and standard deviations. The sample was comprised of 33 men and 17 women with a mean age of 48.6 ± 12.3 and a mean BMI of 26.0 ± 2.8 Kg/m². The mean of the final protruding mandibular position was 8.8 ± 1.3 mm.

The results of the comparison between the baseline (initial) and the with-OA measurements for all patients are shown in Table 1 and, specifically in relation to the number of apneas and hypopneas per hour of sleep (AHI), are illustrated in Graph 1. Statistically significant improvements were noted in several of the parameters studied, like the reduction in sleepiness measured by the Epworth scale, increased percentage of REM sleep, decrease in AHI, increased minimum oxyhemoglobin saturation as well as the decrease in the number of micro-arousals per hour of sleep (Table 1).

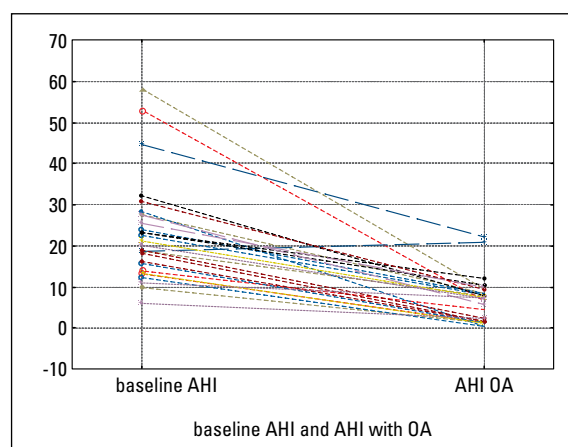
In 28 patients (56% of the sample), the AHI normalized with the use of the OA, i.e., it was less than 5 events/hour (success); in 19 patients (38% of the sample), the AHI was more than 5 events/hour with the use of the OA but decreased over 50% compared to the baseline condition (partial success); and in 3 patients (6% of the sample), the AHI was reduced less than 50% from the baseline or not reduced (failure) (Box 1).

According to the AHI results, the patients were divided into two groups: good and poor responders to the treatment. A patient was considered a good responder when the AHI with OA reduced more than 50% from the baseline and was lower than 10 events/hour ($n = 43$); otherwise, they were considered as poor responders ($n = 7$) (Tables 2 and 3). It is shown in Table 2 that there were statistically significant improvements in various polysomnographic parameters evaluated in isolation when studying the group of good responders, but it is also important to note that even the group of poor responders showed significant improvement in sleepiness, the AHI and the number of micro-arousals during sleep (Table 3).

TABLE 1 - Comparison between the baseline parameters and those with use of the OA (BRD) (mean $\pm$ standard deviation).

	BASILINE (n = 50)	BRD (n = 50)	P
BMI (Kg/m ²)	26.0 $\pm$ 2.8	26.1 $\pm$ 2.8	ns
Epw.S.S	10.1 $\pm$ 4.9	5.6 $\pm$ 3.5	p < 0.05
%SWS	14.5 $\pm$ 11.0	16.6 $\pm$ 11.2	ns
%REM	16.0 $\pm$ 6.1	19.5 $\pm$ 6.9	p < 0.05
AHI	19.7 $\pm$ 10.3	5.6 $\pm$ 4.7	p < 0.05
Micro-arousals/h	19.7 $\pm$ 10.3	10.6 $\pm$ 6.0	p < 0.05
Mean O ₂ Sat	94.1 $\pm$ 2.4	94.5 $\pm$ 1.9	ns
Minimum O ₂ Sat	84.1 $\pm$ 7.4	87.5 $\pm$ 4.4	p < 0.05

BMI = body mass index (kg/m²); Epw.S.S = Epworth Sleepiness Scale; %SWS = % slow-wave sleep; % REM = % REM sleep; AHI = number of apnea and hypopnea events per hour of sleep; Mean O₂ Sat = mean oxyhemoglobin saturation; Minimum O₂ Sat = minimum oxyhemoglobin saturation, ns = not statistically significant.



GRAPH 1 - Baseline AHI and AHI with the use of the OA for all patients.

	n	%
success	28	54
partial success	19	38
failure	03	06

BOX 1 - Percentage of success, partial success and failure for the total sample treated with the OA (BRD).

A comparison of the results between good and poor responders showed that those who responded poorly to treatment had a greater body mass index ($p < 0.05$), including weight gained during treatment (Table 4, Graph 2, A and B). On the other hand, two other parameters showed a

TABLE 2 - Comparison between the baseline parameters and those with the use of the OA (BRD) (mean $\pm$ standard deviation) in the group of good responders.

n = 43	BASELINE	BRD	P
BMI (Kg/m ²)	25.7 $\pm$ 2.8	25.8 $\pm$ 2.8	ns
Epw.S.S	10.1 $\pm$ 5.2	5.3 $\pm$ 3.5	p < 0.05
%SWS	13.7 $\pm$ 9.9	15.4 $\pm$ 10.9	ns
%REM	15.9 $\pm$ 6.4	19.9 $\pm$ 7.2	p < 0.05
AHI	19.2 $\pm$ 10.2	4.3 $\pm$ 2.9	p < 0.05
Micro-arousals/h	19.7 $\pm$ 10.5	10.5 $\pm$ 6.0	p < 0.05
Mean O ₂ Sat	94.1 $\pm$ 2.5	94.6 $\pm$ 2.0	ns
Minimum O ₂ Sat	83.8 $\pm$ 7.8	88.1 $\pm$ 4.3	p < 0.05

BMI = body mass index (kg/m²); Epw.S.S = Epworth Sleepiness Scale; %SWS = % slow-wave sleep; % REM = % REM sleep; AHI = number of apnea and hypopnea events per hour of sleep; Mean O₂ Sat = mean oxyhemoglobin saturation; Minimum O₂ Sat = minimum oxyhemoglobin saturation, ns = not statistically significant.

TABLE 3 - Comparison between the baseline parameters and those with the use of the OA (BRD) (mean $\pm$ standard deviation) in the group of poor responders.

n = 07	BASELINE	BRD	P
BMI (Kg/m ²)	27.7 $\pm$ 2.1	28.2 $\pm$ 2.3	ns
Epw.S.S	10.4 $\pm$ 3.0	7.2 $\pm$ 3.3	p < 0.05
%SWS	19.4 $\pm$ 16.7	23.9 $\pm$ 11.2	ns
%REM	16.4 $\pm$ 4.3	16.8 $\pm$ 3.7	ns
AHI	22.9 $\pm$ 10.9	13.9 $\pm$ 5.3	p < 0.05
Micro-arousals/h	19.7 $\pm$ 9.2	11.6 $\pm$ 6.9	p < 0.05
Mean O ₂ Sat	94.3 $\pm$ 1.6	94.4 $\pm$ 1.6	ns
Minimum O ₂ Sat	85.7 $\pm$ 4.5	83.7 $\pm$ 2.6	ns

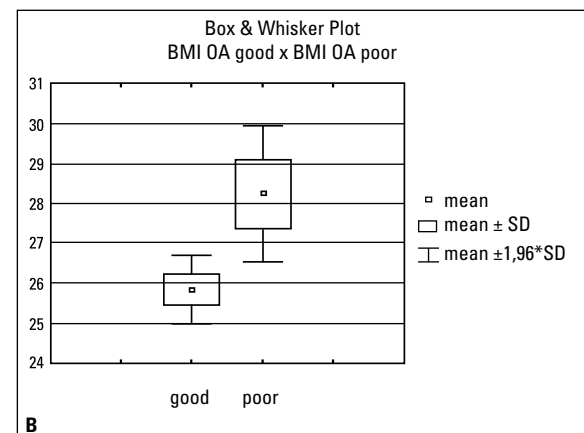
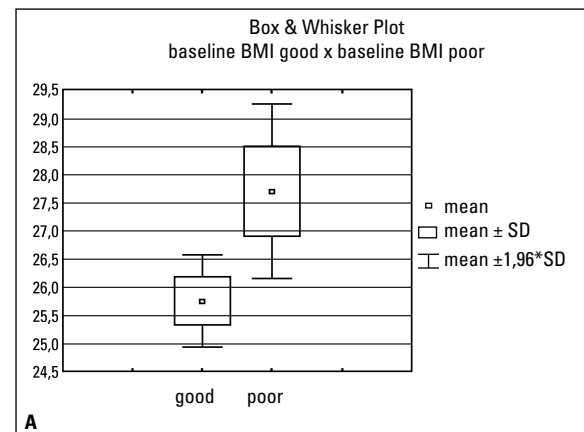
BMI = body mass index (kg/m²); Epw.S.S = Epworth Sleepiness Scale; %SWS = % slow-wave sleep; % REM = % REM sleep; AHI = number of apnea and hypopnea events per hour of sleep; Mean O₂ Sat = mean oxyhemoglobin saturation; Minimum O₂ Sat = minimum oxyhemoglobin saturation, ns = not statistically significant.

TABLE 4 - Comparison between good and poor responders.

	GOOD RESPONDERS	POOR RESPONDERS	P
AGE	47.5 $\pm$ 11.6	55.3 $\pm$ 15.4	ns
baseline BMI	25.7 $\pm$ 2.8	27.7 $\pm$ 2.1	p < 0.05
BMI w/ OA	25.8 $\pm$ 2.8	28.2 $\pm$ 2.3	p < 0.05
baseline Epw.S.S	10.1 $\pm$ 5.2	10.4 $\pm$ 3.0	ns
baseline AHI	19.2 $\pm$ 10.2	22.9 $\pm$ 10.9	ns
baseline micro-arousals	19.7 $\pm$ 10.5	19.7 $\pm$ 9.2	ns
baseline mean O ₂ Sat	94.1 $\pm$ 2.5	94.3 $\pm$ 1.6	ns
baseline minimum O ₂ Sat	83.8 $\pm$ 7.8	85.7 $\pm$ 4.5	ns
OA advancements (mm)	8.8 $\pm$ 1.3	8.6 $\pm$ 1.9	ns

ns = not statistically significant.

tendency to differentiate, although not in a statistically significant manner; these were age (greater in poor responders) and the severity of OSAS (more severe in poor responders), the latter being insignificant for AHI and oxyhemoglobin saturation. It is noteworthy that the final position (protrusion) with the OA was not different between responders and non-responders (Table 4).



GRAPH 2 - A) Baseline BMI for the good and poor response groups. B) BMI with the OA for the two groups.

DISCUSSION

The mandibular repositioners for OSAS and snoring treatment may be of two subtypes: adjustable and non-adjustable. This latter category is on the decline due to difficulty of use and worse patient adherence to use. Of the OA, those that seem to be more effective are those of progressive or adjustable mandibular advancement, showing optimal retention as much on the maxilla as on the mandible, in addition to increasing comfort due to a reduced size.⁸

The differences in the BRD compared to other devices are that it contains a buccal opening and that there are two joining elements between the arches (two expansion mechanisms) positioned on the internal part of the superior arch. Devices that only possess retention in the maxilla cannot maintain a stable mandibular position,² allowing buccal opening during sleep and a clockwise turning of the mandible that may adversely influence the pharyngeal dimensions. The fact that there are two independent expanders causes the device to position the lower arch in a more stable manner, allowing an anterior position without permitting much buccal opening. Making these devices with a single expander permits greater opening, which does not allow stable mandibular positioning, letting the tongue obstruct the superior airflow passage. Furthermore, a single expander does not allow asymmetric mandibular advancements. In devices made with two expanders positioned externally, the arches have important limitations to mandibular freedom in the lateral direction and the possibility of injury to the jugal mucosa.

This new design, by incorporating two internal expanders, permits asymmetric activation when necessary without impeding small lateral mandibular movements during sleep. Besides this, it does not cause injuries to the dorsal tongue.

The design of the BRD was developed to address these issues, as the device provides a stable mandibular position both vertically (opening) and

in the anterior-posterior direction (mandibular protrusion). It also promotes greater comfort, as it is individualized, measurable and extremely versatile with respect to the possibility of progressive mandibular advancements, making its use more physiological.

The results of 30 different studies in 456 patients with OSAS and 224 with snoring during a period of 10 years (1982-1992) shows that intra-oral devices have the potential for significant airway increases, with a 54.3% reduction in the means of OSAS indices and an improvement of snoring in 87.5% of cases.²³ In 1995, Nowara et al²⁰ selected 21 publications with which they reviewed the results of 320 patients treated for OSAS and snoring with OAs. They observed that snoring was completely eliminated in almost all patients and that others showed at least great improvements. For OSAS, there was an improvement of 60% of the apnea-hypopnea index, AHI, on average (AHI before = 47 and after = 19), and approximately half of patients achieved an AHI <10, which is considered successful by many authors.²⁰ Liu et al¹⁹ observed a mean reduction in AHI from 40.3 to 17.1 and an insignificant mean improvement in SaO₂ from 76% to 80% with the Klearway™ device. However, it is noted that these results are not uniform, with some patients responding very quickly to therapy and others in whom the results are not as encouraging. This can be attributed to the lack of standardization of these studies, mainly in relation to selected samples and the process for evaluating results.

In the present study, there was a careful selection of those individuals who actually had a need for OA therapy, and the monitoring of the individuals followed the updated guidelines of the Brazilian consensus of snoring and apnea.⁷ For this reason, the evaluation of the results involved polysomnographic aspects in relation to respiratory parameters (like the apnea-hypopnea index) but also in relation to sleep architecture (like percentage

of slow-wave sleep and REM sleep). Valid and extremely important clinical criteria such as the Epworth Sleepiness Scale were also used. Statistically significant improvements were observed in several evaluated parameters, like the reduction of sleepiness via the Epworth scale, increased percentage of REM sleep, decreased apnea-hypopnea index, increased minimum oxyhemoglobin saturation as well as the decrease in the number of micro-arousals per hour of sleep (Table 1). These findings corroborate the research of Bernhold and Bondemark,⁶ whom reported an improvement in SaO_2 and a decrease in daytime sleepiness in the majority of their patients with OA. There was an observed improvement in the sleep quality of the patients, with increased percentages of REM stage, but little influence on the duration of NREM sleep, as also found by Henke; Frantz and Kuna.¹⁶ However, Rose et al²⁴ reported that the sleep architecture did not significantly change during their study with the Karwetzky-type activator OA.

With regard to obstructive events per hour of sleep (AHI), the results showed that in 56% of the sample the AHI with OA normalized, i.e., it was less than 5 events/hour (success); in 38% of the sample, the AHI was above 5 events/hour with the OA, but it had reduced more than 50% compared to baseline (partial success); and in 6% of the sample the AHI was reduced less than 50% from baseline or not reduced (failure). Generally, the effectiveness is reported based on an improvement in rates reaching 50% to 80% of those obtained initially, but there is still a big controversy on how to standardize the rates of success or the effectiveness of therapy.¹⁹

When the patients were separated into good responders (AHI with OA reduced more than 50% and less than 10 events/hour) and poor responders to treatment (AHI with OA greater than 10 events/hour), it was found that forty-three patients fell into the first group and seven fell into the second group. Significant improvements in the majority of the evaluated parameters were

detected in the group of good responders (Table 2), but it is worth mentioning here that even the group of poor responders showed significant improvements in drowsiness, the AHI and number of micro-arousals during sleep (Table 3).

Liu et al¹⁹ studied patients with OSAS divided into three groups according to the degree of improvement in AHI: a group with good responses (reductions of AHI > 75%), a group with moderate responses (reductions in AHI from 25 to 75%) and a group with poor responses (reductions in AHI < 25%) in relation to treatment with intra-oral devices. This study showed that there was a significant difference in age between the group with poor response and the other groups. In older patients and those with higher BMI values, the OA was less effective. The study presented here also found a greater body mass index, including weight gain during treatment (Table 4, Graph 2, A and B), in patients who responded poorly to treatment with OA. There also seems to be a trend of greater age among the poor responders.

An important aspect is that the final position (protrusion) with the OA was not different between the responders and non-responders. This presupposes that extreme mandibular advancements, without other criteria, will not improve the effectiveness of intra-oral devices. Exaggerated increases in the amount of mandibular advancement do not seem to have a great influence on the improvement of OSAS.²⁹

Intra-oral devices offer the most practical and logical way to start a treatment for the majority of OSAS cases. A well-prescribed device that is properly manufactured and periodically monitored is effective, does not represent major expenses for patients and is easily accepted by most of them, while also being associated with other treatment modalities.^{9,12} The device tested in this study achieved satisfactory results and is an alternative to a mandibular repositioning device for the treatment of patients with obstructive sleep apnea.

CONCLUSION

With the utilized therapy, there were significant improvements in the sleepiness scale, AHI, micro-arousals and minimum oxyhemoglobin saturation. Elevated Body Mass Index appears to unfavorably affect the performance of the device under study, suggesting that most patients who

are obese or who gain weight during treatment may become an unsuccessful group for this therapeutic approach to OSAS.

Submitted: November 2008
Revised and accepted: February 2009

REFERENCES

1. Adams N, Strauss M, Schluchter M, Redline S. Relation of measures of sleep-disordered breathing to neuropsychological functioning. *Am J Respir Crit Care Med*. 2001 Jun;163(7):1626-31.
2. Almeida FR, Dal-Fabbro C, Chaves Jr CM. Síndrome da apnéia e hipopnéia obstrutiva do sono (SAHOS): tratamento com aparelhos intra-orais. In: Tufik, S. *Medicina e biologia do sono*. 1ª ed. São Paulo: Manole; 2008. p. 263-80.
3. American Academy of Sleep Medicine. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep*. 1999 Aug;22(5):667-89.
4. American Academy of Sleep Medicine. International classification of sleep disorders. 2nd ed. Diagnostic and coding manual. Westchester: Illinois; 2005.
5. Bassiri AG, Guilleminault C. Clinical features and evaluation of obstructive sleep apnea-hypopnea syndrome. In: Kryger MH, Roth T, Dement WC. *Principles and Practice of Sleep Medicine*. 3rd ed. Philadelphia: W.B. Saunders; 2000. p. 869-78.
6. Bernhold M, Bondemark L. A magnetic appliance for treatment of snoring patients with and without obstructive sleep apnea. *Am J Orthod Dentofacial Orthop*. 1998 Feb;113(2):144-55.
7. Bittencourt LRA. Diagnóstico e tratamento da Síndrome da Apnéia Obstrutiva do Sono (SAOS)-Guia Prático. 1ª ed. São Paulo: Médica Paulista; 2008.
8. Chaves CM Jr, Dal-Fabbro C, Almeida FR. Aparelhos intrabucais de avanço mandibular para tratamento da apnéia obstrutiva do sono. In: Dominguez GC. *Nova visão em Ortodontia e Ortopedia Funcional dos Maxilares*. 1ª ed. São Paulo: Ed. Santos; 2007. p. 355-60.
9. Clark GT, Nakand M. Dental appliances for the treatment of obstructive sleep apnea. *J Am Dent Ass*. 1989; 118:611-9.
10. Davies SF, Iber C. Obstructive sleep apnea associated with adult-acquired micrognathia from rheumatoid arthritis. *Am Rev Respir Dis*. 1983 Feb;127(2):245-7.
11. George PT. A new instrument for functional appliance bite registration. *J Clin Orthod*. 1992 Nov;26(11):721-3.
12. George PT. Treatment of snoring and obstructive sleep apnea with a dental device. *Gen Dent*. 1993 Jul/Aug;41(4):294-8.
13. Gozal D, Kheirandish L. Sleepiness and neurodegeneration in sleep-disordered breathing: convergence of signaling cascades. *Am J Respir Crit Care Med*. 2005 Jun 15;171(12):1325-7.
14. Grunstein R, Sullivan C. Continuous positive airway pressure for sleep breathing disorders. In: Kryger MH, Roth T, Dement WC. *Principles and practice of sleep medicine*. 3rd ed. Philadelphia: W.B. Saunders; 2000. p. 894-912.
15. Guilleminault C, Simmons FB, Motta J, Cumiskey J, Rosekind M, Schroeder JS, Dement WC. Obstructive sleep apnea syndrome and tracheostomy. Long-term follow-up experience. *Arch Intern Med*. 1981 Jul;141(8):985-8.
16. Henke KG, Frantz DE, Kuna ST. An oral elastic mandibular advancement device for obstructive sleep apnea. *Am J Respir Crit Care Med*. 2000 Feb;161(2 Pt 1):420-5.
17. Kushida CA, Morgenthaler TI, Littner MR, Alessi CA, Bailey D, Coleman J Jr, Friedman L, Hirshkowitz M, Kapen S, Kramer M, Lee-Chiong T, Owens J, Pancer JP. Practice parameters for the treatment of snoring and obstructive sleep apnea with oral appliances: An update for 2005. *Am American Academy of Sleep Medicine Report. Sleep*. 2006 Feb;29(2):240-3.

18. Li KK, Riley RW, Powell NB, Kushida C, Troell RJ. Obstructive sleep apnea syndrome in the Asian patient. Annual meeting of the American Academy of Otolaryngology-Head and Neck Surgery Foundation. New Orleans (LA); 1999.
19. Liu Y, Lowe AA, Fleetham JA, Park YC. Cephalometric and physiologic predictors of the efficacy of an adjustable oral appliance for treating obstructive sleep apnea. *Am J Orthod Dentofacial Orthop.* 2001 Dec;120(6):639-47.
20. Nowara WS, Lowe A, Wiegand L, Cartwright R. Oral appliances for the treatment of snoring and obstructive sleep apnea: a review. *An Amer Sleep Disorders Association Review.* 1995; 18(6):501-11.
21. Partinen M, Jamieson A, Guilleminault C. Long term outcome for obstructive sleep apnea syndrome patients. *Mortality Chest.* 1988;94:1200-4.
22. Robinson A, Guilleminault C. Obstructive sleep apnea syndrome. In: Chokroverty S. *Sleep disorders Medicine: basic science, technical considerations, and clinical aspects.* 2nd ed. Woburn: Butterworth Heinemann; 1999. p. 331-54.
23. Rogers RR, Lowe AA. *Oral appliances for the management de snoring and obstructive sleep apnea.* 2nd ed. Wexford: Sleep Disorders Dental Society; 1996.
24. Rose EC, Barthlen GM, Staats R, Jonas IE. Therapeutic efficacy of an oral appliance in the treatment of obstructive sleep apnea: a 2-year follow-up. *Am J Orthod.* 2002;121:273-9.
25. Sakakibara H, Tong M, Matsushita K, Hirata M, Konish Y, Suetsugu S. Cephalometric abnormalities in non-obese and obese patients with obstructive sleep apnoea. *Eur Respir J.* 1999;13:403-10.
26. Shamsuzzaman AS. Obstructive sleep apnea: implication for cardiac and vascular disease. *JAMA.* 2003;290(14):1906-14.
27. Smirne S, Iannaccone S, Ferini-Strambi L. Muscle fiber type and habitual snoring. *Lancet.* 1991;337:597-9.
28. Sullivan CE, Issa FG, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnea by continuous positive airway pressure. *Lancet.* 1981;1:862-5.
29. Tegelberg A, Walker-Engström ML, Vestling O, Wilhelmsson B. Two different degrees of mandibular advancement with a dental appliance in treatment of patients with mild to moderate obstructive sleep apnea. *Acta Odontol Scand.* 2003;61(6):356-62.
30. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med.* 1993;328:1230-5.

Contact address

Cauby Maia Chaves Junior
 Rua Tibúrcio Cavalcante, 2860, Dionísio Torres
 CEP: 60.125-101 – Fortaleza / CE
 E-mail: cmcjr@uol.com.br

Aesthetics in Orthodontics: Six horizontal smile lines

Carlos Alexandre Câmara*

Abstract

Introduction: Smile analysis is an important stage for the diagnosis, planning, treatment and prognosis of any dental treatment involving aesthetic objectives. The evaluation of the intrinsic characteristics of the smile is a necessary procedure to achieve consistent form in orthodontic treatments, which in turn makes it necessary to recognize the components and factors that affect these characteristics. **Objective:** The objective of this work is to present six horizontal smile lines and their importance in obtaining the desired results in orthodontic treatments. **Conclusion:** The analysis of the six horizontal smile lines facilitates the understanding of the intrinsic characteristics that interfere in the aesthetics of the mouth. Moreover, a harmonization of these lines gives each professional a higher possibility of success in their treatments that include aesthetic objectives.

Keywords: Orthodontics. Aesthetics in Orthodontics. Dental aesthetics. Mouth aesthetics. Smile.

INTRODUCTION

Obtaining a beautiful smile is always the main objective of any aesthetic dental treatment. After all, it is the beauty of the smile that will make the difference between an acceptable or pleasing aesthetic result for any given treatment. Nevertheless, in spite of its importance, the intrinsic characteristics of the smile are little discussed. Much is said of the clinical consequences of dental procedures on the smile, but its intrinsic characteristics are not widely evaluated. These characteristics can sometimes be altered and sometimes not, as they are integral parts of the individual. As such, the field of dentistry has

no reach over these characteristics, and can only make evaluations of them.

Evaluating beauty is always subjective. However, we need adequate tools to overcome the challenge of this subjectivity. In orthodontics, it is not enough only to recognize what is interfering with the smile—it requires a diagnosis of what is not normal, in order to establish a treatment plan. Just as in functional problems, in which we follow conducts that lead us to a diagnosis of the anomalies, aesthetic problems also require parameters so we can find the defects. When searching for the visualization of problems, several rules and assumptions are created, leading sometimes to an

* Specialist in Orthodontics (FO-UERJ). Certified member of the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

underestimation of defects or an overvaluing of rules, creating paradigms that are not supported by proven scientific data. The very essence of aesthetic dentistry, which involves artistic criteria, contributes to this fact. The use of simple and reliable mechanisms can improve the possibilities of success, if not eliminate performance errors.

There are some tools that can be used for that purpose. The Diagram of Dental Aesthetic References (DDAR) is an auxiliary diagnostic tool that is well suited to that purpose. The diagram consists of six frames that surround the maxillary incisors and canines; their limits are specific to each aesthetic reference. The function of the DDAR is to give an exact idea of the positioning and ratios between teeth, as well as their relationship with the gum and lips.⁵ Originally conceived to aid in the visualization of maxillary anterior teeth, DDAR, when aided by additional data, makes it possible to objectively evaluate the smile, facilitating the aesthetic diagnosis and prognosis. Thus, the objective of this work will be to present the new characteristics of DDAR and its role in the “six horizontal smile lines”, which in turn assist the diagnosis, treatment and prognosis of mouth aesthetics.

DIAGRAM OF DENTAL AESTHETIC REFERENCES - DDAR (new characteristics)

The Diagram of Dental Aesthetic References (DDAR) was created to facilitate the visualization

of maxillary anterior teeth, by suggesting what needs to be created or achieved with those teeth, aiming for the best possible dental aesthetics. The objective of the diagram is to give an exact idea of the positioning and ratios between teeth, as well as their relationship with the gum and lips in frontal view. As previously mentioned, the diagram consists of six frames that surround the maxillary incisors and canines; their limits are specific to each dental reference. Each frame surrounds its respective tooth, observing its limits (Fig 1). Although these frames can serve as references in the different observation planes, DDAR is evaluated at a 90° view from the frontal plane—in other words, perpendicular to it. Its use facilitates the planning and visualization of the best aesthetic positioning of anterior teeth, and its objective is to provide data that can assist the reorganization and restructuring of those teeth, whenever they need to be repositioned and/or restored. However, although the original conception of DDAR is useful to assist in the evaluation of mouth aesthetics, a few references of dental, gingival and labial structures can be added to its format, improving and facilitating the visualization of the smile.

In its original format, DDAR makes reference to the gingival zenith, which are most apical landmarks of the gingival contour. The present reevaluation will add the locations of the extremities of gingival papillae (papillary tips) and emphasize the contact points (Fig 2).

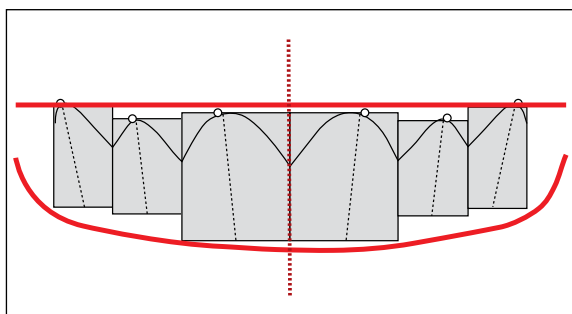


FIGURE 1 - Diagram of Dental Aesthetic References (DDAR).

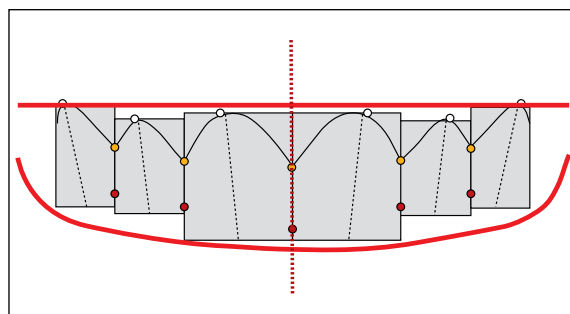


FIGURE 2 - DDAR with new reference points: contact points and gingival papillary tips.

The union of these points will form lines that give evaluative references in the analysis of the smile. As such, DDAR will intrinsically have four lines, formed by the following structures (Fig 3):

- Cervical line–gingival zenith.
- Papillary line–papillary tips.
- Contact points line–contact points.
- Incisal line–incisal edges (incisal line).

The relationship of the papillary line with the contact points line will create a band named connector band, in a reference to the concept of dental connectors.¹⁹ This band, formed by the two lines (papillary and contact points), added to the cervical and incisal lines, will provide the horizontal dental references of the smile in a frontal view.

The other two lines that make up the group of horizontal smile lines are the upper lip line and lower lip line. These lines, along with the dental and gingival lines, compose the group of six horizontal smile lines (Fig 4).

CERVICAL LINE

The cervical or gingival line is formed from the union of the apexes of the canines, maxillary lateral and central incisors. As the most apical point of the gingival contour, the apex in

maxillary teeth is usually located distal to the long axis of the tooth. However, this rule does not always apply to the maxillary lateral incisors. On those teeth, the gingival limit may be centered on the long axis. Because the apexes of the maxillary canines are most often higher than the lateral incisors and about the same level as the central incisors, the cervical line attains a convex aspect in relation to the occlusal plane. That would be the ideal form of the cervical line. When the lateral incisors are positioned more apical, at the same height as the canines and central incisors, the line becomes plain. When the gingival contour of the canines is below the lateral incisors, the line formed will be concave (Figs 5 to 7). The concave cervical line is the least pleasing among the three possibilities.

There will be situations in which the heights of the anterior teeth will be asymmetrical, leading to the formation of an asymmetrical cervical line (Fig 8). It should be clear that the position of the gingival zenith can vary widely between teeth and each individual will have a uniquely shaped cervical line, making it practically impossible to characterize all the possibilities. The nomenclature used for the cervical line (plain, concave, and convex) serves only as an evaluation

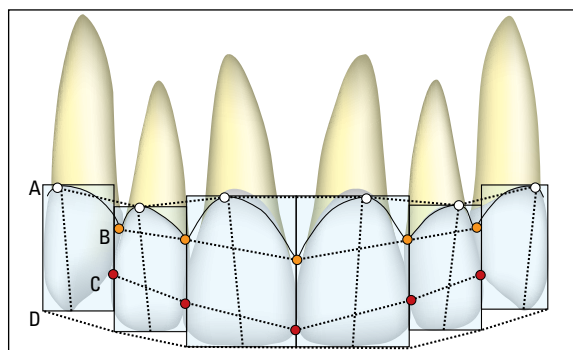


FIGURE 3 - Aesthetic reference lines: Cervical Line (A); Papillary Line (B); Contact Points Line (C); Incisal Line (D).



FIGURE 4 - The six horizontal smile lines. Cervical Line (A); Papillary Line (B); Contact Points Line (C); Incisal Line (D); Upper Lip Line (E); Lower Lip Line (F).

reference. The variation in the cervical height of teeth will depend on the periodontal conditions of each tooth, as well as on tooth size, tipping, eruption pattern, and occlusal plane tipping.

INCISAL LINE

The incisal line follows the edges of anterior maxillary teeth. The ideal is that in young patients the incisal edges of the central incisors be below the edges of the lateral incisors and canines in a frontal view. In that configuration, the form of the incisal line resembles the outline of a “deep plate” (Fig 9). A change in the positioning of the incisal edges modifies that figure. When the incisal edge of the central incisors are no longer below the lateral incisors, the outline will change, becoming known as “shallow plate”, or depending on the relation, an “inverted plate”.

In general, the configuration of the incisal line is related to the patient’s age. Over time, there is wear of the central incisors, leading to these changes. However, it is not only wear-related changes that affect the outline of the incisal line.

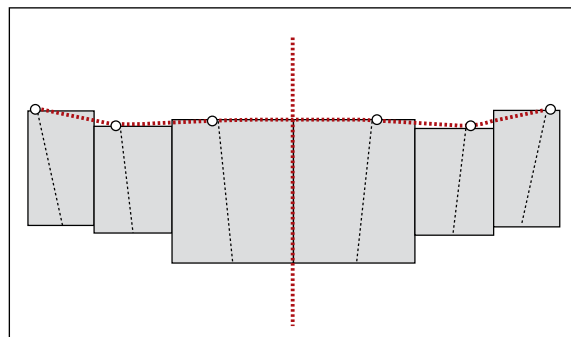


FIGURE 5 - Convex form of the cervical line.

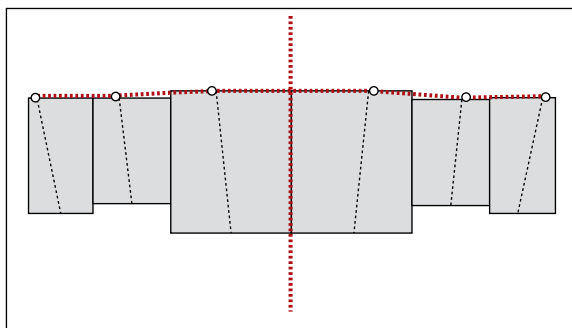


FIGURE 6 - Plain form of the cervical line.

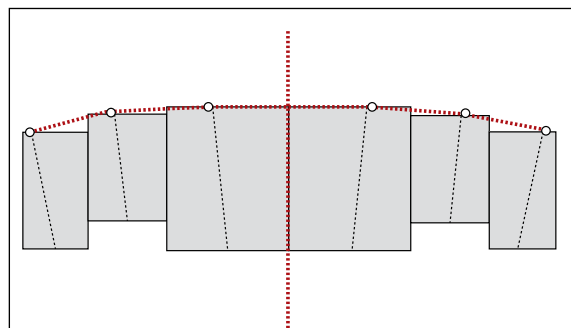


FIGURE 7 - Concave form of the cervical line.

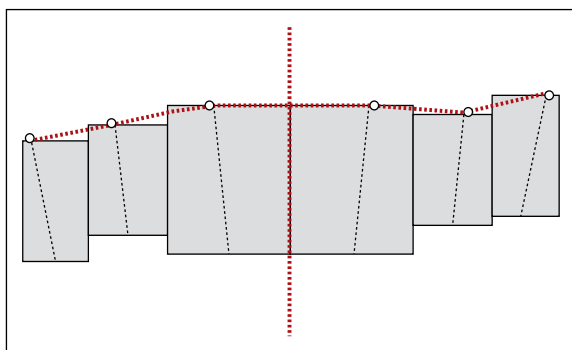


FIGURE 8 - Asymmetrical cervical line.

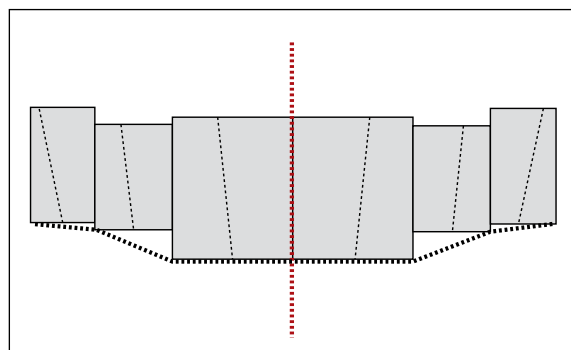


FIGURE 9 - Incisal line in the form of a “deep plate”.

As with the cervical line, tooth size, tipping, eruption patterns, and occlusal plane tipping can also alter the outline. The most utilized term when the incisal line forms an “inverted plate” is “inverted smile”. The line becomes concave in relation to the frontal occlusal plane, giving an aged and anti-aesthetic appearance. The classification of the incisal line may also use the nomenclature concave (“inverted plate”), plain (“shallow plate”) and convex (“deep plate”). Other frequently used terms to describe the incisal line are the “smile arch”,²⁵ “incisal curvature”⁶ and “seagull wing”.¹⁶

CONTACT POINTS LINE

The contact between anterior maxillary teeth is done in a descending fashion, starting from the canine. The contact between the canine and lateral incisor is positioned higher than the contact between the lateral and central incisors; the contact between the central incisors is even lower. The contact points should be narrow, unless there is a discrepancy in the mesio-distal diameter of the crown.² The position of the contact between teeth is related to tooth position and form.¹⁶ As such, the line that unites these points will be parallel to the incisal line, whenever there is no discrepancy between the sizes, shapes and angles of anterior teeth. Although there is a contact point whenever a tooth touches another, the ideal is when that contact happens in an area broader than a single point, forming a connector space. Connector spaces are areas in which teeth appear to touch. As will be seen further on, this fact has a positive influence on dental aesthetics. For practical purposes, whenever the dental contact takes place over an area instead of in a single point, we consider the most apical site as the reference for the contact point (Fig 10).

PAPILLARY LINE

The papillary line is formed by the tips of the gingival papillae located between the canines and

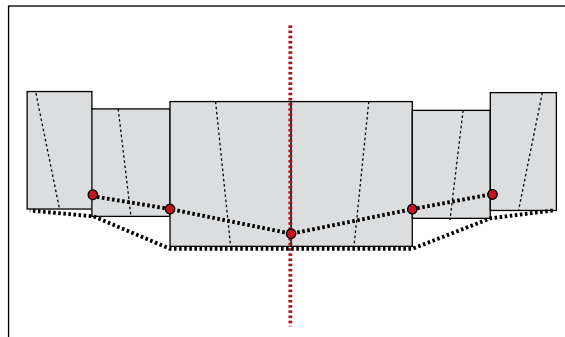


FIGURE 10 - Contact points line. This line should have a certain parallelism with the incisal line.

lateral incisors, and between the maxillary lateral incisors and central incisors. There are no studies that have evaluated the standard height for this relationship. In other words, there is no definition of an ideal model for the relationship between the heights of the papillae. Nevertheless, based on works that evaluated the ideal height of the central incisors and the relationship between the papillary tips and the position and size of teeth,^{13,27} it can be presumed that an ideal line would be parallel to the line formed by the contact points. According to the work of Kurt and Kokich,¹³ the papilla in the central incisors fills half the size of those teeth, under normal conditions. As such, it would be expected that the same pattern would be repeated for the lateral incisors and canines. Given that the lateral incisors are smaller than the central incisors and the papilla should fill half the height of their crowns, the position of the papilla between the central and lateral incisor should be in an apical aspect in relation to that of the central incisors, as well as to the papilla of the lateral incisor and canine (Fig 11).

Connector band

The location where anterior teeth appear to touch is named a connector space. As previously mentioned, there is a difference between a connector space and a contact point. Contact points are small areas in which teeth touch. Connector spaces are larger, broader, and can be defined

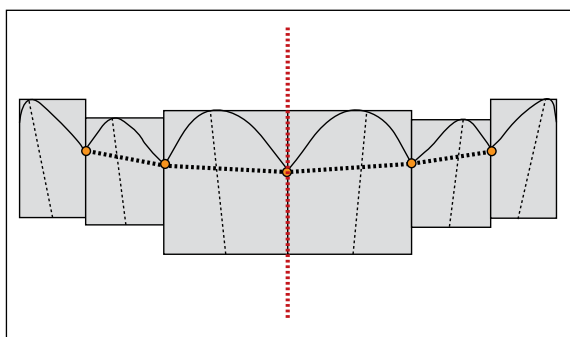


FIGURE 11 - Papillary line. It consists of the tips of gingival papillae.

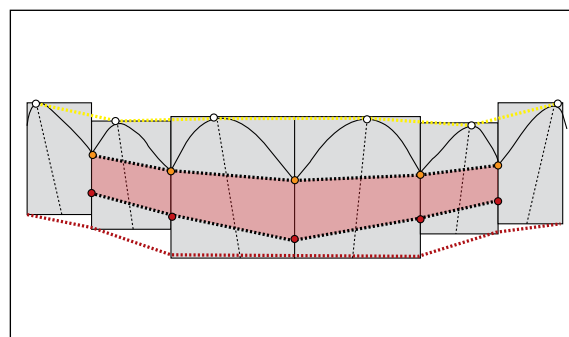


FIGURE 12 - Connector band. This band is delimited by the contact points line and papillary line. The figure of the band resembles the shape of a "hang glider".

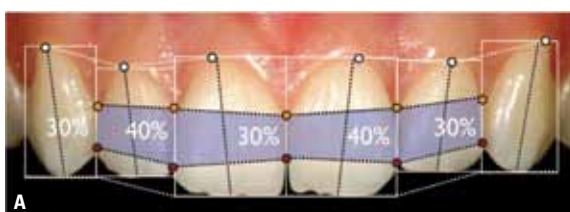


FIGURE 13 - Unfavorable ratio of the "connector band" 30-40-30-40-30 (A). A simple re-contour with the addition of composite resin between the central incisors led to the formation of a favorable "connector band": 30-40-50-40-30 (B).

as zones in which two adjacent teeth appear to touch. The best aesthetic relationship of anterior teeth is one that follows the 50-40-30 rule for the connector space.¹⁹ This rule establishes that the connector space between the central incisors should be 50% of the size of those teeth. The ideal connector space between the central and lateral incisor is 40% of the length of the central incisors, and the connector space between the lateral incisor and the canine is 30% of the same reference. Although the reference points to determine the connector space were not defined by Morley and Eubank,¹⁹ these references can be created from the contact points and the gingival papilla. Therefore, whenever there are no dark spaces or diastemas between two teeth, with the space filled by the gingival papilla, the area of the connector spaces will be delimited by the papillary tips and the contact points. As such, using the papillary line and the contact points line as

reference, we will have a band named "connector band". The figure of this band resembles the shape of a "hang glider" (Fig 12). Small changes in this band can make a difference in dental aesthetics. Dental remodeling can increase or decrease the connector space, resulting in an improved configuration of the area (Fig 13).

Clinical Application

The clinical evaluation of DDAR with the four lines and connector band will permit the use of a checklist that will be able to detect errors in tooth positions and their relationship to the gingiva. By observing the form of each line, a plan can be drawn focusing on correcting the defects, harmonizing the lines, and later evaluating the achieved results. This evaluation facilitates the diagnosis and makes it easier and more practical for all professionals who treat aesthetic problems to detect problems (Fig 14).

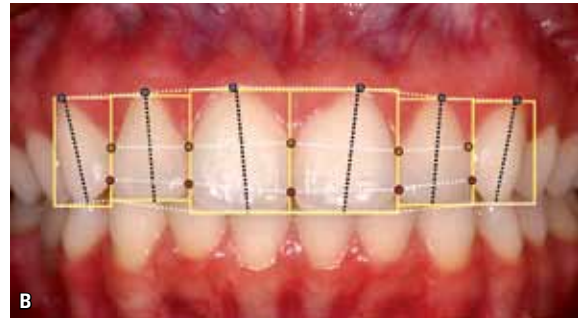


FIGURE 14 - CHECKLIST – Cervical line: concave (accentuated) and asymmetrical. Incisal line: inverted “deep plate” form (concave) and asymmetrical. Connector band: 30% (13/12) – 20% (12/11) – 40% (11/21) – 20% (21/22) – 20% (22/23) (A). CHECKLIST – Cervical line: concave (slight) and symmetrical. Incisal line: “deep plate” form (convex) and symmetrical. Connector band: 30% (13/12) – 35% (12/11) – 40% (11/21) – 35% (21/22) – 30% (22/23) (B).

Lip analysis

In addition to teeth, DDAR also involves the lips. After the labial evaluation, the six horizontal smile lines are found – in addition to the four dento-gingival lines, there are the upper and lower lip lines. Both the upper and lower lips have a marked effect on the beauty of the smile. Individually, each lip will influence the dentolabial ensemble, and together they will create figures that will determine the visible tooth exposure. The lip separation that occurs during smiling will permit the exposure of dental and gingival structures. This separation can be called “labial unveiling”, as it will be this unveiling that will give the dental work a chance to be shown (Fig 15). Labial unveiling is what makes possible the evaluation of the relationship between the white (teeth) and pink (gums) aesthetics, and their relationship with the lips. The three-dimensional relationship these structures have with one another is what will cause the effect of beauty or not.

This concept is essential, as it leads to the need to know a series of factors that influence that unveiling. The greater or lesser tooth exposure will be influenced by labial unveiling and all intrinsic factors to it, such as its formation, stages, phases and lip involvement. As such, before we begin evaluating the upper and lower lip lines, we will present the factors that affect the smile.

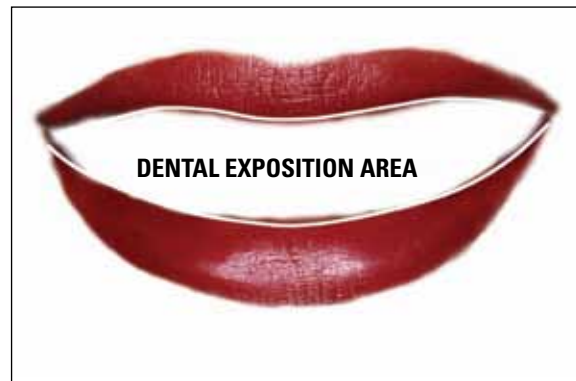


FIGURE 15 - “Labial unveiling”.

Smile formation

The smile can be defined as a change in facial expression that involves a sparkle in the eyes, an upper curvature in the corners of the lips, no sound emission, and less distortion of muscle forms than with a laugh.¹² It begins at the commissure and extends laterally; the lips may initially remain in contact, except in people who do not feature passive lip seal or have a short upper lip. As the smile expands, the lips separate, the commissures curve upwards, and the teeth are exposed. The maxillaries are separated, and a dark space develops between upper and lower teeth, known as negative space.¹⁸ During smiling, upper lip height is diminished, and the width of the mouth is increased by 23% to 28% compared to the lip at rest.²⁶

The symmetry of muscle activity should not be overestimated. In normal people, individual variability of motor function is observed between different sides of the same individual. Combined measurements, both of skin mobility and muscle activity, indicate that there is an average asymmetry of 64% between the sides of the human face.⁴

Stages of the smile

In smile analysis, its stages should be observed. There are two stages in smile formation: the first (voluntary smile) elevates the upper lip towards the nasolabial groove through the contraction of the elevator muscles that originate in this groove and are inserted in the lip. The medial bundles elevate the lip in the area of the anterior teeth, and the lateral bundles act on the area of the posterior teeth. The lip then finds resistance due to the adipose tissue in the cheeks. The second stage (spontaneous smile) begins with higher elevation, both in the lip and in the nasolabial groove, under the action of three muscle groups: the elevator of the upper lip, originating in the infraorbital area; the zygomatic major muscle and the upper fibers of the buccinator muscle.²³

The appearance of half-shut eyes should accompany the final stage and represents the contraction of the periocular musculature (orbicular muscles of the eyes), in order to support the maximum elevation of the upper lip through the nasolabial fold. The half-shut look that accompanies the smile is a muscular trigger of the face that activates the centers in the temporal anterior area of the brain, which regulates the production of pleasant emotions. Therefore, without this final action of semi-closure of the eyes, the noticeable happy smile is probably a false smile, without joy from the person who gives it⁹ (Fig 16).

Phases of the smile

In addition to the stages, the smile also follows phases. These phases are threefold: the first is named the initial “peak” phase, which corresponds to the period in which the lips depart from a neutral position until the position of maximum lip contraction during the spontaneous smile. During this phase, mouth width is increased and lip height is reduced, the commissures move upwards and sideways in the same ratio, with great individual variability in the direction of the movement of these points. It is

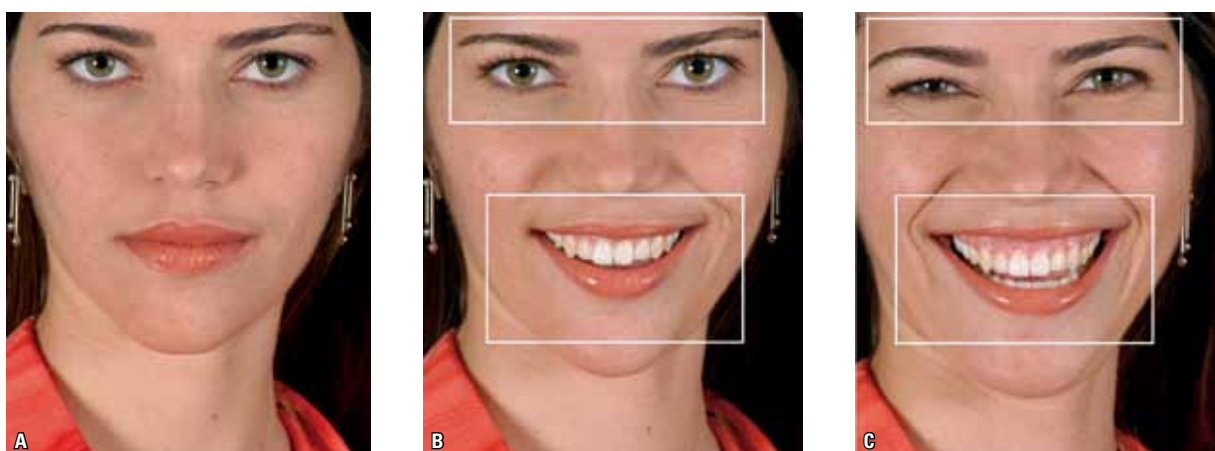


FIGURE 16 - Resting position (A). First stage of the smile – Social smile (B). Second stage of the smile – Spontaneous smile. Notice that in this stage the patient's eyes are half-shut. (C).

the shortest phase of the cycle, lasting on average less than 0.5 second. The second phase is lip support. It is during this phase that the smile is dependent on stimulus. The duration of this phase is quite variable and depends on individual volition. The last phase is the decline, in which the lips close again. The duration of this phase is usually longer than the initial peak phase, but as with the support phase, it is not possible to measure its duration because it is subject to a stimulus. In evaluating the smile cycle, it can be observed that the only reproducible phase is the initial one. Unlike the other phases, which can be influenced by individual volition, the peak phase depends only on the initial stimulus that causes the smile, although its duration is extremely brief.²⁶ This hinders the collection of static images, such as photographs, as it is practically impossible to record the maximum smile obtained during the first phase. That is why several authors advise against evaluating the smile using photographic images, recommending instead that video images be taken.^{1,24}

Stimulating and recording the smile

Although 18 types of smiles have been recorded,⁹ the smile that directly interests the field of dentistry is the one that expresses joy. This is the smile type known as Duchenne, in which there is a contraction of the orbicular musculature of the eyes combined with traction of the corner of the lip by the zygomatic major muscle; among the different types of smiles, it is the one that best demonstrates satisfaction or happiness. It is the spontaneous smile.⁹ As such, the smile that expresses pleasure is the type that professionals seek to record. For that type of record, a stimulus is necessary. In this case, the stimulus becomes a problem, as what is funny to one person is not so to another. The difficulty in obtaining photographs that represent the patient's natural smile in clinical practice was observed by Rigsbee et al,²² who reported that the interac-

tion of the photographing professional and the patient should not be underestimated, and suggested the use of phrases to obtain the picture. This method is also recommended by Zachrisson³⁰, who suggests the use of the word "cheese" to stimulate the exposure of the incisors during smiling. For records of the resting position, the author recommended that teeth be slightly apart, and that perioral soft tissues and the mandibular position be relaxed.³⁰ Although the use of phrases can be useful, the best way to obtain a smile is through comic stimulus. The use of videos, photographs, or even the professional's comic ability can be used to provoke the stimulus. What is important is that the stimulus causes a smile that expresses pleasure. For evaluations that involve the relationship between the teeth and upper lip, it is recommended, in spite of possible questioning, that the patient pronounce the sound of the letter "e" in an uninhibited and exaggerated manner. This causes the maximum elevation of the upper lip.²¹

Recording the smile is another problem. The ideal is that static (photographs) and moving (video) records be made. In the static records, image gathering should include close-up shots in frontal, sagittal, and oblique planes. For the moving records, video should be recorded and uploaded to a computer, and the best image selected.^{24,25} During the evaluation, preference can be given to the social or spontaneous smile with maximum elevation of the upper lip. What is important is that the initial record be the same as the final record, so that differences can be evaluated without interference from the different stages. In other words, if the first record was made in stage 1, so should the final record.

UPPER LIP LINE

The upper lip line represents the lower edge of the lip, and dictates the exposure of upper teeth. Not only anterior teeth have their exposure limited by this line, but posterior teeth as

well. Several authors recommend that during smiling, the position of the lower edge of the upper lip should coincide with the gingival edge of the maxillary central incisor.^{14,15,17} However, other authors consider that a smile could be aesthetically acceptable with exposure of up to 2 mm of gingival tissue.^{3,10,30} This difference in opinions leads to inadequate and confusing concepts that do not help the standardization of smile classifications. Although the simplest way to classify the smile line—using the relationship between the maxillary incisors and the upper lip—is through height (low, medium, and high), the description of the parameters is still inadequate. For example, the classification of smile heights as described by Tjan et al²⁹ used by Dong et al,⁸ regards as high any smile in which the crown of the maxillary central incisor is totally exposed. Therefore, a smile with a band of gingival tissue only 1 mm thick would receive the same classification as a smile with, for instance, 5 mm of gingival tissue exposure. The same can be said of the classification described by Teo,²⁸ which classifies as Class I all smiles in which the buccal surface of the incisor is totally exposed, regardless of the amount of visible gingival tissue. Likewise, the classification of a smile when the upper lip does not expose the maxillary incisors is also confusing in the descriptions by some authors.^{3,11} In the Goldstein¹¹ classification, a smile featuring the upper lip covering only 1 mm of the crown of the maxillary central incisor will receive the same classification as another smile with the upper lip covering more than half or even the entire crown of the maxillary central incisor.

As previously mentioned, the ideal is for the height of the smile line to be classified using as reference the relationship between the lower edge of the upper lip and the gingival edge of the maxillary central incisor. However, a 2 mm limit should be established above and below the gingival edge, thus instituting the three classes of smile height: high, medium, and low (Fig 17).

As such, a positive aspect is that, with a 4 mm difference, the differentiation of high and low smiles—the smile types that lead patients to seek treatment—is clinically facilitated.²¹ Moreover, a numeric differentiation is created among the heights, making it easier to measure their classification.

Smile height is influenced by age and gender. The older the individual, the greater is the tendency for a low-type smile.⁷ This piece of information is clinically relevant, as high smiles tend to become medium smiles with age, and low smiles become even lower over time. In other words, there is a possibility of self-correction for “gingival” smiles over time, which is not true for low smiles.

Gender also seems to influence smile height. Although not many studies exist on the subject, the work of Puppini²¹ shows that there is a greater tendency for women to show medium (55.9%) and high (37.7%) smile lines, while men feature medium (54%) and low (23.8%) smile lines. These findings are similar to the values found in the work of Peck, Peck and Kataja,²⁰ who also observed that medium (52.2%) and high (32.5%) smiles are more common in women and that medium (48%) and low (33%) smiles prevail in men.

The smile line can be regarded as a determining factor in the evaluation of mouth aesthetics.

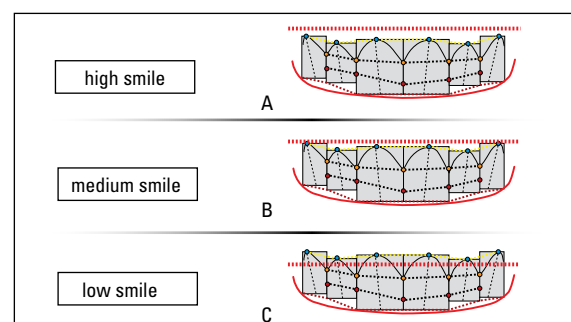


FIGURE 17 - High smile (A); medium smile (B); low smile (C).

The aesthetic results of orthodontic treatments always maintain a strong relationship to this line. It is not uncommon for the conclusion of orthodontic treatments to be compromised by the smile line. Either high or low smiles can compromise the results. This is perhaps the great challenge of contemporary orthodontics in its search for excellence. The integration between the different dentistry specialties will need to be expanded also to the medical fields that can positively interfere in the solution of mouth aesthetic problems that are compromised by the negative influence of the smile line, in particular the upper lip line. Medical and dental interventions that are able to correct a negative labial influence are always welcome. This integrated approach by professional teams will bring new possibilities of better results, expanding treatment options, and perhaps creating a higher demand for the solution of problems involving mouth, facial and dental aesthetics.

LOWER LIP LINE

Although the lower lip line is less studied than the upper lip line, it is no less important. It consists of the group formed by the upper and lower lips that will produce labial unveiling.

In general, it is the shape of the lower lip and the incisal edges of maxillary and mandibular tips that create a pleasing or unpleasing smile ensemble.²⁵ What is important is that the maxillary incisal plane and the shape of the lower lip retain a harmonious relationship.³⁰ That harmony is represented in the parallelism of the arch formed the incisal edges of maxillary teeth with the upper edge of the lower lip.

There should be harmony between the curvature of the incisal edge of anterior maxillary teeth with the curvature of the upper edge of the lower lip during voluntary smiling.¹¹ This relationship between the incisal edges of canines and maxillary incisors with the lower lip is called the smile arch.^{10,24} The ideal is for the curvature

of incisal edges to be parallel to the lower lip and the incisal edges slightly apart or softly touching the lip. However, this is only possible when the lower lip creates a natural curvature, with the corners of the mouth turned upwards, and incisal edges follow that curvature. In other words, in order to achieve a pleasing effect, it is necessary that dental and labial structures be symmetrical. In case the lips or teeth limit the parallelism between them, the smile arch will not be possible. Labial asymmetry is also a limiting factor for this harmony between teeth and lip.

As previously mentioned, the ideal is that the line formed by the incisal edges of anterior teeth creates the form of a “deep plate”, in which the central incisors are positioned more inferior to the lateral incisors and canines, and are in harmony with the other smile lines⁵ (Fig 18).

This configuration varies with age. As age advances, the “deep plate” form is altered, giving way to a new “shallow plate” or “inverted plate” form. That is, the line that contours the incisal edge becomes plainer or more concave. The wear in the incisal edges creates these new forms over time. Knowledge of these characteristics creates the possibility of rejuvenating or aging a smile. A change in the “plate forms” can make this effect possible⁵ (Fig 19).



FIGURE 18 - The vertical positioning of the maxillary incisors and canines forms a curvature; the line that contours this relationship resembles the figure of a “deep plate”.

It should be clear that the ideal relationship of parallelism between maxillary teeth and lower lip is dictated by the lip. The contraction pattern of the lower lips and their relationship with teeth are much less uniform than those of the upper lips. Whereas in the relationship between the upper lip and maxillary teeth it is possible to establish three defined positions with regard to the smile line (high, medium, and low), the same is not possible with the lower lip. The smile's own dynamics complicate this evaluation. The possibility of an individual opening his mouth wider or not makes a standardized evaluation more difficult. Maxillary teeth may occasionally touch the lower lip (contact position), remain apart (non-contact position), or else be covered by the lip (covered position).¹⁰ This situation can vary among individuals or even in the same person depending on mouth opening. The muscle contractions of the lower lip also alter this relationship. Muscles such as the risorius, mentalis, triangularis and quadratus of the lower lip are responsible for the contraction of the lower lip and its greater or lesser participation during smiling interferes in labial contraction and symmetry.²³ Variations in the contraction and intensity of muscle groups play an important role in the creation of different smiles.

Vigorous contractions pull down the lower lip, increasing tooth exposure. Individuals with intense contractions of the lower lip tend to also expose their lower teeth (Fig 20).

This situation requires attention, as the needs and possibilities of the aesthetic treatment change perspective, because the evaluation is usually made of the relationship between the lips and maxillary teeth, and not the full arch. Seeking parallelism between the incisal line and the lower lip (smile arch) is totally unfeasible, showing us that establishing aesthetic rules and objectives by taking the lower lip in consideration does not allow standardizations. Another situation that also creates difficulties in obtaining the smile arch is when the lower lip contracts in an inverted fashion; the contraction of the lower lip is greater in the area of the canines than in the area of the incisors, possibly due to greater action by the risorius muscle. When the upper lip also contracts in the same manner, the appearance of “mirroring” is created between the lips. This lower lip contour is usually accompanied by a low smile line and the figure formed by the lips resembles the infinity symbol (∞). (Fig 21). This “infinity-type” smile figure indicates an unfavorable prognosis for mouth aesthetic treatments.

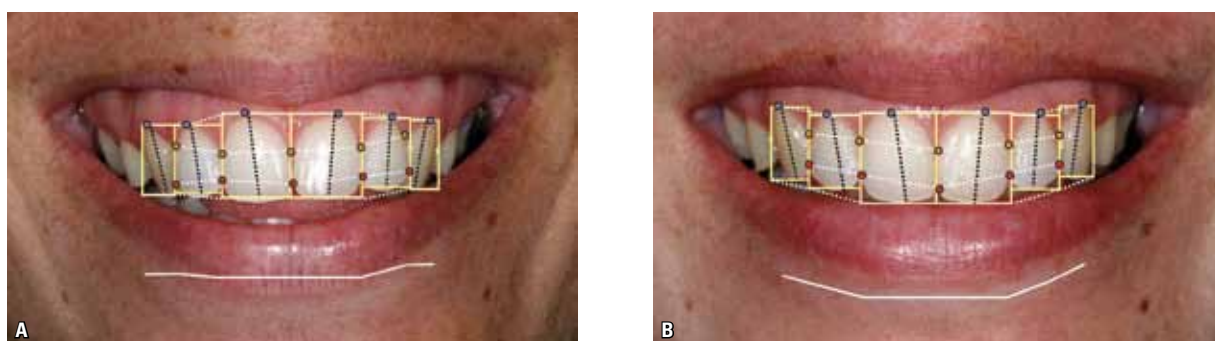


FIGURE 19 - The vertical repositioning of the maxillary incisors and canines, after an ortho-surgical treatment featuring maxillary impaction and rotation, resulted in an improved relationship between the incisal edges of the maxillary anterior teeth and the lower lip, creating the “deep plate” figure. This convex line gives a more pleasing and jovial aesthetic aspect (A, B).



FIGURE 20 - Excessive contraction of the lower lip, completely exposing the mandibular incisors.

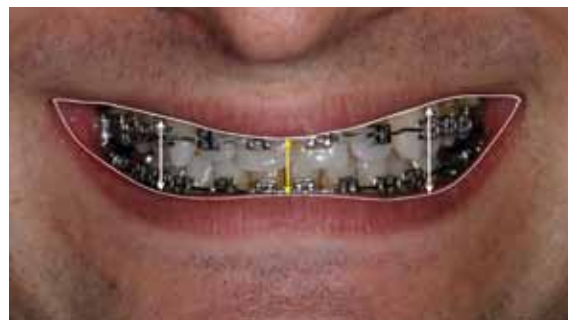


FIGURE 21 - "Mirroring" of lower lip and upper lip forms. Notice that the area of the lower lip (yellow arrow) is closer to the upper lip than the lateral areas (white arrows). The figure formed by the lips resembles the infinity symbol (∞).

CONCLUSION

Knowledge of the intrinsic characteristics of the smile helps in the aesthetic perception of it. Being able to evaluate the smile of each patient assures the professional of the possibility of seeing what needs to be done, what can be done, and what should be accepted. In other words, being able to interpret the nuances of a smile gives each orthodontist the opportunity to act in a conscious manner in the mouth aesthetic treatment of their patients, allowing the diagnosis to be integrated with the prognosis and giving a realistic outlook of the results than can be obtained. In that perspective, the six horizontal smile lines meet this purpose, as the analysis of these lines facilitates the understanding of the intrinsic characteristics of the smile and gives each professional a better look into their chances for success. Nevertheless, we know that observing the six lines is not enough to evaluate a smile. Several other factors also need to be taken in consideration. Buccal corridor, number of exposed teeth during smiling, frontal, oblique and profile facial analyses, relationship between resting and speech positions and the smile are some factors that should also be observed in order to achieve a better diagnosis of mouth aesthetics. Although these components were not examined in this work,

they should not be ignored, as, along with the six lines, they can allow a complete observation of the smile, facilitating its understanding and treatment possibilities.

ACKNOWLEDGEMENTS

Adilson Torreão, Adilson Torreão Filho, Aldino Puppim, Isana Álvares, Jonas Capelli Jr., Marco Antônio Almeida, Vera Cosendey.

Submitted: March 2009
Revised and accepted: December 2009

REFERENCES

- Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. *J Clin Orthod*. 2002 Apr;36(4):221-36.
- Andrews LF. *Straight-Wire: the concept and appliance*. San Diego: Wells; 1989.
- Arnet GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. *Am J Orthod Dentofacial Orthop*. 1993 Apr;103(4):299-312.
- Burres SA. Facial biomechanics: the standards of normal. *Laryngoscope*. 1985 Jun;95(6):708-14.
- Câmara CALP. *Estética em Ortodontia: diagramas de referências estéticas dentárias (DRED) e Faciais (DREF)*. Rev Dental Press Ortod Ortop Facial. 2006 nov/dez;11(6):130-56.
- Chiche G, Pinault A. Artistic and scientific principles applied to esthetic dentistry. In: Chiche G, Pinault A. *Esthetics of anterior fixed prosthodontics*. St. Louis: Quintessence; 1994. p. 13-32.
- Cosendey V L. *Avaliação do relacionamento entre o lábio superior e incisivos durante a fala e o sorriso*. [dissertação]. Rio de Janeiro (RJ): Universidade do Estado do Rio de Janeiro; 2008.
- Dong J, Jin T, Cho H, Oh S. The esthetics of the smile: a review of some recent studies. *Int J Prosthodont*. 1984 Jan;12(1):16-24.
- Ekman P, Davidson RJ, Friesen WV. The Duchenne smile: emotion expression and brain physiology II. *J Pers Soc Psychol*. 1990 Feb;58(2):342-53.
- Fowler P. Orthodontics and orthognathic surgery in the combined treatment of an excessive gummy smile. *New Zealand Dent J*. 1999 Jun;95:53-4.
- Goldstein RE. *Estética em Odontologia*. Rio de Janeiro: Ed. Guanabara Koogan; 1980.
- Grove PB. Webster's third new international dictionary of the English language. Springfield: G and C Merriam Company; 1961.
- Kurth JR, Kokich VG. Open gingival embrasures after orthodontic treatment in adults: prevalence and etiology. *Am J Orthod Dentofacial Orthop*. 2001 Aug;120(2):116-23.
- Legan HL, Burstone CJ. Soft tissue cephalometric analysis for orthognathic surgery. *J Oral Surg*. 1980 Oct;38(10):744-51.
- Levine RA, McGuire M. The diagnosis and treatment of the gummy smile. *Compend Contin Educ Dent*. 1997 Aug;18(8):757-62, 764; quiz 766.
- Magne P, Belser U. *Restaurações adesivas de porcelana na dentição anterior. Uma abordagem biomimética*. São Paulo: Quintessence; 2003.
- Marckley RJ. An evaluation of smiles before and after orthodontic treatment. *Angle Orthod*. 1993 Fall;63(3):183-9.
- Mathews TG. The anatomy of a smile. *J Prosthet Dent*. 1978 Feb;39(2):128-34.
- Morley J, Eubank J. Macro esthetic elements of smile design. *J Am Dent Assoc*. 2001 Jan;132(1):39-45.
- Peck S, Peck L, Kataja M. Some vertical lineaments of lip position. *Am J Orthod Dentofacial Orthop*. 1992 Jun;101(6):519-24.
- Puppin FA. *Avaliação quantitativa de medidas dento-faciais relacionadas à altura da linha do sorriso*. [dissertação]. Rio de Janeiro (RJ): Universidade do Estado do Rio de Janeiro; 2002.
- Rigsbee OH 3rd, Sperry TP, BeGole EA. The influence of facial on smile characteristics. *Int J Adult Orthodon Orthognath Surg*. 1988;3(4):233-9.
- Rubin LR. The anatomy of a smile: its importance in the treatment of facial paralysis. *Plast Reconstr Surg*. 1974 Apr;53(4):384-7.
- Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 1. Evolution of the concept and dynamic records for smile capture. *Am J Orthod Dentofacial Orthop*. 2003 Jul;124(1):4-12.
- Sarver DM. The importance of incisor positioning in the esthetic smile: smile arc. *Am J Orthod Dentofacial Orthop*. 2001 Aug;120(2):98-111.
- Tarantili VV, Halazonetis DJ, Spyropoulos MN. The spontaneous smile in dynamic motion. *Am J Orthod Dentofacial Orthop*. 2005 Jul;128(1):8-15.
- Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *J Periodontol*. 1992 Dec;63(12):995-6.
- Teo CS. An evaluation of the smiling lip line. *Singapore Dent J*. 1981 May;6(1):27-30.
- Tjan AH, Miller GD, The JG. Some esthetics factors in a smile. *J Prosthet Dent*. 1984 Jan;51(1):24-8.
- Zachrisson BU. Esthetic factors involved in anterior tooth display and smile: vertical dimension. *J Clin Orthod*. 1998;32(7):432-45.

Contact address

Carlos Alexandre Câmara
 Rua Joaquim Fagundes 597, Tirol
 CEP: 59.022-500 – Natal / RN
 E-mail: cac.ortodontia@digicom.br

Angle Class II, Division 2, malocclusion with deep overbite

Paulo Renato Carvalho Ribeiro*

Abstract

This case report describes the orthodontic treatment of an adult patient, who presented a Angle Class II, Division 2, malocclusion, with overbite, severe curve of Spee, right maxillary lateral incisor proclined and gingival recessions. The patient was treated with extraction of the first premolars and maximum anchorage control. This case was presented to the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) representing the category 6, deep overbite malocclusion, as part of the requirements for obtaining the title of Diplomate by BBO.

Keywords: Angle Class II malocclusion. Corrective Orthodontics. Deep overbite.

HISTORY AND ETIOLOGY

The patient presented for initial examination at the age of 24 years and 7 months in good general health and no history of serious illness or injury. Her main complaint was related to the fact that the incisors were malpositioned with significantly altered axial inclination. The patient reported having undergone endodontic treatment in the upper left central incisor and had extensive resin restorations in the anterior teeth. No orthodontic treatment had hitherto been performed.

DIAGNOSIS

The patient presented with an Angle Class II, Division 2 malocclusion, a 100% overbite, sharp retroclination of teeth 11, 21 and 22, and labioversion of tooth 12. The upper dental arch contained extensive restorations in the central incisors, some recession, especially in the first molars,

and crowding. The lower arch exhibited adequate alignment, but with a pronounced Curve of Spee (Figs 1 and 2).

An analysis of the periapical radiographs disclosed an endodontic treatment in tooth 21 and reassured the author that the patient did not present with any condition that might compromise the orthodontic treatment (Fig 3). The side profile X-ray and cephalometric tracing showed: Incisor uprighting ($I-NA = 0^\circ$); Class II skeletal pattern, ANB angle = 5° , ($SNA = 80^\circ$ and $SNB = 75^\circ$) and normal mandibular growth in the vertical orientation ($SN-GoGn = 32^\circ$, $FMA = 23^\circ$ and $Y-axis = 60^\circ$). This information can be viewed in Figure 4 and Table 1.

A facial evaluation showed a straight side profile ($UL = 1\text{ mm}$ and $LL = 0\text{ mm}$), with passive lip seal, absence of significant asymmetries and proportional facial thirds.

* Specialist in Orthodontics and Facial Orthopedics, Rio de Janeiro State University (UERJ). Professor at the Course of Specialization in Orthodontics and Facial Orthopedics, Brazilian Dental Association (ABO) Juiz de Fora (MG). Graduate from the Brazilian Board of Orthodontics and Facial Orthopedics.



FIGURE 1 - Initial facial and intraoral photographs.

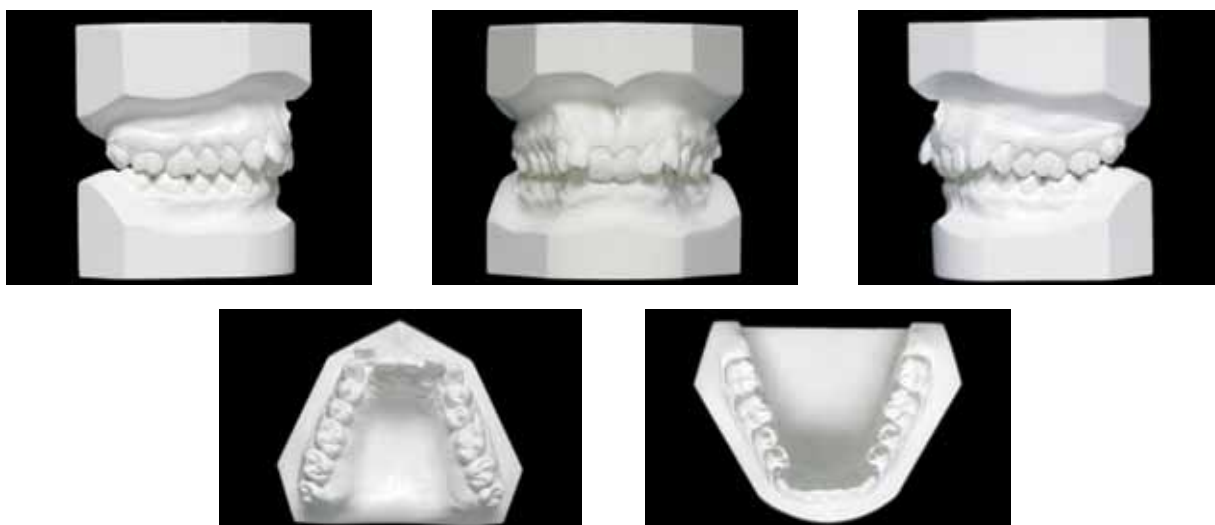


FIGURE 2 - Initial casts.

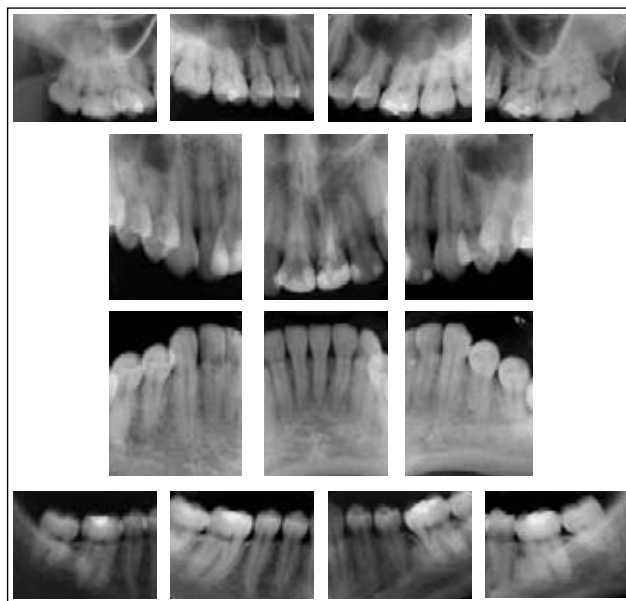


FIGURE 3 - Initial periapical radiographs.

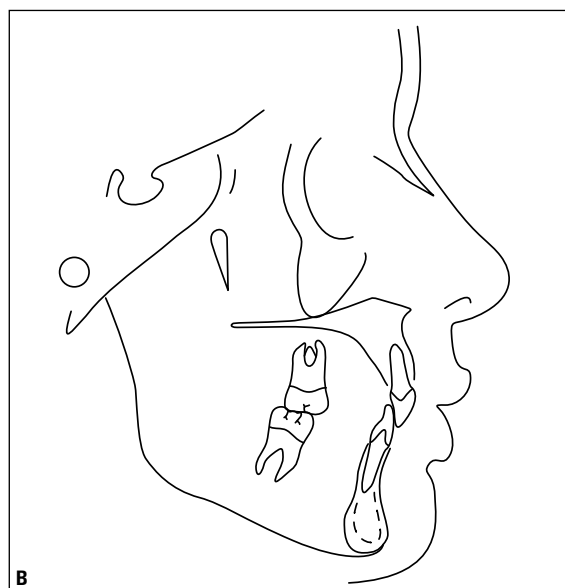


FIGURE 4 - Initial cephalometric radiograph of side profile (A) and cephalometric tracing (B).

TREATMENT GOALS

Considering that this is an adult patient with a harmonious facial profile, the author attempted to maintain the vertical, transverse and antero-posterior position of the bone bases. As regards

maxillary dentition the intent was to maintain the Class II molar relation with total control over anchorage, overbite correction and upper incisor inclination.^{4,5,6} The specific goal for the mandibular dentition was to level the Curve of Spee

while maintaining the intercanine and intermolar widths. Thus, it was anticipated that upon treatment completion correct guides would be achieved for the canines with adequate overbite and overjet, promoting a significant improvement in smile esthetics.

TREATMENT PLAN

To achieve the proposed goals the patient was informed that the treatment plan involved the extraction of the first upper premolars. In the following step, an orthodontic appliance was fixed to the upper arch teeth (Standard Edgewise system, slot 0.022 x 0.028-in), a headgear and transpalatal arch were fitted and round stainless steel 0.014 to 0.020-in arch wires were used for alignment and leveling of the posterior segments. To enable the alignment of the upper anterior teeth, the canines were moved slightly distally using sectional arch wires (T loops). At the same time a Ricketts^{5,6} utility arch wire was made from round stainless steel and used to correct the overbite and projection of the upper incisors. Whenever possible, based on this projection of the upper incisors, the orthodontic appliance was bonded to the lower arch and a series of 0.014 to 0.020-in straight arch wires installed for leveling. For anchorage control the use of Class II mechanics was also planned, in case it proved necessary. After moving the upper canines distally the incisors were retracted using rectangular 0.019 x 0.025-in stainless steel arch wires, with vertical loops between the lateral incisors and canines. The cases were finished using upper and lower 0.019 x 0.025-in arch wires with individual bends, as needed. Upon completion of the active treatment, the author used, as planned, an upper removable wraparound retainer made of 0.036-in stainless steel wire, and on the lower arch, an intercanine retainer using 0.032-in wire. The patient was duly instructed, verbally and in writing, about the necessary cares in handling the retention appliances, as well as their oral hygiene.

TREATMENT PROGRESS

Attachments were welded to orthodontic bands, which were fitted to the first and second molars and a transpalatal arch was installed on teeth 16 and 26. Subsequently, the patient was instructed to have teeth 14 and 24 extracted, and finally Standard Edgewise metal brackets (slot 0.022 x 0.028-in)—with no built-in angulation or torque—were bonded. Then a Klohen type traction device was provided for the patient to wear during night time. Sectional arches were used to start the alignment and leveling on the right and left hand sides from second molar to canine with 0.015-in coaxial stainless steel wire and straight 0.014 to 0.018-in round arch wires. To promote incisor alignment canines were moved slightly distally. Simultaneously, a Ricketts utility arch was fashioned using round stainless steel 0.014-in arch wire initially applied only to achieve central incisor projection. As soon as possible the lateral incisors were included and alignment and leveling proceeded up to a 0.018-in arch wire. The canines continued to be retracted with a stainless steel 0.017 x 0.025-in sectional arch. However, anchorage control was compromised due to inadequate patient compliance in using the traction device, which required a change in mechanics. To intrude the anterior teeth 0.018-in stainless steel wire was used as a stabilizing arch, including all upper teeth except the canines—which were bypassed—, and Burstone T-loops made with 0.017 x 0.025-in TMA wire were used for canine retraction. Thanks to this change, anchorage control was achieved. On the lower arch, the same type of brackets bonded to the upper arch were utilized. Alignment and leveling were performed using 0.014 to 0.020-in stainless steel arch wires. For upper incisor retraction 0.018 x 0.025-in stainless steel arch wires were used, with loops. On the lower arch, an arch wire of the same thickness was formed, with well adjusted omegas loops, and the use of Class II intermaxillary elastics was prescribed to improve anchorage. Upon

completion of space closure, the upper arch was re-bonded for re-leveling with 0.014 to 0.020-in stainless steel wire. The treatment was completed using ideal stainless steel 0.019 x 0.025-in arch wire on the upper and lower arches and the use of Class II elastics. Third molar extraction was prescribed. After ensuring that all the intended goals had been achieved the orthodontic appliance was removed and the retention phase began. To this end, we used a removable upper wraparound retainer, made with stainless steel wire 0.036-in and a lower retainer with round wire 0.032-in bonded

to teeth 33 and 43. The patient was recommended to wear the upper retainer 24/7 for the first year and after that period, twelve hours a day for six months, and finally, just nights for another six months. The lower intercanine retainer was prescribed indefinitely.

TREATMENT RESULTS

In reviewing the patient's final records (Figs 5 to 9), it becomes clear that the goals were attained.^{1,7} In the maxilla, the bone base was kept at a vertical and transverse position, with a small



FIGURE 5 - Final facial and intraoral photographs.

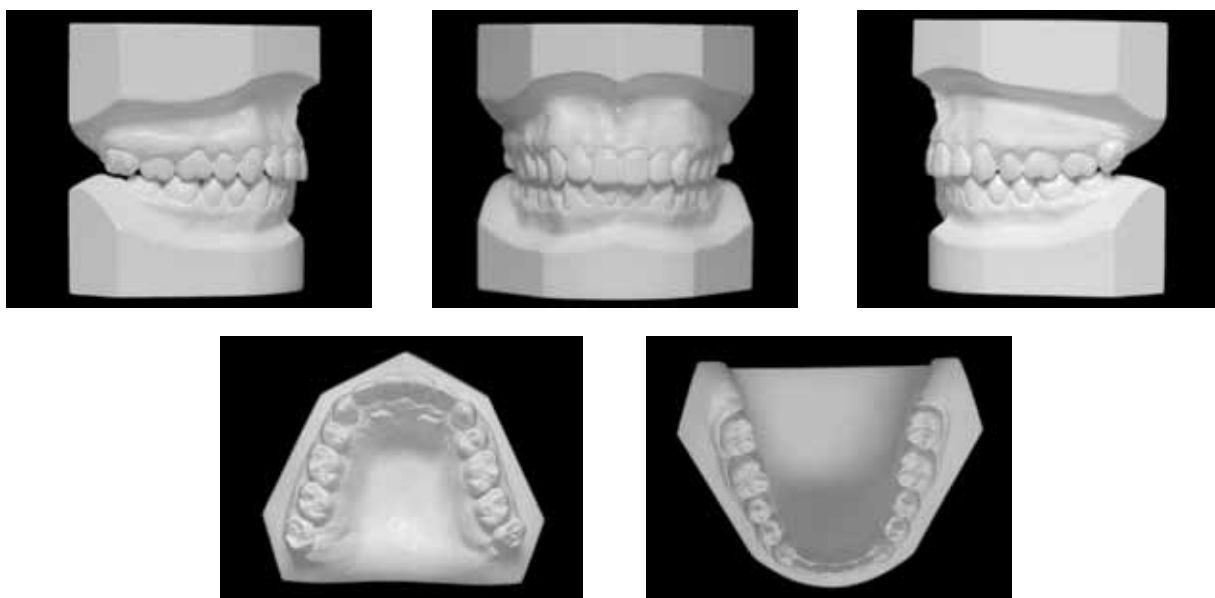


FIGURE 6 - Final casts.



FIGURE 7 - Final panoramic radiograph.

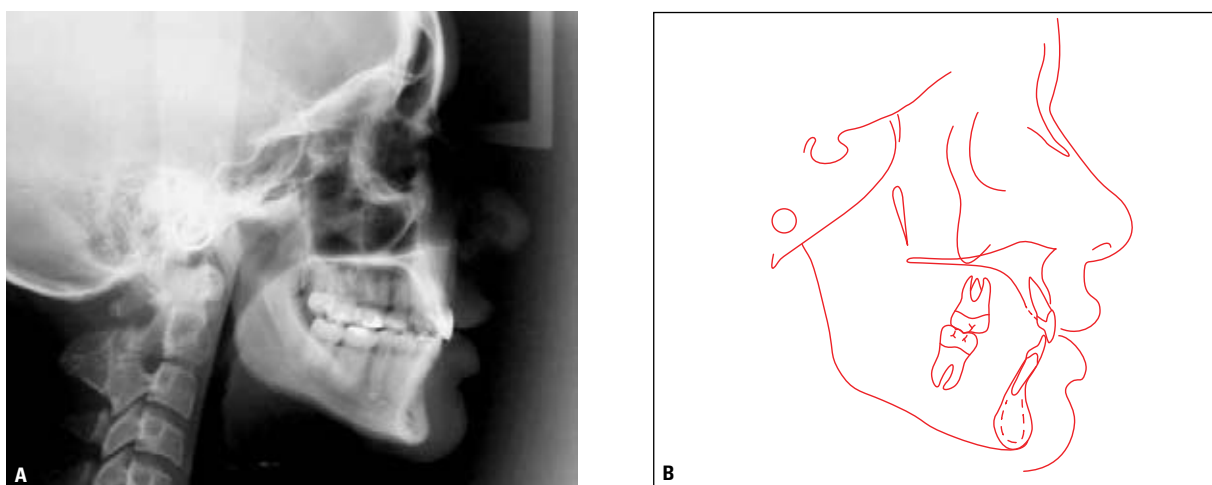


FIGURE 8 - Final cephalometric radiograph of side profile (A) and cephalometric tracing (B).

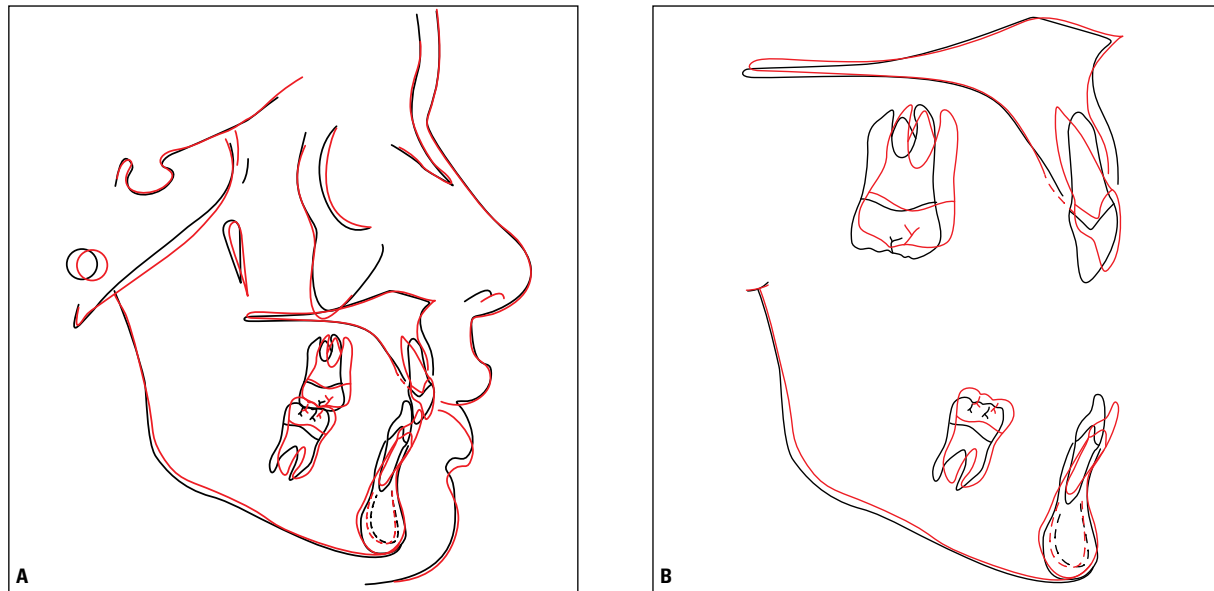


FIGURE 9 - Total (A) and partial (B) superimposition of initial (black) and final (red) cephalometric tracings.

anteroposterior change reflected in the slight movement of point A, due to the correction of incisor inclination. This resulted in a Class I skeletal pattern with the ANB angle changing from 5° to 4° . As can be seen in Table 1, the 1-NA angle underwent a major change from 0° to 16° and the linear positioning of the incisors (1-NA, mm) increased by 2 mm, increasing from 2 mm to 4 mm. This change was made to allow overbite correction, considering that the initial retroclination precluded intrusion owing to the proximity of the incisors' root apex to the cortical bone of the maxilla. The intercanine and intermolar widths were maintained (Table 2).

In the mandible, there was no change in the position of the bone base. There was an increase in incisor inclination, as can be seen in Table 1, reflected in alterations in the 1-NB measurements (from 14° to 26°) and the IMPA angle (from 87° to 98°). Thus, the interincisal angle underwent a significant change from 161° to 135° . Similarly to the maxilla, the intercanine and intermolar

widths remained unchanged (Table 2).

An analysis of the panoramic radiograph (Fig 7) revealed adequate root parallelism, except in the region between the upper lateral incisor and canine on the right hand side and between the lower canine and first premolar on the same side. There was also a slight apical blunting of the upper incisors, compatible with the significant movement performed in these teeth.

The dental occlusion showed an improved posterior intercuspation on both sides and the treatment was finished with a Class II relation on the molars, occlusion key on the canines, as well as adequate overbite and overjet. The gingival recessions, which had been noted initially, remained unchanged. The patient was requested to undergo an aesthetic rehabilitation treatment in the anterior region as well as to have her third molars extracted. Facial aesthetics did not change significantly while the facial profile was maintained. The smile, however, improved significantly due to the proper alignment and leveling of the anterior teeth.



FIGURE 10 - Facial and intraoral control photographs taken three years and four months after treatment completion.

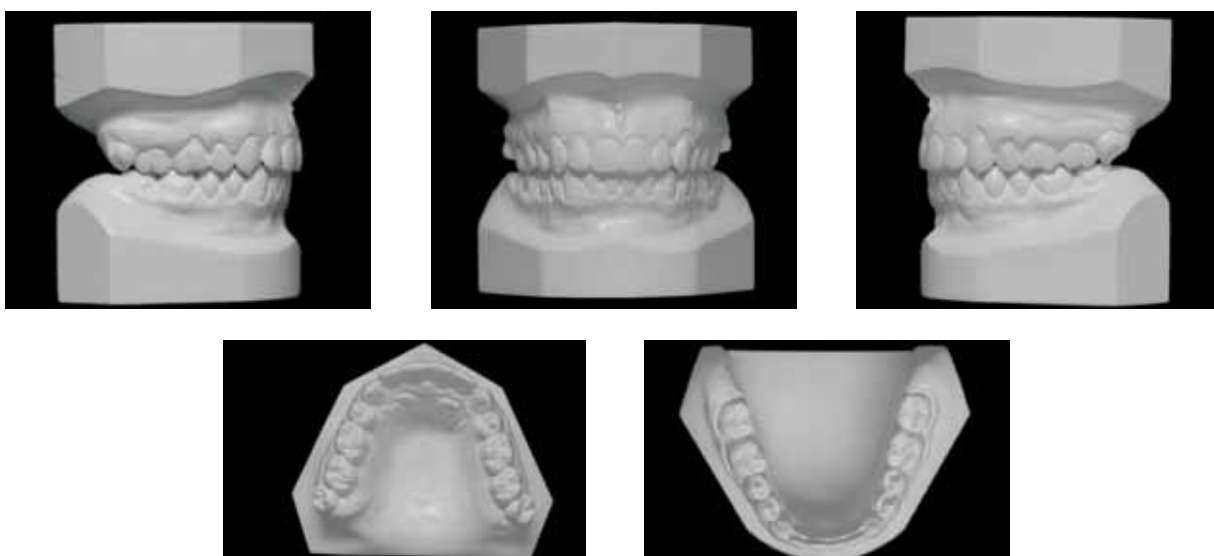


FIGURE 11 - Control casts - three years and four months after treatment completion.



FIGURE 12 - Panoramic (A) and periapical (B) control radiographs of incisors acquired three years and four months after treatment completion.

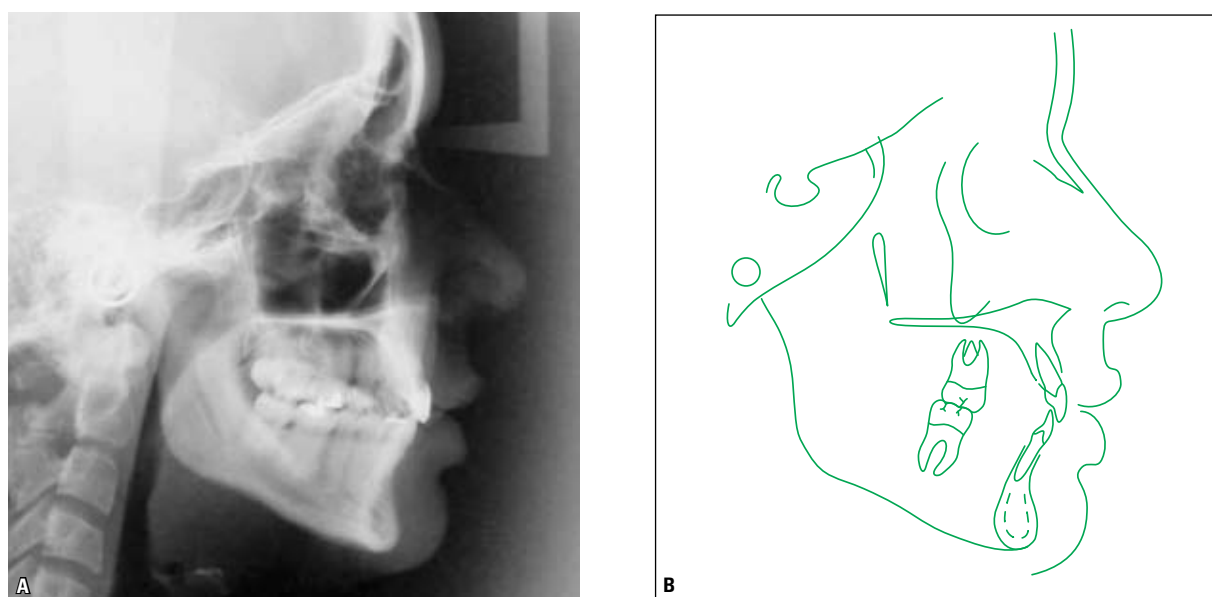


FIGURE 13 - Control cephalometric radiograph (A) and cephalometric tracing (B) - three years and four months after treatment completion.

Tests obtained three years and four months after the end of the corrective orthodontic treatment period (Figs 10 to 14) demonstrated that such positions remained stable. Upon treatment completion, the aesthetic rehabilitation had not

yet been fully performed and the third molar extractions had not been implemented. The cephalometric values had minor variations and the intercanine and intermolar widths were stable, as shown in Tables 1 and 2.

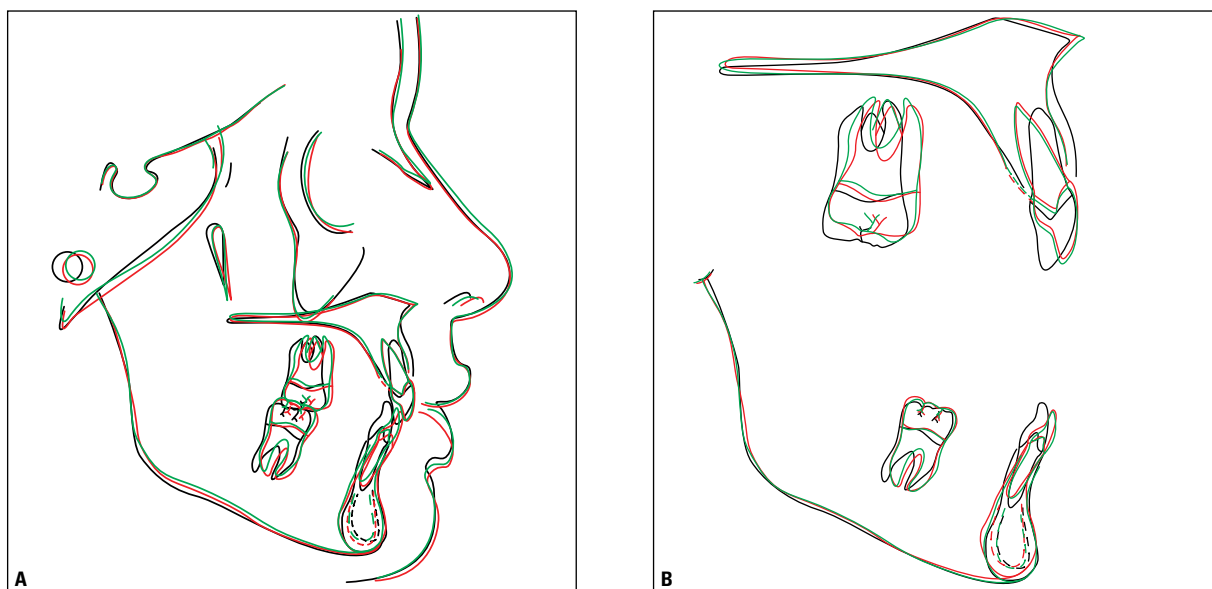


FIGURE 14 - Total (A) and partial (B) superimposition of initial (black), final (red) and control (green) cephalometric tracings - three years and four months after treatment completion.

TABLE 1 - Summary of cephalometric measurements.

	MEASUREMENTS	NORMAL	A	B	A-B DIFFERENCE	C
SKELETAL PATTERN	SNA (Steiner)	82°	80°	79°	1	79°
	SNB (Steiner)	80°	75°	75°	0	75°
	ANB (Steiner)	2°	5°	4°	1	4°
	Convexity Angle (Downs)	0°	7°	4°	3	6°
	Y-axis (Downs)	59°	60°	61°	1	61°
	Facial Angle (Downs)	87°	85°	84°	1	83°
	SN – GoGn (Steiner)	32°	32°	32°	0	33°
	FMA (Tweed)	25°	23°	25°	2	26°
	IMPA (Tweed)	90°	87°	98°	11	96°
DENTAL PATTERN	$\perp$ – NA (degrees) (Steiner)	22°	0°	16°	16	15°
	$\perp$ – NA (mm) (Steiner)	4 mm	2 mm	4 mm	2	4 mm
	$\bar{\perp}$ – NB (degrees) (Steiner)	25°	14°	26°	12	24°
	$\bar{\perp}$ – NB (mm) (Steiner)	4 mm	3 mm	6 mm	3	6 mm
	$\frac{1}{1}$ – interincisal angle (Downs)	130°	161°	135°	26	136°
PROFILE	$\bar{\perp}$ – APo (mm) (Ricketts)	1 mm	0 mm	3 mm	3	2 mm
	Upper Lip - S Line (Steiner)	0 mm	1 mm	0 mm	1	0 mm
	Lower Lip – S Line (Steiner)	0 mm	0 mm	0 mm	0	0 mm

TABLE 2 - Measurements of transverse distances on the dental arches (mm).

MEASUREMENTS		A	B	A - B Difference	C
Inter canine width	Upper	34.5 mm	34.5 mm	0	34.5 mm
	Lower	26 mm	26 mm	0	26 mm
Inter molar width	Upper	47 mm	47 mm	0	47 mm
	Lower	43 mm	43 mm	0	43 mm

FINAL CONSIDERATIONS

Angle Class II, Division 2 malocclusion is characterized by retroclination of central incisors usually associated with a pronounced overbite. To correct this anomaly in adult patients professionals often rely on the extraction of first premolars. This procedure, as in our case, requires adequate anchorage control to ensure an appropriate relation between the canines. The treatment described in this study shows that—even in the face of compliance issues regarding the patient's use of headgear—thanks to ongoing result assessment and a timely change in mechanics (in this case, the author resorted to the Burstone sectional arch mechanics) it is possible to keep anchorage under control by means of specific biomechanical principles²⁻⁷ and thus achieve the goals laid down at the start of treatment. The correction of severe overbite was performed by a set of well-planned tooth movements that initially included the projection of the upper incisors by means of an uncontrolled tipping movement so

as to allow the apex of these teeth to move away from the labial cortex. Only then was intrusion performed, as required, with the aid of a round Ricketts^{5,6} utility arch.

During upper incisor retraction as well as during the finishing phase it became necessary to use Class II⁸ elastic mechanics to facilitate anchorage control in view of some initial difficulties. With the increasing inclination of upper and lower incisors the interincisal angle's final value was very close to the ideal and by superimposing the initial, final and control cephalometric phases (Fig 14), as can also be seen in the occlusal records of the control phase (Figs 10 and 11), the stability of the mechanics used by the author is clearly demonstrated.

Submitted: October 2009
Revised and accepted: December 2009

REFERENCES

1. Andrews LF. The six keys to normal occlusion. *Am J Orthod.* 1972 Sep;62(3):296-309.
2. Burstone CR. Deep overbite correction by intrusion. *Am J Orthod.* 1977 Jul;72(1):1-22.
3. Burstone CJ, Koenig HA. Creative wire bending: the force system from step and V bends. *Am J Orthod Dentofacial Orthop.* 1988 Jan;93(1):59-67.
4. Nanda R. *Biomechanics in clinical Orthodontics.* 9ª ed. Philadelphia: W. B. Saunders;1997.
5. Ricketts RM. Bioprogressive therapy as an answer to orthodontic needs. Part I. *Am J Orthod.* 1976 Sep;70(3):241-68.
6. Ricketts RM. Bioprogressive therapy as an answer to orthodontic needs. Part II. *Am J Orthod.* 1976 Oct;70(4):359-97.
7. Strang R. *Tratado de Ortodontia.* 3ª ed. Buenos Aires: Bibliográfica Argentina;1957.
8. Tweed CH. *Clinical Orthodontics.* St. Louis: C. V. Mosby; 1966.

Contact address

Paulo Renato Carvalho Ribeiro
Rua Oswaldo Cruz, 75 – Santa Helena
CEP: 36.015-430 – Juiz de Fora / MG
E-mail: paulorenatojf@terra.com.br

Anticipated Benefit: a new protocol for orthognathic surgery treatment that eliminates the need for conventional orthodontic preparation

Jorge Faber*

Abstract

Introduction: Conventional orthodontic-surgical treatment for the correction of dentofacial deformities takes up a lengthy period of time preparing the patient orthodontically, which sometimes causes a temporary deterioration in the patient's appearance. This fact has set the stage for the development of a new treatment technique aimed at addressing these issues. **Objectives:** To introduce a new protocol—named Anticipated Benefit—and to illustrate it with a clinical case. **Methods:** The planning stages are presented and then illustrated by treating a patient with a Class III deformity. According to this method, after some careful planning the orthodontic appliance is fixed and subsequently orthognathic surgery is performed. **Conclusion:** Although both the traditional and the Anticipated Benefit techniques provide excellent functional and aesthetic results, the new protocol achieves significant improvements soon after the start of treatment. The new method has proved very convenient, particularly for the patient.

Keywords: Orthognathic surgery. Dentofacial deformities. Orthodontic preparation.

INTRODUCTION

Conventional orthodontic-surgical treatments for the correction of dentofacial deformities comprise—after diagnosis and treatment plan—a presurgical orthodontic stage, the orthognathic surgery *per se* and the orthodontic finishing stage.¹ This treatment method has also been tested by time. It has been used for decades and proved very effective. However, it has limitations because when patients decide to undergo

the treatment they have to wait for almost a year and a half for the surgery² and in most cases patients see their facial appearance worsen during this period. This is a paradox, as many patients who seek treatment expect to gain some aesthetic improvement,^{3,4,5,6} although the treatment produces a significant functional effect.

This limitation led me to develop and use in my private practice, since 2004, a treatment methodology that anticipates surgery. Applied

* Editor of the Dental Press Journal of Orthodontics. PhD in Biology – Morphology by the Electronic Microscopy Lab – University of Brasília. MSc in Orthodontics and Facial Orthopedics – Federal University of Rio de Janeiro.

after the diagnostic phase, this protocol is based on planning extensively all treatment stages, installing the orthodontic appliance, operating on the patient and only then proceeding with the orthodontic treatment.

This methodology anticipates the benefits derived from surgery and, accordingly, has been named Anticipated Benefit. It does not change the surgical technique significantly but rather the orthodontic treatment, which becomes more complex as it incorporates skeletal anchorage in most of the cases and requires a commitment by the orthodontist to achieve the goals established at the beginning of treatment. This article aims to describe this protocol by means of a case report.

ESTABLISHING THE GUIDELINES FOR AN ORTHODONTIC-SURGICAL TREATMENT

The first step is diagnosis, followed by a definition of the treatment guidelines and finally the treatment plan. The diagnosis—which requires anamnesis, physical and complementary examination—is essential. It provides guidance to the surgeon and the orthodontist regarding the needs of the case. However, the diagnosis does not change with this protocol. I therefore suggest the reading of specific articles on this subject.^{7,8,9} Once the diagnosis is ready the treatment is outlined. It might involve, for example, combined surgery of the maxilla and mandible for the correction of a Class III deformity. This approach is discussed with the patient and, if necessary, it is also discussed with the persons responsible for the patient. A technically ideal treatment is not always indicated for a specific patient. Cultural, social and economic aspects may have a bearing on the decision made by the patient. However, the doctor should advise the patient of the pros and cons of each treatment option.

Once the patient makes an informed decision the treatment plan is established.

COMBINED TREATMENT OF DENTOFACIAL DEFORMITIES

The treatment plan requires an integration of every specialty involved in the case. Thus, when a dentofacial deformity is treated by orthognathic surgery there will be at least two distinct but compatible plans, i.e., the orthodontic and surgical plans. Occasionally, a periodontal, prosthetic, restorative treatment, among others, may also be necessary.

In this article, we will focus our discussion on the orthodontic and surgical plans.

Orthodontic plan

Orthodontic plans are very complex and require that the professional possess a solid background. A treatise in orthodontics is not sufficient to encompass every aspect of the treatment plan. Thus, I will refrain from going into interdisciplinary details or matters that extend beyond the limits of a treatment in which the patient typically has a healthy, non-reduced periodontium with every tooth in place up to the second molars.

One decision should be made at the very start when performing the cephalometric tracing, namely, the final position of the upper and lower incisors. Next, it is very important to carefully assess incisor exposure during resting and smiling. The tracing should take into account both the inclination and the anteroposterior and vertical positions of these teeth. If the professional wishes to make any orthodontic changes in the maxillary or mandibular planes involving the intrusion or extrusion of the posterior teeth then this is the moment to plan it. However, these changes, related to open bite treatments,¹⁰ are very rarely implemented.

Once these positions are established, it is necessary to analyze the cast models and sometimes the patient him/herself. It is necessary to verify that there is appropriate periodontal structure to support tooth movement.

In addition, it is important to evaluate if there is enough space for such movements. For instance, when the upper molars are distalized it is necessary to verify if there is enough space on the tuberosity for the movement. If these changes are feasible, then one can proceed as planned. Otherwise, it is necessary to check it over again. Once incisor position has been established, the next step is making a set-up that simulates the desired orthodontic tooth movement. This technique has been described in detail in other publications.^{11,12} The purpose of the set-up is to allow the viewing of the tooth movement as a whole. With it, it is possible to see the prosthetic spaces at the end of treatment, detect the need for dental extractions, adjust the Bolton discrepancies, etc. However, above all, the set-up allows professionals to identify the anchorage required by each case.

After a realistic evaluation of the treatment, tooth movement is transferred to the cephalometric tracing. The molars are traced in their initial and final orthodontic treatment positions.

Currently, I use only *in silica* set-ups, i.e., on the computer. However, I apply the exact same principles used on cast model set-ups.

Surgical plan

Once the orthodontic treatment is viewed on the set-up the surgical plan can be performed. At this time, since there was no orthodontic treatment prior to surgery, the surgeon and the orthodontist should consider both the initial and the final tooth positions, after orthodontics. The surgical prediction tracing is performed along the same lines as the conventional tracing. The only difference is the fact that the whole plan should be carried out with the initial and final tooth positions included in the tracing and using different colors.

Orthognathic surgery

The surgical procedure itself does not

change. But some details should be considered by both surgeon and orthodontist.

The first pertains to the need for interocclusal acrylic trays after surgery. The trays enable the surgeon to find the position of the osseous fragments and give the orthodontist any hints as to the risk of surgical relapse during the first post-operative days. This is because any change in the occlusal relationship can be easily identified by an improper fitting of the tray on the dental arches.

The second detail relates to intermaxillary fixation. The establishment of a intermaxillary fixation after surgery depends on several factors which will not be discussed here such as, for instance, the fragility of the osseous fragments or a bad split. However, a transurgical fixation is almost always necessary. Thus, since the patient is not submitted to an orthodontic preparation and the surgery is performed in the aligning and leveling stages of treatment, specific arrangements are needed for the fixation.

The arrangements may be the preparation of passive rectangular arch wires with prewelded hooks, brackets with hooks on the cuspids and bicuspid, or Kobayashi hooks. Occasionally, intermaxillary screws may be required. Such screws are similar to mini-implants and are inserted directly into the bone through the gingiva while elastics or stainless steel wires are placed on the screws. Orthodontic mini-implants may be used for this purpose. In any case, however, the orthodontic arch wires must be tied with metal ligature. Elastic ligatures are not recommended given the risk that they be dropped into the surgical wound.

Personally, I do not use passive rectangular arch wires. In most cases, patients undergo surgery using active super-elastic arch wires with Kobayashi hooks. Due to the use of surgical acrylic trays for three weeks, orthodontic tooth movement is limited during the immediate post-operative stage.

Limitations

The main limitations for surgery at the beginning of treatment are severe curves of Spee and vertical asymmetries. The curve of Spee can make it difficult to establish a predictable mandible position. When asymmetries are the challenge, it is difficult to make a proper evaluation of the occlusal plane and the surgical needs to correct the asymmetries, due to the differences in height among teeth. In both cases, a pre-surgical aligning and leveling stage is highly recommended.

CASE REPORT

Diagnosis

A male patient, 18.9 years old, came to my office with a major complaint of facial disharmony. His deformity had appeared in his childhood and there were similar cases in his family, i.e., an aunt and a cousin. His condition exerted

a negative impact not only functionally but also, and very significantly so, aesthetically.

A facial analysis (Fig 1) showed a symmetric Class III dentofacial deformity with concave facial profile. The zygomaticnasolabial line was sinuous in the paranasal area with a disruption in the commissural level.^{7,8} The nose was well proportioned with the nasal apex well positioned to the vertical (Fig 4). Tooth exposure was moderate when smiling.

The intraoral clinical examination (Fig 1) and the study model (Fig 2) showed a Class III dental relationship with upper and lower crowding. A cephalometric analysis (Table 1, Fig 4) showed a skeletal Class III and a very significant mandibular prognathism. The upper incisors were buccally tipped and the lower incisors retroclined. In turn, the panoramic (Fig 3), cephalometric (Fig 4) and periapical X-rays of the whole mouth showed a Class III

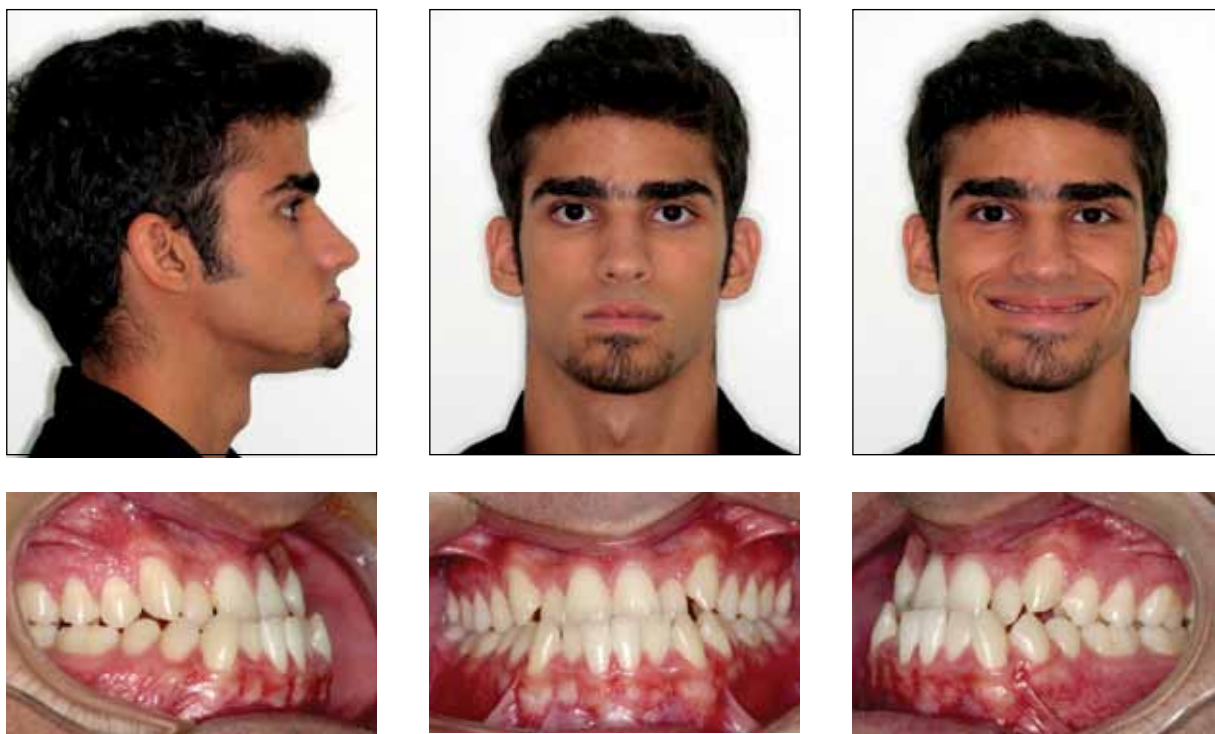


FIGURE 1 - Pretreatment extraoral and intraoral photographs.

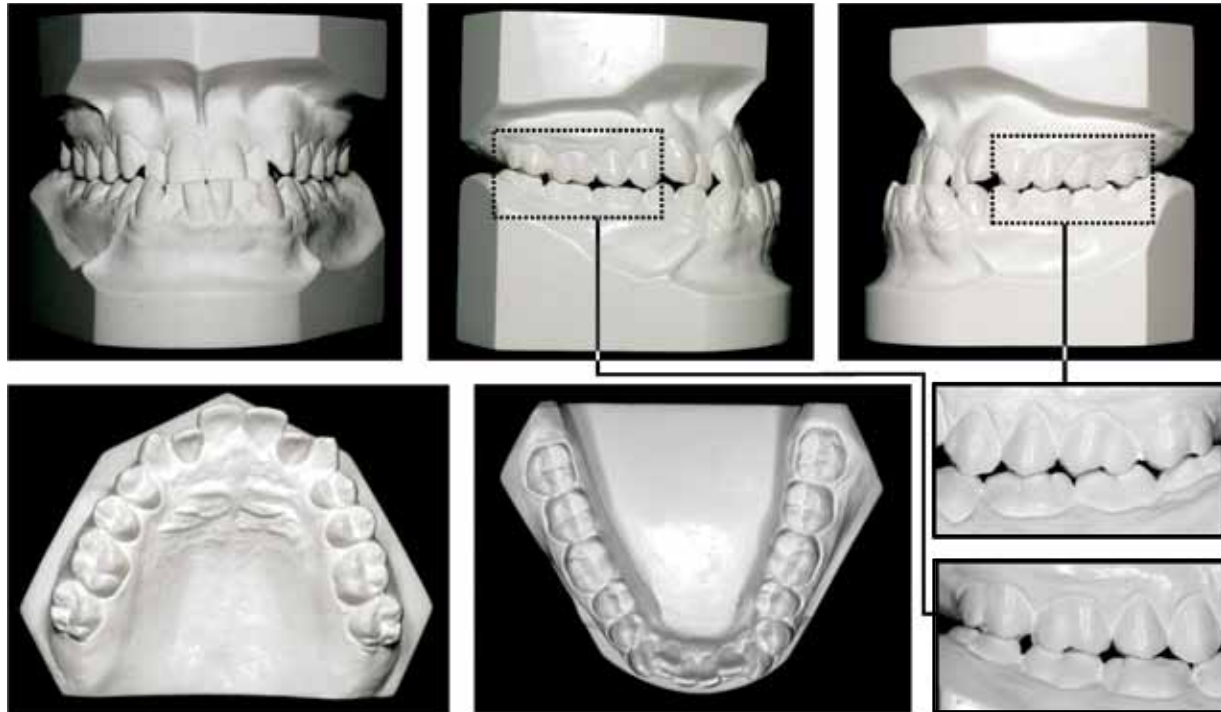


FIGURE 2 - Pretreatment study models. The tracing areas are augmented on the lower right corner. Note the Class III relationship.



FIGURE 3 - Pretreatment panoramic X-ray.

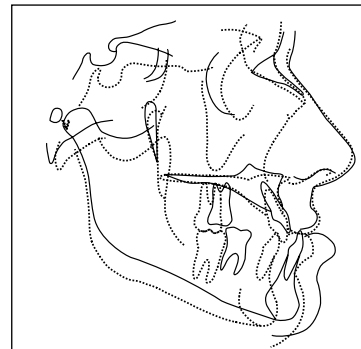


FIGURE 4 - Cephalometric X-ray and pretreatment tracing (continuous line). The pretreatment tracing is overlying the Bolton standard tracing. Note that the superimposition shows the maxilla in a good anteroposterior position, but vertically deficient. The nose is well proportioned ("Bolton Standards of Craniofacial Development & Growth", Bolton-Broadbent-Golden, Case Western Reserve University - Cleveland, Ohio).

deformity as well as good periodontal and dental health. The third molars were in place.

The diagnosis was Class III dentofacial deformity with a Class III malocclusion. The skeletal relations were determined by a significant mandibular prognathism associated with mild to moderate anteroposterior and vertical deficiencies of the maxilla.

Treatment options

After finalizing the diagnosis, guidelines were established for the treatment. It consisted in the orthodontic-surgical correction of the deformity combining a mandibular setback with potential maxillary advancement. All the treatment options included orthodontic treatment and orthognathic surgery using the Anticipated Benefit protocol. Third molars would be extracted during the orthognathic surgery. The alternatives were:

1. Mandibular setback combined with maxillary advancement. In this treatment option, the mandible would be set back and the maxilla advanced. The lower teeth would be protruded and the upper teeth retracted.

2. Mandibular setback associated with paranasal graft. In this case, there would be no maxillary advancement; the paranasal areas would receive an autogenic or haloplastic graft.

3. Mandibular setback. In this alternative, the maxilla would not be advanced and the paranasal areas would not be filled. The patient and his family chose this treatment option.

Treatment plan

The first step in the treatment plan was to establish the final position for the upper and lower incisors. Here, the choice was to keep the upper incisors in position to prevent the upper lip from retracting. This decision was based on aesthetics, as there would be no maxillary advancement. Furthermore, it was also in the plan to protrude the lower incisors. All these tooth

TABLE 1 - Pretreatment, post-operative and final cephalometric measurements.

MEASUREMENT	VALUE	INITIAL	POST-OPERATIVE (AFTER 2 WEEKS)	FINAL (15 MONTHS AFTER THE START)
ANTEROPOSTERIOR ANALYSIS				
SnV - ULP	1 to 2 mm	1 mm	0 mm	0 mm
SnV - LLP	0 to -1 mm	8 mm	-3 mm	-1 mm
SnV - Po'	-1 to -4 mm	3 mm	-10 mm	-6 mm
nasolabial angle	110°	110°	113°	108°
VERTICAL ANALYSIS				
1/Stms	1 to 4 mm	1 mm	-1 mm	0 mm
G - Sn	50%	50,4%	48,5%	50,7%
Sn - Me'	50%	49,6%	51,5%	49,3%
Sn - Stms	33% of lower half	29,8%	30%	30%
Stmi - Me	66% of lower half	70,2%	70%	70%
ILG	0 to 3 mm	1 mm	0	0
INCISORS POSITION ANALYSIS				
1/ - HP	114° to 116°	124°	125°	127°
1/ - PP	110° ± 5°	125°	125°	127°
/1 - GoMe	95 ± 5°	80°	81°	89°
HARD TISSUE ANALYSIS				
NPer - A	1 mm	1 mm	2 mm	0.5 mm
NPer - B	-3 mm	11 mm	-3 mm	0
GoGn-SN	32	21°	26°	25°

movements are similar to when the patient is treated conventionally with orthodontic preparation. Cephalometrics was used¹³ to establish the protrusion for the lower incisors. Initially, they were 10° towards the lingual (Table 1). Thus, the plan was to protrude them by 10° (Fig 5, A and D). The lower lip was protruded by 80% of the tooth movement. Nevertheless, no adequate algorithms for predicting lip movement are available to this date for any planning scenario, be it conventional or Anticipated Benefit. As soon as the position for the anterior teeth was established, it was possible to plan the mandibular retraction. It was achieved by

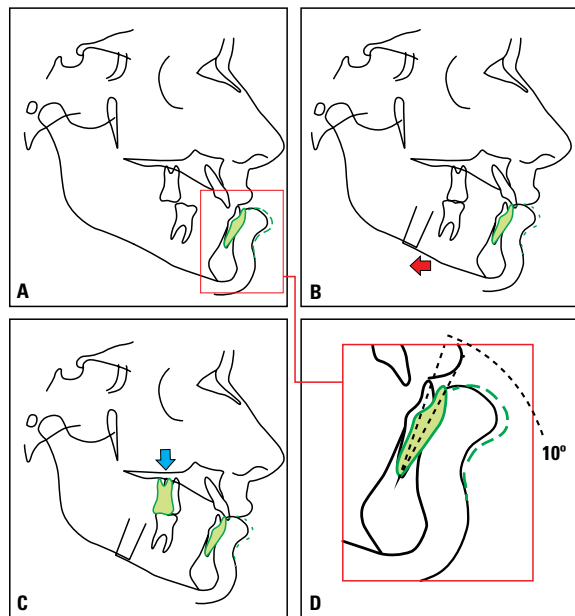


FIGURE 5 - A) To the pretreatment cephalometric tracing, in black, overlies, in green, the incisor and the lower lip positions. The lower lip had 80% of tooth movement predicted protrusion. **B)** The red arrow emphasizes the mandible draw back to a proper incisors relationship. The occlusal plane was used as a reference for the posterior sliding of the mandible. Note that the dental relationship of the posterior teeth is a Class II relationship. **C)** After working on the set-up to establish a correct position for the posterior teeth, these positions were traced (blue arrow). In this case, the upper incisors and the lower molars did not change their anteroposterior relationship. The red square in **A)** is emphasized in **D)**, showing the 10° change in the lower incisors angulation. The treatment plan was discussed with the surgeons who operated the patient (Dr. Frederico Salles and Dr. Marcos Anchieta).

sliding the partial tracing of the mandible towards the posterior region along the occlusal plane until the incisors reached a proper relationship in their final position (Fig 5, B). From this new position, the predicted results could be evaluated. It is important to emphasize that the patient, who had dental and skeletal Class III relationship, would have his osseous base ideally positioned. This would give him—and in fact did—a balanced facial profile. However, the dental relationship would change to a Class II. In some situations from this point on it may be necessary to reassess the results planned for the treatment. Sometimes, it is necessary to consider other treatment options, which may

include other dental and skeletal movement combinations and, sometimes, additional discussion between orthodontist, surgeon and patient.

This was not the case in this treatment. After the position for the anterior teeth was established, it was necessary—as in most cases—to view the position of the posterior teeth on the set-up. I have been using for some time now set-up procedures that are similar to those used on cast models.^{11,12} Nonetheless, I scan the models with a 3D scanner, sectioning the teeth with a computer program and thereby establishing the movements.

My clinical experience suggests that this technique takes less working time than the traditional one, allowing as many treatment combinations as possible. Additionally, the set-up findings can be used to assist in communicating with the patient. A demonstration of this technique will be presented in another upcoming article. In the treatment reported here the set-up findings showed that the planned movement allowed an adequate dental relationship at the end of treatment (Fig 6). It was also clear that a minor retraction of the upper posterior teeth would be necessary (video 1, available at www.dentalpress.com.br/journal). The same study showed that positioning the lower incisors with a protrusion of 10° would enable the alignment of the lower dental arch with no need for stripping or any additional maneuver (video 2, available at www.dentalpress.com.br/journal). All the data collected studying the set-up was important to determine which anchorage devices to use. Two mini-plates were used on the maxilla to retract the posterior teeth by 2 mm. These mini-plates were inserted during the orthognathic surgery. Tooth movement was transferred to the cephalometric tracing (Fig 5, C).

Treatment progress and results

After the orthodontic and surgical plans had

been defined the fixed orthodontic appliance was installed with 0.022 x 0.028-in preadjusted brackets on both dental arches. Bands were placed on the molars, except the upper second molars.

The purpose was to facilitate extraction of the upper third molars. NiTi 0.014-in arch wires were engaged immediately after appliance installation.

The patient underwent surgery after appliance installation. During the 11 mm mandibular setback surgery mini-plates were placed on the maxilla for anchorage to retract the upper posterior teeth. The third molars were extracted.

An interocclusal tray was made and served as reference on two occasions. Firstly, to establish fragment relationship during surgery and secondly, to clinically follow up on surgical stability for a period of three weeks. Two weeks after surgery, the facial aspect showed

significant improvement (Fig 7). After surgery, the dental relationship was that of a Class II but with facial Pattern I. Upper and lower crowding did not change (Fig 7). The mandibular setback was considerable and caused very important cephalometric changes (Table 1, Fig 8).

After a three-week post-operative period, NiTi springs were placed from the mini-plates to the upper cuspids. Buccal tubes were bonded to the second molars and these teeth were included in the treatment. The activation aimed at distalizing the upper teeth, creating spaces for upper-anterior alignment. The springs were kept in place as the aligning and the leveling arch wires progressed with treatment. On the lower dental arch the arch wires progressed gradually from 0.014-in NiTi to a 0.017 x 0.025-in stainless steel arch wire.

During finishing, intermaxillary elastics were used for a short period of time to improve

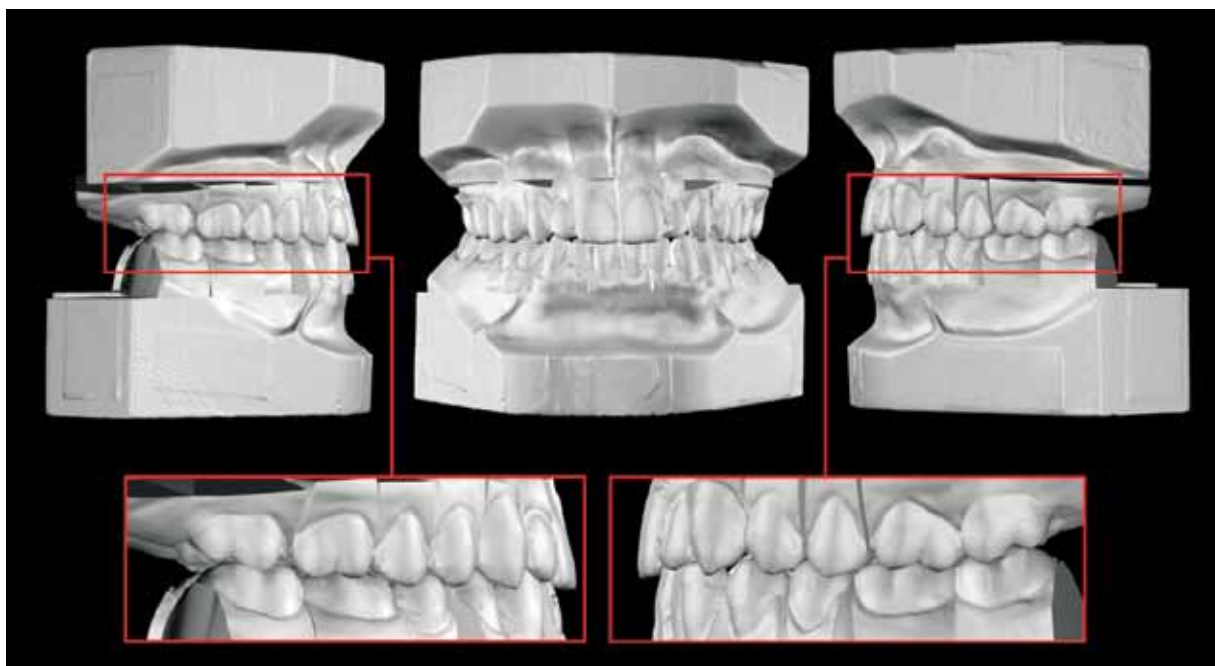


FIGURE 6 - Surgical computerized set-up of the treatment. Study models were scanned in a 3D scanner; teeth were crosscut, in a computer program, and tooth movement established. General procedures applied to the virtual set-up are the same as the ones applied to the physical models. The red squares show details of the teeth relationship after the proposed tooth movement and the mandible draw back.

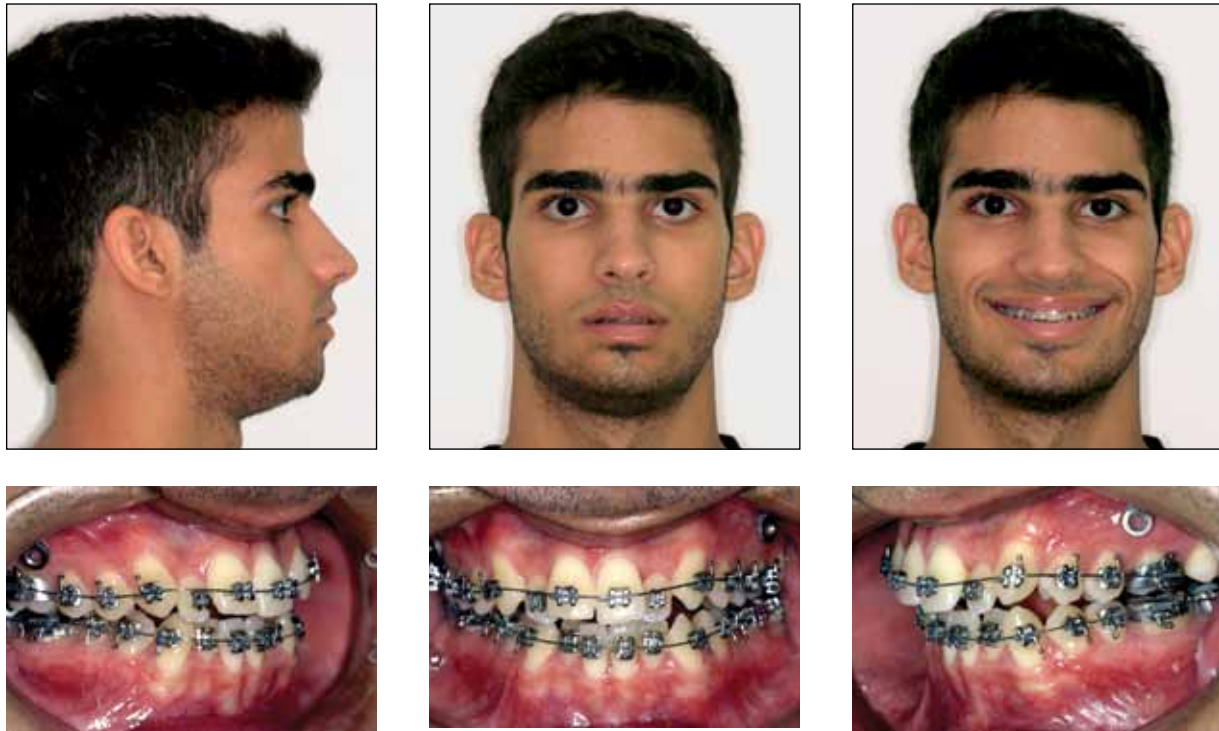


FIGURE 7 - Two weeks after surgery, the facial appearance presented some edema yet. After surgery, the malocclusion was a Class II malocclusion. But, the patient had already a face pattern I (surgeons Drs. Frederico Salles and Marcos Anchieta).

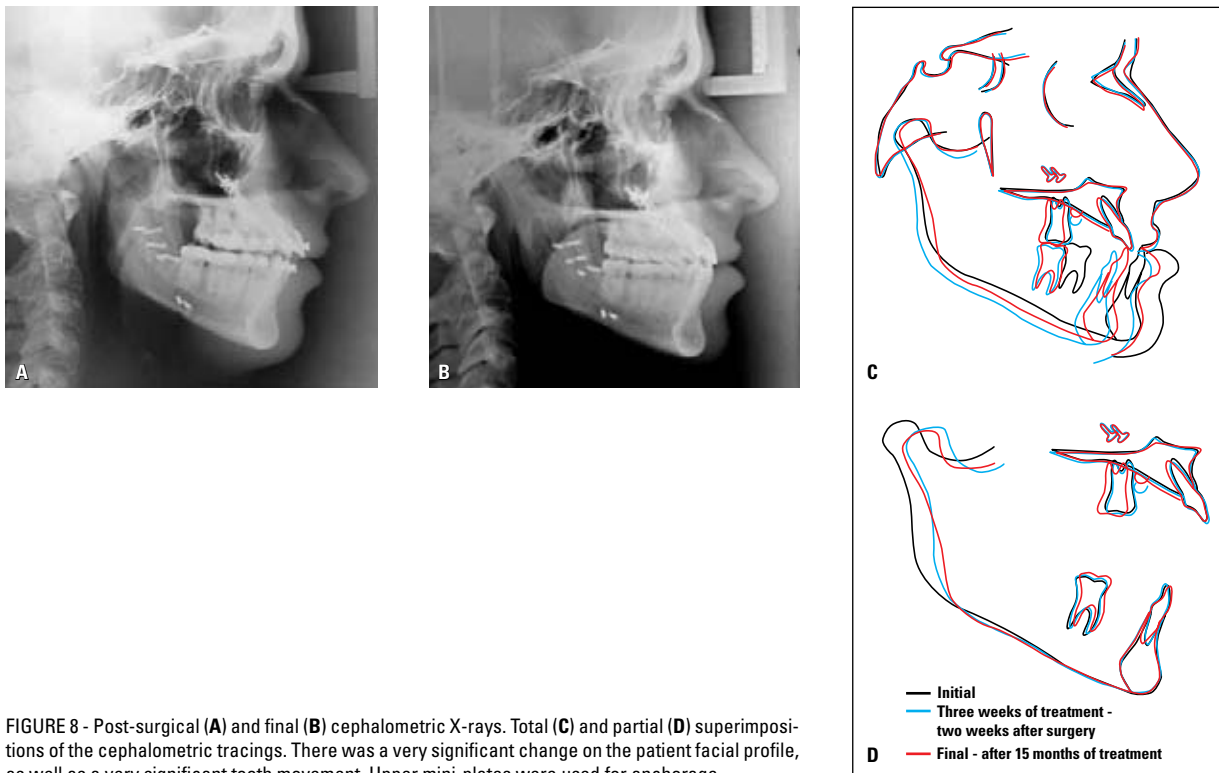


FIGURE 8 - Post-surgical (A) and final (B) cephalometric X-rays. Total (C) and partial (D) superimpositions of the cephalometric tracings. There was a very significant change on the patient facial profile, as well as a very significant tooth movement. Upper mini-plates were used for anchorage.

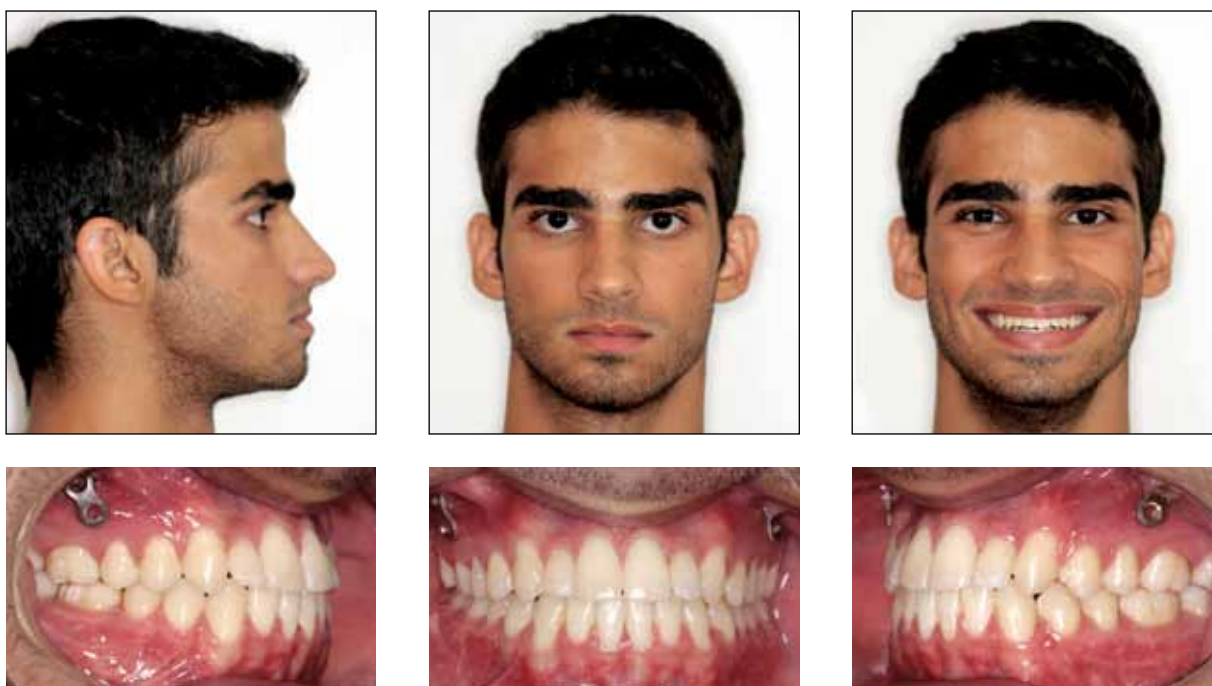


FIGURE 9 - Extraoral and intraoral photographs in the end of treatment (surgeons Drs. Frederico Salles and Marcos Anchieta).

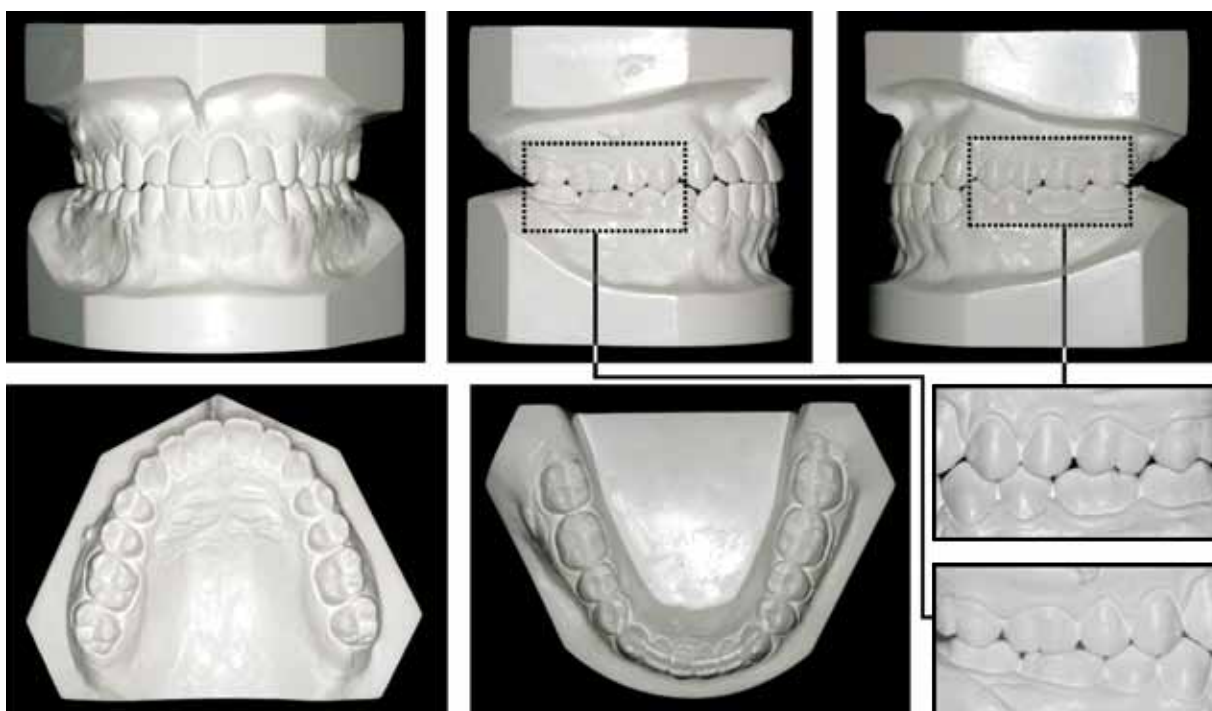


FIGURE 10 - Study models in the end of treatment. The tracing areas are augmented in the lower right corner. Note the molars relationship.



FIGURE 11 - Final panoramic X-ray.

intercuspatation. The patient was very pleased with the end result of treatment as reflected in both facial aesthetics and occlusion. The appliance was removed after 15 months of treatment. A wraparound type removable appliance was used on the upper arch and a 3 x 3 fixed retainer was bonded on the lower arch.

Two years after treatment (Fig 12), the occlusion remained stable.

DISCUSSION

An orthodontic-surgical treatment that deploys the Anticipated Benefit technique offers valuable advantages to patients. These advantages stem from the fact that the period of conventional orthodontic preparation is eliminated and surgery anticipated. Both techniques provide excellent functional and aesthetic results (Fig 13, C and 14, C). However, by anticipating surgery the treatment focus can be shifted to the patient. Application of the new protocol is justified insofar as it brings about significant improvement of serious health problems, such as obstructive sleep apnea, as well as facial aesthetic issues, right from the start of treatment (Fig 14, A and B).

Therefore, patients are spared the deterioration of their facial appearance typical of most conventional treatments (Fig 13, A and B), particularly in the treatment of Class III deformities. The facial aesthetic deterioration

that accompanies conventional treatment is a paradox. A large number of patients who undergo orthognathic surgery seek aesthetic improvement,³⁻⁶ although the surgery also affords palpable functional gains.¹⁴ In order to benefit from such aesthetic gains, however, patients must endure a transitional—17 months, on average—period of facial aesthetic deterioration.

The core of this technique relies on very careful orthodontic planning. It does not change the diagnosis of dental deformities but makes the treatment plan more demanding as it incorporates the need for viewing the orthodontic goals in the cephalometric tracing and on the set-up.

The set-up plays a vital role in determining the final position of posterior teeth. This prediction is relevant not only for academic purposes but also because it assists the orthodontist in the patient's final occlusion and in identifying the anchorage needs. However, the set-up is not necessary in every single case and can be offset by a professional's skill in treating similar cases.

Perhaps the best general rule one can apply to set-ups is to use one every time there is any doubt about the treatment, especially about anchorage and prosthetic spaces. When using Anticipated Benefit, skeletal anchorage is essential in most but not all cases.

My clinical experience shows that the use of mini-plates as anchorage is an advantage in many treatments, as reported in this article. A very similar article was published recently.¹⁵ However, in some cases mini-implants can be used and skeletal anchorage may not be necessary. Nevertheless, it should be underscored that skeletal anchorage increases orthodontic tooth movement predictability.^{10,16,17} This is what makes it possible for tooth movement—which would normally be implemented prior to surgery, according to the conventional treatment method—to be carried out, in many cases,



FIGURE 12 - Extraoral and intraoral photographs two years after the end of treatment (surgeons Drs. Frederico Salles and Marcos Anchieta).

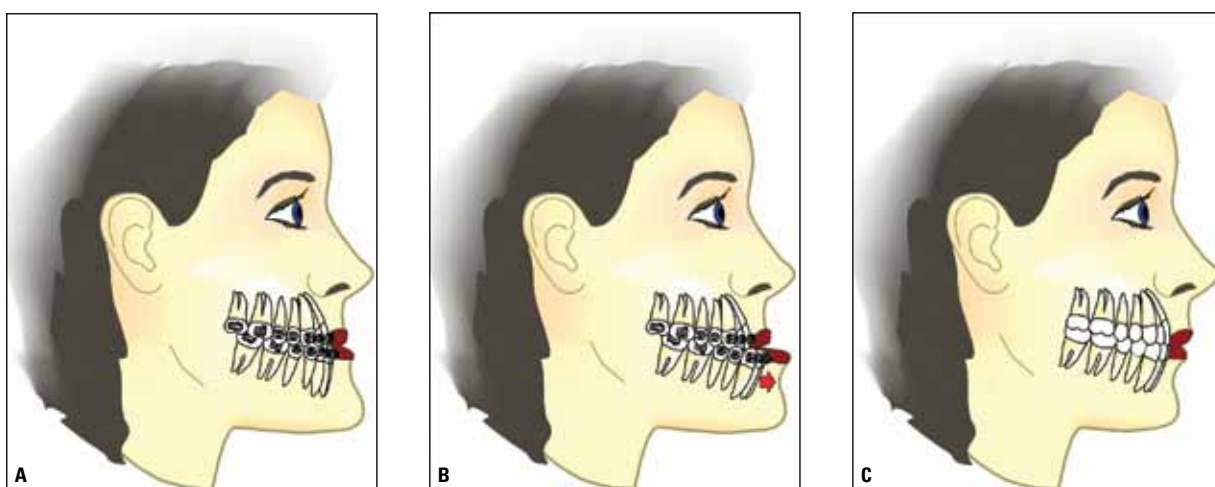


FIGURE 13 - Orthodontic-surgical treatment using the conventional method. **A)** Illustration of a Class III deformity. After orthodontic preparation (**B**), with distal movement of the lower incisors (**arrow**), worsening of the facial pattern III. End of treatment with well-balanced results (**C**).

after the orthognathic surgery.

Although the orthodontic plan is more complex than conventional treatment, surgical plans are not. Surgeons, however, should be

aware of all orthodontic steps taken throughout the treatment. This means that there should be better communication between orthodontist and surgeon than in conventional treatment.

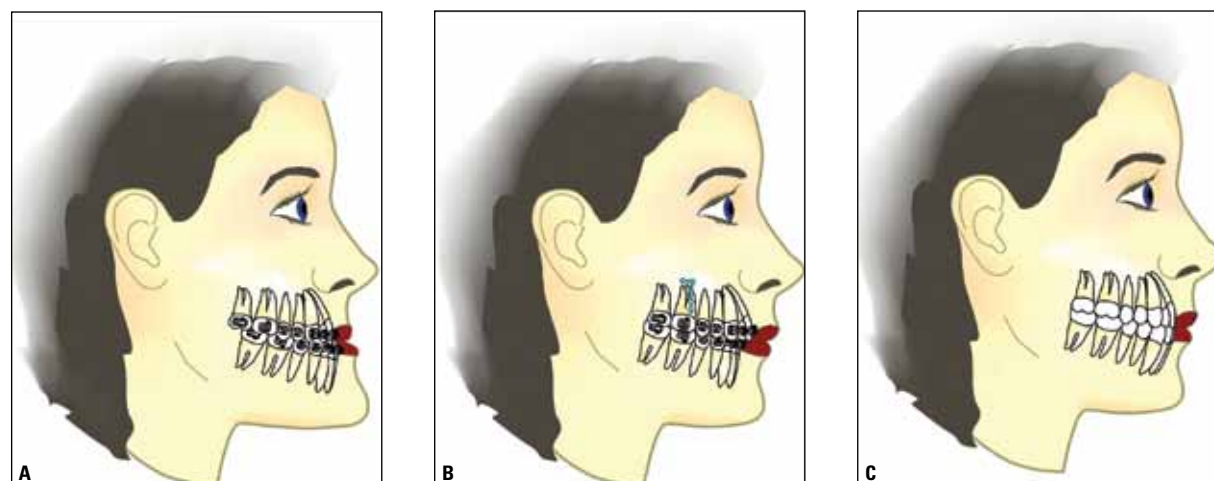


FIGURE 14 - Illustration of an orthodontic-surgical treatment of Anticipated Benefit. **A)** Pretreatment. **B)** The deformity soon after the orthognathic surgery, without orthodontic conventional preparation. Very significant facial change to a facial pattern I, but, the lips do not show a correct relation yet. Mini-plates are used to retract the upper teeth. **C)** End result of treatment very similar to the conventional method.

Orthodontists must feel reassured that surgeons will be able to implement the treatment plan. Surgeons, in turn, must feel confident that orthodontists will finalize the patient's occlusion in a relationship such as the one shown in Figure 7.

It should be emphasized that Anticipated Benefit treatment changes to the dental relationship differ significantly from conventional treatment. In this new method, one type of malocclusion is replaced by another and the new malocclusion is subsequently treated (Fig 14, A and B). In other words, due to the typical pattern of tooth positions in Class III deformities, after surgery the patient will exhibit a balanced facial appearance but very likely combined with a Class II malocclusion (Fig 14, A, B and C). The opposite is true of Class II deformities.

This means that the general pattern of tooth movement accomplished by this new treatment option is very similar to the conventional method except that orthodontic tooth movement tends to occur faster. This probably happens

because tooth movement benefits from—instead of countering—muscular forces, as is the case in the conventional treatment. Furthermore, this factor may— at least partly—account for the fact that most treatments that use this approach require a shorter time period.

CONCLUSION

In summary, the Anticipated Benefit orthodontic-surgical treatment applies the principles reported in the dental literature to reverse treatment stages and anticipate the surgery. It provides some key advantages such as faster improvement of both aesthetics and function, averting the temporary deterioration of facial aesthetics often found in many treatments of dentofacial deformities.

ACKNOWLEDGEMENTS

I would like to thank Drs. Frederico Salles, Marcos Anchieta, João Milki Neto and Rogério Zambonato Freitas for their team-work and for dedicating their expertise to the treatment of patients using the Anticipated Benefit protocol.

Drs. Frederico Salles and Marcos Anchieta were responsible for the surgical treatment reported in this article. I am also grateful to Dr. Carla Virginia Araújo Vasconcelos for providing professional services to the patient described in this article for several months in Fortaleza, Ceará State; to Dr. Lilian Fonseca, for her assistance in

illustrating this article, and to Dr. Patricia Berto, for her invaluable input, careful revision of this article and treatment of patients using the Anticipated Benefit technique.

Submitted: November 2009
Revised and accepted: December 2009

REFERENCES

1. Jacobs JD, Sinclair PM. Principles of orthodontic mechanics in orthognathic surgery cases. *Am J Orthod.* 1983; 84:399-407.
2. Luther F, Morris DO, Hart C. Orthodontic preparation for orthognathic surgery: How long does it take an why? *Br J Oral Maxillofac Surg.* 2003 Dec;41(6):401-6.
3. 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.* 2007 set/out;12(5):63-70.
4. Forssell H, Finne K, Forssell K, Panula K, Blinnikka LM. Expectations and perceptions regarding treatment: a prospective study of patients undergoing orthognathic surgery. *Int J Adult Orthodon Orthognath Surg.* 1998;13(2):107-13.
5. Vargo JK, Gladwin M, Ngan P. Association between ratings of facial attractiveness and patients motivation for orthognathic surgery. *Orthod Craniofac Res.* 2003 Feb;6(1):63-71.
6. Williams AC, Shah H, Sandy JR, Travess HC. Patients motivations for treatment and their experiences of orthodontic preparation for orthognathic surgery. *J Orthod.* 2005 Sep;32(3):191-202.
7. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning - part I. *Am J Orthod Dentofacial Orthop.* 1993;103:299-312.
8. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning - part II. *Am J Orthod Dentofacial Orthop.* 1993;103:395-411.
9. Arnett GW, Gunson MJ. Facial planning for orthodontists and oral surgeons. *Am J Orthod Dentofacial Orthop.* 2004;126:290-5.
10. Faber J, Morum TFA, Leal S, Berto PM, Carvalho CK dos S. Miniplates allow efficient and effective treatment of anterior open bites. *Rev Dental Press Ortod Ortop Facial.* 2008 set/out;13:144-57.
11. Bolognese AM. Set-up: uma técnica de confecção. *Rev SOB.* 1995;2:245-9.
12. Tavares CAE, Zanini LK. A confecção do "Set Up" de diagnóstico ortodôntico. *Rev Dental Press Ortod Ortop Facial.* 1999 set/out;4(5):20-3.
13. Bell WH, Jacobs JD, Quejada JG. Simultaneous repositioning of the maxilla, mandible, and chin treatment planning and analysis of soft tissues. *Am J Orthod.* 1986 Jan;89(1):28-50.
14. Turnbull NR, Battagel JM. The effects of orthognathic surgery on pharyngeal airway dimensions and quality of sleep. *J Orthod.* 2000 Sep;27(3):235-47.
15. Nagasaka H, Sugawara J, Kawamura H, Nanda R. "Surgery first" skeletal Class III correction using the Skeletal Anchorage System. *J Clin Orthod.* 2009 Feb;43(2):97-105.
16. Janssen KI, Raghoebar GM, Vissink A, Sandham A. Skeletal anchorage in Orthodontics: a review of various systems in animal and human studies. *Int J Oral Maxillofac Implants.* 2008 Jan/Feb;23(1):75-88.
17. Yao CCJ, Lai EHH, Chang JZC, Chen I, Chen YJ. Comparison of treatment outcomes between skeletal anchorage and extraoral anchorage in adults with maxillary dentoalveolar protrusion. *Am J Orthod Dentofacial Orthop.* 2008 Nov;134(5):615-24.

Contact address

Jorge Faber
Brasília Shopping Torre Sul sala 408
CEP: 70.715-900 – Brasília/DF
E-mail: faber@dentalpress.com.br

- 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 the submission and evaluation of manuscripts. To submit manuscripts please visit:
www.dentalpress.com.br/pubartigos.
- Please send all other correspondence to:
Dental Press Journal of Orthodontics
Av. Euclides da Cunha 1718, Zona 5
ZIP CODE: 87.015-180, Maringá/PR
Phone. (44) 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 must follow the guidelines below.
- **All articles must be written in English. However, Portuguese-speaking authors must also include a version in Portuguese.**

GUIDELINES FOR SUBMISSION OF MANUSCRIPTS

- Manuscripts must be submitted via www.dentalpress.com.br/pubartigos. Articles must be organized as described below.

1. Title Page

- Must comprise the title in English, an abstract and keywords.
- Information about the authors must be provided on a separate page, including authors' full names, academic degrees, institutional affiliations and administrative positions. Furthermore, the corresponding author's name, address, phone numbers and e-mail must be provided. This information is not made available to the reviewers.

2. Abstract

- Preference is given to structured abstracts in English 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 in English must be accompanied by 3 to 5 keywords, or descriptors, which must comply with MeSH.

3. Text

- The text must be organized in the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, References and Illustration legends.
- Texts must contain no more than 4,000 words, including captions, abstract and references.
- Illustrations and tables must be submitted in separate files (see below).
- Insert the legends of illustrations also in the text document to help with the article layout.

4. Illustrations

- 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 illustrations are cited in the text.

5. Graphs 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 (not editable).
- Drawings may be improved or redesigned by the journal's production department at the discretion of the Editorial Board.

6. 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).

7. Copyright Assignment

- All manuscripts must be accompanied by the following written statement signed by all authors: "Once the article is published, the undersigned author(s) hereby assign(s) all copyright of the manuscript [insert article title here] to Dental Press International. The undersigned author(s) warrant(s) that this is an original article and that it does not infringe any copyright or other third-party proprietary rights, it is not under consideration for publication by another journal and has not been published previously, be it in print or electronically. I (we) hereby sign this statement and accept full responsibility for the publication of the aforesaid article."
- This copyright assignment document must be scanned or otherwise digitized and submitted through the website*, along with the article.

8. Ethics Committees

- Articles must, where appropriate, refer to opinions of the Ethics Committees.

9. 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 limit of 30 references must not be exceeded.
- 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

Kina S. Preparos dentários com finalidade protética. In: Kina S, Brugnara A. *Invisível: restaurações estéticas cerâmicas*. Maringá: Dental Press; 2007. cap. 6, p. 223-301.

Book chapter with editor

Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2ª ed. Wiecezorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper

Beltrami LER. Braquetes com sulcos retentivos na base, colados clinicamente e removidos em laboratórios por testes de tração, cisalhamento e torção. [dissertação]. Bauru: Universidade de São Paulo; 1990.

Digital format

Câmara CALP da. Estética em Ortodontia: Diagramas de Referências Estéticas Dentárias (DRED) e Faciais (DREF). *Rev Dental Press Ortod Ortop Facial*. 2006 nov-dez;11(6):130-56. [Acesso 12 jun 2008]. Disponível em: www.scielo.br/pdf/dpress/v11n6/a15v11n6.pdf.

* www.dentalpress.com.br/pubartigos

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,

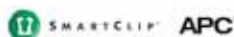
Jorge Faber, DDS, MS, PhD
 Editor-in-Chief of Dental Press Journal of Orthodontics
 ISSN 2176-9451
 E-mail: faber@dentalpress.com.br

Clarity™ SL Self-Ligating Ceramic Brackets

Clarity™ SL Self-Ligating Appliance System



Uncompromising
Results with
Aesthetic Self-Ligation



CRC Centro de Relacionamento com o Consumidor

CRC 3M Unitek: 0800-0153131
www.3munitek.com.br
e-mail: faleconosco@mmm.com

3M Unitek

from the 3M Health Care family

2009 3M. Todos os direitos reservados.
016-954 0705-BR

3M Unitek

Roth Max[®]

A new line of brackets sized to attend the orthodontic demand.

- Comfort patients
- Bases adaptation
- Accuracy measures
- High performance in collages



kit Max
with 1 case



Morelli adopts the concept of 3R's from the social responsibility for the rational residues use, before the world-wide necessity of preservation of natural resources not renewed.



3R **Reduce:** the quantity of produce material
Reuse: the package more than one time
Recycle: the things that you do not use

Max Social responsibility:

The new packages of Morelli products attend the 3R's concept.

Reduce: More products using less packages.

Reuse: The Max packages are reusable for Elastomerics and many accessories, besides the brackets.

Recycle: The materials used in the Max packages are totally recycles.



kit Max
with 5 cases

(10% economy)

Max economy...

...with social responsibility:

Available in more than 20 countries or through the Morelli Sales Dpt.
☎ 0800 121455 / 0800 7031455 - www.morelli.com.br

MORELLI
ORTODONTIA
www.morelli.com.br