

Dental Press Journal of
ORTHODONTICS

Volume 16, Number 3, May / June 2011



Dental Press Journal of
ORTHODONTICS

v. 16, no. 3

May/June 2011

EDITOR-IN-CHIEF**Jorge Faber** UnB - DF - Brazil**ASSOCIATE EDITOR****Telma Martins de Araujo** UFBA - BA - Brazil**ASSISTANT EDITOR**

(Online only articles)

Daniela Gamba Garib HRAC/FOB-USP - SP - Brazil**Fernanda Angelieri** USP - SP - Brazil**Matheus Melo Python** UESB - BA - Brazil**ASSISTANT EDITOR**

(Evidence-based Dentistry)

David Normando UFPA - PA - Brazil**ASSISTANT EDITOR**

(Editorial review)

Flávia Artese UERJ - RJ - Brazil**PUBLISHER****Laurindo Z. Furquim** UEM - PR - Brazil**EDITORIAL SCIENTIFIC BOARD****Adilson Luiz Ramos** UEM - PR - Brazil**Danilo Furquim Siqueira** UNICID - SP - Brazil**Maria F. Martins-Ortiz** ACOPEM - SP - Brazil**EDITORIAL REVIEW BOARD****Orthodontics**

Adriana C. da Silveira Univ. of Illinois - Chicago - USA

Adriana de Alcântara Cury-Saramago UFF - RJ - Brazil

Adriano de Castro UCB - DF - Brazil

Aldrieli Regina Ambrósio SOEPAR - PR - Brazil

Alexandre Trindade Motta UFF - RJ - Brazil

Ana Carla R. Nahás Scocate UNICID - SP - Brazil

Ana Maria Bolognese UFRJ - RJ - Brazil

Andre Wilson Machado UFBA - BA - Brazil

Antônio C. O. Ruellas UFRJ - RJ - Brazil

Armando Yukio Saga ABO - PR - Brazil

Arno Locks UFSC - SC - Brazil

Ary dos Santos-Pinto FOAR/UNESP - SP - Brazil

Björn U. Zachrisson Univ. of Oslo - Norway

Bruno D'Aurea Furquim Priv. practice - PR - Brazil

Camila Alessandra Pazzini UFMG - MG - Brazil

Camilo Aquino Melgaço UFMG - MG - Brazil

Carla D'Agostini Derech UFSC - SC - Brazil

Carla Karina S. Carvalho ABO - DF - Brazil

Carlos A. Estevanel Tavares ABO - RS - Brazil

Carlos Martins Coelho UFMA - MA - Brazil

Cauby Maia Chaves Junior UFC - CE - Brazil

Célia Regina Maio Pinzan Vercelino FOB-USP - SP - Brazil

Christian Viezzer UFRGS - RS - Brazil

Clarice Nishio University of Montreal - Canada

Cristiane Canavarro UERJ - RJ - Brazil

Eduardo C. Almada Santos FOA/UNESP - SP - Brazil

Eduardo Franzotti Sant'Anna UFRJ - RJ - Brazil

Eduardo Silveira Ferreira UFRGS - RS - Brazil

Enio Tonani Mazzeiro PUC-MG - MG - Brazil

Eustáquio Araújo University of Saint Louis - USA

Fabrício Pinelli Valarelli UNINGÁ - PR - Brazil

Fernando César Torres UMESP - SP - Brazil

Giovana Rembowski Casaccia Priv. practice - RS - Brazil

Gisele Moraes Abrahão UERJ - RJ - Brazil

Glaucio Serra Guimarães UFF - RJ - Brazil

Guilherme Janson FOB-USP - SP - Brazil

Guilherme Pessoa Cerveira ULBRA-Torres - RS - Brazil

Gustavo Hauber Gameiro UFRGS - RS - Brazil

Haroldo R. Albuquerque Jr. UNIFOR - CE - Brazil

Helio Scavone Júnior UNICID - SP - Brazil

Henri Menezes Kobayashi UNICID - SP - Brazil

Hiroshi Maruo PUC-PR - PR - Brazil

Hugo Cesar P. M. Caracas UNB - DF - Brazil

Jesús Fernández Sánchez Univ. of Madrid - Madrid - Spain

Jonas Capelli Junior UERJ - RJ - Brazil

José Antônio Bósio Univ. of Marquette - Milwaukee - USA

José Augusto Mendes Miguel UERJ - RJ - Brazil

José Fernando Castanha Henriques FOB-USP - SP - Brazil

José Nelson Mucha UFF - RJ - Brazil

José Renato Prietsch UFRGS - RS - Brazil

José Vinícius B. Maciel PUC-PR - PR - Brazil

Julia Cristina de Andrade Vitral Priv. practice - SP - Brazil

Júlia Harfin Univ. of Maimonides - Buenos Aires - Argentina

Júlio de Araújo Gurgel FOB-USP - SP - Brazil

Julio Pedra e Cal Neto UFF - RJ - Brazil

Karina Maria S. de Freitas UNINGÁ - PR - Brazil

Larry White AAO - Dallas - USA

Leandro Silva Marques UNINCOR - MG - Brazil

Leniana Santos Neves UFVJM - MG - Brazil

Leopoldino Capelozza Filho HRAC/USP - SP - Brazil

Liliana Ávila Maltagliati USC - SP - Brazil

Livia Barbosa Loriato PUC-MG - MG - Brazil

Luciana Abrão Malta Priv. practice - SP - Brazil

Luciana Baptista Pereira Abi-Ramia UERJ - RJ - Brazil

Luciana Rougemont Squeff UFRJ - RJ - Brazil

Luciane M. de Menezes PUC-RS - RS - Brazil

Luís Antônio de Arruda Aïdar UNISANTA - SP - Brazil

Luiz Filipe Canuto FOB-USP - SP - Brazil

Luiz G. Gandini Jr. FOAR-UNESP - SP - Brazil

Luiz Sérgio Carreiro UEL - PR - Brazil

Marcelo Bichat P. de Arruda UFMS - MS - Brazil

Marcelo Reis Fraga UFJF - MG - Brazil

Márcio Rodrigues de Almeida UNIMEP - SP - Brazil

Marco Antônio de O. Almeida UERJ - RJ - Brazil

Marcos Alan V. Bittencourt UFBA - BA - Brazil

Marcos Augusto Lenza UFG-GO - Brazil

Maria C. Thomé Pacheco UFES - ES - Brazil

Maria Carolina Bandeira Macena FOP-UPE - PB - Brazil

Maria Perpétua Mota Freitas ULBRA - RS - Brazil

Marília Teixeira Costa UFG - GO - Brazil

Marinho Del Santo Jr. Priv. practice - SP - Brazil

Maristela Sayuri Inoue Arai Tokyo Medical and Dental University - Japan

Mônica T. de Souza Araújo UFRJ - RJ - Brazil

Orlando M. Tanaka PUC-PR - PR - Brazil

Oswaldo V. Vilella UFF - RJ - Brazil

Patrícia Medeiros Berto Priv. practice - DF - Brazil

Patrícia Valeria Milanezi Alves Priv. practice - RS - Brazil

Pedro Paulo Gondim UFPE - PE - Brazil

Renata C. F. R. de Castro UMESP - SP - Brazil

Renata Rodrigues de Almeida Pedrin CORA - SP - Brazil

Ricardo Machado Cruz UNIP - DF - Brazil

Ricardo Moresca UFPR - PR - Brazil

Robert W. Farinazzo Vitral UFJF - MG - Brazil

Roberto Justus Univ. Tecn. of Mexico - Mexico

Roberto Rocha UFSC - SC - Brazil

Rodrigo César Santiago	UFJF - MG - Brazil	Phonoaudiology	
Rodrigo Hermont Cançado	UNINGÁ - PR - Brazil	Esther M. G. Bianchini	CEFAC-FCMSC - SP - Brazil
Rolf M. Faltin	Priv. practice - SP - Brazil		
Sávio R. Lemos Prado	UFPA - PA - Brazil		
Sérgio Estelita	FOB-USP - SP - Brazil	Implantology	
Tarcila Triviño	UMESP - SP - Brazil	Carlos E. Francischone	FOB-USP - SP - Brazil
Weber José da Silva Ursi	FOSJC/UNESP - SP - Brazil		
Wellington Pacheco	PUC-MG - MG - Brazil	Dentofacial Orthopedics	
		Dayse Urias	Priv. practice - PR - Brazil
		Kurt Faltin Jr.	UNIP - SP - Brazil
Oral Biology and Pathology		Periodontics	
Alberto Consolaro	FOB-USP - SP - Brazil	Maurício G. Araújo	UEM - PR - Brazil
Edvaldo Antonio R. Rosa	PUC - PR - Brazil		
Victor Elias Arana-Chavez	USP - SP - Brazil		
Biochemical and Cariology		Prosthesis	
Marília Afonso Rabelo Buzalaf	FOB-USP - SP - Brazil	Marco Antonio Bottino	UNESP-SJC - SP - Brazil
		Sidney Kina	Priv. practice - PR - Brazil
Orthognathic Surgery		Radiology	
Eduardo Sant'Ana	FOB/USP - SP - Brazil	Rejane Faria Ribeiro-Rotta	UFG - GO - Brazil
Laudimar Alves de Oliveira	UNIP - DF - Brazil		
Liogi Iwaki Filho	UEM - PR - Brazil		
Rogério Zambonato	Priv. practice - DF - Brazil	SCIENTIFIC CO-WORKERS	
Waldemar Daudt Polido	Priv. practice - RS - Brazil	Adriana C. P. Sant'Ana	FOB-USP - SP - Brazil
		Ana Carla J. Pereira	UNICOR - MG - Brazil
Dentistics		Luiz Roberto Capella	CRO - SP - Brazil
Maria Fidela L. Navarro	FOB-USP - SP - Brazil	Mário Taba Jr.	FORP - USP - Brazil
TMJ Disorder			
José Luiz Villaga Avoglio	CTA - SP - Brazil		
Paulo César Conti	FOB-USP - SP - Brazil		

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

Dental Press Journal of Orthodontics

(ISSN 2176-9451) is a bimonthly publication of Dental Press International Av. Euclides da Cunha, 1.718 - Zona 5 - ZIP code: 87.015-180 - Maringá / PR, Brazil - Phone: (55 044) 3031-9818 - www.dentalpress.com.br - artigos@dentalpress.com.br.

DIRECTOR: Teresa R. D'Aurea Furquim - EDITORIAL DIRECTOR: Bruno D'Aurea Furquim - MARKETING DIRECTOR: Fernando Marson - INFORMATION ANALYST: Carlos Alexandre Venancio - EDITORIAL PRODUCER: Júnior Bianco - DESKTOP PUBLISHING: Fernando Truculo Evangelista - Gildásio Oliveira Reis Júnior - Tatiane Comochena - REVIEW / COPYDESK: Ronis Furquim Siqueira - IMAGE PROCESSING: Andrés Sebastián - JOURNALISM: Beatriz Lemes - LIBRARY/NORMALIZATION: Simone Lima Lopes Rafael - DATABASE: Adriana Azevedo Vasconcelos - ARTICLES SUBMISSION: Roberta Baltazar de Oliveira - COURSES AND EVENTS: Ana Claudia da Silva - Rachel Furquim Scattolin - INTERNET: Edmar Baladeli - FINANCIAL DEPARTMENT: Roseli Martins - COMMERCIAL DEPARTMENT: Roseneide Martins Garcia - DISPATCH: Diego Moraes - JOURNALISM: Beatriz Lemes - SECRETARY: Rosane Aparecida Albino.

Indexing:



since 1999



since 2011



since 1998



since 1998



since 2008



since 2005



since 2008



since 1998



since 2002



since 2008



since 2009

Dental Press Journal of Orthodontics

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

Bimonthly
ISSN 2176-9451

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

CDD 617.643005



- 6 Editorial**
- 19 Events Calendar**
- 20 News**
- 22 What's new in Dentistry**
- 25 Orthodontic Insight**
- 32 Interview with James A. McNamara Jr.**

Online Articles

- 54** *Imaging from temporomandibular joint during orthodontic treatment: a systematic review*

Eduardo Machado, Renésio Armino Grehs, Paulo Afonso Cunali

- 57** *Cytotoxicity of electric spot welding: an in vitro study*

Rogério Lacerda dos Santos, Matheus Melo Pithon, Leonard Euler A. G. Nascimento, Fernanda Otaviano Martins, Maria Teresa Villela Romanos, Matilde da Cunha G. Nojima, Lincoln Issamu Nojima, Antônio Carlos de Oliveira Ruellas

- 60** *In vitro study of shear bond strength in direct bonding of orthodontic molar tubes*

Célia Regina Maio Pinzan Vercelino, Arnaldo Pinzan, Júlio de Araújo Gurgel, Fausto Silva Bramante, Luciana Maio Pinzan

Original Articles

- 63** *Evaluation of the bone age in 9-12 years old children in Manaus-AM city*

Wilson Maia de Oliveira Junior, Julio Wilson Vigorito, Carlos Eduardo Nossa Tuma

- 70** *Treatment effects on Class II division 1 high angle patients treated according to the Bioprogressive therapy (cervical headgear and lower utility arch), with emphasis on vertical control*

Viviane Santini Tamburús, João Sarmiento Pereira Neto, Vânia Célia Vieira de Siqueira, Weber Luiz Tamburús

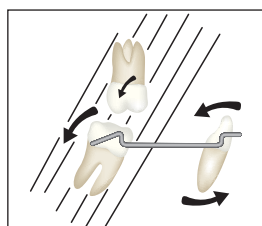
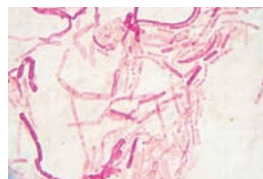




TABLE 1 - Mean values and standard deviation for Plaque Index (PI), Gingival Index (GI) and bleeding index (BI) at baseline examination, and after 6, 12 and 24 weeks of follow-up.

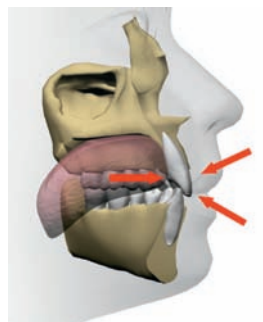
	PI	GI	BI
Baseline	83 (12.11) ^a	1.21 (0.31) ^a	33.33% (16.69) ^a
6 weeks	65 (10.61) ^a	0.79 (0.25) ^a	12.49% (8.60) ^a
12 weeks	55 (19.28) ^a	0.71 (0.28) ^a	12.39% (8.78) ^a
24 weeks	51 (13.99) ^a	0.55 (0.19) ^a	6.52% (2.79) ^a

- The different lowercase letters in the same column indicate significant differences, as analyzed by ANOVA and Tukey's test (p<0.05, n = 27).



Variables		Frequency	
		n	%
Age	≤ 13.06 years	14	50
	≥ 13.06 years	14	50
Gender	Female	16	57.1
	Male	12	42.9
Facial Pattern	Dolicho	11	39.3
	Meso	17	60.7
MPA Type	1+2	11	39.3
	3+4	17	60.7
Archwire	0.018" x 0.025" SS	16	57.1
	0.021" x 0.025" + 0.018" x 0.025" SS	12	42.9
Technique	Straightwire	12	42.9
	Standard	16	57.1

TABLE 1 - Relationship between variables and sample distribution. Natal, Rio Grande do Norte State, Brazil, 2005.



79 Analysis of the correlation between mesiodistal angulation of canines and labiolingual inclination of incisors

Amanda Sayuri Cardoso Ohashi, Karen Costa Guedes do Nascimento, David Normando

87 Evaluation of shear strength of lingual brackets bonded to ceramic surfaces

Michele Balestrin Imakami, Karyna Martins Valle-Corotti, Paulo Eduardo Guedes Carvalho, Ana Carla Raphaelli Nahás Scocate

95 Education and motivation in oral health — preventing disease and promoting health in patients undergoing orthodontic treatment

Priscila Ariede Petinuci Bardal, Kelly Polido Kaneshiro Olympio, José Roberto de Magalhães Bastos, José Fernando Castanha Henriques, Marília Afonso Rabelo Buzalaf

103 Microbiological analysis of orthodontic pliers

Fabiane Azeredo, Luciane Macedo de Menezes, Renata Medina da Silva, Susana Maria Deon Rizzatto, Gisela Gressler Garcia, Karen Revers

113 Cephalometric evaluation of the effects of the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance on the skeletal structures of patients with Angle Class II, division 1 malocclusion

Emmanuelle Medeiros de Araújo, Rildo Medeiros Matoso, Alexandre Magno Negreiros Diógenes, Kenio Costa Lima

125 BBO Case Report

Angle Class II, division 2 malocclusion treated with extraction of permanent teeth
Sílvia Luís Dalagnol

136 Special Article



Criteria for diagnosing and treating anterior open bite with stability

Alderico Artese, Stephanie Drummond, Juliana Mendes do Nascimento, Flavia Artese

162 Information for authors

Planning is necessary; running risks is not necessary

Along the many years dealing with topics in the frontiers of orthodontic possibilities, I have often answered questions about treatment risks. It started with the first lectures about skeletal anchorage about fifteen years ago, when concerned eyes paid — and still pay — attention to new treatment forms. Such concern should be expected, as responsible professionals fear that expected results may not be achieved when new treatments are used. This is especially true when dealing with complex treatments that involve new steps or additional knowledge. But do these treatments actually pose greater risks?

Maybe, let's admit it, but not always. To give a better answer to this question, however, it is important to make it clear that there is a great difference between "exposing to danger" and "running risks". This difference is called planning. Planning comprises identifying the problem clearly, understanding its progression and the consequences of not solving it, establishing different resolution scenarios and choosing one consciously, and, at last, recording step by step the actions that will be taken. In the Second World War, the greater commander of the Allied Forces, General Dwight Eisenhower, once said: "Plans are useless, but planning is indispensable."

There are endless new resources for planning, and I have recently witnessed an excellent example of that. In a Conference, I attended a lecture that is definitely one of the best that I have ever seen. It dealt with a new perspective for the diagnosis of anterior open bites, which leads to treatment

planning that is actually focused on the etiology of the problem. The lecturer, Dr. Flávia Artese, described the work conducted by her father, Professor Alderico Artese, while we, the audience, were enchanted by the extraordinary revelations of her paper. It is incredible that, in the era of fantastic imaging diagnoses and highly sophisticated examinations, a new form of diagnosis, particularly one for such an old problem, should be brought to light by means of critical observation and sharp intelligence.

Their work has been summarized and published in the Special Article section of this issue. They argue that the lack of consensus about the etiology of anterior open bites has given rise to several treatment variations, which might explain the high degree of posttreatment instability in this type of malocclusion. In addition, their study provides criteria for the diagnosis and treatment of open bites based on different tongue postures. That is such a clear finding that it is amazing that nobody noticed it before.

Again: Plans are nothing, but planning is everything. But how can we plan if we do not even understand the cause of the problem? I strongly suggest the reading of this article, which will be a landmark in the literature about an anomaly whose correction is one of the most difficult.

Enjoy your reading!

Jorge Faber
Editor-in-chief (faber@dentalpress.com.br)



Vem aí...

Congresso Internacional de Ortodontia,
Implantodontia e Cirurgia Ortognática
Vale do Paraíba - SP - Brasil - 04 e 05 novembro 2011

**...o maior evento internacional de
especialidades do vale do paraíba**



Dando continuidade à tradição dos eventos apoiados pela UNIVERSIDADE DE NOVA YORK, São José dos Campos acolherá nos dias 04 e 05 de Novembro de 2011 o maior expoente da Ortodontia, Implantodontia e Cirurgia Ortognática.

Destaque

ORTODONTIA AUTOLIGANTE: SISTEMAS ATIVO X PASSIVO - QUAL A MELHOR OPÇÃO?

Dr. Martin Epstein

PROFESSOR – DEPARTAMENTO DE ORTODONTIA, DIVISÃO DE
PÓS GRADUAÇÃO, New York University College of Dentistry

- DIPLOMADO PELO the American Board of Orthodontics
- PRÊMIO DE PROFESSOR DO ANO – NYU College of Dentistry, Postgraduate Orthodontics
- PALESTRANTE INTERNACIONAL – EUROPA, ÁSIA E AMÉRICA DO SUL
- VÁRIOS ARTIGOS PUBLICADOS EM PERIÓDICOS NORTE AMERICANOS E INTERNACIONAIS
- REVISOR: American Journal of Orthodontics and Dentofacial Orthopedics
- CLÍNICA PRIVADA DE ORTODONTIA EM NEW JERSEY POR MAIS DE 35 ANOS



Abordaremos temas atuais para a especialidade, privilegiando a discussão dos assuntos polêmicos, duvidosos e necessários para nossa evolução científica e educacional.

Secretaria executiva

GSENNE
SOLUÇÕES EM NEGÓCIOS

Tel.: (11) 4368.5678

Save the Date for the Best Orthodontic Event in Sao Paulo State 2011!

15^o ALUMNI MEETING

AOA | ARARAQUARA - SP

AUGUST 26th and 27th 2011

DE VOLTA PARA O SEU FUTURO

Hotel Fazenda
Salto Grande
Araraquara - SP



Guest Speakers



Dr. Marcos Janson
MS in Orthodontics,
USP Bauru and the
author of the textbook
"Interdisciplinary
treatment for Adult"
edited by Dental Press.



Dr. Gustavo Barreto
Ms and Ph.D in
Orthodontics, Unesp
Araraquara and Clinical
Director of University
Tiradentes and Scientific
Director of Abor-SE
Association



Hilton Goldreich, DDS,
MS, PA Diplomate of the American
Board of Orthodontics, a member
of the American Association of
Orthodontists (AAO), Texas Dental
Association, Southwest Society of
Orthodontists and Clinical Professor
of Orthodontics Department at Baylor
College of Dentistry, Texas A&M
University System.



Larry Wolford, DMD
Clinical Professor of
Oral and Maxillofacial
Surgery at Baylor College
of Dentistry, Texas A&M
University System.

New program combined with the
knowledge, quality and family
sharing time.

Visit our website www.aoa.org.br
for more information. I hope to see
everybody soon!

Dr Adriano Marotta Araujo
(AOA Association's President)

Participação de palestrante internacional

Realização Instituto Oral Esthetic (Lages - SC)

25 de agosto de 2011 - A Mecânica do Arco Segmentado Aprimorando a sua Mecânica do Arco Contínuo.



Prof. Dr. Arno Locks



Pós-Doutorado no Royal Dental College of Aarhus, University of Aarhus, Dinamarca;

Especialista, Mestre e Doutor em Ortodontia e Ortopedia Facial. (UFRJ e UNESP)

Diplomado pelo Board Brasileiro de Ortodontia e Ortopedia Facial;

Prof. do Curso de Mestrado em Ortodontia da UFSC;

Prof. dos Cursos de Mestrado e Doutorado em Saúde Pública da UFSC;

Prof. do Curso de Especialização em Ortodontia da UFSC;

Professor das disciplinas de Ortodontia da UFSC;

Consultor Científico das revistas Dental Press de Ortodontia e Ortopedia Facial, revista Clínica de Ortodontia, revista Gaúcha de Odontologia.

Assessor ad-hoc da revista Brazilian Oral Research (IADR/SBPqO).

Conselheiro científico da revista Archives of Orthodontics Dentofacial Orthopedics.

26 de agosto de 2011 - Biomecânica no tratamento de pacientes adultos.



Prof. Dr. Maurício Sakima



Pós-Doutorado .

University Of Aarhus Royal Dental College.

Doutorado em Odontologia - Ortodontia - Araraquara.

Universidade Estadual Paulista Júlio de Mesquita Filho, UNESP, Brasil.

Mestrado em Odontologia - Ortodontia - Araraquara.

Universidade Estadual Paulista Júlio de Mesquita Filho, UNESP, Brasil.

27 de agosto de 2011 - el tratamiento en pacientes adultos con periodonto de inserción normal o disminuído



Prof. Dra. Julia Harfin



Dr. Julia Harfin completed her dental and orthodontic training at the University of Buenos Aires, where she later received her doctorate in 1970 . She serves as professor at the Department of Orthodontics , Maimonides University . Dr. Harfin has spoken and published extensively domestically and internationally and belongs to numerous orthodontic and dental societies , including the American

* Association of Orthodontics and the Sociedad Argentina de Ortodoncia , where she served as president from 1990 to 1996 . Currently , Dr. Harfin is president of the Asociación Latinoamericana de Ortodoncistas and the Argentine chapter of the International College of Dentists . She maintains her private practice of orthodontics in Buenos Aires , with a heavy emphasis on adult treatment

ATÉ 30.06.2011

R\$ 190,00

(Assinantes Dental Press,
Sócios ABO, ABCD e ex-alunos
Instituto Oral Esthetic Ortodontia)

R\$ 240,00

(Demais profissionais)

a partir de 01.07.2011

até a data do congresso

R\$ 400,00

Inscreva-se através do

Fone/Fax: 49 3224 0838

8406 0272.

(Informações com Vanessa)

REALIZAÇÃO:

Instituto Oral Esthetic

DADOS PARA DEPÓSITO

Banco do Brasil

AG. 0307-7 / CC. 28778-4

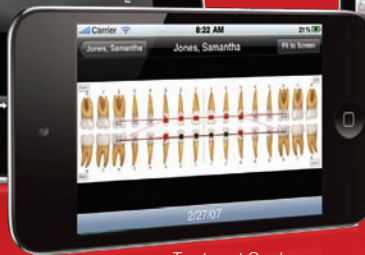
Enviar Comp. via Fax.



Put Dolphin in
your pocket.



X-ray panoramic on the iPad



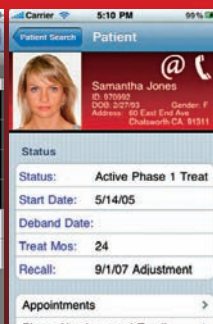
Treatment Card



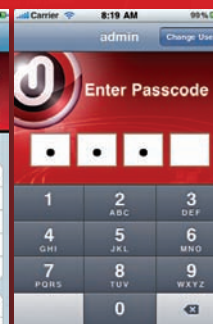
Patient images



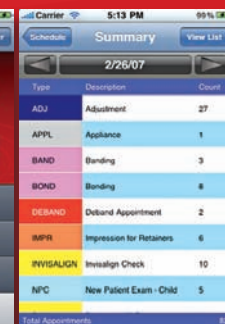
Month-at-a-glance



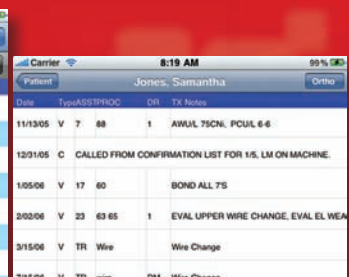
Patient information



Secure login



Today's procedures



Treatment Card

Use the new Dolphin Mobile app to securely access your Dolphin database from an iPhone, iPad or iPod touch. Get a close-up view of a patient's treatment chart entries and referring doctor information; quickly glance at your daily schedule; easily zoom in on patient 2D and 3D images, and more.

\$99 activation fee per device. For more information, visit www.dolphinimaging.com/dolphinmobile.





10 | 11 | 12 | NOV | 2011 | LISBOA CONGRESS CENTRE | PORTUGAL

LISBON NOV. 2011



XX CONGRESSO
ORDEM DOS MÉDICOS DENTISTAS
PORTUGUESE DENTAL ASSOCIATION ANNUAL MEETING



OMD CONGRESS

INVITED SPEAKER

JORGE FABER | BR | ORTHODONTICS

www.ond.pt

GOLD SPONSORS



OFFICIAL SPONSORS



ABOR



8th CONGRESS OF THE BRAZILIAN ASSOCIATION OF ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

12-15th october, 2011, Belo Horizonte, Minas Gerais, Brazil

- 6** parallel events of ALADO, BBO, GRUPO, ENAP, ABOL e CFO.
- 15** courses with the highlights of **national** and **international** speakers.
- 50** hours of **activities** to broaden your knowledge.
- 152** lectures forming a diversified scientific grid.
- 1000** m² of trade show full of **attractions**.

And a city full
of **warmth**
and **entertainment**
to welcome you!

International Speakers confirmed



James McNamara
USA

McNamara Course Free
for members registered before June 30, 2011 ABOR.

Take advantage of special conditions related to ABOR.



Albino Triaca
Germany



Eustáquio Araújo
USA



Giuseppe Scuzzo
Italy



Leena Palomo
USA



Marco Rosa
Italy



Martin Palomo
USA



Rolf Behrents
USA



Stephen Yen
USA

www.congressoabor2011.com.br

Register now!

Special conditions related to ABOR.
Submit your Scientific Paper:
FREE THEME, POSTERS, or CASE STUDY.

Achievement



Sponsorship



Organization



Agency Official



Support



**In the Republic Day Holiday,
participate in a Great Encounter
in the South of Brazil.**



1st FASURGS INTERNATIONAL CONGRESS
Bucomaxilofacial Surgery
Implantology
Orthodontics

PASSO FUNDO/RS – From 12 to 14 of Nov/2011



International Guest:

Júlio Cifuentes (Chile)

Sleep Apnea Syndromes with Surgical Treatment

National Guests:

Leopoldino Capellozza Filho – Facial Standard Diagnoses

José Capellozza – Orthodontics

Mauricio Cardoso – Orthodontics

Antenor Araújo – Orthognathic Surgery

Reinaldo Mazzotini – Orthognathic Surgery

Marcos Pita – T.M.J. Surgery and Prothesis

Hugo Nary – Implantology

Luciano Artioli – Laser in Surgery – Facial Pathologies

Claiton Hertz – T.M.J. Surgery

Marcio Grossi – Bruxism and Apnea.

Diderote Parreira – Otorhinolaryngology

Accomplishment



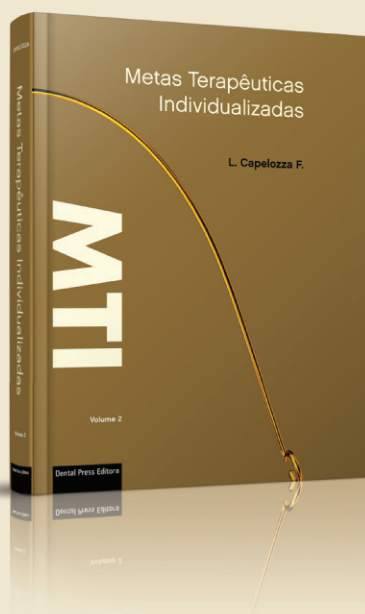
FASURGS – College Specialized in the Area of Health of Rio Grande do Sul

Rua Angélica Otto, 160 – ZIP CODE: 99025-270 - Passo Fundo/RS

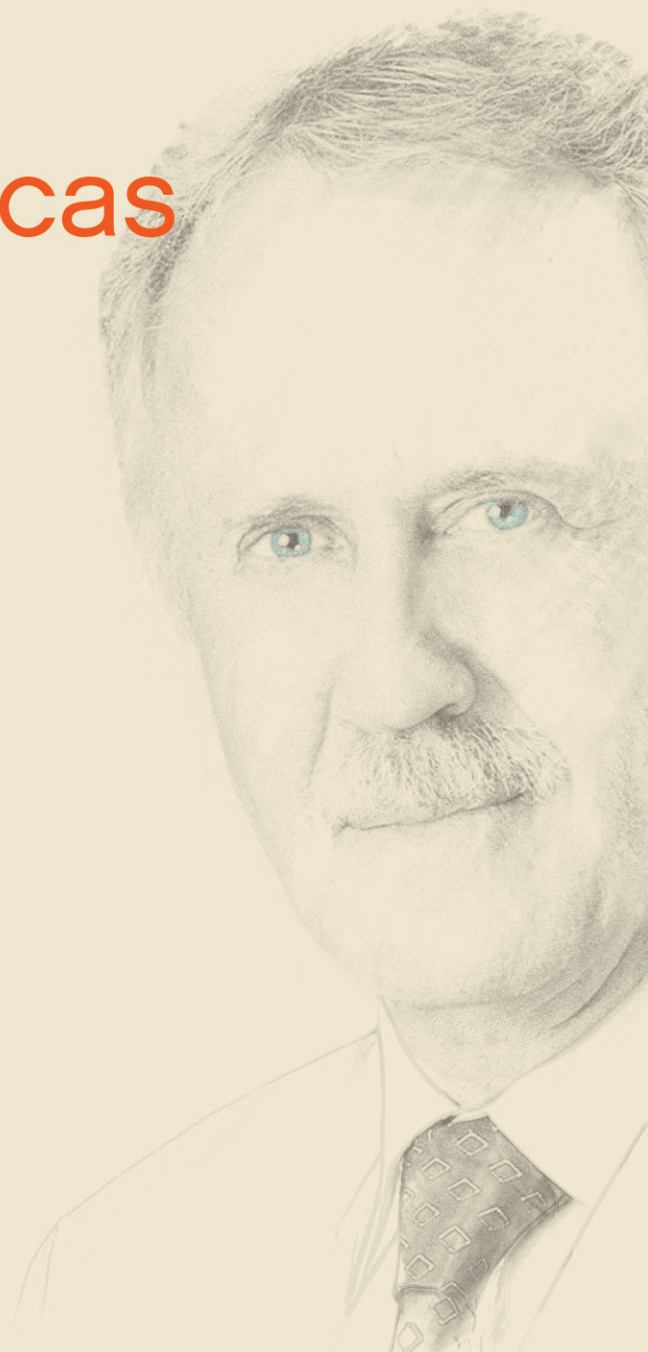
Phone: 54 3312-4121 - www.fasurgs.edu.br/congresso - congresso@fasurgs.edu.br

Metas Terapêuticas Individualizadas

L. Capellozza F.



2 volumes capa dura
984 páginas coloridas
23 x 30cm



Saiba tudo sobre o livro e leia uma entrevista com o autor no site www.dentalpress.com.br

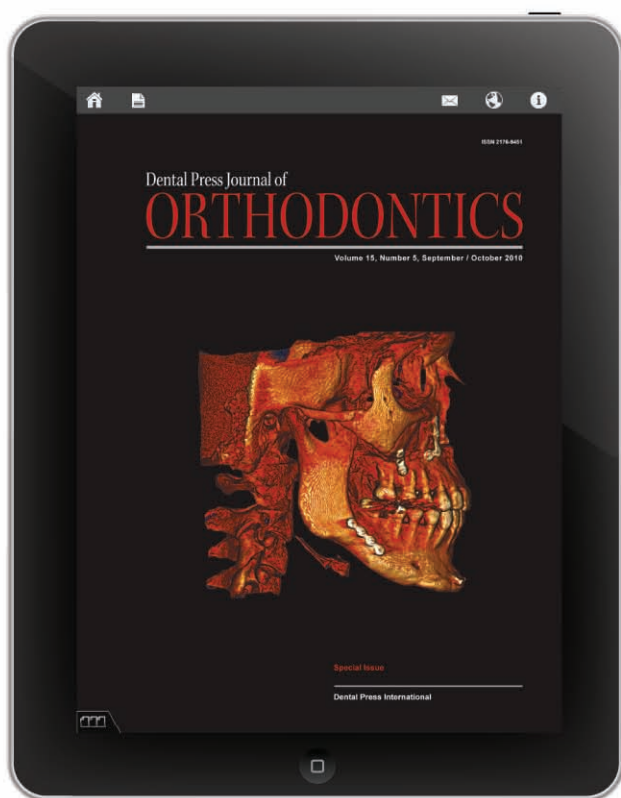


Adquira o seu em:
www.dentalcompras.com.br
ou pelo fone 44 3031-9818

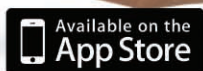
Dental Press Journal of

ORTHODONTICS

Agora, no Ipad.



Ao toque de suas mãos

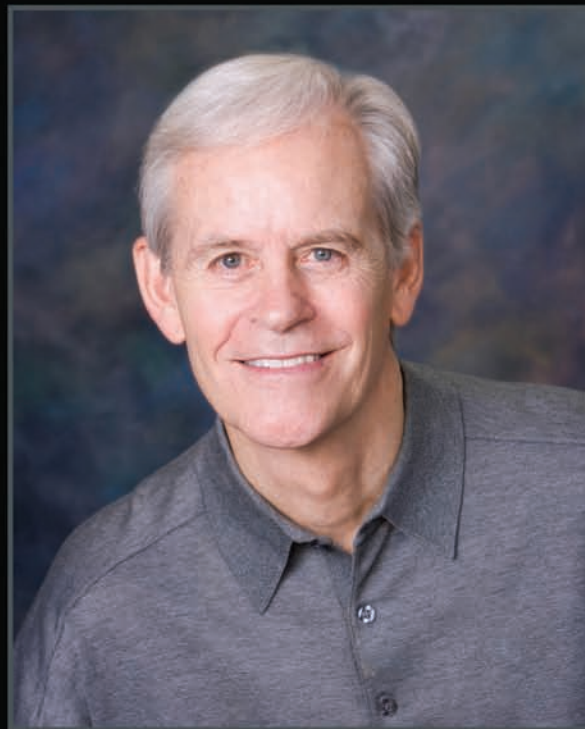


Ertty

Simpósio com o Dr. Wick Alexander 8 a 10 de Agosto de 2011

Conhecida como a "Cidade Maravilhosa", Rio de Janeiro é a cidade mais visitada no hemisfério sul e oferece um cenário fabuloso para este simpósio de três dias intensivos. Os Participantes irão se beneficiar da riqueza do Dr. Alexander, de seu conhecimento e experiência adquirida ao longo de quatro décadas como um educador de renome mundial.

Dr. Wick Alexander é reconhecido internacionalmente por sua inovação em procedimentos ortodônticos. Ele é bem conhecido por seu trabalho na concepção da Disciplina de Alexander, um sistema de braquetes e auxiliares, que são utilizados por ortodontistas em todo o mundo. Ministrou aulas sobre a disciplina Alexander, internacionalmente; bem como publicou vários trabalhos e artigos em revistas profissionais.



Telefones para contato:

Campinas/SP: 0800 771 6010

Rio de Janeiro: 0800 726 6786

Rio Grande do Sul: 0800 600 9775

São Paulo / Capital: 0800-7049025

www.power2reason.org

RIO DE JANEIRO

supported by



Uma programação científica voltada para a prática avançada da Ortodontia e da Ortopedia Funcional dos Maxilares.

A scientific agenda focused on the advanced practice of Orthodontics and the Functional Orthopedics of the Maxillaries.



15 a 17 de setembro • 2011 • Anhembi • São Paulo
September 15 thru 17, Anhembi Convention Center, Sao Paulo, Brazil

Módulo/module 1: Finalização ortodôntica: estética e oclusão / *Orthodontic completion: esthetics and occlusion*
Ministradores/lecturers: Ana Carla Nahás; Flávio Vellini Ferreira; Weber Ursi; Flavio Cotrim-Ferreira

Módulo/module 2: Tratamento ortodôntico de más-oclusões assimétricas / *Orthodontic treatment of bad asymmetric occlusions*
Ministradores/lecturers: Arno Locks; Marcos Janson; Maurício Sakima; Guilherme Janson

Módulo/module 3: O estado da arte na Ortodontia – filosofia de tratamento ortodôntico MBT – uma Ortodontia ao alcance de todos / *The state-of-the-art in Orthodontics – philosophy of the MBT orthodontic treatment – Orthodontics that everyone can afford*
Ministradores/lecturers: Ricardo Moresca; Reginaldo Zanelato Trevisi; Cristina Domingues; Hugo Trevisi

Módulo/module 4: Disgenesias: visão contemporânea do diagnóstico; bases biológicas para compreensão, orientação e tratamento / *Dysgenesis, contemporary vision of the diagnosis; biological bases for understanding, guidance and treatment*
Ministradores/lecturers: Alberto Consolaro; Daniela Garib; Maurício Cardoso; Leopoldino Capelozza Filho

700 places
320 already completed

OrtoNews2011

O Encontro **Mais** de Ortodontia e Ortopedia Funcional dos Maxilares.

Um encontro para quem é Mais. Participe. Virada de preço em 3/6.
A meeting for someone who is More. Participate. Enrollment fee will change on June 3rd.

Programação científica completa e adesões on-line / Complete scientific agenda and on-line enrollments
www.ortociencia.com.br/ortonews

Informações adicionais e adesões / Additional information and enrollments

☎ 55 11 2168-3400 (Camila Adrieli) – ortonews@ortociencia.com.br



ACADEMIA BRASILEIRA DE FISIOPATOLOGIA CRÂNIO-ORO-CERVICAL





2º Congresso Internacional MBT

Date: August 25, 26 and 27, 2011

Location: Abzil - São José do Rio Preto /SP, Brazil

Information: (55 18) 3222-4285
cursos@trevisi.com.br



15º Encontro AOA - "De Volta Para o Seu Futuro"

Date: August 26 and 27, 2011

Location: Hotel Fazenda Salto Grande - Araraquara / SP, Brazil

Information: (55 16) 3397-4924
gestos@gestos.com.br



2º CIOMT – Congresso Internacional de Odontologia de Mato Grosso

Date: September 15, 16 and 17, 2011

Location: Hotel Fazenda Mato Grosso - Cuiabá / MT, Brazil

Information: (55 65) 3321-4428 / 3624-5212
www.ipeodonto.com.br



8º Congresso da Associação Brasileira de Ortodontia e Ortopedia Facial

Date: October 12 to 15, 2011

Location: Belo Horizonte / MG, Brazil

Information: www.congressoabor2011.com.br/



Congresso Internacional de Ortodontia, Implantodontia e Cirurgia Ortognática

Date: November 4 and 5, 2011

Location: Vale do Paraíba / SP, Brazil

Information: (55 11) 4368-5678



XX Congresso OMD (Ordem dos Médicos Dentistas)

Date: November 10, 11 and 12, 2011

Location: Centro de Congressos de Lisboa - Portugal

Information: www.ond.pt/congresso



1º Congresso Internacional FASURGS - Cirurgia Bucomaxilofacial, Implantodontia e Ortodontia

Date: November 12, 13 and 14, 2011

Location: FASURGS - Passo Fundo / RS, Brazil

Information: (55 54) 3312-4121
www.fasurgs.edu.br/congresso

Chicago AAO 2011 Annual Session

Dental Press attended the 111th AAO Annual Session (American Association of Orthodontists), which was held between the 13th and 17th of May in Chicago (USA). During the event, it was presented a version of the Dental Press Journal of Orthodontics for iPad, the first magazine in the specialty for tablets.



Drs. Vincent Kokich, Rachel Furquim, Teresa Furquim and Adilson Ramos.



Drs. Patricia and Márcio Almeida Rodrigues.



Drs. Merian L. de Moura and Ertty Silva.



Drs. Telma Martins de Araújo and Carlos Vogel.



Drs. Rachel Furquim, Kurt Faltin Jr. and Merian L. de Moura.



Drs. Guilherme Janson, Tassiana Simão, Ajalmair and Nair Maia.



Drs. Teresa Furquim, Larry White and Rachel Furquim.



Drs. Will A. Andrews, Thiene and David Nor-mando.



Dr. Marcos Janson.

Brazilian Board meeting with the American Board in Chicago

During the Congress of the AAO, Chicago, USA, on the morning of Monday, May 16 at the Peninsula Hotel, a historic meeting was held. The meeting between directors and former presidents of the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) and directors of the American Board of Orthodontics (ABO). At the meeting agenda, the discussion about the reasons for the certification by the Board, including raising of the quality of care and protection of the public. It was an extremely positive opportunity, with many questions and the promise of support in every sense of the ABO for the consolidation and improvement of the Brazilian Board.



Attended the meeting: President of the ABO, Barry S. Briss, president of BBO, Ademir Roberto Brunetto. Directors: Deocleciano da Silva Carvalho, Sadi Flávio Horst, Eustáquio Alfonso Araújo, Roberto Rocha, Carlos Alberto Estevanell Tavares, Jonas Capelli Junior, Roberto Carlos Bodart Brandão, besides the former presidents Roberto Mario Amaral Lima Filho, Carlos Jorge Vogel, José Nelson Mucha and Telma Martins de Araújo.

7th Meeting Abzil/3M of Individualized Orthodontics

It was held in Belém (PA, Brazil), between 26 and 28 of May, the 7th Meeting of Individualized Orthodontics, with the presence of the speakers: Leopoldino Capellozza Filho, Laurindo Furquim, Jesus M. Pinheiro Jr., Sílvia Braga Reis, Sérgio Luiz de Azevedo Silva, José Valladares Neto and David Normando. Prof. Capellozza presented the book "Metas Terapêuticas Individualizadas (Individualized Therapeutic Goals)", his second publication by the Dental Press Publishing Co.



Drs. Diana A. Athayde Fernandes and Dr. Leopoldino Capellozza.



Drs. Thiene Normando and Sílvia Reis.



Event organizers and professors.



Drs. Mielli Teixeira e Silva and Mara Sandra Ferrais Tobias.



Drs. Eduardo Maranhão, Eurico Correia, Jesus Maués P. Junior and Theodorico Neto.



Drs. Adriana V. M. da Silva and Edilson da Silva.



Drs. Hellen G. A. Santos and Lucyana Azevedo.



Drs. Roberta F. Marbá and Renata B. Neri.



Drs. Carolina Lima and Leopoldino Capellozza.



Drs. Marília Guimarães and Fernanda Pinheiro.



Drs. Murilo Neves and Rafael Simas.



Drs. Iara Reis, Yuri Sasai, Laurindo Furquim and Socene Veloso.

Cephalometry is an important predictor of sleep-related breathing disorders in children

Jorge Faber*, Flávia Velasque**

Sleep-related breathing disorders (SBD) have been studied and treated for a long time in adults, but little attention has been given to children, for whom SBD may be as serious as for adults. Parents, guardians and healthcare personnel should pay close attention to these problems, which may be treated during childhood. Their effects on everyday life, such as hyperactivity and poor school achievement, may have a severe impact on the development of an individual and may clearly affect health.

The relevance of this problem has motivated authors to evaluate the cephalometric characteristics of children with SBD.¹ Cephalometry is an important facial morphometry tool available practically all over the world. This study sample included 70 children (34 boys; mean age = 7.3 ± 1.72 years) who usually snored and had symptoms of sleep-related obstructive breathing disorders for over 6 months. Nocturnal polysomnography was used to divide children into 3 groups: 26 children with a diagnosis of obstructive sleep apnea (OSA); 17 with signs of upper airway resistance syndrome (UARS), and 27 snorers. The control group had 70 children with no breathing obstructions paired for age and sex. Lateral head radiographs were obtained, and cephalograms were traced and measured.

Children with SBD had a shorter mandible ($P = 0.001$) and a greater inclination in relation to the palatal plane ($P = 0.01$). Anterior face height ($P = 0.01$) and lower face height ($P = 0.05$) were greater than in control children. Their soft palate was longer ($P = 0.018$) and thicker ($P = 0.002$). Airways

had a smaller diameter in the nasopharyngeal region, but the oropharynx had a greater diameter at the base of the tongue ($P = 0.01$). The hyoid bone was placed at a more inferior position ($P < 0.01$), and craniospinal angles were greater than those found in the control group, in which children had no breathing obstruction.

When divided in subgroups according to disease severity, children with OSA had significant differences from children in the control group, particularly for the oropharyngeal variables. Children with UARS and snoring also had differences from the control groups, but subgroups with obstruction were not reliably distinguished from each other by cephalometric measures. Logistic regression revealed that UARS and OSA were associated with a decrease in pharyngeal diameter in the adenoid and uvula tip regions, an increase in its diameter in the region of the base of the tongue, and a thick soft palate. In addition, their maxilla had a more anterior position in relation to the cranial base.

This is an important study because it shows that cephalometry may be an important predictor of SBD in children. Special attention should be given to the pharyngeal measures. Children with SBD should undergo systematic orthodontic evaluations because of the effects of OSA on the development of craniofacial bones. The orthodontist is the specialist with the best knowledge of the diagnostic tools for these cases and may substantially contribute to improving health and quality of life of children with SBD.

* Associate Professor, Orthodontics, Universidade de Brasília, Brazil.

** Private practice, Orthodontics and Pediatric Orthodontist.

Should teeth be extracted at the beginning of prosthetic treatment?

The usual first option for dentists and lay-people when a tooth has problems is to treat and preserve it. However, clinical management often has to be less conservative. Therefore, dentists often face the difficult task of deciding about the effect and importance of the multiple risk factors of periodontal, endodontic or prosthetic origin that may affect the prognosis of an abutment. The relevance of this topic and the changes in concepts due to the development of new techniques in the different dental specialties led the authors to conduct a review whose purpose was to summarize the critical factors involved in decisions about whether a problematic tooth should be treated and preserved or extracted and possibly replaced with an implant.²

A literature search was conducted for peer reviewed studies published in English and found in MEDLINE (PubMed) from 1966 to 2009. Different keyword combinations were used, such as treatment plan and decision making,

periodontics, endodontics, dental implants or prosthesis. In addition, the reference lists of all relevant studies and reviews were surveyed.

The study concluded that tooth preservation and the acceptance of risks are properly defined for several situations. At first, the tooth should be preserved if not extensively damaged and when it has a strategic value, either esthetic or functional. This applies especially for patients with implant contraindications. Moreover, preservation is further recommended in case the tooth is in an intact arch, and when the preservation of the gingival structures is fundamental.

In contrast, when restorations are planned for all the mouth, the strategic use of tooth implants is recommended. In addition, several smaller fixed prostheses, either implants or abutments, may be used. In this case, teeth whose long-term prognosis is excellent should be selected. These procedures ensure that the risk of failure of all the restorations will be reduced.

Obesity is associated with periodontal infection

A common observation made by clinical dentists is that obese patients seem to have more frequent periodontal infections than the rest of the population. This possible association, relevant because additional care should be provided for obese people, has been recently analyzed in an adult population.³

The study included 2,784 dentate, non-diabetic individuals aged 30 to 49 years. Obesity was assessed according to body mass index (BMI), body fat percentage (BF%) and waist circumference (WC). The extension of periodontal infection was assessed using the number of teeth with periodontal pockets (whose depth was equal to or greater than 4 mm) and was classified into four categories 0; 1-3; 4-6; 7 or more.

The authors found a significant positive association between the number of teeth with deep periodontal pockets and BMI. The association was found among both men and women, and also among those who never smoked. The number of teeth with deep periodontal pockets was also associated with BF% and WC among individuals who never smoked.

This study results suggest that periodontal infection, measured according to the number of teeth with deep periodontal pockets, seems to be associated with obesity. However, no causal inference may be made, and further studies should elucidate the role of periodontal infection in obesity. However, findings suggest that the periodontal health of obese patients deserves special attention.

REFERENCES

1. Pirilä-Parkkinen K, Löppönen H, Nieminen P, Tolonen U, Pirttiniemi P. Cephalometric evaluation of children with nocturnal sleep-disordered breathing. *Eur J Orthod*. 2010;32(6):662-71.
2. Zitzmann NU, Krastl G, Hecker H, Walter C, Waltimo T, Weiger R. Strategic considerations in treatment planning: deciding when to treat, extract, or replace a questionable tooth. *J Prosthet Dent*. 2010;104(2):80-91.
3. Saxlin T, Ylöstalo P, Suominen-Taipale L, Männistö S, Knuuttila M. Association between periodontal infection and obesity: results of the Health 2000 Survey. *J Clin Periodontol*. 2011;38:236-42.

Contact address
Jorge Faber
E-mail: faber@dentalpress.com.br

Indirect bone resorption in orthodontic movement: when does periodontal reorganization begin and how does it occur?

Alberto Consolaro*, Lysete Berriel Cardoso**, Angela Mitie Otta Kinoshita***, Leda Aparecida Francischone***, Milton Santamaria Jr****, Ana Carolina Cuzzol Fracalossi*****, Vanessa Bernardini Maldonado*****

Tooth movement induced by orthodontic appliances is one of the most frequent therapeutic procedures in clinical dental practice. The search for esthetics and functionality, both oral and dental, demands orthodontic treatments, which are often associated with root resorptions that may, in extreme cases, lead to tooth loss, periodontal damage, or both.

The knowledge of induced tooth movement biology, based on tissue, cell and molecular phenomena that take place on each day during movement progression, enable us to act safely and consciously when using drugs, procedures and interventions to optimize orthodontic treatment and patient comfort, to reduce or avoid root resorptions and to treat systemically compromised patients.

The experimental model of induced tooth movement described by Heller and Nanda⁵ has been widely adopted^{3,10} because results can be extrapolated to orthodontic clinical practice (Fig 1). Standardization and detailed descriptions of this experimental model ensure greater applicability and easier result extrapolations. The improvement of this model may provide further knowledge about the biology of induced tooth movement.^{3,10}

In general, experimental times were 5 to 7 days in the first studies.^{7,8,9,13} However, it remains unclear what tissue phenomena take place in murine maxillary first molar roots that received intense forces and produce indirect bone resorption. Several questions raised in previous studies^{4,6,10,11} using this model have not been answered to this date:

- » Is the root resorption associated with experimental induced tooth movement more closely related with frontal or undermining bone resorption?
- » How long does it take to eliminate the hyaline areas, and when does the periodontal ligament begin its reorganization?
- » When and how is the reabsorbed cortical bone replaced to reinsert the periodontal ligament?
- » Do the hyalinized areas of connective tissue undergo phagocytosis, resorption or circumscription?
- » Where does root resorption occur, immediately next to or away from hyaline areas?
- » When indirect bone resorption is suspected, do microscopic data suggest the adoption of a greater interval for the reactivation of the orthodontic appliance?

How to cite this article: Consolaro A, Cardoso LB, Kinoshita AMO, Francischone LA, Santamaria Jr M, Fracalossi ACC, Maldonado VB. Indirect bone resorption in orthodontic movement: when does periodontal reorganization begin and how does it occur? *Dental Press J Orthod.* 2011 May-June;16(3):25-31.

* Head Professor, School of Dentistry of Bauru (FOB) and Graduate Program of School of Dentistry of Ribeirão Preto (FORP), University of São Paulo (USP), Brazil.

** Professor, Histology, Anhanguera School, Bauru, Brazil.

*** Professor, Oral Biology Program, Sagrado Coração University, Bauru, Brazil.

**** Professor, Orthodontics Program, Araras University, Araras, Brazil.

***** MSc in Oral Pathology from FOB. PhD from Federal University of São Paulo, São Paulo, Brazil.

***** MSc in Pediatric Dentistry from FORP-USP.

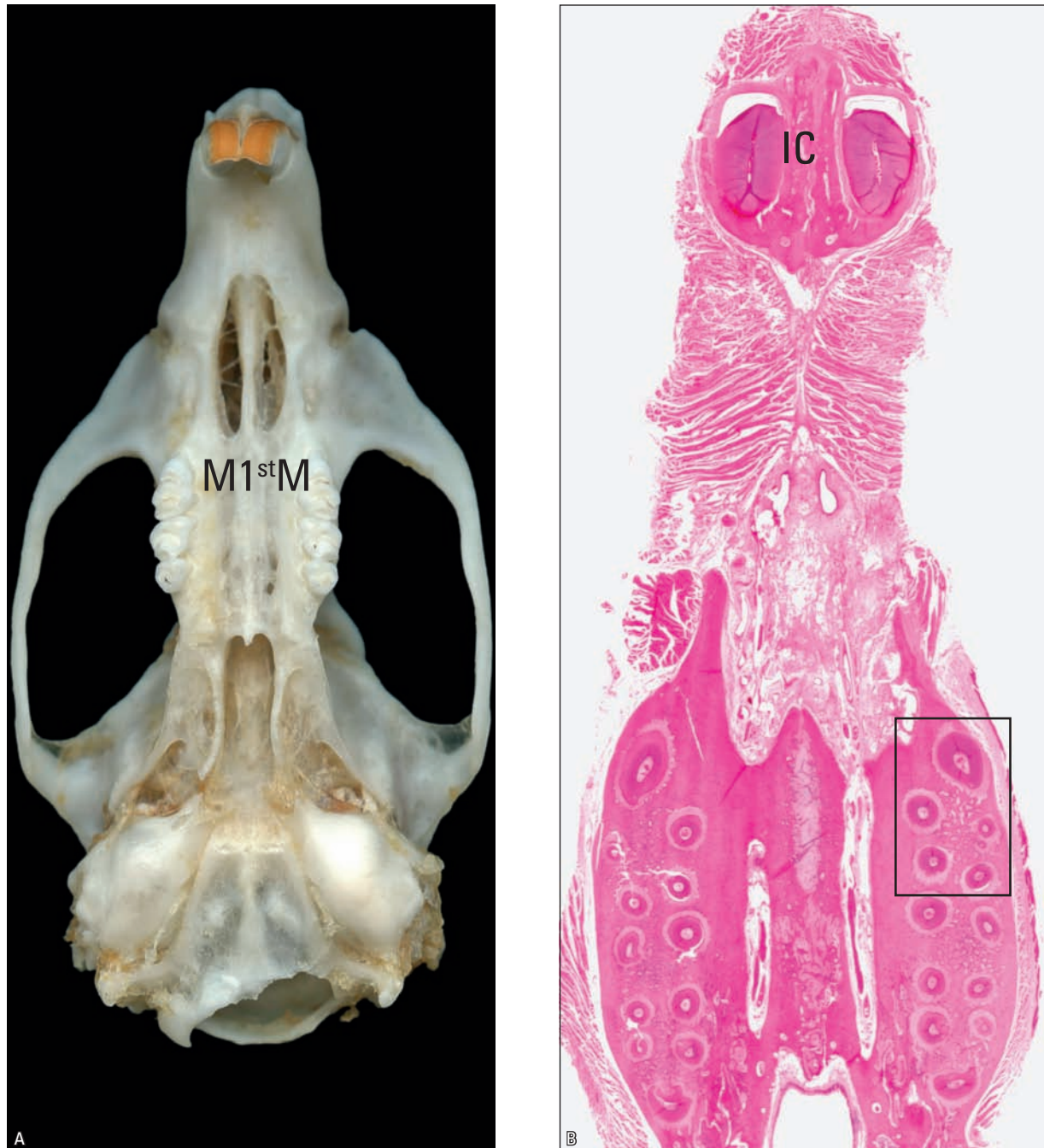


FIGURE 1 - Murine skull where molars and incisors (IC) are seen, particularly maxillary first molar (M1stM) after movement by appliance designed by Heller and Nanda.⁵ Microscopic cross-section (B) shows tooth roots, particularly M1stM, in cervical plane.

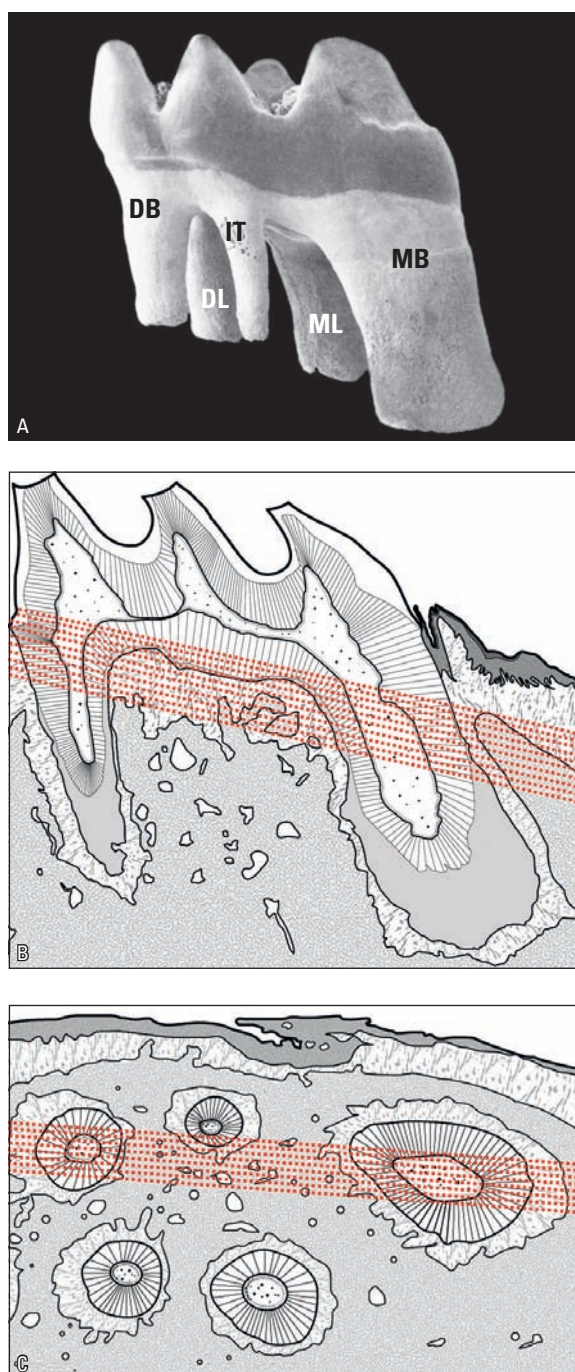


FIGURE 2 - In **A**, murine first molar and its five roots. In the mesio-buccal (MB) root, forces dissipate along its larger and longer structure. In other roots (distobuccal, intermediate, distolingual and mesiolingual), delicate structures clearly show effects of forces on periodontal tissues. In **B**, red lines show cross-sections at cervical level in schematic drawing of a longitudinal section of murine first molar. In **C**, red lines correspond to longitudinal views in cross-section of murine maxillary first molar (**A**: modified from Alatlí-Kut et al.¹; **B** and **C**: of Fracalossi⁴).

» When palatal expansion is used, appliance anchorage in maxillary premolars promotes hyalinization of the periodontal ligament on the buccal face. Forces dissipate and the process ends when the midpalatal suture is separated. Does indirect bone resorption begin long before that? When does it actually begin, at 3, 5, 7 or 9 days?

Few studies investigated the chronology and sequential events of indirect bone resorption and the consequent periodontal reorganization resulting from it. Microscopic analyses of the events induced by intense forces on teeth that undergo experimentally induced movement in murine models contributed to answer some of the questions raised, such as in the study conducted by Cardoso,² together with Consolaro, Kinoshita, Francischone, Santamaria Jr., Fracalossi and Maldonado. Their most interesting findings were the late results, when the periodontal ligament is reorganized and root resorptions are more active and intense (Figs 6, 7 and 8).

In patients, delayed events and periodontal reorganization occur at each activation time, between 15 and 21 days. At the end of six to twelve years, the resulting sum of the several orthodontic appliance activation times may be demonstrated by radiographic and CT images of periodontal tissues and tooth roots. Knowing each activation time and its beginning, middle and end substantially increases our chances of acting to reduce unwanted consequences.

Some of the interventions that orthodontic specialists may choose, based on results of experimental studies, are:

- 1) Defining plans to prevent root resorption and bone loss.
- 2) Distributing the application of forces on tooth structure to reduce patient pain and discomfort.

Ligament hyalinization reduces or blocks tooth movement and may also be associated with root resorption. Knowledge about tissue,

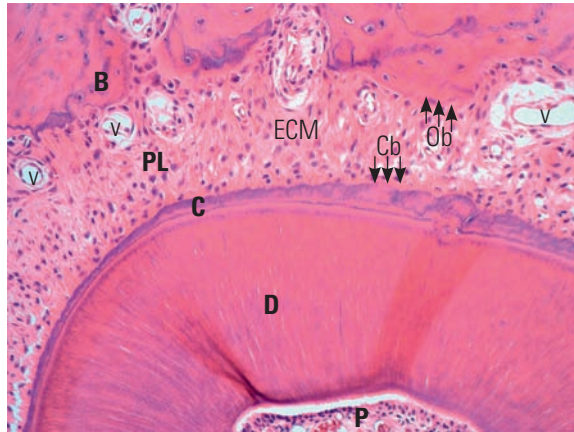


FIGURE 3 - Normal periodontal structures on the mesial face of murine M1stM distobuccal root, which received intense forces in the experimental model designed by Heller and Nanda.⁵ B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; P = tooth pulp; V = vessels; Cb = cementoblasts; Ob = osteoblasts; ECM = extracellular matrix. (HE;10X).

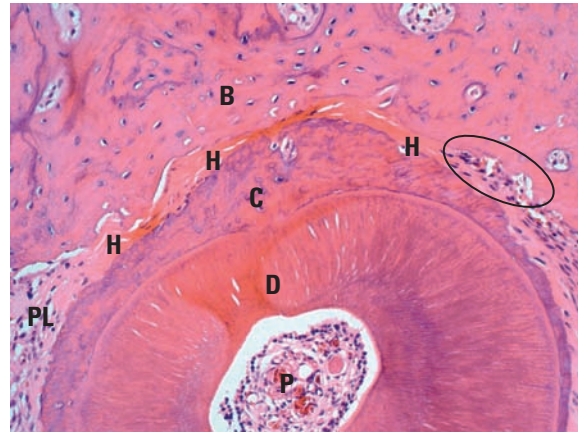


FIGURE 4 - Incipient indirect bone resorption on mesial face of murine M1stM distobuccal root after application of intense forces for 3 days. Hyalinized periodontal ligament (H) and initial clastic activity (circle) surround it. B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; P = tooth pulp. (HE; 10X).

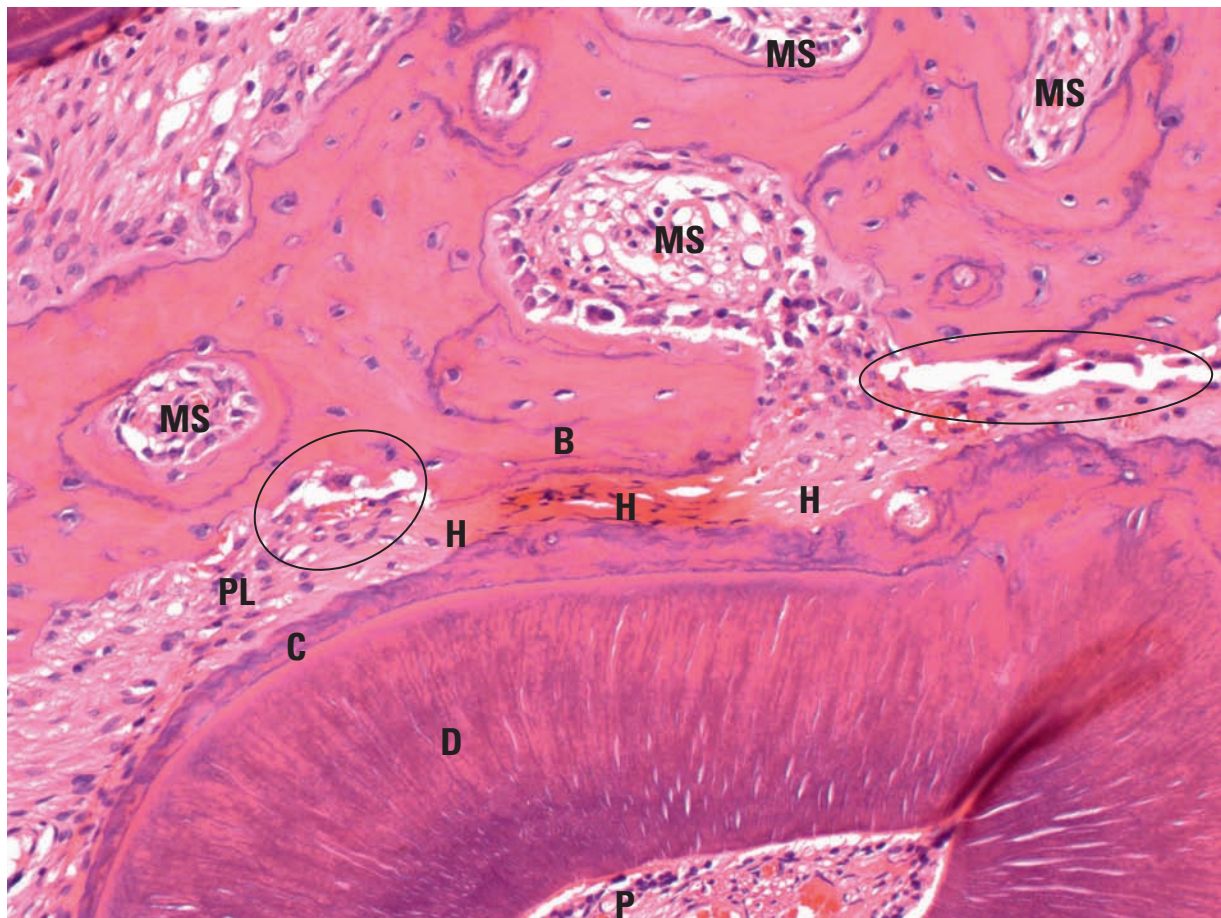


FIGURE 5 - Indirect bone resorption on mesial face of murine M1stM distobuccal root after application of intense forces for 5 days. Hyalinized periodontal ligament (H) and clastic activity (circle) surround it. B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; P = tooth pulp; MS = marrow space. (HE; 10X).

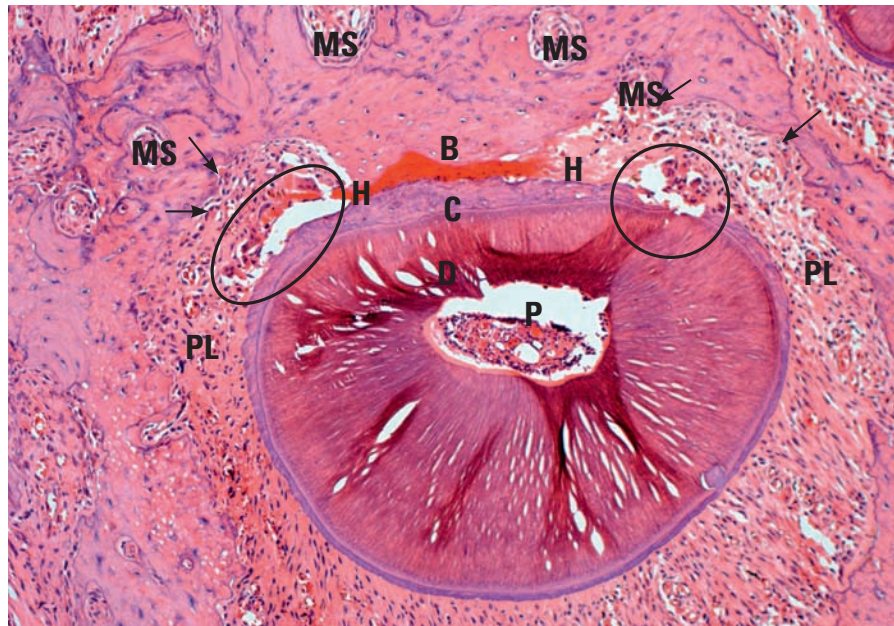


FIGURE 6 - Indirect bone resorption (arrows) on mesial face of murine M1^M distobuccal root after application of intense forces for 7 days. Hyalinized periodontal ligament (H) and clastic interaction with hyalinized areas surround it. Root surface exposure due to root resorption induced by death of cementoblasts; several associated bone remodeling units (circles). B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; P = tooth pulp; MS = marrow space. (HE; 10X).

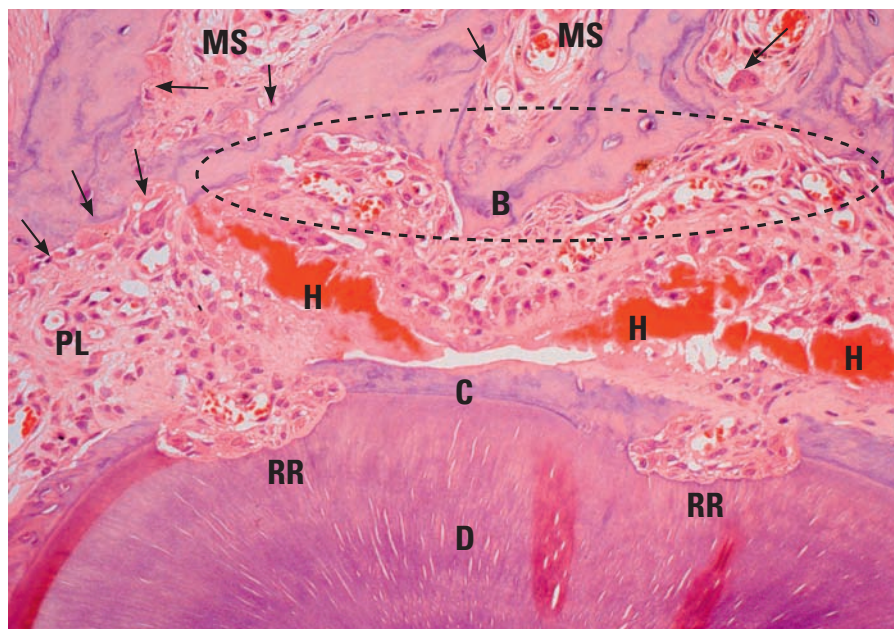


FIGURE 7 - Indirect bone resorption (arrows) on mesial face of murine M1^M distobuccal root after application of intense forces for 9 days. Ligament is reorganizing and frontal bone resorption is already visible on periodontal surface of cortical plate (circle). Hyaline areas remaining from previously hyalinized periodontal segment (H) are associated with clastic activity. Root resorption (RR) is seen in cement and dentine, together with active bone remodeling units. B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; MS = marrow space. (HE; 10X).

cell and molecular phenomena involved in induced tooth movement may provide a basis for clinical procedures.

Murine molars have 5 roots,^{3,5,12} and the experimental orthodontic appliance (Fig 1) designed by Heller and Nanda⁵ applies intense forces on four roots: distobuccal, intermediate, distolingual and mesiolingual (Fig 2). In the mesial or mesiobuccal root, the forces applied by the appliance dissipate along larger and longer root structures, which affect periodontal tissues

similarly to the application of slight or moderate forces. Because of these characteristics, in the experimental model the effects of two types of forces may be analyzed at the same time according to their intensity: mild/moderate or intense.

The distolingual root, according to the study by Cardoso,² may show morphological changes associated with indirect buccolingual bone resorption in cross-sections of the cervical region of the root and the alveolar bone process, as illustrated in Figures 3, 4, 5, 6, 7 and 8.



FIGURE 8 - Indirect or undermining bone resorption (arrows) on mesial face of murine M1*M distobuccal root after application of intense forces for 9 days, and more advanced reorganization than in Figure 7. Periodontal ligament is reorganizing together with remnants of cortical bone. Hyaline areas remaining from previously hyalinized periodontal segment (H) are associated with clastic activity. B = alveolar bone; PL = periodontal ligament; C = cement; D = dentine; P = tooth pulp; MS = marrow space. (HE;10X).

Final considerations

The conclusions of the study discussed here showed that:

1. At 3 days of tooth movement induced by intense forces, indirect bone resorption had not begun in most of the specimens analyzed, but some showed discrete points of bone remodeled units (Fig 4).
2. Only at 5 days were osteoclasts from bone remodeled units seen on adjacent bone surfaces and around hyaline areas. At this time, root resorption was still incipient and limited to cement (Fig 5).
3. At 7 days, there was clear indirect bone resorption on trabecular bone and cortical surfaces, but is far from the cortical bone associated with the segment of hyalinized periodontal ligament (Fig 6). Bone resorption in ortho-

odontic movement, when induced by mild to moderate forces, occurs on the surface of cortical bone in front of the area of periodontal ligament compression and is, therefore, called frontal bone resorption. In indirect bone resorption, the connections of cortical bone with adjacent and underlying bone are undermined by numerous bone remodeling units. Root resorptions are active, occur in a larger extension and affect dentine more deeply.

4. At 9 days of tooth movement induced by intense forces, the hyaline areas are under partial resorption (Figs 7 and 8). The periodontal ligament is under reorganization. Only isolated signs of the previous undermined cortical plate remain because it is undergoing complete remodeling. Root resorptions are still actively occurring.

REFERENCES

1. Alatli-Kut I, Hultenby K, Hammarstrom L. Disturbances of cementum formation induced by single injection of 1-hydroxyethylidene-1,1-bisphosphonate (HEBP) in rats: light and scanning electron microscopic studies. *Scand J Dent Res*. 1994;102(5):260-8.
2. Cardoso LB. Análise morfológica da evolução da reabsorção óssea à distância na movimentação dentária induzida em molares murinos [dissertação]. Bauru: Universidade Sagrado Coração; 2011.
3. Consolaro A. Reabsorções dentárias nas especialidades clínicas. 2ª ed. Maringá: Dental Press; 2005.
4. Fracalossi ACC. Análise da movimentação dentária induzida em ratos: influência do alendronato nas reabsorções dentárias, estudo comparativo em cortes transversais e longitudinais e avaliação microscópica em diferentes períodos de observação [dissertação]. Bauru: Universidade de São Paulo; 2007.
5. Heller IJ, Nanda R. Effect of metabolic alteration of periodontal fibers on orthodontic movement: an experimental study. *Am J Orthod*. 1979;75:239-58.
6. Maldonado VB. Efeitos microscópicos do ácido salicílico (aspirina) e do acetaminofeno (tylenol) na movimentação dentária induzida e nas reabsorções radiculares associadas [dissertação]. Ribeirão Preto: Universidade de São Paulo; 2009.
7. Mazziero ET. Bisfosfonato e movimentação dentária induzida: avaliação microscópica de seus efeitos [tese]. Bauru: Universidade de São Paulo; 1999.
8. Ortiz MFM. Influência dos bisfosfonatos na movimentação dentária induzida, na frequência e nas dimensões das reabsorções radiculares associadas [tese]. Bauru: Universidade de São Paulo; 2004.
9. Pereira ACC. Influência da gravidez e dos anticoncepcionais na reabsorção radicular e na remodelação óssea consequente à movimentação dentária induzida: avaliação microscópica [dissertação]. Bauru: Universidade de São Paulo; 1996.
10. Ren Y, Maltha JC, Kuijpers-Jagtman AM. The rat as model for orthodontic tooth movement: a critical review and proposed solution. *Eur J Orthod*. 2004;26:483-90.
11. Santamaria Jr M. Biologia da movimentação dentária induzida e das reabsorções radiculares associadas. Influência do gênero e dos bisfosfonatos [tese]. Bauru: Universidade de São Paulo; 2009.
12. Schour I, Massler M. The teeth. In: Farris EJ, Griffith JK. *The rat in laboratory investigation*. 2nd ed. New York: Hafner; 1963. p. 104-65.
13. Vasconcelos MHF. Análise morfológica comparativa do periodonto de sustentação submetido a forças biologicamente excessivas em ratas adultas sem e sob o uso de anticoncepcionais e ratas prenhas [dissertação]. Bauru: Universidade de São Paulo; 1996.

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

An interview with James A. McNamara Jr.

- Degree in Dentistry and Orthodontics, University of California, San Francisco.
- PhD in Anatomy from the University of Michigan.
- Professor of Thomas M. and Doris Graber Chair, Department of Orthodontics and Pediatric Dentistry - University of Michigan.
- Professor of Cell Biology and Development - University of Michigan.
- Research Professor at the Center for Human Growth and Development at the University of Michigan.
- Author of the book "Orthodontics and Dentofacial Orthopedics."
- Milo Hellman Research Award (AAO - 1973).
- Lecturer Sheldon E. Friel (European Society of Orthodontics -1979).
- Award Jacob A. Salzmann (AAO - 1994).
- Award James E. Brophy (AAO - 2001).
- Lecturer Valentine Mershon (AAO - 2002).
- Award Albert H. Ketcham (AAO - 2008).
- Graduate of the American Board of Orthodontics - ABO.
- Fellow of the American College of Dentists.
- Former President of Edward H. Angle Society of Orthodontists - Midwest.
- Editor of series "Craniofacial Growth Monograph" - published by University of Michigan.
- Over 250 published articles.
- Wrote, edited or contributed to more than 68 books.
- Taught courses and conferences in 37 countries.



I met James A. McNamara Jr. in the late 70's when we both became full members of the Edward H. Angle Society of Orthodontists - Midwest. Jim is one of the most active members, always looking on to break boundaries with new works. During over 30 years, I saw him being presented with all the existing awards and honors in the field of orthodontics. Knowing his ability and persistence, I'm sure that if in the future other awards are instituted, Jim will be there to, with all merits, conquer them. It is fortunate to have a family that supports and encourages: his wife Charlene, who accompanies him on every trip, and Laurie, his daughter and colleague, now a partner in his clinic. In addition to Orthodontics, he is passionate about golf and photography.

My sincere thanks to colleagues Bernardo Quiroga Souki, José Maurício Vieira de Barros, Roberto Mario Amaral Lima Filho, Weber Ursi, and Carlos Alexandre Câmara, who accepted the invitation to prepare questions that facilitated the development of the script of this interview. I hope that readers will experience the same pleasure and satisfaction I felt, when reading the answers. Jim was able to show growth and maturity of his clinical career, based on scientific evidence, with a clarity and simplicity that makes him, besides clinician and researcher emeritus, one of the best speakers of our time.

I thank the Dental Press for the opportunity to conduct this interview and wish you all a good reading.

Carlos Jorge Vogel

1) May I begin by asking you to tell us about your general educational background and your education in orthodontics?

I began my collegiate education at the University of California Berkeley, where I majored in Speech (today called Forensics), not science or biology. I then attended the School of Dentistry at the University of California San Francisco, where I received my dental degree and my specialty education in orthodontics. In 1968, I traveled 2000 miles east to Ann Arbor and began my doctoral studies in the Department of Anatomy at the University of Michigan. I also became affiliated with the Center for Human Growth and Development, an interdisciplinary research unit on the Ann Arbor campus that was headed by Dr. Robert Moyers. I had many wonderful mentors during my PhD years, including bone biologist Donald Enlow as well as orthodontists Frans van der Linden from the Netherlands, Kalevi Koski from Finland, Takayuki Kuroda from Japan and José Carlos Elgoyhen from Argentina. It was an exciting time for a young man like me to conduct research at the University of Michigan. My dissertation concerned the adaptation of the temporomandibular joints in rhesus monkeys, a study completed in 1972.^{1,2} I then was appointed to the University of Michigan faculty. I have been at Michigan ever since.

In addition to my current appointments in the School of Dentistry, the School of Medicine, and the Center for Human Growth and Development, I have maintained a part-time private practice in Ann Arbor, now sharing the practice with my daughter and partner Laurie McNamara McClatchey. Given my 40 years experience in private practice (with my partners and I sharing the same patients) as well as through my clinical supervision at the University of Michigan (and for eight years at the University of Detroit Mercy), I estimate that I have participated in the treatment of over 9,000 orthodontic patients. Thus, I have both academic and clinical perspec-

tives concerning orthodontics and dentofacial orthopedics. Maintaining a private practice while being on the Michigan faculty has had many advantages.

In addition, our research group, which includes Tiziano Baccetti and Lorenzo Franchi from the University of Florence, has addressed many orthodontic conditions from a clinical perspective, providing data on treatment outcomes. In this interview, I will be referring primarily to clinical investigations conducted by our group because the protocols used in our research efforts are consistent across studies.

2) You have been in private practice for a long time and have been an innovator of many orthodontic and dentofacial orthopedics treatments. How has your practice evolved over the years?

If anything, my practice philosophy has become simpler as the years have passed. I was well educated at UCSF in fixed appliance treatment and even used some preadjusted appliances during my residency in the mid 1960s. Beginning in the early 1970s, I began working with a variety of appliances aimed at modifying craniofacial growth, including functional jaw orthopedics (FJO), rapid maxillary expansion (RME) and facial mask therapy.

In 1980, I began formulating and testing protocols in the early mixed dentition for the correction of crossbites and of tooth-size/arch-size discrepancies, first with a bonded expander and later adding a removable lower Schwarz expansion appliance. As time passed, I began to realize how important it is for the orthodontist to have patience during treatment, letting normal growth and development of the patient take place after early intervention (for example, we will talk about creating an environment allowing “spontaneous improvement” in Class II malocclusion later in this discussion).

Today our treatment protocols are far less

complex that they were 20 years ago. Our regimens are clearly defined and standardized for the most part,³ as they had to become when I began sharing patient treatment with partners in my practice beginning in 1989. We also have placed significant emphasis on using those protocols that are not dependant on required high levels of patient compliance.

3) You thus have been an advocate of early orthodontic and orthopedic treatment for much of your professional career. Today, what are the most important issues related to early treatment?

In my opinion, perhaps the critical issue today is treatment timing.³ With the recent emphasis on “evidence-based” therapies in both medicine and dentistry, we now are gaining an appreciation concerning the nature of the treatment effects produced by specific protocols in patients of varying maturational levels. We are moving toward a better understanding concerning the optimal timing of orthodontic and orthopedic intervention, depending on the clinical condition.

In recent years, there has been considerable discussion among clinicians and researchers alike concerning the appropriate timing of intervention in patients who have Class II malocclusions, as has been evidenced by the ongoing discussions concerning the randomized clinical trials of Class II patients funded by the US National Institutes of Health (e.g., North Carolina, Florida). But the issue of “early treatment” is far broader than simply arguing about whether a Class II patient is better treated in one or two phases.

A variety of other malocclusions also must be considered within this topic, including the management of individuals with Class III malocclusions, those with open and deep bites, and the many patients with discrepancies between the size of the teeth and size of the bony bases (the latter comprise about 60% of the patients in our

private practice in Ann Arbor). The management of digital habits also falls within this discussion.

4) What are your views about the extent to which a clinician can alter the growth of the face?

In general, the easiest way for a clinician to alter the growth of the face is in the transverse dimension, orthopedically in the maxilla, orthodontically in the mandible.⁴ Rapid maxillary expansion (Fig 1) has been shown to be an extremely efficient and effective way of widening the maxillary bony base. In the lower arch, however, there is no mid-mandibular suture—so it is virtually impossible to produce orthopedic change in the mandible other than in combination with surgical distraction osteogenesis at the midline. The changes in the lower arch essentially are dentoalveolar in nature, such as those resulting from the use of a removable lower Schwarz appliance (Fig 2).

5) How about the correction of Class II and Class III problems?

As far as sagittal change is concerned, I think there is a substantial amount of experimental^{5,6} and clinical evidence⁷⁻¹⁰ that mandibular length can be increased over the short-term in comparison to untreated Class II controls, using a variety of functional orthopedic appliances. It should be noted, however, that not all investigators have come to this conclusion. The long-term effect of bringing the mandible forward functionally is much more uncertain at this time; most recent research has shown that the long-term mandibular skeletal effect may be limited to 1-2 mm over what would have occurred without treatment.^{11,12}

The best data that I have seen that considers the question of how much mandibular growth can be influenced over the long term has been derived from our recent study of Class II patients treated with the Fränkel appliance. In this

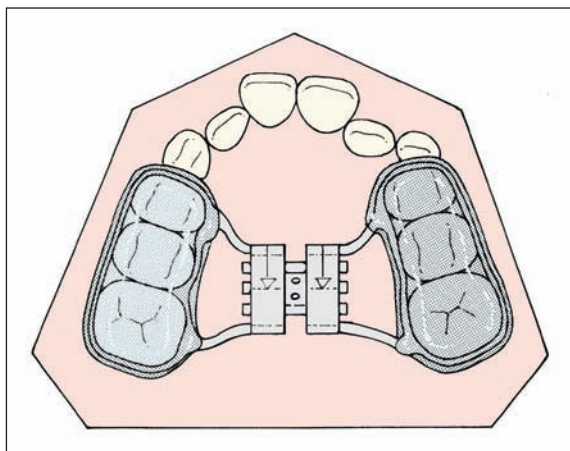


FIGURE 1 - The bonded acrylic splint type of rapid maxillary expander that is used primarily in patients in the mixed dentition is representative of the orthopedic expansion appliances used during treatment. The acrylic portion of the appliance is made from 3 mm thick splint Biocryl.³

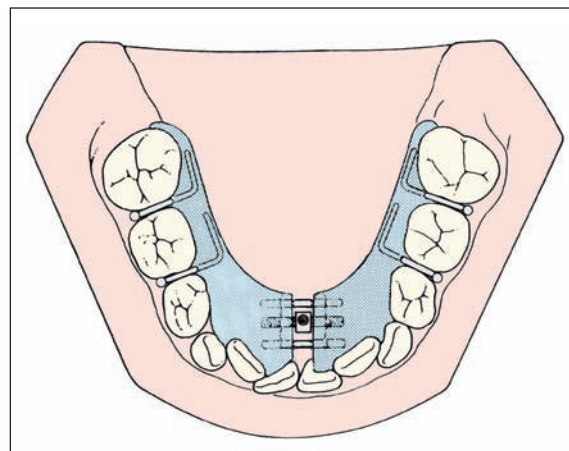


FIGURE 2 - The removable lower Schwarz appliance³ can be used prior to RME to upright the lower posterior teeth and gain a modest increase in arch perimeter anteriorly. It produces orthodontic tipping of the teeth only.

investigation by Freeman and co-workers,¹³ we evaluated patients treated with the FR-2 appliance by Rolf Fränkel of the former German Democratic Republic. Based on my experience with a variety of FJO appliances, I consider the function regulator (FR-2) the best of the functional appliances in that it addresses neuromuscular problems directly as well as skeletal and dental problems. A sample of 30 FR-2 patients was compared to a matched group of untreated Class II patients. Over the long-term, the increase in mandibular growth in the treated sample was 3 mm in comparison to controls.

6) If mandibular growth can be increased in length only by 1-2 mm with functional jaw orthopedics under most circumstances, why use it?

Hans Pancherz answered that question eloquently during a seminar at the University of Michigan when asked the same questions by our residents.¹⁴ He stated simply that “you get the growth when you need it.” Most studies of the Herbst appliance have shown that the

treatment effect produced by this tooth-borne type of FJO appliance is 50% dental and 50% skeletal.^{8,15} In comparison to untreated Class II controls, Herbst treatment produces about 2.5 to 3.0 mm increased mandibular length during the first phase of treatment; our investigation of Twin Block therapy has shown even larger short-term gains in mandibular length.^{9,16}

Normally Herbst or Twin Block wear results in the Class II patient having a Class I or super-Class I molar and canine relationship at the end of the first phase of treatment. Full fixed appliances then are used to align and detail the dentition. If the overall treatment outcome is evaluated, some of the gains in mandibular length observed during Phase I treatment may disappear by the end of fixed appliance therapy.^{11,12} Thus, FJO helps the clinician correct the underlying Class II malocclusion in a relatively short (9-12 months) and predictable manner. Some Class II patients with particularly favourable craniofacial features before treatment (a relatively closed gonial angle, for instance) may present an appreciable improvement in their

facial profile due to mandibular advancement following FJO. If a substantial change in the position of the chin is the primary focus of the treatment protocol, however, then corrective jaw surgery might be indicated, be it a mandibular advancement or a simple advancement by genioplasty.

Attempting to restrict the growth of the mandible presents a significant clinical challenge, particularly in the management of Class III malocclusion. One such appliance is the chin cup. I have not had extensive first-hand experience with the chin cup clinically, although at any given time we usually have one or two chin cup patients in our practice or in the university clinic, with the chin cup used primarily as a long-term retention device following facial mask therapy. The chin cup is indicated in patients who have mandibular prognathism and in whom an increase in lower anterior facial height is not desirable. A chin cup is not indicated in a patient who has maxillary retrusion.

There have been many studies, especially in Asian populations such as the Chinese, Korean and Japanese, that have shown over the short-term that there can be a restriction in mandibular projection in comparison to untreated Class III individuals.^{17,18} As of now, however, there is little evidence to support the premise that the growth of the mandible can be restricted over the long term (unless the patient wears the chin cup continuously from age 6 to age 18, a level of compliance that is difficult to attain).

7) You said earlier that the midface is responsive to treatment in the transverse dimension. How responsive is the maxilla to sagittal forces?

The growth of the midface seems to be influenced more readily by treatment than is the mandible. In the midface, restriction of the forward movement of the maxilla and maxillary dentition in Class II patients has been well-

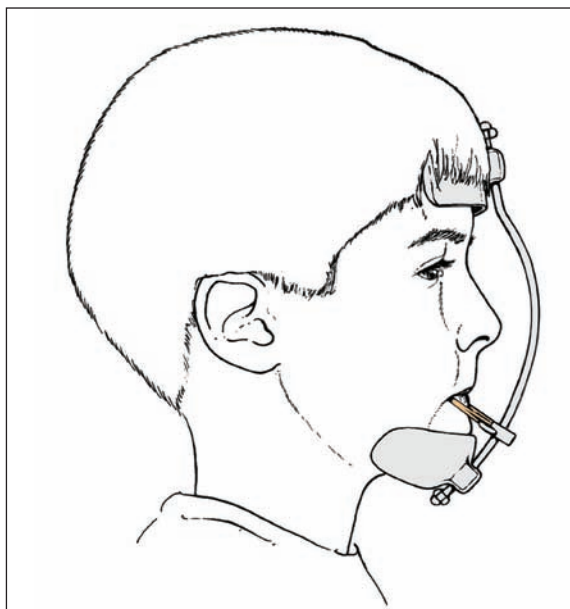
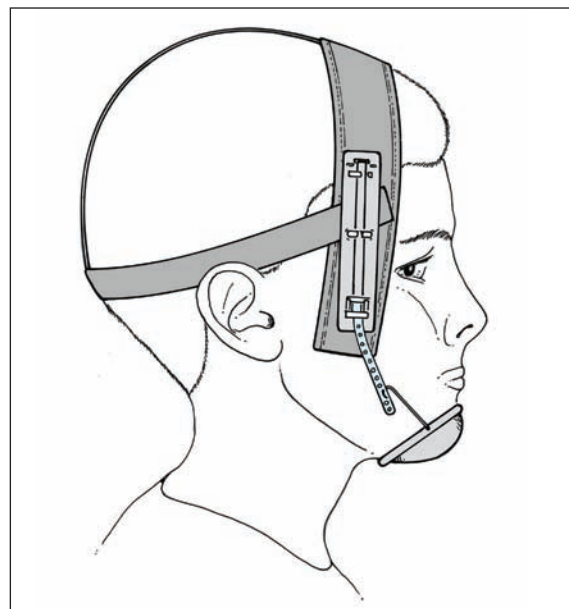
documented for over 60 years, beginning with the work of Silas Kloehe,¹⁹ among others. Given good cooperation in a growing patient, there is no question that extraoral traction is effective in changing the occlusal relationship from Class II toward Class I. However our research on the components of Class II malocclusion has shown that true maxillary skeletal protrusion is relatively rare in a Caucasian population.^{20,21} In addition, good patient compliance is an essential component of this type of treatment.

Regarding protraction of the maxilla with an orthopedic facial mask (Fig 3) in Class III patients, most clinical studies have shown that the amount of true maxillary skeletal protraction is only 1-2 mm over what would occur during growth in untreated Class III subjects.^{22,23} Class III correction still can occur as a consequence of facial mask wear due mainly to mandibular modifications, especially because of favorable changes in the direction of condylar growth, also in relation to appropriate early treatment timing. Increased forward protraction amounts may be produced if the facial mask is attached to dental implants or if microimplants or bone anchors are used for skeletal anchorage.²⁴⁻²⁶

8) What changes can be produced in the vertical dimension of the face of a growing patient?

Most orthodontists have found that the vertical dimension is the dimension that is the most difficult to correct therapeutically, and that observation certainly has been substantiated by my clinical experience. In a growing patient, increasing a short lower facial height is accomplished most effectively with a FJO appliance such as the Twin Block^{9,27} or the FR-2 of Fränkel,⁷ less so with the Herbst appliance.

In the long-face patient, controlling the vertical dimension has been particularly challenging. For example, a study by our group evaluated modification in growth following the

FIGURE 3 - The orthopedic facial mask of Petit.³FIGURE 4 - The vertical-pull chin cup typically is used in combination with an acrylic splint expander.³

use of a bonded rapid maxillary expander and vertical-pull chin cup²⁸ (Fig 4). The effect of the vertical-pull chin cup was evident only in the mixed dentition, with little effect noted in the permanent dentition even though the appliance was worn at night for 5.5 years on average.

9) In Class III cases in the deciduous or early mixed dentition, what cephalometric parameters do you use to differentiate among a true Class III, true developing Class III, and a dentoalveolar Class III malocclusion?

I typically do not perform a detailed cephalometric analysis on a young patient with those questions in mind. Our approach to Class III treatment primarily is through the use of a bonded acrylic splint expander to which have been attached hooks for elastics (Fig 5) and an orthopedic facial mask (Fig 3). Typically, the first appliance that we use is the bonded expander.²⁹ In many patients (perhaps one-third of mixed dentition Class III patients), we observe

a spontaneous improvement of the Class III or Class III tendency toward Class I simply by expanding the maxilla. This favorable change occurs almost immediately after maxillary expansion. If further intervention is necessary, then we will incorporate an orthopedic facial mask into the treatment protocol.

Any time a patient has a Class III molar relationship and we use this protocol, first any CO-CR discrepancy is eliminated just by placing the facial mask; so we do not try to make the differentiation between those three conditions you asked about, in that all three conditions are managed by the same treatment regimen.

10) Do you still use the FR-3 Fränkel appliance? You previously have recommended the use of the FR-3, especially in maxillary retrognathic cases. What are your contemporary views on its use?

Currently, I actually use more FR-3 appliances³⁰ (Fig 6) than I do FR-2s. Today, the FR-3

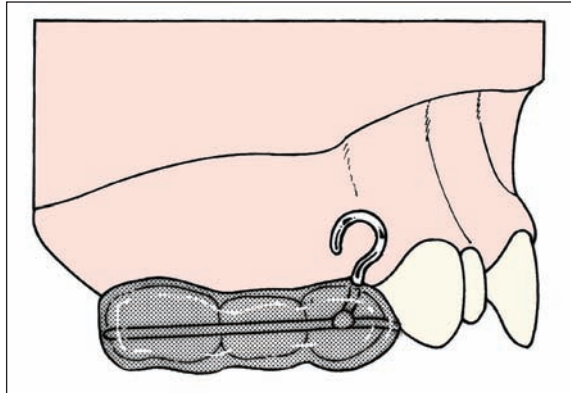


FIGURE 5 - The acrylic splint expander to which have been attached facial mask hooks.³

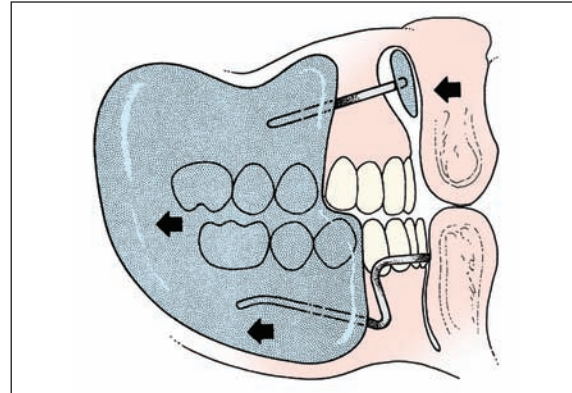


FIGURE 6 - The Fränkel FR-3 appliance.³ Fränkel⁶² states that the distracting forces of the upper lip are removed from the maxilla by the upper labial pads. The force of the upper lip is transmitted through the appliance to the mandible because of the close fit of the appliance to that arch.

usually serves as a retainer, rather than as a primary treatment appliance. The FR-3 is an appliance that has vestibular shields and also upper labial pads that free the maxilla from the forces of the associated musculature.³¹ The FR-3 produced similar treatment effects as does a facial mask-expander combination, but the effects take much longer to occur in FR-3 therapy.³

In the patient about whom we are suspicious of a strong tendency for relapse toward a Class III malocclusion after facial mask therapy, we will use the FR-3 as a retainer to be worn at night and around the house during the day. This approach of using the FR-3 as a retainer after successful facial mask therapy seems to be a reasonable way of incorporating this type of Fränkel appliance into our overall treatment scheme. We do not use the FR-3 often, but its use is essential in patients with difficult Class III problems.

11) Tell us more about the acrylic splint expander used in combination with the orthopedic facial mask. Can you elaborate on the use of this treatment protocol in dentoal-

veolar Class III or mandibular prognathism cases?

As stated before, we use the same basic protocol regardless of the etiology of the Class III problem. When I first heard Henri Petit (then of Baylor University in Dallas, Texas) speak about facial mask therapy in 1981, I was somewhat critical of his presentation because he did not differentiate among the various types of Class III malocclusions according to their etiology. I soon realized that the facial mask-expander combination is effective regardless of the underlying etiology of the Class III problem. I have used essentially the same protocol for the last 30 years, starting with the bonded expander. Typically we will deliver the expander and have the patient expand the appliance 28 times. If we need more turns, the patient is instructed to do so at the next appointment; then we will deliver the face mask if the underlying Class III malocclusion has not corrected spontaneously.

We usually recommend that the timing of facial mask therapy correspond to the eruption of the maxillary permanent central incisors.²⁹ I do not like to start much earlier than that because I

want to make sure that there is maximum vertical overlap of the permanent upper and lower central incisors at the end of facial mask treatment. The establishment of substantial vertical overlap of the incisors is critical in maintaining the corrected Class III malocclusion during the transition to the permanent dentition.

12) Do you use as a rule the maxillary expansion appliance with a facial mask, irrespective of the transverse width of the maxilla?

We use the bonded expander regardless of whether or not expansion is required. If the patient would benefit from widening of the maxilla, we have them expand the appropriate number of times. If there is no need to expand, we still have the patient expand 8-10 times to loosen the circummaxillary sutural system.²⁹ We and others have found that by mobilizing the sutures of the midface, we presumably affect the circummaxillary sutural system and facilitate the forward movement of the maxilla.^{3,32}

13) In the RME/FM appliance, where do you place the hooks for elastic attachment? Is it at the deciduous canines or deciduous first molars?

We typically use hooks that extend above the upper first deciduous molars. A downward and forward pull on the maxilla produced by the elastics counteracts the reverse autorotation of the maxilla that might occur because of the direction of pull on the teeth, resulting in a counterclockwise rotation of maxillary structures.

14) What are the force levels of the elastics that you prefer?

Three different elastics, the same elastics as originally recommended by Petit,³³ are used. The first elastic is 3/8" in length and is rated at 8 ounces (e.g., Tiger elastics fromOrmco Corp.).

These elastic generate about 200 grams of force against the maxillary RME appliance. After a week or so, we switch to heavier elastics (1/2", 14 oz; Whale) that generate about 350 g of force. The final elastic is 5/16" and is rated at 14 oz (Walrus). These elastics generate about 600 g of force, so that by the time we use the third type of elastics, there is a considerable amount of force generated against the maxillary and mandibular structures.

15) Is there any particular method you recommend to remove the bonded expander?

The debonding procedure is relatively straightforward. First, one of my chairside assistants applies a topical anesthetic gel above the appliance in the region of the first and second deciduous molars bilaterally. We let the gel activate for a few minutes, and then I will use a pair of ETM 349 pliers to remove the bonded expander. The ETM 349 plier actually is an anterior bond remover that has a sharp edge on one side and a Teflon cap on the other. The Teflon cap is placed on the occlusal surface of the appliance, and the sharp edge is inserted under the gingival margin of the appliance between the first and second deciduous molars. I then use a single strong pulling motion that takes about half a second, debonding the left and then the right side of the appliance in one continuous motion. Very little or no discomfort is felt by the patient.

Obviously the ease of removal of the appliance is dependent on a number of technical factors. One of these factors is making sure that the proper material is used for the acrylic. I do not recommend the "salt and pepper" type of cold cure acrylic application for expander construction because the resulting type of acrylic is too rigid; rather, I strongly recommend the use of 3 mm thick splint Biocryl (Great Lakes Orthodontic Products) applied over the wire framework in a thermal pressure machine such

as a Biostar. By using the latter material, the expander is somewhat flexible; it then becomes very easy to break the seal of the adhesive to the teeth.

I also recommend that the chemical cure adhesive Excel™ (Reliance Orthodontics) is used for the bonding procedure. This adhesive is made specifically for the bonding of large acrylic appliances. In addition, a sealer should be placed on the teeth, and “plastic bracket primer” should be painted inside the expander prior to the bonding procedure. This primer actually is methyl methacrylate liquid; it softens the inside of the expander so that it can accept the bonding agent. So when we remove the appliance, all the bonding agent comes out in the appliance and none remains on the teeth, making clean-up easy.

16) Do you favor the use of slow expansion or rapid expansion?

I have not had much experience in dealing with protocols that deliver so-called “slow expansion.”³⁴ By that, I mean having the expander turned every other day or every third day (as might be used in some young adult patients). In our practice, we use a one turn-per-day protocol in growing patients, which is not as rapid as the original protocol of two turns-per-day advocated by Andrew Haas.³⁵

There are two distinct reasons why I have taken the one-turn-per-day approach, one practical and one based on long clinical experience. From a practice management standpoint, having a patient activate the expander twice per day simply means that I have to see the patient twice as frequently. We now have almost all patients activate the expander once a day for 28 days, which means that I only need to see the patient every four weeks, a more practical interval than once each week or once every two weeks.

The second reason has to do with the speed of expansion. Orthodontists across the United

States often contact me concerning problems they are experiencing that are associated with RME. One such problem is “saddle nose deformity,” a condition characterized by a loss of height of the nose because of the collapse of the bridge. This clinical problem can occur in young children undergoing rapid maxillary expansion (if the expander is removed immediately the unwanted deformity usually resolves without treatment). I have heard of 10 instances of this deformity over the years. In each instance, the orthodontist was using a protocol of twice-per-day expansion, a protocol that I do not recommend. It should be noted, of course, that this clinical recommendation is based purely on anecdotal information and clinical intuition, not hard science.

17) You have advocated expanding the maxilla using RME to alleviate moderate crowding. What is the basis of this approach?

This topic has been of great interest to me for over 3 decades. I received my orthodontic education during a time that the extraction of permanent teeth was a common occurrence in orthodontics, with a national extraction rate of 40% or greater observed during the 1960s and 1970s.³⁶ Since then, the rate of extraction gradually has decreased in the United States today to about 25% nationally. In our practice we extract about 12-15% of the time in Caucasian patients; however, the extraction rate is substantially higher in patients of Pacific Rim ancestry.

In 2003, our research group published a paper in the *Angle Orthodontist*³⁷ that dealt with an analysis of 112 individuals treated with a Haas-type expander (Fig 7) combined with fixed appliance therapy in the permanent dentition. We found that by using this treatment protocol, in comparison to a control sample from the University of Michigan Growth Study and University of Groningen Growth Study, a

residual increase of about 6 mm in maxillary arch perimeter and about 4.5 mm in mandibular arch perimeter was observed at age 21 years, value that are highly significant clinically. These data are the “best” data that I have seen with regard to increasing arch perimeter expansion in adolescent patients over the long term.

Subsequently, we have conducted many studies of patients treated initially in the early mixed dentition, two of which I will highlight: one that dealt with the bonded expander used alone³⁸ and one in which a mandibular Schwarz expansion appliance³⁹ that is intended to decompensate the lower arch and gain a modest amount of arch perimeter anteriorly was used prior to expansion. In general, the difference in arch perimeter in these two studies over the long term (patients were ~20 years of age) was slightly less than 4 mm in the maxilla and 2.5-3.7 mm in mandible in comparison to matched untreated control groups. Our investigations have shown that in a borderline case of crowding (i.e., 3-5 mm mandibular tooth-size/arch-size discrepancy) these early expansion protocols are reasonable approaches to treatment. On the other hand, if a patient has 7-10 mm or more of crowding in the mandible, an extraction approach (serial or otherwise) may be in order.

18) Tell me about serial extraction as used in your private practice? Do you advocate any particular sequence?

In our private practice my daughter and I currently have about 800 active patients, about 10 of whom are going through a protocol involving serial extraction. We use the size of the teeth as a guide to patient who requires serial extractions as the appropriate treatment. In a serial extraction protocol, extractions are indicated when there is at least 7 mm of arch length deficiency in the mandible; usually this protocol is undertaken in patients who have well balanced faces. If a patient has a severe man-

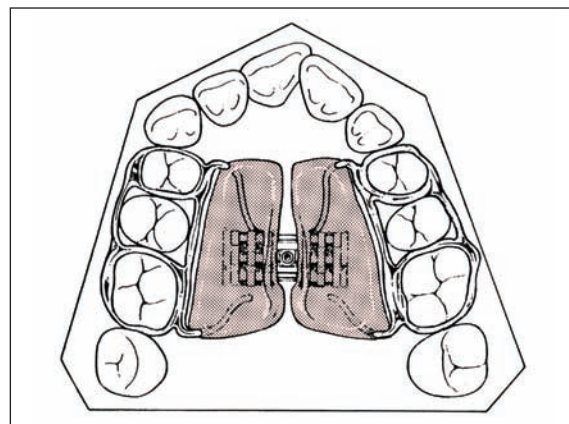


FIGURE 7 - The Haas-type rapid maxillary expander that has both metal and acrylic components.³

dibular skeletal retrusion or severe mandibular prognathism, it is not a good idea to use a serial extraction approach.

Our studies of the subjects in the University of Michigan Growth Study have shown that the size of the maxillary permanent central incisor in males of European ancestry is about 8.9 mm and in females about 8.7 mm, with a standard deviation of 0.6 mm for both sexes.⁴⁰ So, as a guideline, if we have a patient whose central incisor is 10 mm or greater in mesiodistal diameter, he or she would be a potential candidate for a serial extraction protocol. Obviously, the clinician has to take into account the size of all the teeth as well as the size of the bony bases. But generally a serial extraction protocol is performed in patients who have large tooth size (maxillary incisor ≥ 10 mm). In some instances, expansion of the maxilla followed by a serial extraction procedure ultimately is the treatment of choice.

Typically we order the extraction of all four deciduous canines, followed 6-12 months later by all deciduous first molars. This protocol hopefully encourages the first premolars to erupt before the canines, so that they can be

removed easily, later permitting the canines to erupt into the available arch space. In our serial extraction protocol, ultimately four first premolars almost always are removed.

19) Let's move on to the treatment of Class II malocclusion. If you have a choice as to the optimal timing of Class II intervention, at what stage is the best treatment outcome achieved?

Today, evidence seems to indicate that the most effective time in the maturation sequence of the “generic” Class II patient who does not have a severe skeletal problem is during the circumpubertal growth period. The maturational stage can be determined best by the level of cervical vertebra maturation⁴¹ (CVM) (Fig 8), as observed routinely in the lateral headfilm. This method originally was developed by Don Lamparski^{42,43} when he was an orthodontic resident at the University of Pittsburgh. This system was not used widely for the next 25 years. We discovered a copy of the Lamparski thesis serendipitously in the late 1990s and have been refining the CVM method ever since.^{41,44,45} Dentitional stage, meaning the late mixed or early permanent dentition, also can be used to determine the best time to initiate definitive Class II therapy. So in most such individuals, if it is reasonable we will defer any type of Class II correction until the circumpubertal growth period.

If a patient has a “socially debilitating” Class II malocclusion, however, then I would not hesitate to intervene in a 7-9 year old child, either with a functional appliance such as the Twin Block (Fig 9), the MARA appliance (Fig 10) or perhaps the cantilever version of the Herbst appliance. I would not expect, however, to have an abundant increase in mandibular growth during that early developmental stage. Rather, I would be attempting to make the patient socially acceptable from a psychological standpoint, hopefully leading to an improvement in his or her overall self image.

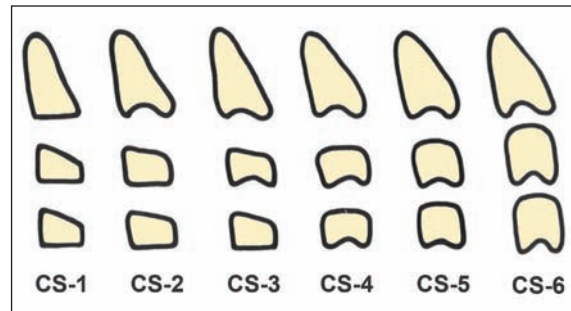


FIGURE 8 - CVM maturational stages. The six stages in cervical vertebrae maturation. Stage 1 (CS-1): The inferior borders of the bodies of all cervical vertebrae are flat. The superior borders are tapered from posterior to anterior. Stage 2 (CS-2): A concavity develops in the inferior border of the second vertebra. The anterior vertical height of the bodies increases. Stage 3 (CS-3): A concavity develops in the inferior border of the fourth vertebra. One vertebral body has a wedge or trapezoidal shape. Stage 4 (CS-4): A concavity develops in the inferior border of the fourth vertebra. Concavities in the lower borders of the fifth and sixth vertebrae are beginning to form. The bodies of all cervical vertebrae are rectangular in shape. Stage 5 (CS-5): Concavities are well defined in the lower borders of the bodies of all six cervical vertebrae. The bodies are nearly square and the spaces between the bodies are reduced. Stage 6 (CS-6): All concavities have deepened. The vertebral bodies are now higher than they are wide. The largest amount of mandibular lengthening normally occurs between CS-3 and CS-4.⁴¹

20) In your publications over the last 15 years, little emphasis has been assigned to the use of the Fränkel devices, in contrast to your earlier studies. What brought about this change to favor the use of Twin Block and Herbst appliances?

As I said earlier in the interview, I still consider the functional appliance system developed by Rolf Fränkel to be the most biologically based of any fixed or removable appliance. However, the technical manipulation of the appliance and the difficulties in having the function regulator FR-2 appliance (Fig 11) constructed properly still are daunting. In addition, appliance breakage and problems with patient compliance have caused the FR-2 to not be used often by most orthodontists in North America.

A few years ago, I polled six of the major orthodontic laboratories in the United States about FJO appliance fabrication. The results were startling—more Herbst appliances (Fig 12) are made today than all other functional

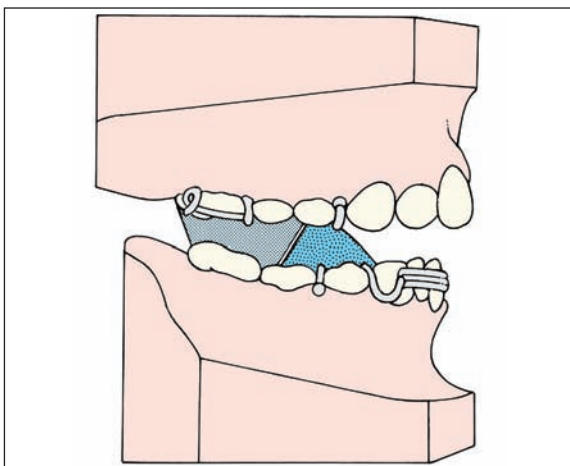


FIGURE 9 - The Twin Block appliance³ shown here is the modified version of the appliance that has a lower labial bow with acrylic to increase the stability of the appliance during the transition to the permanent dentition.

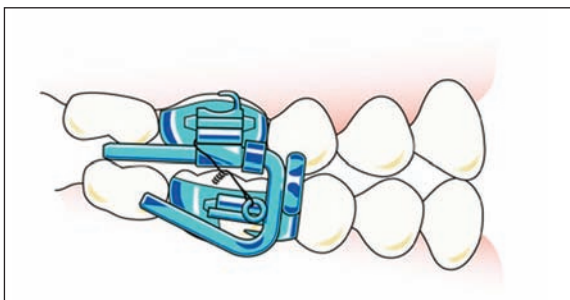


FIGURE 10 - The Mandibular Anterior Repositioning appliance (MARA).⁶³ This appliance has stainless steel crowns on the first permanent molars. The attachments cause the patient to bite in a forward position.

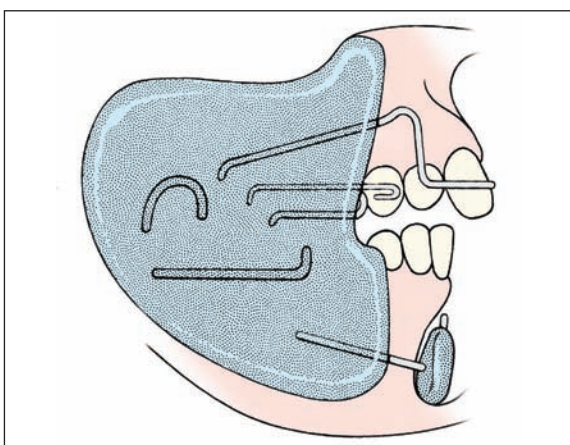


FIGURE 11 - The Fränkel Function Regulator FR-2.³ This appliance is characterized by buccal shields that are connected by a series of wires. The lower labial pads are used to retrain the mentalis muscle in patients with weak perioral musculature.

appliances combined. Most popular among the other FJO devices are the Twin Block (Fig 9) and the MARA (Fig 10) appliance and the bionator. About as many Fränkel appliances are made as bionators, but both are made less frequently than are the other appliances already mentioned.

21) For the last 20 or so years, you have talked about the “spontaneous improvement” in Class II malocclusion following maxillary expansion in the mixed dentition. A study from the University of Illinois by Tonya Volk et al,⁵⁴ published in 2010 in the AJO-DO, concluded that rapid maxillary expansion for spontaneous Class II correction does not support “the foot in the shoe theory”. According to this study, improvement in Class II malocclusions occur in about 50% of cases. What is your position today in respect of the concept that when the mandible is free to move forward, positive conditions are created for the mandible to grow to its full extent?

I have evaluated many treatments available for Class II malocclusion for over the last 40 years and have participated in the evolution of many types of functional appliances including the FR-2 of Fränkel as well as the Bionator, Herbst and Twin Block appliances. In addition, my education at the University of California San Francisco was strong concerning the use of extraoral traction. So I have substantial experience with different ways of correcting the sagittal position of the maxillary and mandibular bony bases. I certainly did not anticipate finding that Class II malocclusion improved spontaneously in many patients following expansion. A little personal history is in order.

We began using an acrylic splint expander in 1981 (actually our protocol today remains essentially unchanged from our early beginnings). We started by expanding the maxilla and placing four brackets on the maxillary incisors,

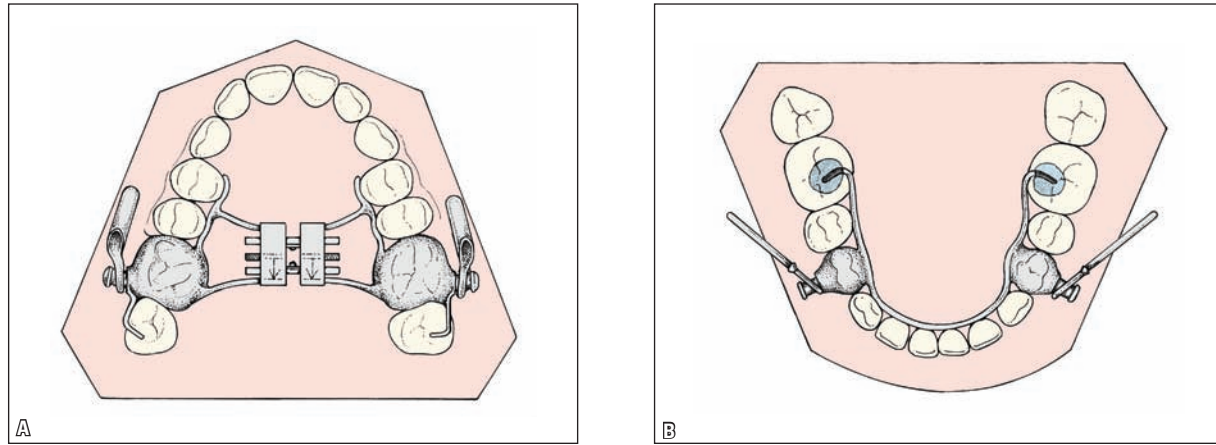


FIGURE 12 - The Stainless Steel Crown Herbst appliance.³ This design is used most commonly in our practice. A rapid maxillary expansion appliance always is added to the design not only to allow for expansion of the maxilla but also to stabilize the appliance. **A)** Maxillary view. **B)** Mandibular view.

if needed, to eliminate rotations and spacing. Treatment was completed and a removable maintenance plate (Fig 13) was delivered at the start of the retention period; some remarkable positive changes were noted post-treatment. Remember that at the end of active treatment, the maxillary dental arch intentionally had been overexpanded relative to the mandibular dental arch. This relationship encouraged the patient to posture his or her jaw forward in order to occlude in the most functionally efficient way. After 6-12 months when follow-up records were taken, many patients had substantial improvement in their sagittal occlusal relationship. It should be noted that discrepancies between centric occlusion and centric relation typically were not observed in the long-term.

Even though I thought that I had uncovered a previously unrecognized phenomenon, I later discovered that the spontaneous improvement in Class II relationship in fact had been noted in the German literature since the early 1900s by Körbitz,⁴⁶ who originally postulated the “foot-in-shoe” theory⁴⁷ mentioned in your question (Fig 14). Even Norman Kingsley, considered by many the “grandfather” of modern orthodontics,

alluded to the expansion of the maxilla as a way of correcting an excessive overjet as far back at 1880.⁴⁸ But until recently, no clinical studies had been carried out that addressed the “spontaneous improvement” issue.

In your question, you mentioned the work of Volk and co-workers on this topic, published in 2010.⁵⁴ Regardless of the findings of their study, the sample size was unacceptably small (N=13) and no control group was included. The question under consideration had to be addressed by a much larger prospective clinical study (as was stated in the last sentence of the Volk article), which we completed and just recently published.⁴⁹ We have gathered prospectively cephalometric and dental cast data on every patient in our practice who underwent an early expansion protocol, beginning in 1981. We stopped counting at 1,135 patients, a group that served as the original sample. We then applied several exclusionary rules to make sure that the patients were at the same stage of dental development and did not have any additional appliances used (e.g., FJO, lip bumper). The final sample size (by chance) was precisely 500 patients who had lateral cephalograms prior to treatment (about

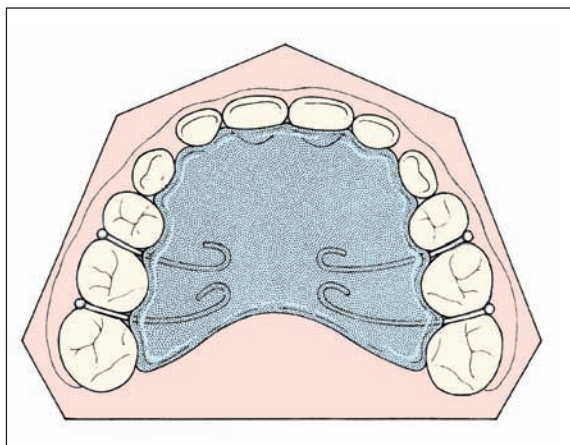


FIGURE 13 - A removable maintenance plate with ball clasps on either side of the second deciduous molars is used to stabilize the treated occlusion.³

8.5 years old) and prior to Phase II treatment (about 12.5 years of age). We then gathered data on 188 untreated subjects at the same two time intervals. Both the treated and untreated groups were separated into a Class II group, an end-to-end group, and a Class I group.

The results of our research are most easily understandable by looking at a more detailed analysis of a subset of individuals⁵⁰ that focused on 50 Class II and end-to-end patients who were matched to 50 untreated subjects. The findings of the latter study are presented in Figure 15. Positive skeletal and dentoalveolar treatment effects of RME were observed routinely; these effects are important in the serendipitous sagittal improvement of a Class II malocclusion after therapy. Forty-six of the 50 patients showed positive molar changes equal to or greater than 1 mm, compared to only 10 of 50 in the control group. On the other hand, 40 of the control subjects had neutral or unfavorable molar changes (less than +1 mm) between the mixed and permanent dentitions, compared to only 4 in the treated group. In other words, 92% of the treated group spontaneously improved their Class II molar relationship by one

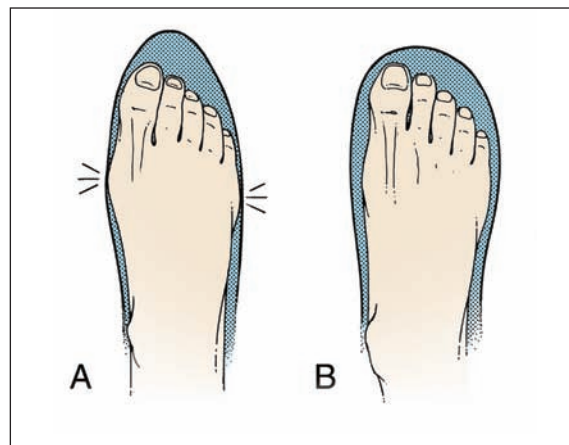


FIGURE 14 - Maxillomandibular relationship as indicated by the "foot and shoe" analogy of Körbitz.⁴⁶ **A)** The foot (mandible) is unable to be moved forward in the shoe (maxilla) due to transverse constriction. **B)** A wider shoe will allow the foot to assume its normal relationship. After Reichenbach et al.⁴⁷

millimeter or more, and almost 50% of treated patients presented with improvement in molar relationship of 2 mm or greater, without any definitive Class II mechanics incorporated into the protocol except for the transpalatal arch worn during the transition to the permanent dentition. There also were significant skeletal improvements from RME treatment including an increase in mandibular length, pogonion advancement, and a reduction in the ANB angle and the Wits appraisal value three and half years after active expansion therapy was completed.

Observations in the control group in this study confirm previously published data on longitudinal observations of untreated subjects with Class II malocclusions.⁵¹⁻⁵³ Arya and co-workers,⁵² for example, observed that all patients presenting with a distal-step relationship of the second deciduous molars ultimately demonstrated a Class II relationship of the permanent molars. In the current study, only 20% of the control subjects improved their molar relationship by 1 mm or 1.5 mm, which indicates that once a subject has a Class II malocclusion, without treatment they likely will remain with a Class II malocclusion in subsequent years.

The favorable effects of RME therapy on antero-posterior relationships occur both in full-cusp Class II and half-cusp Class II subjects. This expansion protocol originally was recommended from clinical anecdotal observations only in half-cusp Class II subjects;³ the results of the study by Guest and co-workers⁵⁰ indicate that spontaneous improvement of Class II malocclusion occurs equally in both half-cusp and full-cusp Class II relationships. Even Volk and co-workers⁵⁴ found improvement in Class II relationship in 7 of their 13 subjects.

The treatment protocol described above includes a Schwarz appliance (if needed), followed by an acrylic splint expander, and four brackets to align the maxillary incisors (if needed). The patient is given a simple maintenance plate (Fig 13) to maintain the achieved result. The lower arch is not maintained following the removal of the Schwarz appliance, but the patient is evaluated for a lower lingual arch (Fig 16) prior to the loss of the second deciduous molars if an arch length deficiency is anticipated. The last step in the protocol is the delivery of a transpalatal arch — TPA (Fig 17) — to maintain the leeway space during the transition to the permanent dentition.

22) Do you believe that the use of TPA in your sample had an important role for the positive outcome?

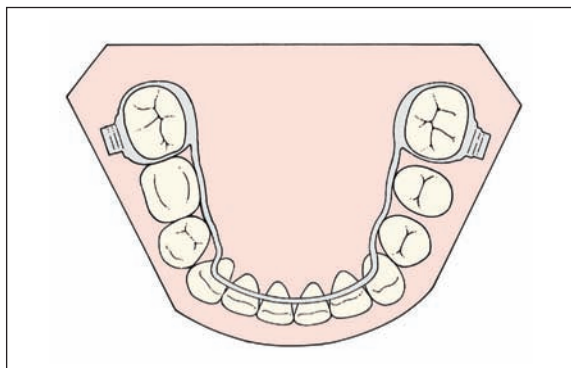


FIGURE 16 - The lower lingual arch is used during the late mixed dentition to maintain the “leeway” space in the region of the erupting second premolar.³ It also can be used during any stage of orthodontic treatment to help in transverse arch coordination, especially in patients who have undergone rapid maxillary expansion.

Each component of this protocol serves a significant role in improving the transverse and occlusal relationships during the transition to the permanent dentition. Obviously the rotation of the upper molars around the palatal root has a positive effect.

23) What happen in those patients in whom an early expansion protocol is undertaken and spontaneous correction of the underlying

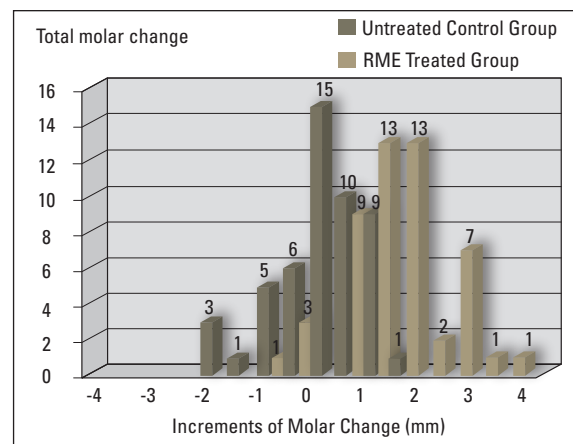


FIGURE 15 - Spontaneous improvement in Class II molar relationship following rapid maxillary expansion in the early mixed dentition. Comparison of amount of molar change from T2 - T1 for both groups. A score of “0” means that there was no change (i.e., 0 mm) in sagittal relationship of the maxillary and mandibular first permanent molars from the first to the second observation, a period of about 4 years. From Guest et al, 2010.⁵⁰

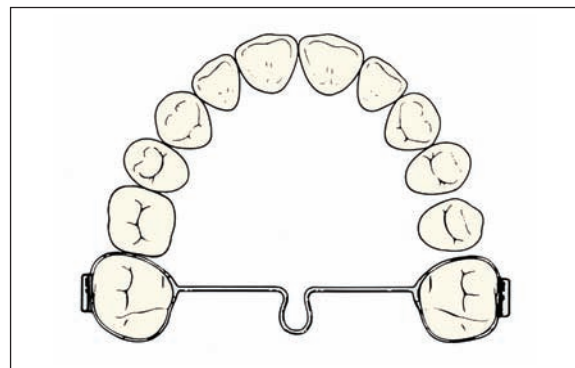


FIGURE 17 - The transpalatal arch is used not only to maintain leeway space, but also to rotate the maxillary first molars around their palatal roots and apply buccal root torque to these teeth.³

Class II molar relationship does not occur? Then what do you do?

All patients receive comprehensive edgewise treatment in the early permanent dentition. If a patient reaches the end of the mixed dentition or the early permanent dentition and still has a Class II malocclusion, a decision is made. If the patient has a reasonable growth potential and the canine relationships are within 1-3 mm of Class I, then routine fixed appliance treatment is undertaken including aggressive Class II elastic ($\frac{1}{4}$ ", 6 oz.) use. On the other hand, if the patient still has an end-to-end or worse Class II relationship, a stainless steel crown Herbst appliance (Fig 12) is used if mandibular skeletal retrusion is present. If the anteroposterior position of the mandible is within normal limits, then a Pendulum^{55,56} (Fig 18) or Pendex (Fig 19) appliance may be recommended. In a few instances, the extraction of 2 maxillary first premolars may be indicated. In any event, full fixed appliances are used to align the permanent dentition.

It seems that the use of a Herbst appliance to bring the mandible forward would be in sharp contrast to the approach taken by distalizing the maxillary dentition with a Pendex or Pendulum appliance; presumably these seemingly opposite treatment approaches would result in very dif-

ferent treatment outcomes. A study by our group that compared the Pendex appliance to 2 types of Herbst appliances¹⁰ showed that even though the expected differences in response in mandibular growth were noted during Phase I, the overall length of the mandible was not statistically different among groups at the end of treatment; a slightly greater increase in lower anterior facial height, however, did result after Pendex therapy combined with fixed appliances. Thus the presumed differences in treatment approach do not appear to be as great as assumed as before the results were made available, again showing the importance of evidence based treatment.

24) What are your views on the use of functional appliances in patients with vertical problems?

Functional appliance therapy in a high angle Class II patient is something I consider. My current treatment of choice is the stainless steel crown Herbst appliance (Fig 12), which I have used fairly routinely since the early 1990s.¹⁰ We also have had good success when using the acrylic splint variety of the Herbst appliance.³⁰ I see no significant contraindication to using either type of appliance in a high angle patient.

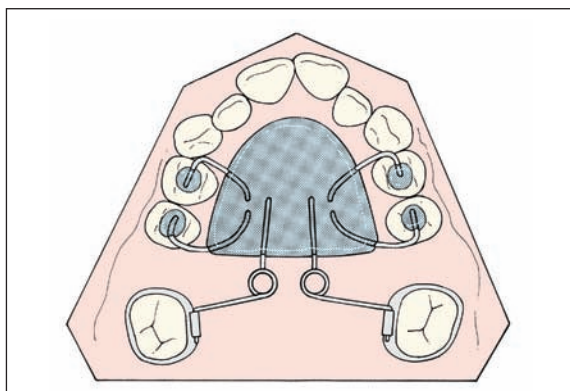


FIGURE 18 - The Pendulum appliance is used to distalize the maxillary first molars, typically one side at a time.³ This treatment is followed by the placement of a Nance holding arch that is left in place until the premolars and canines are distalized.

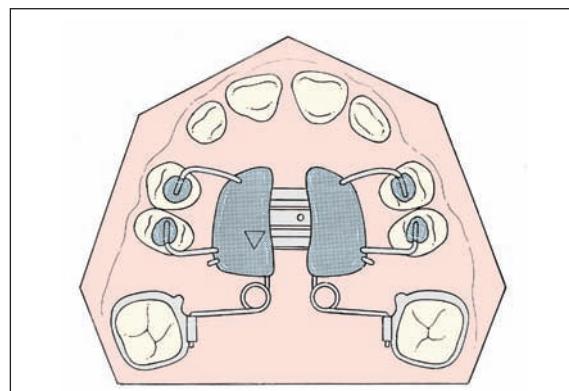


FIGURE 19 - The Pendex appliance incorporates an expansion screw into the palatal acrylic that is activated as necessary prior to molar distalization.³

25) Where do we stand when we are asked by parents whether this early treatment approach is going to result in better or more stable results? What is a safe answer to this question?

I started using the bonded expander protocol 30 years ago, and although we now have treated 1,500+ patients with this protocol, accumulating long-term data on patients who are 20 years of age or older is challenging, especially when conducting a non-federally-funded project such as ours. The data we have analyzed thus far indicate that the protocols we have been using are reasonably stable in comparison to untreated controls. I would tell patients and parents that existing research indicates that the treatment protocols seem to provide a stable result over the long-term as long as the patient wears the retainers at least on a part-time basis after active treatment. We recommend full-time wear of retainers for one year and then nighttime wear indefinitely, a protocol that is prudent to use in all patients treated orthodontically for any type of malocclusion.

26) How do you look at the changes orthodontics has gone through in the last 10 years, such as the use of TADs, self-ligating brackets, SureSmile archwires, lingual brackets and aligners (Invisalign and others)? In the next decade, what can we expect in terms of new technologies in orthodontics?

You certainly are correct with regard to the influence of technology on clinical practice, not only how we practice but also how patients use social and business media to determine which orthodontist to see. I am sure that this phenomenon is just as obvious in Brazil as it is in the United States.

You have asked about some specific technologies that have emerged during the last decade or so, the first being microimplants or TADs. My first exposure to TADs was in about ten years ago when we interacted with Drs. Kyung, Sung

and Park of Kyungpook National University in Daegu, Korea. In fact, I am the last author of a textbook on this subject published by the Daegu group.⁵⁷ Microimplants have been shown to offer new treatment options in orthodontics, particular in patients requiring maximum anchorage during tooth retraction and in managing problems in the vertical dimension. My own success rate with microimplants in our practice and at the university has been mixed, with the biggest problem being the loosening of the TADs during treatment for no apparent reason. With increased experience, I assume that our success rate will improve.

The second subject to be considered concerns self-ligating brackets. I entered this experience with great expectations, having learned the method directly from the developer of the particular system that I used. I then started 20 consecutive cases with the prescribed self-ligating brackets. Treatment progressed nicely at first with good initial leveling and aligning, but by the end I had switch 11 of the patients back to my original preadjusted bracket system. I could not finish the cases to my usual standards. I have tried other self-ligating bracket systems since then, but I still prefer a more traditional approach to straightening teeth.

I will group the next two topics together, SureSmile archwires and lingual brackets. I have not used either in our private practice, so I have no experience and thus no opinions on either. We now are conducting a clinical study comparing patients treated with the SureSmile approach to conventional treatment. In a year or two, we will have some good data as to the efficiency and effectiveness of the SureSmile approach.

One topic that I do know a lot about is invisible retainers. When I went into practice in Ann Arbor in 1971, I rented space for orthodontist John Mortell. He was a friend and colleague of Robert Ponitz, who practiced orthodontics three blocks away. Bob Ponitz published the first paper in the orthodontic literature⁵⁸ on

invisible retainers. I literally have used invisibles for 40 years. In 1985, we published a paper in the *Journal of Clinical Orthodontics* on how to use invisibles to move teeth.⁵⁹ I of course did not envision the CAD CAM revolution that would occur a decade later. We use invisible retainers for 97% of our patients as our primary retention method following the use of a tooth positioner in the vast majority of patients. I am not a fan of Hawley retainers in that Hawleys do not maintain the position of the anterior teeth very well, particularly the lateral incisors.

As far as Invisalign is concerned, this approach has been incorporated into our practice on a limited basis, so we have treated about 175 patients thus far. My daughter Laurie usually tells patients that Invisalign can achieve about 80% of what can be achieved with fixed appliances. We limit our Invisalign cases primarily to those that could be treated with fixed appliances in a year or so and have only minor skeletal discrepancies. For many adult patients, Invisalign is their only acceptable option and thus our treatment expectations must be limited by reality.

27) In that you have brought up the topic of retention, let's finish the interview with you giving us a description of your finishing and retention protocol.

One of the basic principles espoused by Stephen Covey in his popular book "The Seven Habits of Highly Effective People"⁶⁰ is to "start with the end in mind." Thus we place brackets and activate the transpalatal arch with the end of treatment in mind. After 6-12 months, a panoramic film is taken to evaluate bracket position; we reposition brackets as necessary. We typically move from an initial leveling wire (.014" or .016" NiTi or .016x.022" copper NiTi) to a .016x.022" Bioforce NiTi wire and finish in a .016x.022" TMA wire.

A few months before the end of treatment, we take what are called "debond evaluation models" to evaluate the occlusion in all three

dimensions. If additional treatment is indicated, this is completed and the same models are sent to a commercial laboratory for the fabrication of a positioner that is delivered as soon as the appliances are removed.

A week before debonding, all bands are removed including those that are part of the TPA (if still present). The archwires also are removed and the patient has .008" ligature wire placed in a serpentine configuration from second premolar to second premolar on the opposite side of the arch (Fig 20). The patient is instructed to chew gum for a week prior to appliance removal. On that day, all remaining appliances are removed and the patient is given the positioner (Fig 21), with instructions to wear it full-time for the next 24 hours, as much as possible during the next 3-4 days and then 4 hours a day plus sleeping hours for the next few weeks. At the next appointment, post-treatment records are taken as are impressions for invisible retainers (Fig 22). Up to one tooth per quadrant can be reset before the invisible retainers are fabricated.

I would like to make one final comment about our finishing and retention protocol. Most orthodontists finish treatment with fixed appliances and then give Hawley retainers to allow "settling" of the occlusion. We have found that our more complex protocol produces outstanding results, as has been substantiated by the findings of a prospective clinical trial conducted in our practice.⁶¹ The positioner improves the quality of the finished result substantially.

28) You have covered a wide range of topics in this interview. If our readers want additional information concerning the treatment protocols that you recommend, where can they find that information?

I suggest that they go online at www.needhampress.com and find our book "Orthodontics and Dentofacial Orthopedics"³ and well as the books from the Craniofacial Growth Series published by

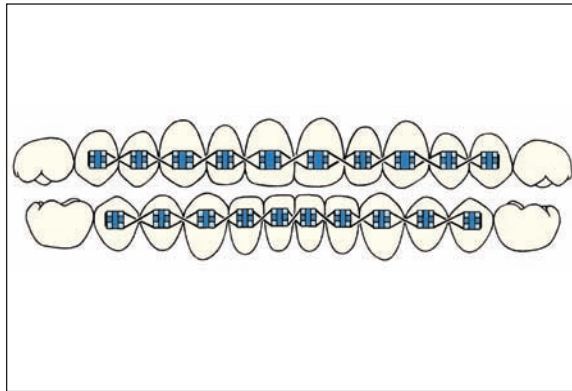


FIGURE 20 - Serpentine wires are placed from second premolar to second premolar in both arches after all bands have been removed.³ In extraction patients, bands adjacent to extraction sites are left in place.



FIGURE 21 - A tooth positioner is fabricated from the debond evaluation models. The teeth are reset ideally after all the brackets and bands have been carved away. The occlusal set-up is ideal.³

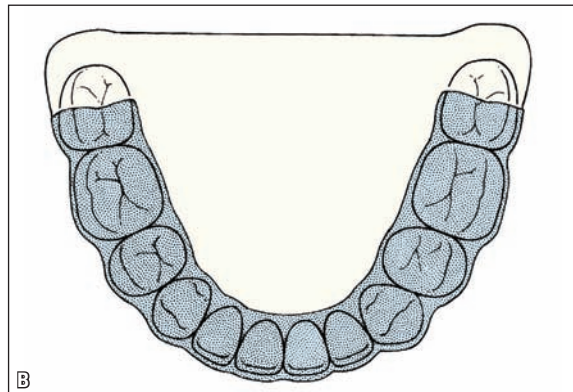
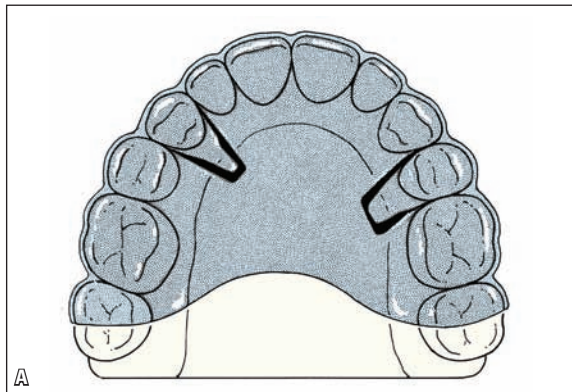


FIGURE 22 - Maxillary and mandibular invisible retainers³ 1 mm in thickness are used as the preferred method of long-term retention in most instances. Up to one tooth per quadrant can be reset in wax prior to the fabrication of the retainers.

the University of Michigan. The reader also can go to Google and search for “James McNamara Michigan.” That search will take them directly to my webpage on our dental school website. If the reader then looks under “Selected Publications,” PDF files of almost all of our publications can be downloaded without charge.

Also, I want to recognize again my two colleagues from the University of Florence, Italy, Lorenzo Franchi and Tiziano Baccetti, who have worked with me since 1994. Our collaboration together and with other researchers throughout the world has enabled all of us to gain unique perspective as to how the face grows and how the

craniofacial structures respond to treatment. Our research definitely has been a group effort.

Finally, I would like to thank you for the invitation to be interviewed. Over the years, I have had a close relationship with many Brazilian orthodontists and have lectured in Brazil many times, including a delightful experience sponsored by Dental Press in Maringá a few years ago (2007).

Just this past fall, we hosted a one-week intensive course for Brazilian orthodontists in Ann Arbor, the third time that we have done so over the years. We are planning another one-week orthodontic experience again through the University of Michigan in 2012.

REFERENCES

- McNamara JA Jr. Neuromuscular and skeletal adaptations to altered orofacial function. Ann Arbor: Monograph 1, Craniofacial Growth Series, Center for Human Growth and Development, The University of Michigan; 1972.
- McNamara JA Jr. Neuromuscular and skeletal adaptations to altered function in the orofacial region. *Am J Orthod*. 1973;64:578-606.
- McNamara JA Jr, Brudon WL. Orthodontics and dentofacial orthopedics. Ann Arbor: Needham Press; 2001.
- McNamara JA Jr. Maxillary transverse deficiency. *Am J Orthod Dentofacial Orthop*. 2000;117:567-70.
- Petrovic A, Stutzmann J, Gasson N. The final length of the mandible: is it genetically determined? In: Carlson DS, editor. Craniofacial Biology. Ann Arbor: Monograph 10, Craniofacial Growth Series, Center for Human Growth and Development, The University of Michigan; 1981.
- McNamara JA Jr, Bryan FA. Long-term mandibular adaptations to protrusive function: an experimental study in *Macaca mulatta*. *Am J Orthod Dentofacial Orthop*. 1987;92:98-108.
- McNamara JA Jr, Bookstein FL, Shaughnessy TG. Skeletal and dental changes following functional regulator therapy on Class II patients. *Am J Orthod*. 1985;88:91-110.
- McNamara JA Jr, Howe RP, Dischinger TG. A comparison of the Herbst and Fränkel appliances in the treatment of Class II malocclusion. *Am J Orthod Dentofacial Orthop*. 1990;98:134-44.
- Toth LR, McNamara JA Jr. Treatment effects produced by the twin block appliance and the FR-2 appliance of Frankel compared to an untreated Class II sample. *Am J Orthod Dentofacial Orthop*. 1999;116:597-609.
- Burkhardt DR, McNamara JA Jr, Baccetti T. Maxillary molar distalization or mandibular enhancement: a cephalometric comparison of the Pendulum and Herbst appliances. *Am J Orthod Dentofacial Orthop*. 2003;123:108-16.
- Pancherz H. The Herbst appliance. Seville: Editorial Aguiram; 1995.
- Lai M, McNamara JA Jr. An evaluation of two-phase treatment with the Herbst appliance and preadjusted edgewise therapy. *Semin Orthod*. 1998;4:46-58.
- Freeman DC, McNamara JA Jr, Baccetti T, Franchi L. Long-term treatment effects of the FR-2 appliance of Fränkel. *Am J Orthod Dentofacial Orthop*. 2008;133:513-24.
- Pancherz H. Personal communication; 2001.
- Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance. A cephalometric investigation. *Am J Orthod*. 1979;76:423-42.
- Schaefer AT, McNamara JA Jr, Franchi L, Baccetti T. A cephalometric comparison of two-phase treatment with the Twin Block and stainless steel crown Herbst appliances followed by fixed appliance therapy. *Am J Orthod Dentofacial Orthop*. 2004;126:7-15.
- Sugawara J, Asano T, Endo N, Mitani H. Long-term effects of chin cap therapy on skeletal profile in mandibular prognathism. *Am J Orthod Dentofacial Orthop*. 1990;98:127-33.
- Mitani H, Sato K, Sugawara J. Growth of mandibular prognathism after pubertal growth peak. *Am J Orthod Dentofacial Orthop*. 1993;104:330-6.
- Kloehn SJ. Orthodontics: force or persuasion. *Angle Orthod*. 1953;23:56-65.
- McNamara JA Jr. Components of Class II malocclusion in children 8-10 years of age. *Angle Orthod*. 1981;51:177-202.
- Ellis E 3rd, McNamara JA Jr, Lawrence TM. Components of adult Class II open-bite malocclusion. *J Oral Maxillofac Surg*. 1985;43:92-105.
- Turley PK. Orthopedic correction of Class III malocclusion with palatal expansion and custom protraction headgear. *J Clin Orthod*. 1988;22:314-25.
- McGill JS, McNamara JA Jr. Treatment and post-treatment effects of rapid maxillary expansion and facial mask therapy. In: McNamara JA Jr, editor. Growth modification: what works, what doesn't and why. Ann Arbor: Monograph 36, Craniofacial Growth Series, Center for Human Growth and Development, University of Michigan; 1999.
- McNamara JA Jr. Implants, microimplants, onplants and transplants: New answers to old questions in orthodontics. Ann Arbor: Monograph 44, Craniofacial Growth Series, Department of Orthodontics and Pediatric Dentistry and Center for Human Growth and Development, The University of Michigan; 2005.
- De Clerck HJ, Cornelis MA, Cevidanes LH, Heymann GC, Tulloch CJ. Orthopedic traction of the maxilla with miniplates: a new perspective for treatment of midface deficiency. *J Oral Maxillofac Surg*. 2009;67:2123-9.
- Cevidanes L, Baccetti T, Franchi L, McNamara JA Jr, De Clerck HJ. Comparison of 2 protocols for maxillary protraction: bone anchors and face mask with rapid maxillary expansion. *Angle Orthod*. in press 2010.
- Clark WJ. Twin block functional therapy. London: Mosby-Wolfe; 1995.
- Schulz SO, McNamara JA Jr, Baccetti T, Franchi L. Treatment effects of bonded RME and vertical pull chin cup followed by fixed appliances in patients with increased vertical dimension. *Am J Orthod Dentofacial Orthop*. 2005;128:326-36.
- McNamara JA Jr. An orthopedic approach to the treatment of Class III malocclusion in young patients. *J Clin Orthod*. 1987;21:598-608.
- Fränkel R, Fränkel C. Orofacial orthopedics with the function regulator. Munich: Karger; 1989.
- McNamara JA Jr, Hulse SA. The functional regulator (FR-3) of Fränkel. *Am J Orthod*. 1985;88:409-24.
- Baik HS. Clinical results of the maxillary protraction in Korean children. *Am J Orthod Dentofacial Orthop*. 1995;108:583-92.
- Petit HP. Adaptation following accelerated facial mask therapy. In: McNamara JA Jr, Ribbens KA, Howe RP, editors. Clinical alterations of the growing face. Ann Arbor: Monograph 14, Craniofacial Growth Series, Center for Human Growth and Development, The University of Michigan; 1983.
- Hicks EP. Slow maxillary expansion. A clinical study of the skeletal versus dental response to low-magnitude force. *Am J Orthod*. 1978;73:121-41.
- Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the mid-palatal suture. *Angle Orthod*. 1961;31:73-90.
- Proffit WR. Forty-year review of extraction frequencies at a university orthodontic clinic. *Angle Orthod*. 1994;64:407-14.
- McNamara JA Jr, Baccetti T, Franchi L, Herberger TA. Rapid maxillary expansion followed by fixed appliances: a long-term evaluation of changes in arch dimensions. *Angle Orthod*. 2003;73:344-53.
- Geran RG, McNamara JA Jr, Baccetti T, Franchi L, Shapiro LM. A prospective long-term study on the effects of rapid maxillary expansion in the early mixed dentition. *Am J Orthod Dentofacial Orthop*. 2006;129:631-40.
- O'Grady PW, McNamara JA Jr, Baccetti T, Franchi L. A long-term evaluation of the mandibular Schwarz appliance and the acrylic splint expander in early mixed dentition patients. *Am J Orthod Dentofacial Orthop*. 2006;130:202-13.
- Moyers RE, van der Linden FPGM, Riolo ML, McNamara JA Jr. Standards of human occlusal development. Ann Arbor: Monograph 5, Craniofacial Growth Series, Center for Human Growth and Development, The University of Michigan; 1976.

41. Baccetti T, Franchi L, McNamara JA Jr. The Cervical Vertebral Maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Semin Orthod*. 2005;11:119-29.
42. Lamparski DG. Skeletal age assessment utilizing cervical vertebrae. Pittsburgh: Unpublished Master's thesis, Department of Orthodontics, The University of Pittsburgh; 1972.
43. Lamparski DG, Nanda SK. Skeletal age assessment utilizing cervical vertebrae. In: McNamara JA Jr, Kelly KA, editors. *Treatment timing: Orthodontics in four dimensions*. Ann Arbor: Monograph 39, Craniofacial Growth Series, Department of Orthodontics and Pediatric Dentistry and Center for Human Growth and Development, The University of Michigan; 2002.
44. Franchi L, Baccetti T, McNamara JA Jr. Mandibular growth as related to cervical vertebral maturation and body height. *Am J Orthod Dentofacial Orthop*. 2000;118:335-40.
45. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. *Angle Orthod*. 2002;72:316-23.
46. Körbitz A. *Kursus der systematischen Orthodontik. Ein Leitfaden für Studium und Praxis*. 2nd ed. Leipzig: Hans Licht; 1914.
47. Reichenbach E, Brückl H, Taatz H. *Kieferorthopaedische Klinik und Therapie*, 6er aufl. Leipzig: Johan Ambrosius Barth; 1967.
48. Kingsley NW. *A treatise on oral deformities as a branch of mechanical surgery*. New York: D. Appleton; 1880.
49. McNamara JA Jr, Sigler LM, Franchi L, Guest SS, Baccetti T. Changes in occlusal relationship in mixed dentition patients treated with rapid maxillary expansion: a prospective clinical study. *Angle Orthod*. 2010;80:230-8.
50. Guest SS, McNamara JA Jr, Baccetti T, Franchi L. Improving Class II malocclusion as a side-effect of rapid maxillary expansion: a prospective clinical study. *Am J Orthod Dentofacial Orthop*. 2010;138(5):582-91.
51. Baccetti T, Franchi L, McNamara JA Jr, Tollaro I. Early dentofacial features of Class II malocclusion: a longitudinal study from the deciduous through the mixed dentition. *Am J Orthod Dentofacial Orthop*. 1997;111:502-9.
52. Arya BS, Savara BS, Thomas DR. Prediction of first molar occlusion. *Am J Orthod*. 1973;63:610-21.
53. Bishara SE, Hoppens BJ, Jakobsen JR, Kohout FJ. Changes in the molar relationship between the deciduous and permanent dentitions: a longitudinal study. *Am J Orthod Dentofacial Orthop*. 1988;93:19-28.
54. Volk T, Sadowsky C, BeGole EA, Boice P. Rapid palatal expansion for spontaneous Class II correction. *Am J Orthod Dentofacial Orthop*. 2010;137:310-5.
55. Hilgers JJ. The pendulum appliance for Class II non-compliance therapy. *J Clin Orthod*. 1992;26:706-14.
56. Hilgers JJ. The pendulum appliance: An update. *Clin Impressions*. 1993;15-17.
57. Sung JH, Kyung HM, Bae SM, Park HS, Kwon OW, McNamara JA Jr. *Microimplants in orthodontics*. Daegu: Dentos; 2006.
58. Ponitz RJ. Invisible retainers. *Am J Orthod*. 1971;59:266-72.
59. McNamara JA, Kramer KL, Jeunker JP. Invisible retainers. *J Clin Orthod*. 1985;19:570-8.
60. Covey SR. *The seven habits of highly effective people*. New York: Simon and Schuster; 1989.
61. Stock GM, McNamara JA Jr, Baccetti T. The efficacy of two finishing protocols in the quality of orthodontic treatment outcome. *Am J Orthod Dentofacial Orthop*. in press.
62. Fränkel R. Maxillary retrusion in Class III and treatment with the function corrector III. *Rep Congr Eur Orthod Soc*. 1970:249-59.
63. Berkman ME, Haerian A, McNamara JA Jr. Interarch maxillary molar distalization appliances for Class II correction: an overview. *J Clin Orthod*. 2008;42:35-42.

Bernardo Quiroga Souki

- Specialist in Pediatric Dentistry, School of Dentistry of Ribeirão Preto - USP.
- Specialist in Orthodontics, PUC Minas.
- MSc in Pediatric Dentistry, UFMG.
- PhD in Health Sciences (UFMG).
- Associate Professor III, Masters Course in Orthodontics at PUC Minas.

José Maurício de Barros Vieira

- Specialist and MSc in Orthodontics, PUC Minas.
- Associate Professor III, Masters Course in Orthodontics at PUC Minas.
- Graduate, Brazilian Board of Orthodontics and Dentofacial Orthopedics - BBO.
- Former President of ABOR-MG.

Carlos Alexandre Camara

- Specialist in Orthodontics, State University of Rio de Janeiro - UERJ.
- Graduate, Brazilian Board of Orthodontics and Dentofacial Orthopedics - BBO.
- Editorial reviewer of the Revista Dental Press de Estética.

Roberto Mario Amaral Lima Filho

- Post-graduate degree in Orthodontics, University of Illinois, Chicago, USA.
- MSc and PhD in Orthodontics, Federal University of Rio de Janeiro - UFRJ.
- Graduate, American Board of Orthodontics - ABO.
- Member of the Edward H. Angle Society of Orthodontists, Midwest.
- Former President of the Brazilian Board of Orthodontics and Facial - BBO.
- Editor of the book "Ortodontia: Arte e Ciência."

Carlos Jorge Vogel

- Postgraduate in Orthodontics, University of Illinois, Chicago, USA.
- PhD in Orthodontics, University of São Paulo - USP.
- Member of the Edward H. Angle Society of Orthodontists Midwest.
- Graduate, Brazilian Board of Orthodontics and Dentofacial Orthopedics - BBO.
- Former President of the Brazilian Board of Orthodontics and Dentofacial Orthopedics - BBO.

Weber Ursi

- MSc and PhD in Orthodontics, University of São Paulo - USP, Bauru.
- Professor at UNESP - São José dos Campos.
- Coordinator of the Specialization Course in Orthodontics - APCD - São José dos Campos.
- Interim Editor - Revista Clínica de Ortodontia Dental Press.

Contact address

James A. McNamara Jr.
mcnamara@umich.edu

Imaging from temporomandibular joint during orthodontic treatment: a systematic review

Eduardo Machado**, Renésio Armindo Grehs***, Paulo Afonso Cunali****

Abstract

Introduction: The evolution of imaging in dentistry has provided several advantages for the diagnosis and development of treatment plans in various dental specialties. Examinations as nuclear magnetic resonance, computed tomography and cone beam volumetric tomography, as well as 3D reconstruction methods, have enabled a precise analysis of orofacial structures. Allied to this fact, the effects of orthodontic treatment on temporomandibular joint (TMJ) could be evaluated with the accomplishment of clinical studies with appropriate designs and methodologies. **Objective:** This study, a systematic literature review, had the objective of analyzing the interrelation between orthodontic treatment and TMJ, verifying if orthodontic treatment causes changes in the internal structures of TMJ. **Methods:** Survey in research bases MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs and BBO, between the years of 1966 and 2009, with focus in randomized clinical trials, longitudinal prospective nonrandomized studies, systematic reviews and meta-analysis. **Results:** After application of the inclusion criteria 14 articles were selected, 2 were randomized clinical trials and 12 longitudinal nonrandomized studies. **Conclusions:** According to the literature analysis, the data concludes that orthodontic treatment does not occur at the expense of unphysiological disc-condyle position. Some orthodontic mechanics may cause remodeling of articular bone components.

Keywords: Temporomandibular joint. Temporomandibular joint dysfunction syndrome. Temporomandibular joint disorders. Orthodontics. Magnetic resonance imaging. Tomography.

How to cite this article: Machado E, Grehs RA, Cunali PA. Imaging from temporomandibular joint during orthodontic treatment: a systematic review. Dental Press J Orthod. 2011 May-June;16(3):54-6.

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

** Specialist in TMD and Orofacial Pain, UFPR. Graduate in Dentistry, UFSM.

*** PhD in Orthodontics and Dentofacial Orthopedics, UNESP/Araraquara – SP. Professor of Graduate and Post-graduate Dentistry course, UFSM.

**** PhD in Sciences, UNIFESP. Professor of Graduate and Post-graduate Dentistry course, UFPR. Head of the Specialization Course in TMD and Orofacial Pain, UFPR.

Editor's summary

The effects of orthodontic treatment on temporomandibular joint (TMJ) is the subject of doubts and discussions until the current days. Many of those doubts persist because of the use of conventional radiographs which have limitations. With the advent of imaging examinations with specificity, sensitivity and greater accuracy in the reproduction of joint anatomical structures, such as nuclear magnetic resonance (NMR), computed tomography (CT) and cone beam volumetric tomography (CBVT) as well as methods of 3D reconstruction, this interrelationship can be assessed with greater accuracy.

The authors' proposal for this article was to analyze within a context of an evidence-based dentistry, which implications orthodontics have on the TMJ and specifically to check changes in condylar and articular disc position, as well as joint morphological changes, that occur due to orthodontic treatment.

Thus the search was performed in MEDLINE, Cochrane, EMBASE, PubMed, Lilacs and BBO in the period from 1966 to February 2009. Inclusion criteria for selecting articles were: studies based on images from NMR, CT

and/or CBVT that evaluated the effects of orthodontic treatment in TMJ; randomized clinical trials (RCTs), non-randomized prospective longitudinal studies, systematic reviews and meta-analysis; studies in which orthodontic treatment was already concluded in the samples; studies written in English and Spanish.

After applying the inclusion criteria 14 studies were obtained, 2 randomized clinical trials and 12 longitudinal studies without randomization criteria. Among the selected studies, 11 were based on magnetic resonance imaging and 3 in computed tomography imaging.

The authors conclude, with this systematic review, that orthodontics when correctly performed does not cause adverse effects to the TMJ. Yet, the application of forces during certain orthodontic mechanics, especially orthopedic situations, can cause alterations in condylar growth and in bone structures of the TMJ.

The authors end the paper noting that further randomized clinical trials are necessary, with longitudinal and interventional nature, for the determination of more precise causal associations, within a context of a scientific evidence-based dentistry.

Questions to the authors

1) The fact that most papers have used orthopedic appliances makes us think that this kind of treatment has been performed in growing patients. Therefore I ask: in adult patients the results would be the same?

Studies involving adult patients in whom follow-up with imaging examinations were performed also found that the correct occlusal relationship after orthodontic treatment was not obtained at the expense of changes in the condyle-articular disc complex. The findings of clinical studies should be added to these results, based on imaging examinations, which have also provided evidences that orthodontics is not a form of development, prevention and treatment for temporomandibular disorders (TMD).

2) In the discussion you mention that in some cases of TMD, an improvement can be obtained as a result of orthodontic treatment. What is the reason of this improvement?

It is important to be noted that the findings of these studies are only suggestive, since the primary objective of the studies was not to evaluate orthodontics as possible therapy for TMD.

Still, it is necessary to emphasize that the scientific evidences indicate that orthodontic treatment does not consist in a form of prevention or treatment for signs and symptoms of TMD. In TMD patients, the treatment option is based on conservative, minimally invasive and reversible therapeutics.

3) What are the major difficulties in conducting a randomized controlled clinical trial evaluating the interrelationship between TMD and orthodontic treatment?

It is a consensus that treatment protocols for temporomandibular disorders should be guided by conservative, minimally invasive and reversible therapeutics. Thus, the accomplishment of randomized clinical trials shows ethical and practical limitations, since some participants would not receive a beneficial treatment, as well as some situations would not be investigated with this methodology. Thus, therapies that change irreversibly the occlusal pattern, such as orthodontics, would provide the patient a treatment that has no scientific basis to support it and change occlusion irreversibly, considering that available conservative treatments are effective for the control and treatment of TMD.

Submitted: February 2009
Revised and accepted: May 2010

Contact address
Eduardo Machado
Rua Francisco Trevisan 20, Nossa Sra. de Lourdes
CEP: 97.050-230 - Santa Maria / RS, Brazil
E-mail: machado.rs@bol.com.br

Cytotoxicity of electric spot welding: an in vitro study

Rogério Lacerda dos Santos**, Matheus Melo Pithon***, Leonard Euler A. G. Nascimento****, Fernanda Otaviano Martins*****, Maria Teresa Villela Romanos*****, Matilde da Cunha G. Nojima*****, Lincoln Issamu Nojima*****, Antônio Carlos de Oliveira Ruellas*****

Abstract

Objective: The welding process involves metal ions capable of causing cell lysis. In view of this fact, the aim of this study was to test the hypothesis that cytotoxicity is present in different types of alloys (CrNi, TMA, NiTi) commonly used in orthodontic practice when these alloys are subjected to electric spot welding. **Methods:** Three types of alloys were evaluated in this study. Thirty-six test specimens were fabricated, 6 for each wire combination, and divided into 6 groups: Group SS (stainless steel), Group ST (steel with TMA), Group SN (steel with NiTi), Group TT (TMA with TMA), Group TN group (TMA with NiTi) and Group NN (NiTi with NiTi). All groups were subjected to spot welding and assessed in terms of their potential cytotoxicity to oral tissues. The specimens were first cleaned with isopropyl alcohol and sterilized with ultraviolet light (UV). A cytotoxicity assay was performed using cultured cells (strain L929, mouse fibroblast cells), which were tested for viable cells in neutral red dye-uptake over 24 hours. Analysis of variance and multiple comparison (ANOVA), as well as Tukey test were employed ($p < 0.05$). **Results:** The results showed no statistically significant difference between experimental groups ($P > 0.05$). Cell viability was higher in the TT group, followed by groups ST, TN, SS, NS and NN. **Conclusions:** It became evident that the welding of NiTi alloy wires caused a greater amount of cell lysis. Electric spot welding was found to cause little cell lysis.

Keywords: Toxicity. Cell culture techniques. Welding in dentistry.

How to cite this article: Santos RL, Pithon MM, Nascimento LEAG, Martins FO, Romanos MTV, Nojima MCG, Nojima LI, Ruellas ACO. Cytotoxicity of electric spot welding: an in vitro study. Dental Press J Orthod. 2011 May-June;16(3):57-9.

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

** Specialist in Orthodontics, Federal University of Alfenas - UNIFAL. Master and Doctor in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Adjunct Professor of Orthodontics, Federal University of Campina Grande - UFCG.

*** Specialist in Orthodontics, Federal University of Alfenas - UNIFAL. Master and Doctor in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Assistant Professor of Orthodontics, State University of Southwestern of Bahia - UESB.

**** Doctoral Student in Orthodontics, Federal University of Rio de Janeiro - UFRJ.

***** Graduated in Microbiology and Immunology, Federal University of Rio de Janeiro. Trainee of the Microbiology Institute of Prof. Paulo de Góes - UFRJ.

***** PhD in Sciences (Microbiology and Immunology) by the Federal University of Rio de Janeiro - UFRJ. Adjunct Professor, Federal University of Rio de Janeiro - UFRJ.

***** MSc and PhD in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Adjunct Professor of Orthodontics, Federal University of Rio de Janeiro - UFRJ.

Editor's summary

Some studies have shown that silver solder, although widely used in orthodontics, has some cytotoxic potential. In view of this fact, clinicians turn to spot welding as the method of choice for bonding orthodontic wires and accessories to achieve the desired orthodontic mechanics. Thus, the purpose of this study was to assess the cytotoxic potential of spot welding involving stainless steel, nickel-titanium (NiTi) and titanium-molybdenum (TMA) wires. Using rectangular 0.019x0.025-in wires welded together by means of an electric spot welder, six specimens were prepared for each of the following groups: SS (steel/steel), ST (steel/TMA), SN (steel/NiTi), TT (TMA/TMA), TN (TMA/NiTi) and NN (NiTi/NiTi). Copper amalgam was used as positive control, glass as negative control and for cell control, cells not previously exposed to

any material. As negative control for each material cylinders made from stainless steel, nickel-titanium and TMA were utilized. After sterilization with ultraviolet light, the specimens were exposed for 24 h to a culture medium of L929 cells, i.e., mouse fibroblasts. Cytotoxicity was evaluated by the neutral red dye-uptake assay for viable cells. Data were subjected to ANOVA followed by Tukey's multiple comparison test ($p < 0.05$). Statistically significant differences were only found between groups NN (nickel-titanium) and cell control. Therefore, no cytotoxic potential was found in the spot welding of stainless steel wire, nickel-titanium and TMA. However, the group composed only of nickel-titanium alloy showed higher cytotoxicity compared to non-exposed cells (cell control), probably due to the large quantities of nickel comprised in this type of alloy.

Questions to the authors

1) Studies assessing the cytotoxicity and genotoxicity of materials used in orthodontics are uncommon despite the relatively prolonged use of different materials that remain in close contact with the oral mucosa during orthodontic treatment. In light of this fact, how important are studies such as this one?

In recent years, the number of studies on cytotoxicity of orthodontic materials has increased significantly. This new reality represents a breakthrough in the area because it is not enough for a material to have good physical, mechanical, aesthetic features, among others. It should also be inert to oral tissues. Studies aimed at identifying materials capable of causing cellular damage will allow these materials to be classified, thereby

providing guidance to professionals with regard to the choice of materials with improved biological characteristics.

2) This study revealed greater cytotoxic potential of nickel-titanium alloy relative to the cell control group. Could this factor indicate a likely contribution of NiTi alloy to the process of carcinogenesis?

This study on spot welding was motivated by the disclosure that silver solder has demonstrated a significant cytotoxic character. The World Health Organization International Agency for Research on Cancer, and the United States National Toxicology Program have determined that metal components in silver solder such as cadmium, copper, silver and zinc are potentially carcinogenic to humans. This study showed that spot welding between NiTi alloys had the

lowest cell viability, but within acceptable limits, i.e., above 80%. Arguably, only those orthodontic materials with less than 50% viability should be withdrawn from clinical use. Nickel's notorious allergenic potential may be related to the lower viability found in this group. For David and Lobner,¹ and Eliades et al² there is clear evidence of a direct relationship between cytotoxicity and nickel but findings by Sestini et al³ showed that nickel and chromium caused a decrease in cell activity. Nickel's role in the process of carcinogenesis still defies clarification, but these materials appear not to have a significant heightening effect in the process, which depends on the duration and amount of material in contact with oral cavity cells.

3) Given the results of your investigation, do you regard spot welding as a biologically safe orthodontic procedure?

Electric spot welding has proven to be a prac-

tical, fast procedure and current machines have shown great effectiveness, which is also crucial. After undergoing spot welding, orthodontic wires appear cleaner and aesthetically pleasant, which attests to a decreased release of cytotoxic ions while facilitating polishing when necessary. Besides, there is certainly a direct relationship between the release of these ions and the results achieved in this study. One essential condition for the use of metallic materials in the oral environment is that these materials resist the corrosive action of saliva, as well as variations in pH and temperature. As an orthodontic material, silver solder is particularly susceptible to corrosion. Furthermore, the use of this solder for bonding orthodontic wires has been shown to cause the release of cytotoxic metallic ions, in part because silver solder polishing is usually inadequate, which facilitates the release of these ions. Therefore, spot welding has been used as a feasible and safe alternative in orthodontics.

REFERENCES

1. David A, Lobner D. In vitro cytotoxicity of orthodontic archwires in cortical cell cultures. *Eur J Orthod.* 2004 Aug;26(4):421-6.
2. Eliades T, Pratsinis H, Kleetsas D, Eliades G, Makou M. Characterization and cytotoxicity of ions released from stainless steel and nickel-titanium orthodontic alloys. *Am J Orthod Dentofacial Orthop.* 2004 Jan;125(1):24-9.
3. Sestini S, Notarantonio L, Cerboni B, Alessandrini C, Fimiani M, Nannelli P, et al. In vitro toxicity evaluation of silver soldering, electrical resistance, and laser welding of orthodontic wires. *Eur J Orthod.* 2006 Dec;28(6):567-72.

Submitted: February 2009
Revised and accepted: October 2009

Contact address

Antônio Carlos de Oliveira Ruellas
Av. Professor Rodolpho Paulo Rocco, 325 - Ilha do Fundão
CEP: 21.941-617 - Rio de Janeiro / RJ, Brazil
E-mail: antonioruellas@yahoo.com.br

In vitro study of shear bond strength in direct bonding of orthodontic molar tubes

Célia Regina Maio Pinzan Vercelino**, Arnaldo Pinzan***, Júlio de Araújo Gurgel****, Fausto Silva Bramante*****, Luciana Maio Pinzan*****

Abstract

Objective: Although direct bonding takes up less clinical time and ensures increased preservation of gingival health, the banding of molar teeth is still widespread nowadays. It would therefore be convenient to devise methods capable of increasing the efficiency of this procedure, notably for teeth subjected to substantial masticatory impact, such as molars. This study was conducted with the purpose of evaluating whether direct bonding would benefit from the application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface. **Methods:** A sample of 40 mandibular third molars was selected and randomly divided into two groups: Group 1 - Conventional direct bonding, followed by the application of a layer of resin to the occlusal surfaces of the tube/tooth interface, and Group 2 - Conventional direct bonding. Shear bond strength was tested 24 hours after bonding with the aid of a universal testing machine operating at a speed of 0.5mm/min. The results were analyzed using the independent t-test. **Results:** The shear bond strength tests yielded the following mean values: 17.08 MPa for Group 1 and 12.60 MPa for Group 2. Group 1 showed higher statistically significant shear bond strength than Group 2. **Conclusions:** The application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface was found to enhance bond strength quality of orthodontic buccal tubes bonded directly to molar teeth.

Keywords: Tooth bonding. Shear strength. Molar tooth.

How to cite this article: Vercelino CRMP, Pinzan A, Gurgel JA, Bramante FS, Pinzan LM. In vitro study of shear bond strength in direct bonding of orthodontic molar tubes. Dental Press J Orthod. 2011 May-June;16(3):60-2.

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

** PhD in Orthodontics, FOB/USP. Assistant Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA).

*** Associate Professor, Department of Orthodontics, Bauru School of Dentistry, University of São Paulo.

**** PhD in Orthodontics, FOB/USP. Coordinator and Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA). Assistant Professor in Speech Therapy Program, FFC - UNESP/Marília.

***** PhD in Orthodontics, FOB/USP. Assistant Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA).

***** Graduate, USC/Bauru. Student, Specialization Course in Orthodontics, APCD, Bauru/SP.

Editor's summary

Direct bonding of tubes to posterior teeth has several advantages over the use of bands: shorter clinical time; greater preservation of periodontal tissues because of easier hygiene and preservation of biological distances; and no need of previous interdental separation. However, due to the incidence of greater masticatory forces in the posterior region, there is a relatively higher rate of bonding failures, which explains the greater prevalence of banding in posterior teeth in orthodontic practice. To increase the efficacy of tubes bonded to posterior teeth, this study evaluated whether the application of an additional resin layer in the tube/tooth occlusal interface might increase its adhesive resistance. Forty mandibular third molars were included in the study and divided into two groups: Group 1 – tubes bonded conventionally, using Transbond XT resin (3M Unitek, Monrovia, CA), light cured for 20 seconds, and

application of an additional composite resin layer in the tube/teeth occlusal interface, light cured for 10 seconds; Group 2 – conventional tube bonding using the same resin, light cured for 20 seconds at first and, 40 seconds later, light cured again for 10 seconds. The specimens were stored in distilled water at 37° C for 24 h. After that, shear bond tests were performed using a universal testing machine (Emic, São José dos Pinhais, Brazil). Adhesive strengths in each group were compared using an independent t test ($p < 0.05$). In Group 1, where an additional composite resin was added to bond the tubes, shear strength was greater and statistically different than in Group 2, which underwent conventional tube bonding. Therefore, the authors concluded that an additional resin layer in the tube/tooth occlusal interface increases the adhesive resistance of tubes bonded to posterior teeth, probably due to the greater contact area between resin and tooth.

Questions to the authors

1) In this study, the addition of a composite resin layer resulted in an increase in adhesive resistance of tubes bonded to mandibular molars. Would the authors recommend the same procedure during bonding of tubes to maxillary molars? Why?

Yes, we recommend the same procedure for maxillary molars. The recommendation of direct bonding of tubes to molars has been recently tested clinically by one of our students in the MS program in Orthodontics in Centro Universitário do Maranhão – Uniceuma, São Luís, Brazil. In this split-mouth trial, 84 maxillary and mandibular molars were selected and randomly divided into 2 groups: in one of the groups, a resin layer

was applied to the tube/tooth occlusal interface; in the other, only conventional bonding was used. Clinical performance was followed up for 1 year. Results showed that the application of an additional resin layer to the tube/tooth interface increased clinical stability of the bonded tube both in maxillary and mandibular molars.

2) Laboratory tests provide a large amount of clinical information, but they often do not accurately reproduce the oral environment and, for example, its pH and temperature variations, as well as the different forces to which orthodontic appliances are exposed. Therefore, which factors should be taken into

consideration clinically when applying an additional resin layer to the tube/tooth occlusal interface, as recommended in your study?

In clinical practice, several factors should be analyzed before making the decision of banding or bonding to molars: the quality of the adhesive material, the type of surface material (amalgam, resin, porcelain, enamel, metal alloys), the clinical needs (type of movement, height of clinical crown, need of anchorage use), as well as the patient's age. If the choice is direct bonding using the method described here, the amount of adhesive material should be calculated so that it does not affect the occlusal relation between maxillary and mandibular molars and does not obstruct the space for ligatures with archwires and elastic bands in the case of using convertible tubes. Clinically, we recommend that, after the application of this reinforcement, the patient should be asked to occlude several times before the resin is light cured to avoid the occurrence of occlusal interferences. This test may be repeated also after the procedure using articulating paper.

3) Clinically, one of the greatest difficulties in bonding tubes to posterior teeth is the excessive accumulation of saliva in that region, which crucially affects the success of the procedure. What possible clinical solutions are there for this problem?

We often bond tubes directly on molars and, honestly, we have not found any great differences in saliva accumulation in the molar region than in the region of second premolars, which are routinely bonded in orthodontic practice. In addition to adequate relative isolation, molars should be bonded one at a time, that is, the molar is first bonded on one side and then on the other, and tubes should only be bonded to other teeth after the procedure is completed. In other words, bonding should move from the posterior to the anterior region. Moreover, the procedure should be conducted with the help of a dental assistant and the use of an oral evacuator and vacuum suction. We usually ask the patient to move the head to the opposite side of the tooth to be bonded, which reduces the accumulation of saliva in the region.

Submitted: September 2009
Revised and accepted: April 2010

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

Evaluation of the bone age in 9-12 years old children in Manaus-AM city

Wilson Maia de Oliveira Junior*, Julio Wilson Vigorito**, Carlos Eduardo Nossa Tuma***

Abstract

Objective: This study evaluated bone age using the Greulich & Pyle method (1959) and pubertal growth according to the study conducted by Martins (1979). **Methods:** Hand and wrist radiographs of 201 children (103 boys) aged 9 to 12 years living in the state of Amazonas (Brazil) were analyzed. A chi-square test was used for statistical analysis at a level of significance of 5% ($p < 0.05$). **Results and Conclusions:** Girls were at more advanced stages in all phases of skeletal growth than boys for the ages under study; 50% of the girls had reached pubertal growth peak, whereas only 11.6% of the boys were in the same stage. The beginning and the peak of the pubertal growth spurt occurred earlier among girls (10.1 ± 0.7 and 11.1 ± 0.8 years) than among boys (11.4 ± 0.7 and 12.3 ± 0.4 years). Early maturation was more frequent among girls than among boys (41.8% vs. 5.8%), and late maturation was more prevalent among boys (38.8% vs. 11.2%). Mean bone age in the group of boys was 10.4 ± 1.7 years, and in the group of girls, 11.7 ± 1.8 years.

Keywords: Growth and development. Puberty. Sexual maturity.

How to cite this article: Oliveira Junior WM, Vigorito JW, Tuma CEN. Evaluation of the bone age in 9-12 years old children in Manaus-AM city. Dental Press J Orthod. 2011 May-June;16(3):63-9.

* Specialist in Craniofacial Orthopedics and MSc in Orthodontics, USP. Assistant Professor of Orthodontics and Occlusion, UFAM.

** Professor of Orthodontics, FO-USP. Coordinator of the Post-graduate Courses of Masters and Doctoral level, FO-USP.

*** Specialist in Orthodontics and Dentofacial Orthopedics, UFAM. MSc in Orthodontics, SLMANDIC. Professor of Orthodontics, UEA

INTRODUCTION

Two thirds of orthodontic patients have malocclusion in which growth and development play an important role in the success or failure of treatment and directly affect the decisions about the use of extraoral mechanics, functional appliances, extractions or even orthognathic surgeries. Orthodontists should understand the events associated with growth because maturation stages have a decisive role in diagnosis, planning and length of treatment, as well as in the prognosis of malocclusion. Orthodontists should understand the events associated with growth because maturation stages have a decisive role in diagnosis, planning and length of the treatment, as well as in the prognosis of malocclusion.¹³ Therefore, individual patterns of growth for each patient are fundamental factors in the success of orthodontic treatment.

Age may be defined in several ways: bone age, morphological age, age at development of secondary sexual characteristics, age at menarche and dental age. These parameters have all been described as means to define physiological age.¹⁸ The time when a patient will reach puberty and even when the pubertal growth spurt (PGS) will occur may be estimated. However, these different types of age have a low correlation, and there are individual variations according to sex, ethnicity, geographic location, genetic factors, climate, nutrition and socioeconomic status. Because of that, the determination of specific chronological ages as the beginning of puberty in male and female patients is no longer used.^{2,11,18}

PGS occurs in adolescence, usually between 10 years and 6 months and 15 years of age in the Brazilian population, and girls reach it at an earlier age. This phase of height and craniofacial growth occurs at the same time as the physical phenomena that follow maturation of the sexual system and the beginning of reproductive life. The estimated age at which they occur is variable and several individuals reach specific stages of skeletal maturation at different chronological ages.^{11,12,13}

The most common methods to measure bone age using hand and wrist radiographs are the ones described by Greulich and Pyle⁷ (1959) and Tanner-Whitehouse²² (TW2) (1983), which are based on the recognition of maturity indicators that are characterized by changes in the radiographic appearance of the epiphysis of long bones from the early mineralization stages to their fusion with the diaphysis.⁶

Several intrinsic and extrinsic factors are known to directly affect an individual's growth pattern. Brazil is a very large country and has regional population differences; therefore, specific studies should be conducted about nutrition, weight, height, and skeletal development patterns. The characteristics of each region should be taken into consideration to establish regional standards for the use of hand and wrist radiographs, to evaluate the growth of that population, and, thus, significantly contribute to the practice of high quality orthodontics. This study evaluated chronological age at the beginning and at the peak of PGS for both sexes and correlated findings with bone age in individuals born in the city of Manaus in the state of Amazonas, Brazil.

Several authors conducted studies using hand and wrist radiographs to determine bone age and PGS beginning and peak. Pubertal growth spurt occurred at 11 to 12 years in their samples, and PGS peak was exactly at 12 years of age.⁴ A study with Swedish children found that PGS occurred at 10 to 12 years and was completed at 14.8 among girls and 17.1 among boys. Height velocity peaked two years after the beginning of PGS in both sexes (12 years for girls and 14.1 for boys).⁹

In general, ossification of the ulnar sesamoid may be used as an indicator of PGS beginning, which occurs between 10 and 11 years in girls and 11 and 12 years in boys. Other authors found similar chronological ages for PGS beginning and peak.^{8,10,17} However, another study found that mean age at height velocity peak for boys was 14 years, and there was a 2 year range of variation, whereas the mean peak

velocity age for girls was 2 years earlier than for boys and ranged from 10 to 14 years.

Data about bone age and PGS are not available for the population in the Northern region of Brazil, particularly in the state of Amazonas. This epidemiological study analyzed hand and wrist radiographs to determine bone age using the Greulich and Pyle radiographic atlas⁷ and to determine, according to the study conducted by Martins,¹² the standard height velocity curve and hand and wrist bone ossification stages.

MATERIAL AND METHODS

Sample size

For a total of 127,133 children enrolled in public schools, a sample size of 132 individuals was calculated for a 95% confidence interval and a 5% error. Therefore, data about 132 children were included in the study.

Sample size and method error

The following equation was used to calculate sample size:

$n = \frac{\partial^2 \cdot p \cdot q \cdot N}{e^2 \cdot (N-1) + \partial^2 \cdot p \cdot q}$	Key: N = universe n = calculated sample ∂ = confidence level e = sample size error p.q = percentage which phenomena occurs
---	--

Where, from a total of 127,133 children enrolled in the public schools in Manaus, a city in the Brazilian state of Amazonas, a sample of 132 individuals was defined for 90%, 95% and 99% confidence intervals and 5.8%, 7.0% and 9.1% errors using the interobserver error method.

A sample of 132 Brazilian boys and girls aged 9, 10, 11 and 12 years, born in Manaus, whose parents and grandparents were born in Amazonas, and who studied in municipal public schools were included in the study and separated into groups according to sex and age. According to the Manaus

Education Department, 127,133 children in this age group were enrolled in school in 2006. An informed consent term was signed by the parents. A special form was used to collect data about medical history, which included place of birth, possible absence of one or more permanent teeth, malocclusion, systemic diseases, nutritional deficiencies, chronic infectious diseases and no previous orthodontic treatments. After data about clinical history were recorded, the children were taken to a radiology center for hand and wrist radiographs. This study was previously approved by the Ethics and Research Committee of the institution where it was conducted under no. 05/093 and in agreement with Resolution no. 196/1996 of the Brazilian National Health Council, Ministry of Health, on April 20, 2006.

Hand and wrist radiographs were acquired using 18 x 24 Kodak T-Mat G/RA film (Atlanta, GA, USA) usable for at least 6 months according to expiration date and an Orthoralex 9200 Plus unit (X Gendex, Dentsply, York, PA, USA) calibrated to operate at 06 mA, 60 KVP and exposure time of 0.16 seconds. The focus-to-film distance was 76 cm. Patients were protected with a lead apron. The radiographs were acquired with the participant's open left hand centered on the film to include the carpal, metacarpal and phalangeal regions.

After acquisition, the radiographs were processed in a dark room using an automatic development method and an AT 2000 XR processor (Air Techniques, New York, NY, USA) according to film manufacturer's recommendations.

After fixing and drying, the radiographs were analyzed in a dimly-lit room using an X-ray box, a 0.5 mm lead pencil, a soft eraser and a form for data recording. Hand and wrist radiographs were analyzed visually and each one was compared with the radiographic standards in the Greulich and Pyle⁷ atlas (Fig 1), a widely used method because the atlas is easy to use and the structures are easy to identify and interpret.²⁰

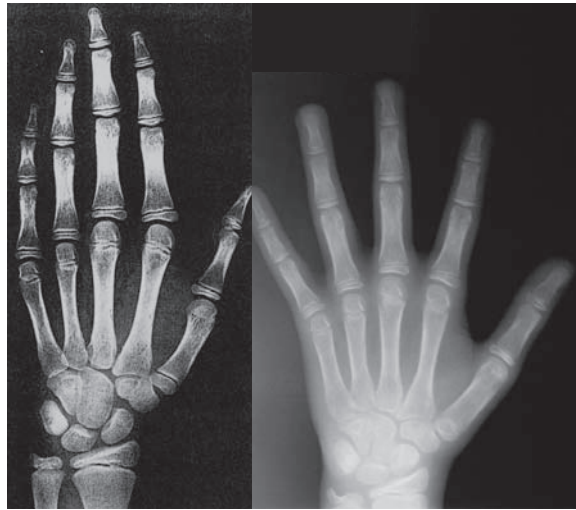


FIGURE 1 - Comparison of hand and wrist radiograph of 10-year-old girl and the corresponding standard in the Greulich & Pyle atlas⁷.

To calculate bone age, first the hand and wrist radiograph was compared with the standard for the same sex and closest chronological age in the atlas. After that, for confirmation, the radiograph was compared with standards for individuals immediately younger and older than the initial standard. When the most similar standard was found, bone age was recorded in a specific form. To check maturation stages of the hand and wrist bones, a corresponding mark was made in the standard height velocity curve to determine the time of PGS, as suggested by Martins.¹²

All radiographs were examined by the same observer. To evaluate intraobserver error, a pilot study was conducted using the whole sample to determine bone age and the standard height velocity curve. After that, the radiographs were examined again in 10 days to evaluate the degree of reliability using a form specifically developed for this study, and no statistically significant intraobserver error was found ($p < 0.05$).¹⁴

Statistical analysis

A chi-square test was used to compare statistically significant differences between groups and the associations between chronological age, bone

age and sex. Linear regression analysis was used to evaluate the correlation between variables. The level of significance was set at 5% ($p < 0.05$).

RESULTS

The results are shown in Tables 1, 2 and 3, and Figures 2, 3 and 4.

TABLE 1 - Distribution of PGS frequency according to sex.

PGS	Boys		Girls		Total	
	N	%	N	%	N	%
Not yet	31	43.7	4	6.1	51	25.4
Beginning	32	44.7	12	19.4	65	32.3
Peak	8	11.6	30	50.0	61	30.4
Completed	-	-	15	24.5	24	11.9
Total	71	100	61	100	132	100

Chi-Squared test $\chi^2=87.411$ ($p < 0.001$).

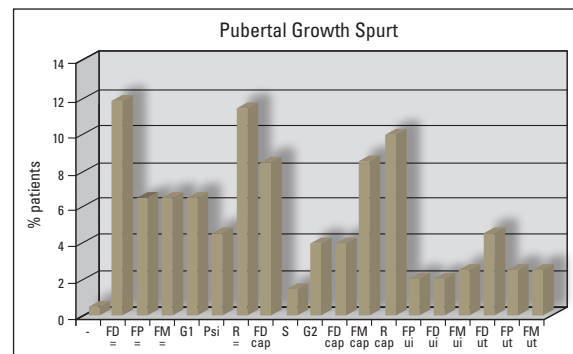


FIGURE 2 - Epiphyseal stages.

TABLE 2 - PGS phases according to chronological age and sex.

PGS	Sex	Mean	SD	Min.	Median	Max.
Not yet	M	10.1	0.7	9	10.1	11.4
Beginning	M	11.4	0.7	9.9	11.3	12.9
Peak	M	12.3	0.4	11.4	12.3	12.9
Completed	M	-	-	-	-	-
Not yet	F	9.6	0.6	9.0	9.7	10.4
Beginning	F	10.1	0.7	9.0	10.1	11.6
Peak	F	11.1	0.8	9.4	11.0	12.8
Completed	F	11.7	0.8	10.4	12.0	12.9

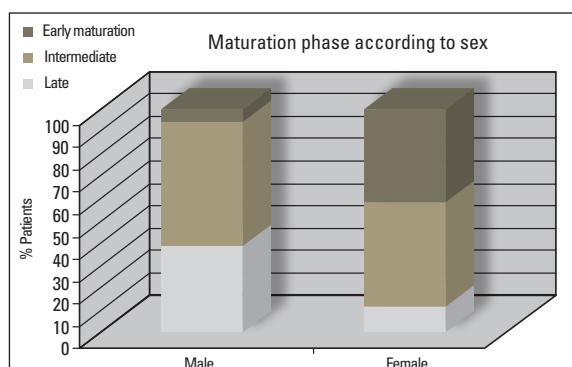


FIGURE 3 - Types of maturation according to sex.

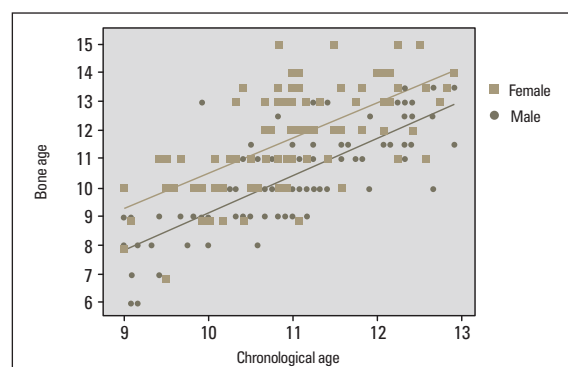


FIGURE 4 - Dispersion plot: chronological age and bone age according to sex.

TABLE 3 - Statistical data on bone age according to chronological age and sex.

Age (years)	Sex	Mean	SD	Min.	Median	Max.
9	M	8.4	1.6	6	8.5	13
10	M	9.8	1.1	8	10	12.5
11	M	10.8	1.0	9	11	13
12	M	12.3	1.0	10	12.5	13.5
9	F	9.6	1.3	6.8	10	11
10	F	11.2	1.5	8.8	11	15
11	F	12.3	1.3	8.8	12	15
12	F	13.2	1.1	11	13.3	15

DISCUSSION

The analysis of absolute and relative number of boys and girls at the different PGS stages revealed that girls were at a more advanced phase than boys (Table 1). In the sample under study, 44.7% of the boys and 19.4% of the girls were at the beginning of PGS, and about 50% of the girls had reached PGS peak, whereas only 11.6% of the boys were in the same phase. No boy had reached the final phase of PGS, whereas 24 girls (24.5%) were in this phase. The comparison between sexes using a chi-square test revealed statistically significant results ($p < 0.001$), which confirmed that girls were at a more advanced pubertal growth stage than boys (Table 1). The results found in this

study for a group of children living in the state of Amazonas, Brazil, confirm data previously reported for Swedish¹¹ and Brazilian children from different regions.¹² Similar results have also been reported in other studies.^{6,8,9}

Figure 2 shows the number of children at each epiphyseal stage regardless of age or sex. One child (0.5%) had not reached the first epiphyseal stage, and no children had completed growth, which was determined as the full fusion of radius epiphysis and diaphysis (Rut). Also, the most frequent stages for the age groups under study were FD= (11.9%), which described children not yet in the PGS; R= (11.4%), of children in the beginning of PGS; and Rcap (10.0%), of children at PGS peak.

Table 2 shows that mean age for boys at the beginning of PGS was 11.4 years, and at peak PGS, 12.3 years (0.9 year after beginning of PGS), and no boy had completed PGS. In the group of girls, mean age at the beginning of PGS was at 10.1 years and at peak PGS, 11.1 years, which was one year after the beginning of PGS. The age of 11.7 years marked the end of PGS in the age groups under study. The comparison of mean age at the beginning and peak of PGS between sexes revealed that girls were younger at the time of each of these events. The analysis of chronological age at the beginning of PGS revealed that girls reached this phase 1.3 year

before boys, and PGS peak was 1.2 year earlier in girls than in boys. However, other studies found that PGS beginning and peak were a mean 1 to 2 years later in their samples than in our study.^{5,8,9,10,17,21}

Figure 3 shows the comparison between the type of maturation (early, intermediate or late) and sex. There was a greater prevalence of intermediate maturation (differences between bone and chronological age below 1 year) in both sexes (boys = 55.3%; girls = 46.9%). Early maturation, that is, bone age at least one year greater than chronological age, was more frequent among girls (41.8%) than boys (5.8%). Late maturation, or chronological age at least one year greater than bone age, had a greater incidence among boys (38.8%) than girls (11.2%). These results confirm data reported in other studies, which found that girls reach all the skeletal maturation phases at an earlier age than boys ($p < 0.001$).^{4,8}

Figure 4 shows the regression line between bone and chronological ages for the study participants and indicates a positive correlation between chronological and bone ages in the groups of both boys and girls. Therefore, results showed that bone age increases with chronological age.

Table 3 shows the statistical results of mean bone age in each chronological age according to sex. In the group of boys, bone age was greater (12.3 years) only at the chronological age of 12 years, and was lower at 9 (8.4), 10 (9.8) and 11 (10.8) years of age. Girls had bone ages rela-

tively greater at all chronological ages, with differences ranging from 0.6 year at 9 to 1.3 year at 11 years. At 9, mean bone age was 9.6 years; at 10, 11.2 years; at 11, 12.3 years; and at 12, 13.2 years. The correlation of bone ages for each chronological age between sexes revealed that girls had bone ages greater than boys at each age group under study: 1.2 year at 9; 1.4 at 10; 1.5 at 11; and 0.9 at 12.

CONCLUSION

Girls were at more advanced stages in the different PGS phases than boys.

Chronological age at the beginning of PGS among girls was 10.1 years, and at peak PGS, 11.1 year. Among boys, chronological ages at the beginning and peak PGS were 11.4 and 12.3 years.

Children in the state of Amazonas had their PGS beginning and peak one to two years earlier than children in other regions of Brazil.

Girls had significantly greater bone ages than boys, and the mean difference was 1.3 year in all age groups under study. Chronological and bone ages were 10.9 and 10.4 for boys and 11 and 11.7 for girls.

Brazil is a very large country, and its population has different ethnic characteristics. Therefore, future studies, particularly those with longitudinal designs, should be conducted to define in greater detail the bone age and the time of pubertal growth in different populations.

REFERENCES

1. Bergensen EO. The male adolescent facial growth spurt: its prediction and relation to skeletal maturation. *Angle Orthod.* 1972;42(4):319-38.
2. Bowden BD. Epiphysal changes in the hand/wrist area as indicators of adolescent stage. *Austr Orthod J Pediat.* 1976;4(3):87-104.
3. Cerveira ARP, Silveira ID, Calmo JAF, Danesi OFP, Rosa RO, Karam LC, et al. Avaliação da idade óssea em adolescentes do sexo masculino na faixa etária de 10 a 12 anos. *Rev Odonto Ciênc.* 1990;5(10):36-46.
4. Damante JH, Freitas JAS, Capelloza Filho L. Estirão de crescimento circumpuberal em meninas brancas, brasileiras, da região de Bauru. *Ortodontia.* 1982;15(3):221-30.
5. 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.
6. Gilli G. The assessment of skeletal maturation. *Horm Res.* 1996;45(2):49-52.
7. Greulich WW, Pyle SI. Radiographic atlas of skeletal development of the hand and wrist. *Calif Med.* 1950 October; 73(4):378.
8. 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):49-58.
9. Hägg V, Taranger J. Maturation indicators and the pubertal growth spurt. *Am J Orthod.* 1982;82:299-309.
10. Iguma KE, Tavano O, Carvalho IMM. Comparative analysis of pubertal growth spurt predictors: Martins and Sakima method and Grave and Brown Method. *J Appl Oral Sci.* 2005 Jan-Mar;13(1):58-61.
11. Magnusson TE. Skeletal maturation of the hand in Iceland. *Acta Odontol Scand.* 1979;37(1):21-8.
12. Martins JCR. Surto de crescimento puberal e maturação óssea em ortodontia [dissertação]. São Paulo: Universidade de São Paulo; 1979.
13. Mercadante MMN. Radiografia de mão e punho. In: Ferreira FV. *Ortodontia: diagnóstico e planejamento clínico.* 6ª ed. São Paulo: Artes Médicas; 2004. p. 188-23.
14. Midtgard J, Bjork G, Linder-Aronson S. Reproducibility of cephalometric landmarks and errors of measurements of cephalometric cranial distances. *Angle Orthod.* 1974 Jan;44(1):56-61.
15. Moraes LC, Moraes MEL. Verificação da assimetria bilateral de desenvolvimento por meio de radiografias de mão e punho, baseada na avaliação da idade óssea. *Rev Odontol UNESP.* 1996;25(n. esp.):183-94.
16. Onishi S, Amaral IM, Carvalho LS. Identificação da menarca na curva de crescimento estatural: radiografia de mão e punho. *Rev Assoc Paul Cir Dent.* 2006;60(3):176-81.
17. Peluffo PL. Indicadores de la maduración. Edad ósea y vértebras cervicales. *Rev Odontol Interdisc.* 2001;2(3):9-15.
18. Prates NS. Crescimento crânio-facial e maturação óssea: estudo em crianças nascidas em Piracicaba, portadoras de oclusão dentária normal [tese]. Campinas: Universidade Estadual de Campinas; 1976.
19. Pryor JW. The hereditary nature of variation in the ossification of bones. *Ana Rec.* 1907;1:84-8.
20. Siqueira VCV, Martins DC, Canuto CE. O emprego das radiografias da mão e do punho no diagnóstico ortodôntico. *Rev Dental Press Ortodon Ortop Facial.* 1999;4(3):20-9.
21. Sullivan PG. A estimativa do surto de crescimento puberal, por meio do osso sesamóide e da menarca. *Rev da ABRO.* 2004;5(1):42-6.
22. Tanner JM, Whitehouse RH, Cameron N. Assessment of skeletal maturity and prediction of adult height (TW2 method). London Academic Press; 1983.
23. Todd TW. Atlas of skeletal maturation (hand). St. Louis: C.V. Mosby; 203 p.

Submitted: January 2008
 Revised and accepted: October 2008

Contact address

Wilson Maia O. Jr
 Rua 6, 192, Conj. Castelo Branco - Parque Dez
 CEP: 69.055-240 - Manaus / AM, Brazil
 E-mail: ortomaia@gmail.com

Treatment effects on Class II division 1 high angle patients treated according to the Bioprogressive therapy (cervical headgear and lower utility arch), with emphasis on vertical control

Viviane Santini Tamburús*, João Sarmiento Pereira Neto**,
Vânia Célia Vieira de Siqueira***, Weber Luiz Tamburús****

Abstract

Objective: This study investigated vertical control and the effects of orthodontic treatment on dolico-facial patients, using cervical headgear (CHG) and lower utility arch. **Methods:** Cephalometric assessment of 26 dolico-facial patients with Class II, division 1, and mean age of 114 months. Orthodontic treatment involved the use of cervical headgear (CHG) in the maxillary arch, lower utility arch in the mandibular arch until normal occlusion of the molars was obtained and finished in accordance with Bioprogressive Therapy, with a mean duration of 56 months. The values of FMA, SN.GoGn, ANB, Fg-S, S-FPm, maxillary length, mandibular length, posterior facial height (PFH), anterior facial height (AFH), facial height index (FHI), occlusal plane angle (OPA), palatal plane angle (PPA), total chin (TC), upper lip (UL) and Z angle were evaluated. **Results:** The results showed that treatment promoted stability of the mandibular, occlusal and palatal planes. Anteroposterior correction of the apical bases occurred, verified by the significant reduction in the variable ANB. The maxilla presented slight anterior displacement and increase in the anteroposterior dimension. The mandible presented improvement in its position in relation to the cranial base and its anteroposterior dimension increased significantly. The posterior and anterior facial heights remained in equilibrium, with no significant alteration in FHI. The tegumental profile presented significant improvement. **Conclusion:** The treatment performed produced correction of the apical basis with control of the horizontal planes and facial heights, and was effective for vertical control.

Keywords: Extraoral cervical traction appliances. Cephalometry. Orthodontics. Vertical control. Malocclusion. Class II, division 1.

How to cite this article: Tamburús VS, Pereira Neto JS, Siqueira VCV, Tamburús WL. Treatment effects on Class II division 1 high angle patients treated according to the Bioprogressive therapy (cervical headgear and lower utility arch), with emphasis on vertical control. Dental Press J Orthod. 2011 May-June;16(3):70-8.

* Professor and Coordinator of the Specialization Course in Orthodontics and Facial Orthopedics, Dental Association of Ribeirão Preto (AORP).

** PhD, Assistant Professor of Orthodontics Area FOP / UNICAMP.

*** Doctor, Associate Professor, Discipline of Orthodontics FOP / UNICAMP.

**** Professor of the Specialization Course in Orthodontics and Facial Orthopedics, Dental Association of Ribeirão Preto (AORP).

INTRODUCTION

The vertical growth pattern of Class II represents an unfavorable factor, since divergence from the horizontal plane generally indicates a mandible positioned more downwards and backwards, accentuating the skeletal and dental discrepancy of this malocclusion,^{7,17} making vertical control in the palatal, occlusal and mandibular planes essential, as well as of the posterior and anterior facial heights during dental treatment.^{6,8,24}

The application of various forms of treatment and mechano-therapy can be found in the dental literature, but the main objective of any strategy should center on reestablishment of the physiological functions, whenever possible normalizing the dentoalveolar and skeletal positions, and consequently providing a more harmonious profile to the patient.

One of the orthodontic appliances available for the correction of Class II, division 1 is the extraoral cervical traction appliance (CHG) developed by Silas Kloehn in 1947,¹² much used and studied during various decades. Amongst the advantages of the CHG one can highlight the anteroposterior repositioning of the apical bases, the attainment of a normal molar occlusion, modification of the occlusal and palatal planes and reduction of horizontal overlapping.^{4,11,19} When the extraoral appliance is incorrectly employed, it causes an extrusive effect on the permanent upper molars, an increase in the anteroposterior facial height and rotation of the mandibular plane in the clockwise direction, making the malocclusion even worse, especially in patients with a dolico-facial pattern.¹⁴

Only two papers were found in the literature focused on the treatment of Class II, division 1 malocclusion with the Kloehn extraoral cervical appliance and lower utility arch.^{4,22}

According to Ricketts et al,¹⁸ the CHG can stabilize the mandibular plane and facial axis of the brachyfacials, rotating the mandible in the anti-clockwise direction, and thus decreasing the antero-

posterior facial height and the mandibular plane angle. The combined headgear (HG) should be used in Class II, division 1 dolico-facial patients, so that the mandible does not rotate in a clockwise direction and does not increase the lower facial height.

Based on the above aspects, the present study proposed to make a cephalometric evaluation of the maxilomandibular changes occurring when applying Bioprogressive treatment using the Kloehn CHG to the upper arch, together with the use of a lower utility arch, for the correction of Class II, division 1 malocclusion in dolico-facial patients, mainly evaluating the vertical control.

MATERIAL AND METHODS

This study was carried out to obtain the title of Master in Orthodontics, and was only started after approval by the Ethics Commission for Research with Human Beings of FOP-UNICAMP, Brazil.

Sample

The sample consisted of 52 lateral cephalometric radiographs obtained at two moments in time, before (T1) and at the end (T2) of an orthodontic treatment with 26 patients, 13 girls and 13 boys, with Class II, division 1 malocclusion and dolico-facial skeletal patterns, with a mean age of 114 months and mean treatment time of 56 months. The patients were selected according to the following inclusion criteria:

- » Brazilian white patients, submitted to orthodontic treatment at the Orthodontic Clinic of the Specialization Course offered by the Ribeirão Preto Dental Association (AORP), Brazil;
- » Patients with absence of syndromes and good oral health;
- » Class II molar and canine relationship;
- » Overjet > 2.5mm;
- » ANB angle > 4°;
- » FMA angle > 25°;
- » SNGoGn > 35°.

Description of the orthodontic treatment according to Ricketts Bioprogressive Philosophy

The treatment of Class II, division 1 malocclusion was performed without any tooth extraction (except for the third molars, when necessary), and according to the Bioprogressive Philosophy, at the Specialization in Orthodontics and Facial Orthopedics Clinic of the Ribeirão Preto Dental Association – AORP. To correct the anteroposterior relationship of the apical bases, the Kloehe type extraoral cervical traction appliance (CHG) was used, which is characterized by an internal arch fitted into triple tubes, welded to the braces on the maxillary first molars, and an external rigid arch, inclined 20° upwards with respect to the internal arch (which is parallel to the occlusal plane), and a cervical band with elastics, pre-adjusted to generate a total force of 450g, adapted to the external arch. The patients were instructed to use the CHG for a period of 12h/day, including while asleep, with the objective of correcting the molar relationship. This period lasted approximately 1 year, and after obtaining normal molar occlusion, the CHG was gradually removed, decreasing the number of hours of use until complete withdrawal.

Concomitant with the use of the CHG on the maxilla, the lower utility arch (LUA), made of 0.016x0.016-in Elgiloy Blue wire, was adapted to the lower arch. The molar sector of the LUA was fitted into the cervical tubes of the double tubes welded onto the lower first molar bands, and the

incisor sector of the LUA onto the brackets of the four mandibular incisors. Activations were performed both for verticalizing and anchoring the mandibular molars in the cortical bone, with the objective of limiting their eruption (caudal angle of 30-45°, caudal deviation of 10-20°, buccal root torque of 30-45° and expansion of 10 mm in the molar sector), as well as intruding or uprighting the mandibular incisors according to the requirements of each case (in the incisor sector, a buccal root torque of 5-10° was incorporated). After uprighting of the mandibular molars, brackets were placed on the premolars, and a stabilizer segmented arch made of 0.016x0.016-in Elgiloy Blue wire was adapted on each side of the occlusal tube of the double tubes welded to the bands of the mandibular first molars, which extended up to the first mandibular premolars, with the object of avoiding excessive inclination of the mandibular molars in the distal direction, while the mandibular incisors were being intruded. The orthodontic treatment proceeded using the Bioprogressive Therapy until the cases were finished, with a harmonious profile and characteristics of normal occlusion.

Cephalometric method

The anatomic structures and cephalometric points were marked, the planes and lines drawn, and the following angular (Fig 1) and linear (Fig 2) variables measured:

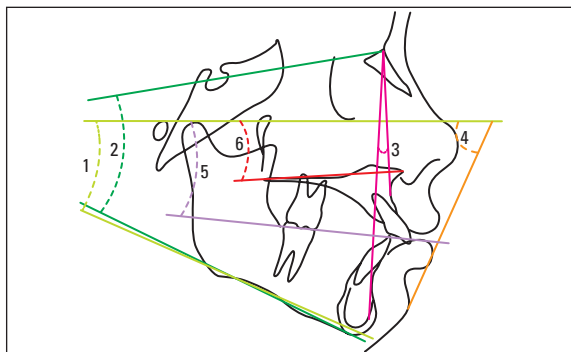


FIGURE 1 - Angular variables: 1) FMA; 2) SNGoGn; 3) ANB; 4) Z Angle; 5) OPA; 6) PPA.

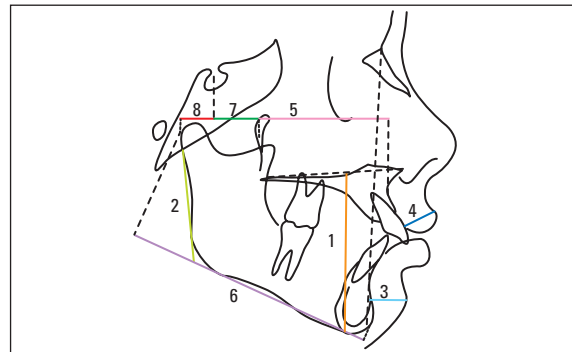


FIGURE 2 - Linear variables. 1) AFH; 2) PFH; 3) TC; 4) UL; 5) Max L; 6) Mand L; 7) S-FPm; 8) Fg-S.

Statistical analysis

The statistical analysis consisted of a univariate analysis to determine the distributions and verify the outliers and normality tests (Shapiro-Wilkens).

The “t” test was used for the comparisons of means in normal distributions. When the “t” test was performed, the equality of variances was tested using the Levene test. When the variances of the groups were shown to be different, the Satterthwaite adjustment was used.

For normal distributions, when data dependence occurred (comparison of means from one and the same individual), the paired “t” test was used. For non normal distributions the Kruskal-Wallis comparison of means test was used, and for the comparison of paired data with non normal distribution, the signed-rank test was used.

Method of Error

The same researcher traced each cephalometric radiograph twice, in an interval of 30 days, and obtained two values for each cephalometric variable. The arithmetic mean of these values was used in the statistical analysis. The Dahlberg index was used to interpret the casual error.¹⁰

TABLE 1 - Characteristic of the patients with respect to age at the beginning and during orthodontic treatment.

	Total (n=26)	Girls (n=13)	Boys (n=13)	p*
Age (months)				
Mean	114.0	127.5	120.0	0.8170
Q1	105.0	105.0	105.0	
Q3	131.0	130.0	131.0	
Min - Max	96 - 201	100 -155	96 - 120	
Duration of Treatment (months)				
Mean	56.0	56.0	57.0	0.7192
Q1	45.0	45.0	48.0	
Q3	67.0	68.0	59.0	
Min - Max	27 - 169	27 - 169	36 -103	

*Value of P for comparison of means - Kruskal-Wallis test ($P < 0.05$ significant).

RESULTS

Sample

Comparison between sexes

No statistically significant difference was observed between the sexes with respect to the alterations that occurred, when the two moments in time were compared (Table 2) for the whole sample.

Comparison of the cephalometric variables

Since no statistical differences were found between the sexes with respect to the initial ages and alterations occurring with the treatment, the sexes were placed together in the same group (Table 3).

TABLE 2 - Comparison of the paired differences between sexes.

	Girls (n=13)			Boys (n=13)			p*
	Pair. diff.	SD	SE	Pair. diff.	SD	SE	
FMA	-1.88	3.04	0.84	-1.35	1.78	0.49	0.5877
SN.GoGn	-1.34	2.74	0.76	-2.19	3.61	1.00	0.5081
ANB	-2.21	1.30	0.21	-3.00	1.36	0.38	0.0810
Fg-S	1.12	1.30	0.36	0.61	1.66	0.46	0.3955
S-FPm	0.57	1.10	0.31	0.58	1.01	0.28	0.9854
Maxillary length	2.18	1.70	0.47	1.53	1.62	0.44	0.3348
Mandibular length	9.08	3.33	0.92	9.81	4.79	1.33	0.6547
PFH	6.60	3.69	1.02	9.78	4.39	1.22	0.0582
AFH	6.39	2.98	0.82	8.05	3.09	0.86	0.1754
FHI	0.008	0.04	0.01	0.008	0.021	0.006	0.9458
Occlusal Pl. Angle	-0.77	3.03	0.84	0.61	3.24	0.90	0.2713
Palatal Pl. Angle	0.23	2.88	0.80	-1.40	2.06	0.57	0.1089
TC	1.61	2.32	0.64	2.06	1.59	0.44	0.5629
UL	1.33	3.38	0.94	1.84	2.34	0.65	0.6580
Z Angle	9.69	5.78	1.60	6.96	4.23	1.18	0.1826

*P Value for the paired Student-t test ($P < 0.05$ – significant).

TABLE 3 - Comparison of the paired differences of all variables.

	Beginning		End		Paired	Diff.		p*
	Mean	SD	Mean	SD		SD	SE	
FMA	28.98	4.01	27.36	4.11	-1.62	2.96	0.48	0.0026*
SN.GoGn	39.21	3.79	37.44	4.29	-1.77	3.18	0.62	0.0088*
ANB	6.11	1.63	3.50	1.77	-2.61	1.15	0.22	< 0.0001**
Fg-S	15.58	2.78	16.45	3.23	0.87	1.49	0.29	0.0064*
S-FPm	18.59	1.93	19.17	2.33	0.57	1.03	0.20	0.0089*
Maxillary Length	51.10	3.30	52.96	3.57	1.86	1.67	0.33	< 0.0001**
Mandibular Length	103.05	4.54	112.49	5.16	9.44	4.06	0.80	< 0.0001**
PFH	38.59	1.48	46.78	4.21	8.19	4.30	0.84	< 0.0001**
AFH	62.90	3.48	70.12	4.5	7.22	3.09	0.61	< 0.0001**
FHI	0.65	0.04	0.66	0.05	0.008	0.29	0.006	0.1830
Occlusal Pl. Angle	7.48	4.26	7.40	3.03	-0.08	3.15	0.62	0.9020
Palatal Pl. Angle	3.27	3.57	2.69	3.60	-0.59	2.59	0.50	0.2592
TC	14.03	1.63	15.87	2.09	1.84	1.96	0.38	< 0.0001**
UL	11.53	2.91	13.12	1.96	1.59	2.86	0.56	0.0090*
Z Angle	61.98	6.36	70.31	6.49	8.33	5.16	1.01	< 0.0001**

*P Value for the paired Student-t test (*P < 0.05 and **P < 0.0001 – significant).

DISCUSSION

Vertical control of the face during the use of orthodontic mechanics has been shown to be of utmost importance in obtaining functional esthetic balance, essential for the final result of a treatment aimed at facial harmony and post-treatment stability.^{6,8}

Various types of appliance have been studied and developed for the correction of Class II, one of which is the cervical headgear.¹² There is a great deal of controversy in the literature with respect to the changes occurring with the use of the cervical headgear. However, the considerations most reported are correlated to the extrusive effect on the permanent maxillary molars, downward inclination of the anterior part of the palatal plane and the increase in inclination of the mandibular plane, aggravating the vertical problem even more.¹⁴ According to Ricketts,¹⁷ cervical traction produces favorable changes for patients with Class II, division 1, such as: retraction of the maxillary complex, decrease in maxillary convexity

and rotation of the palatal plane in the clockwise direction. Some studies have shown that maxillary molar extrusion could be minimal when the CHG is used with the external arch inclined 20° above the internal arch.^{4,11,22}

The sole purpose of this study was to investigate the effectiveness of orthodontic treatment and vertical control in a sample selected from the orthodontic documentation file belonging to the Specialization Course in Dentistry and Facial Orthopedics of the Ribeirão Preto Dental Association - AORP, Brazil.

The data assessed were submitted to a statistical analysis by applying the paired Student-t test. It was observed that no statistically significant differences occurred between the sexes for the initial ages, treatment time or for the alterations that occurred with the orthodontic treatment (Tables 1 and 2). Thus both sexes were assessed in a single group, only studying the alterations occurring between the two moments in time (initial and final).

Assessment of the craniofacial growth pattern is very important, particularly during the growth phase, since selecting the direction of the application of forces depends directly on this evaluation, and can be low, straight or high. According to some authors,^{6,15} orthodontic treatment should not alter the measurements related to vertical control or cause significant mandibular rotation in a clockwise direction, especially in dolichofacial patients. These patients normally have an increased lower facial height, with the mandible positioned more backwards and downwards. If the orthodontic treatment causes clockwise mandibular rotation, there will be an increase in the height, worsening the facial profile of these patients even more.

In the present study carried out with dolichofacial patients submitted to orthodontic treatment with a CHG (with activations of the external arch) and a lower utility arch, there was a statistically significant decrease in the variables that represent the facial pattern and vertical control: angles FMA $-1.62 \pm 2.96^\circ$ and SNGoGn $-1.77 \pm 3.18^\circ$ (Table 3). This result showed that the mandibular plane was stabilized during orthodontic treatment, allowing for the reasoning that the clinically observed alterations were not expressive, since the alteration remained at approximately 1.6° and the standard deviation of around 3° . This result corroborated the results of Decosse and Horn,⁶ who reported that the values of these angles should be maintained with the use of orthodontic mechanics for vertical control to occur. Other results found in the literature showed the stability of the variables referring to the facial pattern with treatment.^{3,4,11,12} Ricketts et al¹⁸ reported that the use of the CHG together with the lower utility arch could cause anti-clockwise rotation of the mandible in brachyfacial patients, which they¹⁸ denominated as the Inverse Reaction. According to these authors,¹⁸ when the upper molar (Fig 3A) is extruded and distalized in an intermittent way, its inclined planes act to upright and distalize the

lower first molar. This occurrence is accentuated by the distal degree of the utility arch (Fig 3B) and labial torque of the root of the lower incisor (Fig 3D). The vertical action of the masseter and pterygoid muscles (Fig 3C) functions in the stabilization of the eruption of the lower molar (Fig 3F) and also limits extrusion of the upper molar. The torque of the labial root on the lower utility arch (Fig 3E) also allowed for the lower incisor to avoid the cortical one while being intruded. The present study assessed dolichofacial patients and showed that the treatment can also result in a tendency for anti-clockwise rotation of the mandible (tendency, since it was considered that the change that occurred — about 1.6° — was not clinically expressive). This alteration occurred due to the intermittent use (12h/day, including while asleep) of the CHG, with activation of the external arch and use of a lower utility arch, which promotes anchorage of the lower molars. A 20° activation of the external arch above the internal arch made the resulting force pass through the center of resistance of the upper molar, promoting an action that controlled the extrusive effect on the upper molars. This result corroborated the findings of Cook et al⁴ and Ulger et al,²² who carried out a study using the CHG with activation of the external arch and use of a lower utility arch, and reported that the mandibular plane remained unaltered even in dolichofacial patients.⁴ Kirjavainen

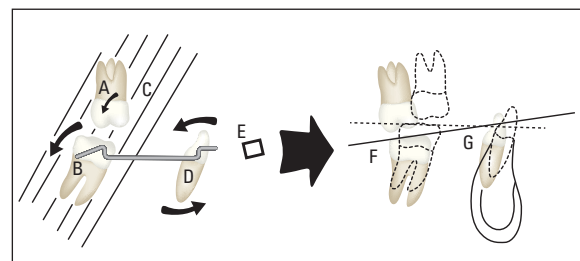


FIGURE 3 - Inverse Reaction – Combined action of the the CHG and LUA. A) upper first molar, B) LUA distal degree, C) vertical action of the masseter and pterygoid muscles, D) buccal root torque of the lower incisors, E) wire activation to generate buccal root torque on the lower incisors, F) limited eruption of the lower first molars, G) lingual movement of the lower incisors and change the functional occlusion plane. Source: Ricketts et al.¹⁸

et al¹¹ reported the occurrence of minimal extrusion of the upper molars in patients who used the CHG with activation of the external arch.

The maxilla protruded slightly with respect to the cranial base at the start of the dental treatment (Table 3), and at the end of the treatment a mild, but statistically significant, forward displacement could be observed. The variable S-FPm showed an increase of 0.57 ± 1.03 mm (Table 3), suggesting that the use of the CHG restricted forward displacement of the maxilla, the mean displacement being 0.57 mm in a period of 4.6 years. Its anteroposterior dimension (FPm-point A) showed a statistically significant increase of 1.86 ± 1.67 mm. Siqueira²⁰ assessed Brazilian patients with normal occlusion and showed that the length of the maxilla increased approximately 3.34 mm from 9 to 10 years of age, and thus it is reasonable to consider that the anteroposterior dimension of the maxilla was restricted by the use of the CHG, since it only increased 2 mm in a period of 4.6 years.

The mandible protruded in relation to the cranial base at the start of treatment (Table 3), but by the end of treatment, the variable Fg-S showed a value of 16.45 ± 3.23 mm, indicating an approximation to the standard value determined by Wylie,²⁵ suggesting an improvement in the anteroposterior mandibular position in relation to the cranial base. The anteroposterior dimension increased significantly during the assessment period, showing an expressive increase in length of 9.44 ± 4.06 mm (Table 3). According to Ricketts et al,¹⁸ this increase could have occurred due to mandibular unlocking or to decompression of the condyle in the glenoid cavity, freeing the mandible for normal growth.

According to Antonini et al,¹ Broadbent et al² and Ricketts,¹⁶ the relationship of the maxillary complex with the cranial base remains relatively constant during growth in patients with predominantly vertical growth, and thus orthodontic and/or orthopedic intervention is necessary for the correction of anteroposterior Class II, division 1 mal-

occlusion. The anteroposterior discrepancy was shown to be corrected by means of a highly significant ($P < 0.0001$) alteration in the ANB angle (Table 3). A reduction of $2.61 \pm 1.15^\circ$ occurred, improving the relationship between the apical bases, confirming the results of other authors.^{3,4,11,22,23} The reduction in ANB was due mainly to the expressive growth of the mandible and to the possible skeletal alterations occurring in the maxilla.

The facial heights increased significantly, PFH 8.19 ± 4.30 mm ($P < 0.0001$) and AFH 7.22 ± 3.09 mm ($P < 0.0001$), whereas the FHI (Table 3) showed no statistically significant alteration ($P = 0.1830$), occurring a very slight increase in its value, but remaining within the values considered normal by Horn (0.65 to 0.75),⁹ the final value obtained being 0.66 ± 0.05 . These findings suggest the effectiveness of the orthodontic treatment during the mechanics used, harmonizing the facial heights, since the posterior facial height increased slightly more than the anterior one and the Inverse Reaction.¹⁸

The alterations occurring in the occlusal and palatal planes were not statistically significant. The occlusal plane angle expresses the dental-skeletal relationship of the occlusal plane with the Frankfurt plane, as determined by the muscular balance. According to some authors,^{5,8,24} its value should be maintained or discreetly reduced in order to avoid a relapse. In the present study the occlusal plane angle showed a statistically non-significant reduction of $0.08 \pm 3.15^\circ$ and $P = 0.9020$ (Table 3), corroborating with other studies found in the literature.^{5,6,24} The palatal plane angle showed a statistically non-significant reduction of $0.59 \pm 2.59^\circ$ and $P = 0.2592$ (Table 3). The results observed suggested that the palatal plane had a tendency to rotate in a clockwise direction, confirming the results of other studies.^{4,11,18,23}

According to Tamburus et al,²¹ the tegumental profile represents the final determinant of the dental positions, since there is no point in

orthodontic planning and treatment other than achieving the basic objectives of obtaining good occlusion, if the facial esthetics remain compromised. The alterations occurring to the profile were statistically significant (Table 3). The cephalometric variables TC and UL showed mean values increased by values of 1.84 ± 1.96 mm and 1.59 ± 2.86 mm, respectively, maintaining the proportionality between them ($TC \geq UL$) from start to finish of the treatment.

The Z angle relates the tegumental profile of the patient with the horizontal and vertical senses.⁸ At the start of the orthodontic treatment (Table 3), the patients showed a decreased mean value of the Z angle, confirming the convex profile, and one of the objectives of the orthodontic treatment was centered on increasing this angle, thus making the profiles of the patients more harmonious. The results of the present study showed a significant increase in the Z angle ($+8.33 \pm 5.16^\circ$ and $P < 0.001$), due mainly to the expressive growth of the mandible, with a final mean of $70.31 \pm 6.49^\circ$, a value close to the normal values found in the studies of Leichsenring et al¹³ and Siqueira²⁰ for patients with harmonious profiles.

CONCLUSIONS

According to the methodology used and the results obtained in the treatment of Class II, division 1 malocclusions with dolico-facial patients, it was concluded that:

As verified by the significant reduction in the ANB angle, the apical bases of the Class II, division 1 malocclusion were corrected by the use of a Kloe-hn-type CHG, due mainly to an expressive growth in mandibular length and restriction or redirection of maxillary growth, thus significantly improving the profile. The horizontal planes and facial heights were controlled, as verified by the changes that occurred in the FMA and SNGoGn angles, occlusal plane angle, palatal plane angle and FHI, showing that the orthodontic treatment was effective in the vertical control.

FINAL CONSIDERATIONS

The present study was a retrospective assessment carried out to obtain the title of Master in Orthodontics at FOP/UNICAMP, Brazil.

The idea of carrying out this study came from various years of clinical experience with good results by applying the methodology of Dr. Clóvis Roberto Teixeira and Dr. Weber Luiz Tamburús.

Since only two papers were found in the international literature reporting on the treatment of Class II, division 1 malocclusion with a CHG and lower utility arch, more research is needed in order to confirm and explain all the modifications that occurred.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Clóvis Roberto Teixeira for his collaboration in this study.

REFERENCES

1. Antonini A, Marinelli A, Baroni G, Franchi L, Defraia E. Class II malocclusion with maxillary protrusion from the deciduous through the mixed dentition: a longitudinal study. *Angle Orthod.* 2005;75(6):980-98.
2. Broadbent BH, Broadbent BH Jr, Golden WH. Bolton standards of dentofacial developmental growth. St. Louis: Mosby; 1975.
3. Ciger S, Aksu M, Germeç D. Evaluation of posttreatment changes in Class II, division 1 patients after nonextraction orthodontic treatment: Cephalometric and model analysis. *Am J Orthod Dentofacial Orthop.* 2005;127(2):219-23.
4. Cook AH, Sellke TA, Begole EA. Control of the vertical dimension in Class II correction using a cervical headgear and lower utility arch in growing patients. Part I. *Am J Orthod Dentofacial Orthop.* 1994;106(4 Pt 1):376-88.
5. Decker WB. Tweed occlusion and occlusal function. *J Charles H. Tweed Int Found.* 1987;15:59-83.
6. Decosse M, Horn AJ. Contrôle céphalométrique et dimension verticale. Introduction aux forces directionnelles de Tweed. *Revue Orthop Dentofacial.* 1978;12(2):123-36.
7. Drelich RC. A cephalometric study of untreated Class II, division 1 malocclusion. *Angle Orthod.* 1948;18(3-4):70-5.
8. Horn A, Jégou I. La philosophie de Tweed aujourd'hui. *Rev Orthop Dento-faciale.* 1993;27:163-81.
9. Horn A. Facial height index. *Am J Orthod Dentofacial Orthop.* 1992;102(2):180-6.
10. Houston WJB. Analysis of errors in orthodontic measurements. *Am J Orthod Dentofacial Orthop.* 1983;83(5):382-9.
11. Kirjavainen M, Kirjavainen T, Hurmerinta K, Haavikko K. Orthopedic cervical headgear with an expanded inner bow in Class II correction. *Angle Orthod.* 2000;70(4):317-25.
12. Kloehn SJ. Guiding alveolar growth and eruption of teeth to reduce treatment time and produce a more balanced denture and face. *Angle Orthod.* 1947;17(1-2):10-33.
13. Leichsenring A, Invernici S, Maruo IT, Maruo H, Ignácio AS, Tanaka O. Avaliação do ângulo Z de Merrefield na fase de denteição mista. *Rev Clín Pesq Odontol.* 2004;1(2):9-14.
14. Melsen B. Effects of cervical anchorage during and after treatment: an implant study. *Am J Orthod.* 1978;51(5):526-40.
15. Ricketts RM. The influence of orthodontic treatment on facial growth and development. *Angle Orthod.* 1960;30:103-33.
16. Ricketts RM. Cephalometric analysis and synthesis. *Am J Orthod.* 1961;31(3):141-56.
17. Ricketts RM. A four-step method to distinguish orthodontic from natural growth. *J Clin Orthod.* 1975;9(4):208-15, 218-28.
18. Ricketts RM, Bench RW, Gugino CF, Hilgers JJ, Schulhof RJ. Técnica bioprogressiva de Ricketts. Buenos Aires: Editorial Médica Panamericana; 1983.
19. Siqueira DF. Estudo comparativo, por meio de análise cefalométrica em norma lateral, dos efeitos dento-esqueléticos e tegumentares produzidos pelo aparelho extrabucal cervical e pelo aparelho de protração mandibular, associados ao aparelho fixo, no tratamento da Classe II, 1ª divisão de Angle [tese]. Bauru: Universidade de São Paulo; 2004.
20. Siqueira VCV. Denteição mista: estudo cefalométrico de estruturas craniofaciais em indivíduos brasileiros, dotados de oclusão clinicamente excelente [dissertação]. Piracicaba: Universidade de Campinas; 1989.
21. Tamburús WL, Teixeira C, Garbin AJL. Classe II divisão 1. In: Baptista JM, Baptista LT, Manfredini M. Ciência Bioprogressiva. [CD-ROM]. Curitiba: Editek; 2000.
22. Ülger G, Arun T, Sayinsu K, Isik F. The role of cervical headgear and lower utility arch in the control of the vertical dimension. *Am J Orthod Dentofacial Orthop.* 2006;130(4):492-501.
23. Üner O, Diñer M, Türk T, Haydar S. The effects of cervical headgear on dentofacial structures. *J Nihon Univ Sch Dent.* 1994;36(4):241-53.
24. Vaden LJ, Harris EF, Sinclair PM. Clinical ramifications of facial height changes between treated and untreated Class II samples. *Semin Orthod.* 1996;2(4):237-40.
25. Wylie WL. The assessment of facial dysplasia in the vertical plane. *Angle Orthod.* 1952;22(3):165-82.

Submitted: July 2008
Revised and accepted: February 2009

Contact address

Viviane Santini Tamburús
Rua Visconde de Inhaúma, nº 580, sala 611 - Centro
CEP: 14.010-100 - Ribeirão Preto / SP, Brazil
E-mail: vikatamburus@hotmail.com

Analysis of the correlation between mesiodistal angulation of canines and labiolingual inclination of incisors

Amanda Sayuri Cardoso Ohashi*, Karen Costa Guedes do Nascimento*, David Normando**

Abstract

Objective: To assess the degree of correlation between canine angulation and incisor inclination. **Methods:** Mesiodistal angulation of canines and labiolingual inclination of incisors were obtained by means of digital graphics software (ImageTool®) from standardized photographs of the casts of 60 patients. Incisor inclination was also assessed by lateral cephalometric radiographs. **Results:** Random error showed a variation of around 2° in measurements made on the casts (1.8-2.5), while systematic error, measured by the intraclass correlation test, displayed excellent reproducibility for both methods used in this study ($p < 0.001$, $r = 0.84-0.96$). Linear correlation tests revealed a significant positive correlation between canine angulation and incisor inclination in the maxillary arch ($r = 0.3$, $p < 0.05$) and even more significantly in the mandibular arch ($r = 0.46$ to 0.51 , $p < 0.001$), when both were measured on the casts. When incisor inclination was examined by cephalometrics, correlation level was statistically insignificant for maxillary incisors ($r = 0.06$ to 0.21 , $p > 0.05$) and varied widely in the mandibular arch ($r = 0.14$ to 0.50). **Conclusions:** The introduction of changes in the angulation of canines with the aim of monitoring compensations observed in incisor inclination is warranted, especially in the lower arch.

Keywords: Malocclusion. Canines, angulation. Incisors, inclination.

INTRODUCTION

Tooth inclination and angulation have long been investigated in orthodontics. In 1928, Angle³ systematized orthodontic treatment by developing the Edge-wise appliance, whereby tooth inclination and angulation were produced through bends placed in the leveling archwire and inserted in the bracket slots.

Andrews¹ published a study in 1972 to perform an in-depth examination of the characteristics of normal, optimal occlusion and identified six features shared by all the study casts. The author then introduced “The Six Keys to Optimal Occlusion” and suggested that attaining these morphological features was the goal of

How to cite this article: Ohashi ASC, Nascimento KCG, Normando D. Analysis of the correlation between mesiodistal angulation of canines and labiolingual inclination of incisors. Dental Press J Orthod. 2011 May-June;16(3):79-86.

* Dental Surgeon - Intern, Discipline of Orthodontics, School of Dentistry, Pará State Federal University.

** MSc in Integrated Clinic (FOUSP). PhD in Orthodontics, Rio de Janeiro State University (UERJ). Professor of Orthodontics, School of Dentistry (UFPA). Coordinator of the Specialization Program in Orthodontics (ABO-Pa).

orthodontic treatment. Andrews noted that the long axes of all teeth were mesially tipped to varying degrees, depending on the group of teeth examined, and termed this feature as the 2nd key to normal occlusion. The 3rd key outlined by Andrews was crown inclination (torque), defining a positive value for the upper incisors (buccal crown torque) and negative, or lingual for the remaining teeth. The angulation and inclination values observed in the Andrews study² were instrumental for the invention of the Straight-Wire appliance.

A few years later, changes were made to the inclination of incisor brackets to compensate for the skeletal discrepancies that were not addressed in its entirety during orthodontic treatment.² In the case of Class III malocclusion, incisors were tipped more buccally in the maxillary arch and more lingually in the mandibular arch, while in Class II the opposite was implemented. It later became evident that, in fact, lower incisor inclination was strongly influenced by the relationship between apical bases in the sagittal plane, which played an important role in achieving a normal⁸ incisal relationship in the same manner that changes in upper incisor inclination significantly affect posterior occlusion.¹²

In addition to the compensatory inclinations designed for the incisor region,² whose effects on the arch length were eventually scientifically proven¹⁰ a few years later, changes were incorporated in canine angulation with the purpose of monitoring the compensations built into incisor brackets.⁴ Thus, the mesiodistal angulation of canines would be increased whenever orthodontic treatment aimed to incline incisors labially, and be decreased when the goal was either to incline incisors lingually or maintain an existing lingual compensation.

The impact exerted by changes in incisor angulation on arch length had been previously assessed by a mathematical model,⁷ which showed that these alterations caused only small changes in the dental arch. However, no study seems to have

examined the effects of mesiodistal angulation of canines on incisor inclination (torque).

In an orthodontic treatment geared toward case individualization, such as skeletal malocclusion cases treated with compensations, it is extremely important to recognize the natural features of each patient's compensations. As well as the role played by incisors, canine angulation needs to be investigated since these teeth are positioned in an important area within the geometric design of the dental arch. The first step seems to consist in examining whether such canine angulation compensations are indeed present in the several skeletal alterations in the face — a fact which was confirmed in a previous study⁹ — and also whether or not such compensations and changes exhibit a significant correlation, which is the purpose of this study.

MATERIAL AND METHODS

This study comprised a sample of 60 patients in the stage of permanent dentition, from the private practice of one single orthodontist, with the aim of establishing a correlation analysis between mesiodistal canine angulation and labiolingual incisor inclination and anteroposterior position.

The sample comprised individuals with different types of malocclusion as determined by molar relationship: Class I (n=20), Class II (n=20) and Class III (n=20) without previous orthodontic treatment. Patients who presented with tooth loss, agenesis, moderate or severe crowding and/or syndromes were immediately excluded since these factors might interfere with canine and incisor inclination.

Canine and incisor inclination were evaluated with the aid of scanned, standardized photographs. To determine canine angulation all quadrants of the patients' casts were photographed, while for incisor inclination only the upper and lower right sides of the same models were photographed. The photographs were taken with a digital camera (Canon Rebel XT 8.0 Megapixel, f=22). The casts

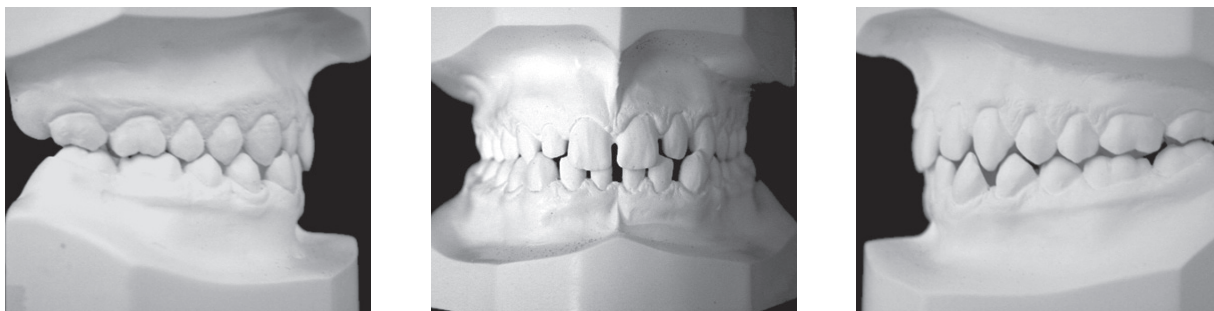


FIGURE 1 - Plaster casts of an individual with Class I malocclusion used in the sample.

were placed on a glass plate (Fig 2a), at a distance of 20 cm from the camera (Fig 2b). At the bottom of each model a black device was placed with a marking in the center, used as reference to centralize the teeth that would be photographed (Fig 2c), as described in a previous study.⁹

The camera lens was propped on a utility wax plate to optimize lens direction (Fig 2d). Canines and incisors were clearly centered at the time the photographs were taken. To better visualize the long axes of canines, these teeth were positioned so that their labial surface faced the examiner (Fig 3A). Incisors were positioned in lateral view so as to render visible their inclination (Fig 3B).

A total of 360 photographs were taken and later exported to a computer program (Adobe Photoshop 7.0®) where the occlusal plane was traced (Fig 4). Those images were subsequently imported into an image editing program (Image Tool® – www.imagetool.com) where canine angulation and incisor inclination were measured.

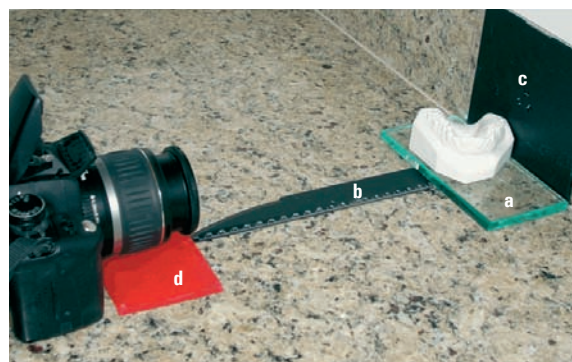


FIGURE 2 - Method used to standardize how photographs of plaster models were taken to determine canine angulation.

When necessary, photograph brightness and contrast were adjusted in order to enhance visualization of structures, thereby providing a sharper outline of the teeth. The occlusal plane was traced from the incisal surface of the central incisors to the mesiobuccal cusp of the first permanent molar to determine both canine and incisor inclination. Canine angulation measurements were then

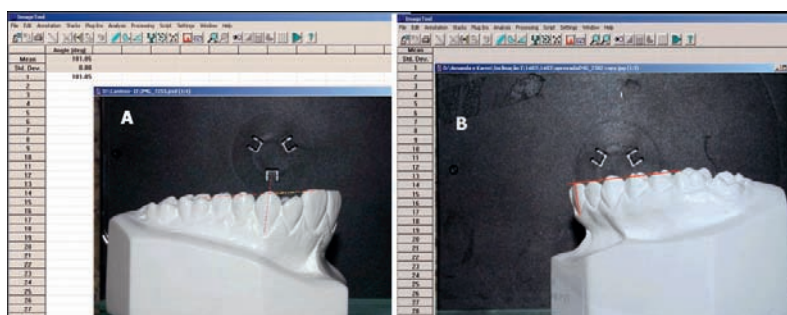


FIGURE 3 - Photograph of plaster study model exported to image editing program to obtain measurements of canine angulation (A) and incisor inclination (B).

performed using the same graphics software used for tracing the long axes of canine crowns. Based on the intersection of these two lines the value of the angle of the clinical crown of the canine was obtained in the plaster casts. The same program was used to measure incisor inclination by drawing a line tangent to the center of the right central incisor crown, which intersected the previously outlined occlusal plane (Fig 3B).

Incisor inclination was measured using lateral cephalometric radiographs of the sample (Fig 4). The angle formed between the long axis of mandibular incisors and the mandibular plane (IMPA) and the angle formed between the long axis of the maxillary incisors and the palatal plane (1.PP) were also examined. Incisor inclination was also assessed using measures 1.NA and 1.NB and distances 1-NA and 1-NB.

Radiographs were traced manually and points were digitized using an 1812 series Genius Tablet. Tracings were performed by one of the researchers and checked by an orthodontist. Measurements were obtained by means of SMTC (Sistema de Medição e Traçado Cefalométrico) computer software.

Statistical analysis

After obtaining cephalometric and dental cast measurements, the D'Agostino-Pearson test was employed to analyze normal data distribution. Method error study was performed by re-assessing 20 cases. Random error was reviewed by Dahlberg's formula while systematic error was analyzed by intraclass correlation test. Correlation analysis between the measurements was performed using Pearson's linear correlation test. The confidence level used throughout the analysis was 5% ($P < 0.05$). Calculation for determining sample size was performed assuming the use of Pearson's linear correlation test with 5% alpha level, 80% power and a minimum correlation coefficient (r value) of 0.35. The sample size found for such conditions comprised 63 individuals.

RESULTS

Data analysis (Table 1) indicated that the samples showed normal distribution ($P > 0.05$). It was also noted that the variation coefficient was approximately 10% for measurements made on the dental casts, and cephalometric angles of the incisors relative to the basal bone (1.PP, IMPA). These values, however, were higher than 25% when the cephalometric measurements related the incisors to a reference line joining their respective basal bones to the nasion point (1.NA, 1-NA, 1.NB, 1-NB).

Random error analysis of measurements made on the casts ranged from 2% to 2.9% of the mean. Cephalometric measurements that examined the incisors relative to a reference line on the cranial base (1.NA, 1-NA, 1.NB, 1-NB) showed a random error greater than 5% of the mean, while for the angle formed between the long axis of the teeth and their apical base (IMPA and 1.PP) error was about 2%. However, for all measures examined by analysis of systematic error using intraclass

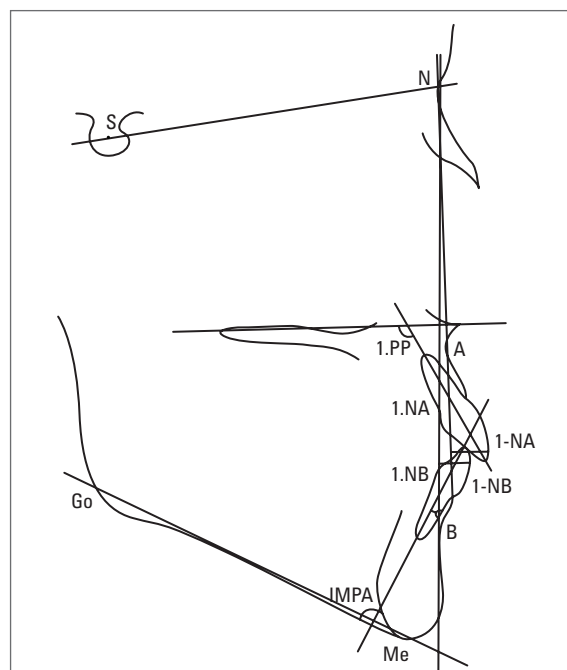


FIGURE 4 - Cephalometric tracing used to obtain cephalometric measurements in this study.

correlation coefficient, the level of replicability was excellent (Table 1).

The results in Table 2 show no significant correlation between the position of the incisors, as measured on the radiographs (1.NA, 1.PP and 1-NA), and canine angulation, as examined on the casts. As can be observed, there was a weak but significant positive correlation between the position of the incisors, as measured on the casts, and canine angulation ($P<0.05$). A strong correlation was found between the position of the upper incisors, as measured on the radiographs and on the casts ($P<0.01$).

Table 3 shows a significant correlation between the position of the lower incisors, as measured on radiographs, and canine angulation, as measured on the casts. The only exception was the correlation between tooth 33 and 1-NB. When both canine angulation and lower incisor position were measured on the casts, a significant correlation ($P<0.01$) was found. There was also a significant correlation between lower incisor position as measured on radiographs vs. on models ($P<0.01$).

The data therefore demonstrate that the mesiodistal angulation of canines tended to follow incisor inclination, when both were measured on the casts, but more significantly in the lower arch than in the upper arch.

DISCUSSION

This study lends support to the notion that changes induced in the mesiodistal angulation of canines aimed at monitoring sagittal compensations observed in incisors allow an increase or decrease in dental arch perimeter. Despite this assertion, some important details should be pointed out in the results, especially with regard to differences in the degree of correlation between these measurements when the upper and lower dental arches are analyzed separately, as well as the method used to measure incisor inclination (Tables 2 and 3).

The results revealed that, in general, when canines are more mesially tipped, the incisors tend to follow this angulation and become more labially inclined. Likewise, when canines

TABLE 1 - Analysis of normal distribution (D'Agostino-Pearson's test), mean, standard deviation, coefficient of variation, random error, systematic error (Intraclass correlation-ICC) and level of replicability.

Measures Evaluated	Normality Value (P) (n=60)	Mean (n=60)	Standard deviation (n=60)	Coeff. of Variation (n=60)	Random error (N=20) (Variation %)	ICC Systematic error (n=20) (replicability)
Casts						
Maxillary incisor	0.93	81.93	8.43	10.29%	1.9 (2.3%)	0.96 (EXC)**
Mandibular incisor	0.30	90.91	9.34	10.27%	1.8 (2.0%)	0.96 (EXC)**
Angulation 13	0.34	77.66	7.83	10.08%	1.8 (2.3%)	0.94 (EXC)**
Angulation 23	0.14	79.48	7.44	9.36%	1.8 (2.3%)	0.93 (EXC)**
Angulation 33	0.30	84.51	7.42	8.78%	2.4 (2.8%)	0.84 (EXC)**
Angulation 43	0.71	86.41	7.22	8.36%	2.5 (2.9%)	0.86 (EXC)**
Cephalometrics						
1.NB	0.49	25.35	6.52	25.73%	1.9 (7.8%)	0.89 (EXC)**
1-NB	0.32	6.58	2.32	35.22%	0.4 (5.8%)	0.97 (EXC)**
IMPA	0.68	90.31	10.08	11.16%	2.1 (2.3%)	0.94 (EXC)**
1.NA	0.95	26.67	8.69	32.60%	1.4 (5.3%)	0.97 (EXC)**
1-NA	0.06	7.69	2.87	37.38%	0.5 (7.1%)	0.98 (EXC)**
1.Palatal Plane	0.70	117.01	8.80	7.53%	1.6 (1.3%)	0.97 (EXC)**

NS= non-significant; EXC= Excellent; ** $P<0.0001$; ICC= Intraclass Correlation.

TABLE 2 - Pearson's correlation matrix (r) and P value (in parentheses) for measurements made in the upper arch.

	Upper Inc (Cast)	13	23	1.NA	1-NA	1.PP
	r (P)	r (P)	r (P)	r (P)	r (P)	r (P)
Maxillary Incisor (Cast)	1.00	---	---	---	---	---
Angulation 13	0.30 (0.018)*	1.00	---	---	---	---
Angulation 23	0.31 (0.017)*	0.62 (0.00)**	1.00	---	---	---
1.NA	-0.72 (0.00)**	-0.16 (0.24)	-0.05 (0.71)	1.00	---	---
1-NA	-0.61 (0.00)**	-0.06 (0.67)	0.03 (0.80)	0.87 (0.00)**	1.00	---
1.PP	-0.72 (0.00)**	-0.21 (0.11)	-0.11 (0.39)	0.91 (0.00)**	0.71 (0.00)**	1.00

* P<0.05; **P<0.01.

TABLE 3 - Pearson's correlation matrix (r) and P value (in parentheses) for measurements made in the lower arch.

	Mandibular Incisor (Cast)	33	43	1.NB	1-NB	IMPA
	r (P)	r (P)	r (P)	r (P)	r (P)	r (P)
Mandibular Incisor (Cast)	1	---	---	---	---	---
Angulation 33	0.46 (0.00)**	1	---	---	---	---
Angulation 43	0.52 (0.00)**	0.44 (0.00)**	1	---	---	---
1.NB	0.61 (0.00)**	0.29 (0.02)*	0.26 (0.04)*	1	---	---
1-NB	0.43 (0.00)**	0.14 (0.28)	0.26 (0.05)*	0.76 (0.00)**	1	---
IMPA	0.69 (0.00)**	0.50 (0.00)**	0.36 (0.00)**	0.73 (0.00)**	0.47 (0.00)**	1

* P<0.05; **P<0.01.

exhibited a smaller mesial angulation, incisors appeared more lingually inclined. This correlation, however, was more evident in the lower arch (Table 3) than in the upper arch (Table 2). The authors could not find a logical explanation for this fact, but it is likely that the manner in which the lower arch was restricted by the upper arch may be related to these results. Data from a previous study⁹ demonstrate that only the lower canines showed a significant change in angulation when Class III subjects were compared with Class I individuals, corroborating the results achieved in this study.

The idea that changes in tooth angulation could influence tooth inclination (torque) and arch length was investigated through a mathematical model¹⁷ that examined the incisors. Moreover, the compensations observed in incisor inclination and their relationship with the maintenance of in-

cisal contacts in the presence of sagittal skeletal alterations had already been detailed on models.⁸ In light of the results of this study, however, it is reasonable to believe that the influence of canine angulation seems to be, as yet, an important factor affecting sagittal incisor compensation in skeletal discrepancy cases.

Several methodologies for assessing tooth angulation and inclination have recently been described in the literature. However, these methods typically involve devices not available in the market and require customized fabrication^{6,11,13} or high cost technologies.⁵ In this study, the angulation of canines was examined in casts, using a method described in a previous study, which offered excellent replicability and a random error of about 2°. Moreover, incisor inclination was examined using a well established method, i.e., cephalometrics, in addition to a method designed

specifically for this study, which also showed an excellent level of replicability and a random error of about 2% (Table 1).

The correlation between canine angulation and incisor inclination yielded different results depending on whether the incisors were examined cephalometrically or on the casts. The maxillary arch (Table 2) exhibited a weak ($r=0.3/0.31$) but significant correlation ($P<0.05$) between incisor inclination, as measured on the casts, and the degree of canine angulation. Furthermore, there was no statistically significant correlation when incisor inclination was examined with the aid of cephalometric measurements ($P>0.05$).

The lower arch (Table 3) showed a statistically significant correlation every time that canine angulation was correlated with incisor inclination, as measured on the casts ($r=0.46/0.52$, $P<0.01$) and cephalometrically. The strongest correlations ($r=0.50/0.36$, $P<0.01$) were obtained for the measurement that reflects the angle formed between the long axes of the incisors and the mandibular plane (IMPA), while the weakest correlations ($r=0.14$, $P>0.05/r=0.26$, $P<0.05$) were found for the measurement that examines (in millimeters) the position of the lower incisors relative to the NB line (1-NB).

The results revealed a different behavior when incisor inclination was examined on the casts vs. cephalometrically. Tables 2 and 3 show that incisor inclination, when measured on radiographs and on the casts, showed a significant correlation, i.e., measurements made on the models closely

followed those made on radiographs. However, the strongest correlation for both the upper and lower arches was noted when incisor inclination, as examined on the casts, was correlated with the cephalometric angles used to assess the inclination of the tooth in direct relation to the basal bone (IMPA and 1.PP), while a weaker correlation was found for both arches when incisor inclination, as measured on the casts, was correlated with incisor protrusion on the radiographs (1-NA and 1-NB).

It is also noteworthy that the cephalometric measures that correlated the incisors with their reference line (1.NA, 1-NA, 1.NB and 1-NB) exhibited the highest coefficient of variation (always greater than 25%). This result has led the authors to regard these measurements with utmost caution, given their extremely wide variation (Table 1).

The differences found in the degree of correlation between canine angulation as measured on the models, and incisor inclination, as measured on radiographs and models, may be explained, in principle, by the inherent characteristics of the method, especially considering the fact that the measurements made on the casts refer to the angulation of the tooth crown, while the measurements made on the radiographs are related to the inclination of the long axis of the whole tooth, including the root portion. In studying the method error, however, excellent replicability was found for both methods, although replicability was higher for the measurements implemented on the casts (Table 1).

REFERENCES

1. Andrews L. The six keys to normal occlusion. *Am J Orthod.* 1972;62(3):296-309.
2. Andrews L. The diagnostic system: occlusal analysis. *Dent Clin N Am.* 1976;20(4):671-90.
3. Angle EH. The latest and best in orthodontic mechanism. *Dent Cosmos.* 1928;70:1143-58.
4. Capelozza Filho L, Silva Filho OG, Ozawa TO, Cavassan AO. Individualização de bráquetes na técnica de straight wire: revisão de conceitos e sugestões de indicações para uso. *Rev Dental Press Ortodon Ortop Facial.* 1999;4(4):87-106.
5. Capelozza Filho L, Fattori L, Maltagliati LA. Um novo método para avaliar as inclinações dentárias utilizando a tomografia computadorizada. *Rev Dental Press Ortodon Ortop Facial.* 2005;10(5):23-9.
6. Ghahferokhi AE, Elias L, Jonssons S, Rolfe B, Richmond S. Critical assessment of a device to measure incisor crown inclination. *Am J Orthod Dentofacial Orthop.* 2002;121(2):185-91.
7. Hussels H, Nanda RS. Effect of maxillary incisor angulation and inclination on arch length. *Am J Orthod Dentofacial Orthop.* 1987;91(3):233-9.
8. Ishikawa H, Nakamura S, Kim C, Iwasaki H, Satoh Y, Yoshida S. Individual growth in class III malocclusions and its relationship to the chin cap effects. *Am J Orthod Dentofacial Orthop.* 1998;114(3):337-46.
9. Azevedo LR, Torres TB, Normando ADC. Angulação dos caninos em indivíduos portadores de má oclusão de Classe I e de Classe III: análise comparativa através de um novo método utilizando imagens digitalizadas. *Dental Press J Orthod.* 2010;15(5):109-17.
10. Ohigiins EA, Kirschen RH, Lee RT. The influence of maxillary incisor inclination on arch length. *Br J Orthod.* 1999;26(2):97-102.
11. Richmond S, Klufas ML, Syawany M. Assessing incisor inclination: a non-invasive technique. *Eur J Orthod.* 1998;20(6):721-6.
12. Sangcharearn Y, Ho C. Maxillary incisor angulation and its effect on molar relationships. *Angle Orthod.* 2007;77(2):221-5.
13. Zanelato ACT, Maltagliati LA, Scanavini MA, Mandetta S. Método para mensuração das angulações e inclinações das coroas dentárias utilizando modelos de gesso. *Rev Dental Press Ortodon Ortop Facial.* 2006;11(2):63-73.

Submitted: August 2008
Revised and accepted: November 2008

Contact address

David Normando
Rua Boaventura da Silva, 567- apt. 1201
CEP: 66.060-060 - Belém / PA, Brazil
E-mail: davidnor@amazon.com.br

Evaluation of shear strength of lingual brackets bonded to ceramic surfaces

Michele Balestrin Imakami*, Karyna Martins Valle-Corotti**,
Paulo Eduardo Guedes Carvalho**, Ana Carla Raphaelli Nahás Scocate**

Abstract

Objectives: The aim of this study was to evaluate the shear strength of lingual metal brackets (American Orthodontics) bonded to ceramic veneers. **Methods:** A total of 40 specimens were divided into four groups of 10, according to bonding material and ceramics preparation: Group I - SONDHI Rapid-Set resin and hydrofluoric acid, Group II - SONDHI Rapid-Set resin and aluminum oxide, Group III - Transbond XT resin and hydrofluoric acid, and Group IV - Transbond XT resin and aluminum oxide. Prior to bonding, the brackets were prepared with heavy-duty resin base (Z-250) and the ceramic veneers were treated with silane. The shear test was conducted with a Kratos testing machine at a speed of 0.5 mm/min. **Results:** The results were statistically analyzed by the Tukey test ($p < 0.05$) and showed a statistically significant difference between groups I (2.77 MPa) and IV (6.00 MPa), and between groups III (3.33 MPa) and IV. **Conclusions:** In conclusion, the bonding of lingual brackets to ceramic surfaces exhibited greater shear strength when aluminum oxide was used in association with the two resins utilized in this study, although Transbond XT showed greater shear strength than SONDHI Rapid-Set.

Keywords: Bonding. Ceramic surface. Orthodontics. Lingual brackets.

INTRODUCTION

A few years ago orthodontic treatment was regarded as exclusively geared toward children and adolescents. As of the 1970's, the orthodontic industry sought to improve the aesthetic ap-

pearance of orthodontic appliances by introducing transparent brackets that could be bonded to the labial surface of the teeth in order to meet the aesthetic needs of adult patients.⁹ In Europe, in the 1980's, studies began to be conducted on

How to cite this article: Imakami MB, Valle-Corotti KM, Carvalho PEG, Scocate ACRN. Evaluation of shear strength of lingual brackets bonded to ceramic surfaces. Dental Press J Orthod. 2011 May-June;16(3):87-94.

* Master in Orthodontics, University of the City of São Paulo (UNICID).

** Master and Doctor in Orthodontics, Faculty of Dentistry of Bauru. Associate Professor of the course of Master in Orthodontics, University of the City of São Paulo (UNICID).

lingual orthodontics, which was indicated for those patients who value aesthetics and sometimes refuse traditional orthodontic treatment.⁹

Besides the concern with aesthetics, another important factor to be considered in adult patients is the presence of prosthetic ceramic crowns. This fact raises the need for studies on the bonding of orthodontic brackets to lingual ceramic surfaces.¹⁵ Although the literature contains research on the bonding of brackets to ceramic surfaces, their results were based on techniques for bonding directly to the labial surface.^{4,8,15}

It is noteworthy that lingual bonding differs from labial bonding in many respects. The first difference is the laboratory phase, which consists in positioning the brackets in a plaster model with the teeth properly positioned in a setup model of the patient's initial malocclusion. Each bracket receives a portion of filler resin on their base to regularize lingual surface anatomy and the buccolingual width of the teeth, thereby preventing the archwire from having inset/offset bends placed during orthodontic treatment. Thus, bracket bonding (in the patient) occurs by adhesion between the resin on the bracket base and the enamel or ceramic surface.²

Another difference is that the lingual surfaces of teeth exhibit different characteristics when compared to labial surfaces. The lingual surface of posterior teeth is narrower mesiodistally in the occlusocervical direction, showing a steep curvature relative to the labial surface. The upper incisors display concave surfaces with compromised visibility while the lower incisors are affected by tongue position, which requires a skilled professional.³

Thus, the lingual technique requires scientific studies to assess and reduce the rate of bracket debonding. It further requires the use of the best possible materials and bonding techniques for preparation of ceramic surfaces

mainly due to the fact that ceramic surfaces exhibit lower adhesion than dental enamel.

OBJECTIVE

Based on the reviewed literature, this study intended to evaluate the shear strength of lingual brackets bonded to ceramic surfaces using two resins, i.e., Sondhi Rapid-Set A and B self-curing resin (3M-Unitek) and Transbond XT light-curing resin (3M-Unitek), in addition to two ceramic surface preparation materials, namely, hydrofluoric acid and aluminum oxide.

MATERIAL AND METHODS

For this experiment 40 lingual premolar metal brackets of the Stealth brand (American Orthodontics, Lot No.: 395-0023B) were prepared and had their shear strength tested as follows:

Bracket base resin preparation

For this research a maxillary arch model in ideal occlusion was selected. The model was duplicated with dental plaster and the lingual brackets were bonded using resin Z-250 (3M, Lot No.: 5BX) to the maxillary right first molars and premolars.

To determine the exact position of the forty brackets on the second premolars a rectangular 0.017x0.025-in stainless steel archwire (American Orthodontics) was adapted to the bonded brackets bypassing the distal side of the second molars, resting on the occlusal surface of the molars and stabilized with self-curing acrylic resin (Ortho Cril yellow, Dental Vip). The mesiodistal position of the brackets was standardized with a red mark on the wire which coincided with the mesial bracket tie wing (Fig 1). The surface of the second premolars received an insulation layer (Cel-lac) to prevent the brackets from adhering to the plaster.

Single Bond 2 (3M) was applied to the second premolar bracket bases prior to Z-250 resin

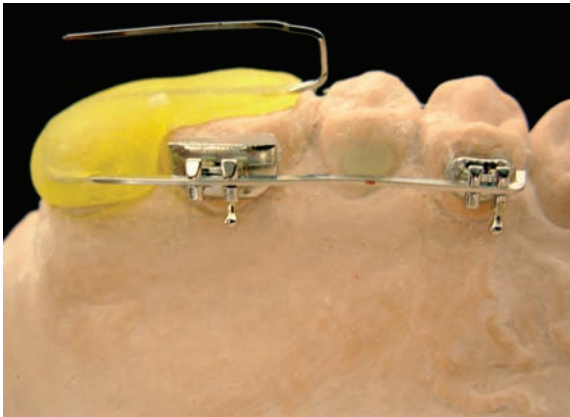


FIGURE 1 - Model with brackets bonded and 0.017x 0.025-in stainless steel adapted with acrylic resin.

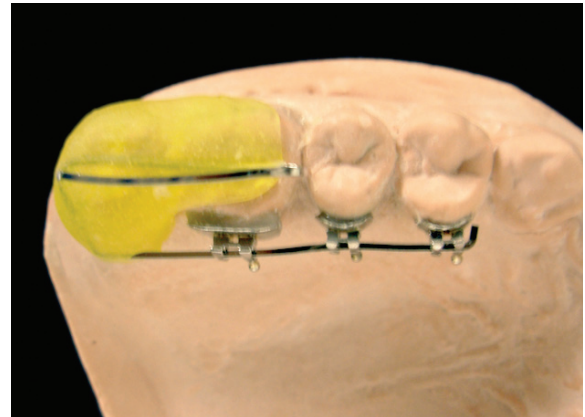


FIGURE 2 - Occlusal view of model with bracket positioned on second premolar and stabilized with occlusal support during resin base Z-250 preparation.

application. After placing the brackets in the model all excesses was removed and the resin was cured for 20 seconds (Fig 2).

The resin bases of the 40 brackets received a jet of aluminum oxide (Bio-art, Lot No.: 156,957) for 5 to 10 seconds at a distance of 10 mm until they turned white and opaque. Subsequently, the resin was cleaned with a brush and a solution of ether at 50% (Removex), followed by acetone solution (5, Lutex AP at 58%, Lot No. 11256208), for removal of any oily resin layer from the bracket bases.

Fabrication of ceramic specimens

The second premolars in the model received a coat of waxing wax in order to compensate for any shrinkage in the ceramics caused by oven heat (Fig 3). An impression of the model was then made with heavy condensation silicone (Zetalabor). On top of this new impression the ceramic body was applied to the lingual half of the crown impression and subsequently dried with an electric dryer to remove moisture from the ceramic.

The ceramic body was placed in a vacuum oven at a temperature of 925°C for 1 minute. Finishing was accomplished with fine-grained diamond stone and polishing was completed



FIGURE 3 - Plaster model with wax added to half of second premolar.

with a special rubber made especially for this procedure. The piece was glazed and surface imperfections corrected. The ceramic body was placed in a non-vacuum oven at a temperature of 880°C for 1 minute.

Acrylic cylinder preparation

A cylinder of Jet acrylic resin was fabricated using a silicone impression tray with 11.0 mm diameter and 8.0 mm thickness to match the



FIGURE 4 - Acrylic cylinder with ceramic specimen adapted with acrylic resin.

size of the metal support on the KRATOS testing machine. The ceramic specimen — in the shape of the second premolar — was attached to the cylinder in such a manner as to allow the metal base of the bracket to be positioned parallel to the acrylic surface after bonding (Fig 4).

Ceramics preparation and bracket bonding

Twenty ceramic pieces, which had already been inserted in the acrylic cylinder, were prepared with a jet of aluminum oxide (Bio-art, Lot No. 156,057) for 5 seconds at a distance of 5 to 10 mm, rinsed thoroughly and dried with air. The other part of the sample was prepared with 10% hydrofluoric acid (Dentsply, Lot No. 579861) for 4 minutes, rinsed and dried for 15 seconds as described by the manufacturer.

All ceramic veneers received an application of silane (Dentsply, Lot No. 209,071) in a 1:1 ratio, mixed for 10 seconds, with a 5-minute rest.

On twenty specimens (10 prepared with aluminum oxide and 10 with hydrofluoric acid) brackets were bonded with Sondhi Rapid-Set A (3M-Unitek, Lot: 051219), applied to the ceramic surface; and Sondhi Rapid-Set B (3M-Unitek, Lot: 0511114), applied to the resin base of the bracket.

On the other twenty specimens (10 prepared with aluminum oxide and 10 with hydrofluoric



FIGURE 5 - Specimen bonded to ceramic veneer attached to acrylic resin cylinder with bracket base parallel to cylinder surface (lateral distal view of bracket).

acid) brackets were bonded using Transbond XT adhesive (3M-Unitek, Lot: 6 CP) (Fig 5).

Thus, taking into account ceramics preparation and bonding system, the samples were divided into four groups with 10 brackets each, as follows:

- » Group I - Sondhi and hydrofluoric acid.
- » Group II - Sondhi and aluminum oxide.
- » Group III - Transbond XT and hydrofluoric acid.
- » Group IV - Transbond XT and aluminum oxide.

Specimen storage for shear strength test

The specimens were stored for seven days prior to shear test in plastic containers with lids and water at room temperature. The containers were kept in a thermal bag to maintain the temperature.

Shear strength test

Tensile shear strength tests were performed with a KRATOS Universal Testing Machine at the Department of Prosthodontics, Bauru School of Dentistry, University of São Paulo (Fig 6), by applying 50 Kgf of force at 0.5 mm/min. The values initially obtained in kgf were converted into MPa, a measure used for pressure evaluation.



FIGURE 6 - KRATOS Universal Testing Machine, Department of Prosthodontics, Bauru School of Dentistry, University of São Paulo.

Statistical Analysis

The test results were analyzed statistically. In order to check whether or not the data had normal distribution, the Kolmogorov-Smirnov test was used, and to test for homogeneity of variance among groups, the Bartlett test was used.²¹ To compare differences between groups, one-criterion variance analysis (ANOVA) was performed. When ANOVA showed a significant difference, the Tukey test for multiple comparisons was applied. In all tests, a significance level of 5% was adopted.²¹ The tests were performed using the program Statistics for Windows v. 5.1 (StatSoft Inc., USA).

RESULTS

Based on the methodology used in this study comparative results were obtained for the four groups. Table 1 shows the results of means and standard deviations for the four groups.

In checking the normal distribution of data, the Kolmogorov-Smirnov test showed no statistically significant difference ($p > 0.05$). The Bartlett test, which was used to check homoscedasticity (homogeneity of variance) between groups showed no statistically significant difference between variances ($p = 0.127$). After the criteria of normality and ho-

moscedasticity had been applied, one-criterion variance analysis was used to compare groups, disclosing a statistically significant difference between groups (Table 2).

Tukey's test for multiple comparisons only showed statistically significant differences between Group I and Group IV, and between Group III and Group IV (Table 3).

TABLE 1 - Shear strength means and standard deviations for the four groups, in Mpa.

Group	Strength	
	mean	SD
I	2.77	0.93
II	4.30	1.74
III	3.33	1.35
IV	6.00	2.17

TABLE 2 - One-criterion variance analysis (ANOVA) for comparing the four groups.

GL effect	QM effect	GL error	QM error	F	p
3	19.444	35	2.663	7.302	0.001*

*Statistically significant difference ($p < 0.05$).

TABLE 3 - Tukey's test for multiple comparisons among the four groups.

Comparison	p
I x II	0.212ns
I x III	0.886 ns
I x IV	0.001*
II x III	0.552 ns
II x IV	0.110 ns
III x IV	0.004*

* Statistically significant difference ($p < 0.05$).
ns = no statistically significant difference.

DISCUSSION

The bonding of lingual brackets to a ceramic surface was evaluated in this study by comparing two kinds of ceramics preparation and two bonding resins.

The decision to use silane in this study was based on data from the literature that prove its effectiveness in the bonding of labial brackets.^{11,15,16,22} When applied to ceramic surfaces, silane increased the shear strength, regardless of how the ceramics was prepared.^{15,16} Although the use of silane is considered optional by some authors^{1,20} — due to difficulties inherent in lingual bonding combined with the inadequate bond strength shown by ceramic surfaces — the silane used on all ceramic surfaces in this research was considered an important element.

Although no research has hitherto been conducted on the bonding of lingual brackets to ceramic surfaces, Wiechmann,¹⁸ in a recent investigation recommended the use of aluminum oxide and hydrofluoric acid prior to bonding ceramic brackets.

The bonding of lingual brackets, which consists of two stages (clinical and laboratory), often with indirect bonding, prompted the need to evaluate the difference in strength between a chemically activated (self-curing) bonding resin (Sondhi Rapid-set A and B) and a light-cured resin (Transbond XT).

The self-curing resin brand commonly found in the literature is Concise which, when combined with hydrofluoric acid showed, respectively, mean values of 17.38 MPa,¹⁵ 9.52 MPa,⁸ and 4.17 MPa.¹¹ In this study, when preparation was carried out using hydrofluoric acid and bonding performed with the self-curing resin (Sondhi) the mean value found was 2.77 MPa.

Cochran et al¹ obtained a mean value of 39.10 MPa when evaluating the shear bond strength of Concise on a ceramic surface previously prepared with aluminum oxide and silane, while Gillis and Redlich⁵ found a mean value

of 17.90 MPa. Sant'Anna et al¹⁵ used a primer (Scotchprime - 3M) after the aluminum oxide and found a mean value of 18.64 MPa. Literature values were found to be higher than those reported in this paper. Group II (Sondhi resin and aluminum oxide) showed shear strength of 4.30 MPa. However, the self-curing resin used was different from those reported in the literature.

The lower values of Groups I and II compared to those observed in the literature may have occurred due to differences between labial and lingual bonding techniques. In the lingual technique, adhesion between brackets and ceramic surfaces occurs between the resin on the base (Z-250) and the bonding material, but in the labial technique adhesion takes place between the metal bracket base and the bonding material.

Transbond XT is the most widely used self-curing resin in the literature and was also selected for this research. Nebbe and Stein¹² also used this resin but prepared the ceramic surface with 37% phosphoric acid and silane, obtaining a mean value of 6.03 MPa. This result was higher than the one found in this study, which yielded a mean value of 3.33 MPa in Group III. However, the acid used in this study was 10% hydrofluoric acid. The choice of acid also differs from the one used by Moreira et al,¹¹ who applied 35% phosphoric acid with silane to the ceramic surface and found a mean value of 4.27 MPa, also higher than the results of this study.

Based on the methodology, the results showed that the values of Groups I, II and III were lower than would be clinically acceptable, i.e., between 6 and 8 MPa.¹⁹ Group IV showed the best result, with values near those indicated for clinical use.

Group IV (Transbond XT + aluminum oxide) yielded a mean value of 6.00 MPa. This group showed the best overall results, demonstrating superior shear bond strength. Nebbe and Stein¹² concluded that bonding with Transbond XT combined with silane achieves a bonding

strength comparable to bonding to enamel. Although the literature reports the effectiveness of Transbond XT and aluminum oxide, no association was found with ceramics bonding.

When the groups were subjected to analysis of variance a statistically significant difference was found between groups (Table 2). Tukey's test showed that this difference was found between Groups I and IV, and III and IV.

The difference between Groups I and IV involved all the factors studied in this research. The resin and preparation used in Group IV (Transbond XT aluminum oxide) showed greater shear strength than in Group I (hydrofluoric acid + Sondhi) (Table 3). Based on the methodology used in this work, light-curing resin proved superior to chemically activated resin. This result differs from other studies in the literature, which did not use Sondhi resin.^{4,10}

Groups III and IV, which were also statistically different, showed that aluminum oxide is superior to hydrofluoric acid when bonding to ceramic surfaces (Table 3). This result is in agreement with Cochran et al,¹ who noted that when ceramics is treated with silane, aluminum oxide affords greater strength than hydrofluoric acid. Some authors contradict the results reported above. Gillis and Redlich⁵ conducted an electron microscopy analysis and revealed that erosion caused by a diamond bur or jet of aluminum oxide produced superficial wear while hydrofluoric acid produced deep wear. In a literature review,

Vieira et al¹⁶ concluded that hydrofluoric acid appears more effective than aluminum oxide for roughening the ceramic surface.

Wiechmann¹⁸ described the influence of a jet of aluminum oxide prior to etching with phosphoric acid. The author concluded that the adhesive strength between enamel and bonding material can be significantly increased with a jet of aluminum oxide prior to etching. He recommended the same procedure when bonding to ceramic surfaces.

Due to difficulties involved in bonding lingual brackets, an effective method has been sought to ensure a low debonding rate. The combination of hydrofluoric acid and aluminum oxide applied to the ceramic surface can increase shear strength. In this study, the best result was obtained with Transbond XT light-curing resin. Some professionals, however, still prefer self-curing resins. It is therefore suggested that other chemically activated resins also be evaluated to meet this market demand.

CONCLUSIONS

Based on the methodology used and results achieved in this study, it can be concluded that:

The bonding of lingual brackets to ceramic surfaces exhibited greater shear strength when aluminum oxide was used in association with either of the two resins utilized in this study, although Transbond XT showed greater shear strength than Sondhi Rapid-Set.

REFERENCES

1. Cochran D, O'Keefe KL, Turner DT, Powers JM. Bond strength of orthodontic composite cement to treated porcelain. *Am J Orthod Dentofacial Orthop*. 1997;111(1):297-300.
2. Chumak L, Galil KA, Way DC, Johnson LN, Hunter WS. An in vitro investigation of lingual bonding. *Am J Orthod Dentofacial Orthop*. 1989;95(1):20-8.
3. Echarri P. Procedimiento para el posicionamiento de brackets em Ortodoncia lingual. Parte I. *Ortod Clin*. 1998;1(2 Pt 1):69-77.
4. Eustaquio R, Garner LD, Moore BK. Comparative tensile strengths of brackets bonded to porcelain with orthodontic adhesive and porcelain repair systems. *Am J Orthod Dentofacial Orthop*. 1988;94(5):421-5.
5. Gillis I, Redlich M. The effect of different porcelain conditioning techniques on shear bond strength of stainless steel brackets. *Am J Orthod Dentofacial Orthop*. 1998;114(4):387-92.
6. Huang TH, Kao CT. The shear bond strength of composite brackets on porcelain teeth. *Eur J Orthod*. 2001;23(4):433-9.
7. Jost-Brinkmann PG, Can S, Drost C. In-vitro study of the adhesive strengths of brackets on metals, ceramic and composite. Part 2: bonding to porcelain and composite resin. *J Orofacial Orthop*. 1996;57(3 Pt 2):132-41.
8. Kao EC, Johnston WM. Fracture incidence on debonding of orthodontic brackets from porcelain veneer laminates. *J Prosthet Dent*. 1991;66(5):631-7.
9. Kurz C, Romano R. Lingual Orthodontics: historical perspective. In: Romano R. *Lingual Orthodontics*. Amilton: BC Decker; 1998.
10. Major PW, Koehler JR, Manning KE. 24-hour shear bond strength of metal orthodontic brackets bonded to porcelain using various adhesion promoters. *Am J Orthod Dentofacial Orthop*. 1995;108(3):322-9.
11. Moreira NR, Sinhoreti MAC, Oshima HMS, Casagrande RJ, Consani RLX. Avaliação in vitro da resistência à tração de braquetes ortodônticos metálicos colados ao esmalte ou à cerâmica, com compósitos químicos ou fotoativados. *Biosci J*. 2001;17(2):171-82.
12. Nebbe B, Stein E. Orthodontic brackets bonded to glazed and deglazed porcelain surfaces. *Am J Orthod Dentofacial Orthop*. 1996;109(4):431-6.
13. Newman SM, Dressler KB, Grenadier MR. Direct bonding of orthodontic brackets to esthetic restorative materials using a silane. *Am J Orthod*. 1984;86(6):503-6.
14. Pannes DD, Bailey DK, Thompson JY, Pietz DM. Orthodontic bonding to porcelain: a comparison of bonding systems. *J Prosthet Dent*. 2003;89(1):66-9.
15. Sant'Anna EF, Monnerat ME, Chevitarese O, Stuardi MBS. Bonding brackets to porcelain – In vitro study. *Braz Dent J*. 2002;13(3):191-6.
16. Vieira S, Saga A, Wieler W, Maruo H. Adesão em Ortodontia – Parte 2. Colagem em superfícies de amálgama, ouro e cerâmica. *J Bras Ortodon Ortop Facial*. 2002;7(41 Pt 2):415-24.
17. Wang WN, Tarng TH, Chen YY. Comparison of bond strength between lingual and buccal surfaces on young premolars. *Am J Orthod Dentofacial Orthop*. 1993;104:251-3.
18. Wiechmann D. Lingual orthodontics (Part 3): intraoral sandblasting and indirect bonding. *J Orofac Orthop*. 2000; 61(4 Pt 3): 280-91.
19. Winchester L. Direct orthodontic bonding to porcelain: an in vitro study. *Br J Orthod*. 1991;18(4):299-30.
20. Zachrisson BU. Orthodontic bonding to artificial tooth surfaces: clinical versus laboratory findings. *Am J Orthod Dentofacial Orthop*. 2000;117(5):592-4.
21. Zar JH. *Biostatistical analysis*. 3rd ed. New Jersey: Prentice-Hall; 1996.
22. Zelos L, Bevis RR, Keenan KM. Evaluation of the ceramic/ceramic interface. *Am J Orthod Dentofacial Orthop*. 1994;106(1):10-21.

Submitted: May 2007
Revised and accepted: November 2007

Contact address

Michele Balestrin Imakami
Avenida Vila Rica, 6 - Centro
CEP: 87.250-000 - Peabiru / PR, Brazil
E-mail: michele_bales@oi.com.br

Education and motivation in oral health — preventing disease and promoting health in patients undergoing orthodontic treatment

Priscila Ariede Petinuci Bardal*, Kelly Polido Kaneshiro Olympio*, José Roberto de Magalhães Bastos**, José Fernando Castanha Henriques**, Marília Afonso Rabelo Buzalaf***

Abstract

Introduction: It is incumbent upon dentists to prevent disease, minimize risks and promote health. Patients also need to be made aware of their role in oral health care. Patients undergoing orthodontic treatment find it particularly difficult to maintain satisfactory oral hygiene owing to the presence of bands, wires and ligatures. It is therefore crucial to establish preventive motivation and guidance methods to ensure mechanical control of dental plaque. **Objectives:** This study investigated the effects of educational, preventive and motivational actions on the oral health of patients undergoing fixed orthodontic treatment. **Methods:** Participants received free toothpaste and toothbrushes throughout the study and instructions on oral hygiene were provided and reinforced throughout the six months of research. Physical examination was performed at baseline and after 6, 12 and 24 weeks for verification of plaque, gingival and bleeding indices. **Results:** Initially, the oral hygiene of participants was inadequate. During the study, significant improvement in oral health occurred in all indices. Preventive, educational and motivational actions undertaken in this study were statistically effective in improving the oral health of orthodontic patients. **Conclusion:** Health promotion and disease prevention should be part and parcel of the care provided by orthodontists directly to their patients whereas oral health care guidance and motivation should be provided before and during treatment.

Keywords: Prevention. Education. Motivation. Orthodontics. Oral health.

How to cite this article: Bardal PAP, Olympio KPK, Bastos JRM, Henriques JFC, Buzalaf MAR. Education and motivation in oral health - preventing disease and promoting health in patients undergoing orthodontic treatment. *Dental Press J Orthod*. 2011 May-June;16(3):95-102.

* MSc in Orthodontics and Public Health Dentistry, FOB-USP. PhD in Public Health, FSP-USP.

** Head Professor, Department of Pediatric Dentistry, Orthodontics and Public Health, Bauru School of Dentistry – FOB-USP.

*** Head Professor, Department of Biological Sciences, FOB-USP.

INTRODUCTION

Preventive dentistry has proved a landmark in the health care field. Oral health care has reached beyond aesthetic concerns. The new health paradigm has raised considerable awareness regarding the need to maintain satisfactory oral health, which in turn is reflected in the overall health of individuals.

Health professionals are responsible for promoting disease prevention, minimizing risks and creating favorable conditions that enable patients to achieve and maintain oral health. Moreover, patients also need to be made aware of their role in oral health care.

One of the major and most common challenges in prevention within the field of oral health is the control of plaque and, consequently, the control of dental caries and gingival inflammation.^{10,32,36}

Mechanical methods such as the use of toothbrush and dental floss, when applied effectively, can promote proper plaque control.^{30,38} Dentists and their staff play a key role in guiding and encouraging patients to perform proper oral hygiene frequently and effectively.

Peculiarities of orthodontic treatment

Due to the declining prevalence of dental caries the population began to lose fewer teeth. Furthermore, racial mixing and improved preventive methods have turned crowding into a commonplace cosmetic and occlusal problem, which ultimately boosts demand for orthodontic treatment.^{5,28}

Patients undergoing fixed orthodontic treatment are more prone to retaining dental plaque. Orthodontic accessories can lead to enamel demineralization, causing white spots, tooth decay and gingivitis.^{15,19,20} Therefore, this group of patients is particularly compelled to take care of their oral hygiene since it is a challenging task to maintain acceptable oral hygiene in the presence of bands, wires and ligatures.²⁷

Mechanical methods of plaque removal require time, motivation and manual skill.¹³ Even patients who are properly trained and instructed to maintain satisfactory hygiene often see their compliance falter unless constant health education reinforcement is provided.³ In light of these factors one cannot ignore that the domestic environment poses certain limitations on proper oral hygiene.³¹

According to Heintze²⁰ treatment with fixed appliances constitutes a substantial intervention in the oral cavity environment. Orthodontic accessories involve a high risk of dental caries and periodontitis. However, iatrogenic complications occur due to patient unpreparedness before the orthodontic appliance is placed, in addition to lack of motivation and reinforcement during treatment.

Microbiological studies have established that after a fixed orthodontic appliance has been placed the number of bacteria rises significantly, particularly lactobacilli and streptococci, subjecting the oral environment to an imbalance that predisposes to the emergence of diseases.¹⁶

Thus, successful orthodontic treatment lies in correcting occlusion in the best possible manner without, however, affecting the pre-existing health of teeth and supporting tissues. Otherwise, treatment benefits may be called into question.³⁷

Patients wearing orthodontic appliances must be encouraged to take good care of their oral cavity as hygiene can prove difficult in these cases. While problem areas in banded teeth are located on the cervical side of the band, in teeth with bonded brackets the critical surfaces are those on the mesial and distal sides of the bracket base. These areas are located under the archwire “shadow” and are inaccessible to toothbrush bristles.²⁰

Perfect cleaning of teeth in patients with fixed appliance takes at least ten minutes,

which requires considerable care and discipline. Preventive treatment remains the most effective weapon in the fight against dental problems. No doubt the only viable approach to address these issues is through awareness and education of patients, who will as a result be encouraged to play an active role in preventive programs.^{20,28}

Prevention in orthodontics

Given the potential — and not uncommon — iatrogenic effects caused by orthodontic treatment, several authors agree that preventive methods should be provided for all patients undergoing orthodontic therapy.^{4,14,17,18,20} The type, frequency and quantity of measures adopted to implement such methods will certainly depend on the individual characteristics of both professionals and patients.^{4,18}

Dental plaque should be monitored before setting up the appliance and if patients are motivated during the course of treatment, one can prevent the gingival index from rising.⁹

The importance of conducting a motivation and guidance program for the mechanical control of dental plaque is emphasized by several authors.^{34,35} Basically, the most efficient and simple method consists in the use of toothbrush and dental floss.^{4,30,37}

Inglehart and Tedesco²² reported that the model of oral health promotion ushered in by the 21st century begins by examining the interaction between patient and oral health professional. Thus, issues related to cognitive, emotional, environmental and behavioral factors must be addressed concurrently.

In dentistry, education is related to the cognitive, affective and psychomotor realms. Systematic education varies with individuals or the target population as well as with the educational tools to be employed. It is important that teachers and learners maintain frequent contact to establish a framework of mutual trust,

ensuring a successful communication process.⁷ The educational component is what enables people to assume their share of responsibility for their own oral health.

Motivation, in turn, is a generic term that refers to needs, motives or desires that prompt action. Although some motives are innate and others acquired, individual response is modified by learning and influenced by culture.⁷ Dentists should develop appropriate skills to be able to persuade patients to change their behavior and thereby gain control over oral diseases. Changing habits is a complex activity and requires effort, practice and building ties with individuals.²³

OBJECTIVE

Within the context of health promotion and disease prevention, this study aimed to determine the effects of educational, preventive and motivational actions on the oral health of patients undergoing fixed orthodontic treatment.

MATERIAL AND METHODS

Selection of participants

After approval by the Ethics in Human Research Committee (FOB – USP), 27 patients from the Clinic of Orthodontics, FOB-USP (master's and specialization) and from the Specialization Course in Orthodontics at Bauru-APCD agreed to participate in this research by signing a Term of Free and Informed Consent. Inclusion criteria were as follows: Being under fixed orthodontic treatment planned to last at least six months beyond the beginning of the study, permanent dentition, good general health condition, not having taken systemic antibiotics within three months before the beginning of research, not being pregnant, not being a smoker and exhibiting only minor gingivitis, verified by means of the Gingival Index.²⁵ The group had a mean age of 16.9 years (14 subjects were female and 13 male).

Study protocol

In this longitudinal clinical study participants received, after baseline examination, a hygiene kit containing a toothbrush, dental floss, floss threader and fluoridated toothpaste (Sorriso Fresh Mint Red®, 1100 ppm F, Kolynos Brazil).

Verbal and written guidelines were provided prohibiting the use of other oral hygiene chemical products during the experiment. Patients were instructed to brush their teeth three times a day.

Toothpaste was supplied to the patients as needed and the amount of tubes that each patient used during the experiment was recorded as used tubes had to be returned upon replacement. Three months into the study patients' toothbrushes were replaced.

At the beginning of the research volunteers completed a questionnaire about their hygiene and any recommendations made by their orthodontists.

Implementation

All volunteers received professional prophylaxis after baseline examination and were further examined at intervals of 6, 12 and 24 weeks. During this examination a new professional prophylaxis was performed.

Instructions and reinforcement on correct oral hygiene and the importance of toothbrushing and proper flossing were provided after baseline examination and after 6, 12 and 24 weeks. Issues were addressed pertaining to the prevention of diseases such as dental caries and periodontal diseases, the fact that the orthodontic appliance required special individual efforts to maintain oral hygiene, and the understanding that plaque accumulates around the brackets, which requires additional care and the proper use of dental floss and a floss threader.

To this end, when dental plaque became apparent, patients were shown in mirrors the regions of greater plaque accumulation and the

clinical characteristics of gingival tissue in the inflamed areas. Proper hygiene instructions were then provided. Floss threader use was explained with the aid of manikins. Educational and preventive activities comprised a lecture at the beginning of the research attended by all patients and their parents and subsequently verbal instructions were given to patients after each clinical examination (baseline, 6, 12 and 24 weeks).

A previously trained examiner²⁹ performed the examinations in a dental office. Examinations were made under artificial light and with compressed air, using probes recommended by the World Health Organization (WHO) and flat clinical mirrors. Two percent fuchsin was applied in order to disclose supragingival dental plaque. The tests were as follows:

1. Gingival index²⁵ to reveal the health condition of gingival tissues and degree of inflammation. Mean GI values ranging from 0.1 to 1.0 indicated mild gingivitis, from 1.1 to 2.0, moderate gingivitis and from 2.1 to 3.0, severe gingivitis.
2. Bleeding index¹ to assess the percentage of sites that bled and those that did not bleed on gentle probing.
3. Orthodontic plaque index²¹ to determine the amount of plaque on the teeth. Index values ranging from 0 to 25 represented good oral hygiene, between 26 to 50 points, moderate oral hygiene, and above 50, poor oral hygiene.

Statistical Analysis

All data were recorded in individual charts especially developed for this study. Numerical data were entered into Excel spreadsheets for index calculation. Statistical analysis was performed using the program InStat GraphPad. Data on gingival, bleeding and plaque indices were tested by analysis of variance with repeated measures, and by Tukey's test. A 5% significance level was adopted.

RESULTS

The initial questionnaire filled out by the participants showed that 44.44% of them reported a toothbrushing frequency of 3 times a day, 22.22% more than three times a day, 29.63% twice daily and 3.70% only once a day. Only 11.11% of the volunteers reported using interdental and end-tufted brushes.

As regards the instructions provided to patients by their respective orthodontists, 88.89% of participants reported receiving some sort of guidance. The need to perform toothbrushing and flossing three times a day was the instruction most often reported (66.67%), while other instructions concerned the use of interdental and end-tufted brushes (14.81%) and the recommendation not to ingest hard foods, chewing gum, candy and soft drinks (18.52%). None of the questionnaires comprised any reference to supervised brushing or a more constant monitoring of the patients' oral health.

Table 1 presents mean values for Plaque Index (PI), Gingival Index (GI) and Bleeding Index (BI) at baseline examination, and after 6, 12 and 24 weeks of follow-up. Initially, oral hygiene conditions were less than satisfactory, which can be attested by the fact that the PI and GI mean values, in their respective scales, reflect poor oral hygiene (PI>50) and moderate gingivitis (GI = 1.0 to 2.0). During the study, the group reported significant improvement in oral health at all levels.

TABLE 1 - Mean values and standard deviation for Plaque Index (PI), Gingival Index (GI) and Bleeding Index (BI) at baseline examination, and after 6, 12 and 24 weeks of follow-up.

	PI	GI	BI
Baseline	83 (12.11) ^a	1.21 (0.31) ^a	33.33% (16.69) ^a
6 weeks	65 (10.61) ^b	0.79 (0.25) ^b	12.49% (8.60) ^b
12 weeks	55 (19.28) ^c	0.71 (0.28) ^b	12.39% (8.76) ^b
24 weeks	51 (13.99) ^c	0.55 (0.19) ^b	6.52% (2.79) ^b

The different lowercase letters in the same column indicate significant differences, as analyzed by ANOVA and Tukey's test. ($p < 0.05$), $n = 27$.

DISCUSSION

Being able to exercise proper control over dental plaque and periodontal health while avoiding inflammation and bleeding remains a great challenge both for the dentist, who needs to assess, guide and treat his/her patients, and for patients, who are largely responsible for maintaining their own health.^{3,32,36} In the case of orthodontic patients, this challenge is even greater. In fixed orthodontic treatment, plaque retention surfaces are increased and, as a result, most patients are confronted with hygiene difficulties, which eventually cause elevated plaque indices.²⁰

Frequent patient visits for orthodontic maintenance are opportunities for the dentist to teach techniques that promote oral hygiene, and to reinforce instructions that encourage healthy habits.¹⁸ Orthodontist should be aware of their patients' oral hygiene problems since one of the main goals of orthodontics is to achieve dental and skeletal harmony while preserving healthy teeth and support surfaces. Berglund and Small⁸ argue that orthodontists play a pivotal role in educating, motivating and monitoring their patients' oral health.

In order to promote and maintain satisfactory oral health, orthodontic patients should undergo a stringent program of oral hygiene and dental plaque control before and during orthodontic treatment.^{5,39} Despite the large number of resources available for patient guidance and motivation, such as audiovisual resources, films, printed material, among others, the major tool is still direct, personal guidance.¹¹

The vast majority of patients in this study reported having received instructions on toothbrushing and flossing. However, in view of the results obtained in the baseline tests, one can only speculate that the guidance offered by orthodontists at the start of treatment was not effective enough to ensure satisfactory oral hygiene since the mean index values showed

poor oral hygiene. This fact demonstrates that if hygiene instructions are not reinforced on a continuous basis maintaining oral health can be challenging.^{20,35}

The instructions and encouragement offered to participants during this research were reflected in clinical and statistical improvement (Table 1). Since the most common brushing frequency was maintained, i.e., 3 times a day (according to what was reported in the initial questionnaire), it is possible to demonstrate that toothbrushing quality is the decisive factor during oral hygiene.

It is reasonable to assume that the distribution of free toothpaste throughout this 6-month study also contributed to improving the group's oral health. Davies et al.¹² found that the free and regular supply of fluoridated toothpaste in a program conducted in England succeeded in significantly reducing dental caries rates in 5-year-old children.

Control of plaque, gingivitis and bleeding should be ongoing and effective in orthodontic patients. Glans, Larsson, Ogaard¹⁹ found that after installation of the orthodontic appliance all patients exhibited mild gingivitis, but after removal of the orthodontic appliance gingival conditions returned to normal. This fact does not justify neglecting hygiene during treatment, especially when one is engaged in a philosophy of health promotion. Moreover, in the presence of gingival inflammation, forces produced by the orthodontic appliance worsen tissue response, producing as a result increased destruction of protective and support tissues.²⁶

Heintze²⁰ asserts that, especially in adolescents, gingival hyperplasias often emerge in response to plaque accumulation, thereby hindering oral hygiene and creating a vicious circle.

Feliu¹⁸ demonstrated that patients undergo-

ing orthodontic treatment may have lower levels of plaque and gingival inflammation than patients who are not under orthodontic treatment provided that they first attend an educational-preventive program.

Silva et al.³³ showed that one group of orthodontic patients who received oral hygiene instructions only on the first day of treatment did not change their habits while the other group, who was given instructions every fortnight throughout the period with hygiene classes and motivation and were monitored with a plaque control chart, achieved a better oral hygiene index given the additional encouragement.

Motivation is based on understanding what is normal and what is pathological in the oral cavity. Thus, one can change patient habits and render them active participants in the control, treatment and maintenance of their own oral health.²⁴

Well planned, evidence-based educational programs with a solid scientific background and an understandable terminology tailored to meet the needs of the target group are highly likely to achieve planned results.^{5,7}

CONCLUSIONS

The preventive, educational and motivational actions undertaken in this study proved statistically effective in improving the oral health of orthodontic patients.

The current health paradigm requires that patients be regarded as one single whole. Health promotion and disease prevention should be part of the philosophy adopted by orthodontists in caring for their patients. Furthermore, professionals should provide guidance and motivation to their patients regarding oral health care before and during orthodontic treatment.

REFERENCES

1. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *Int Dental J.* 1975;25:229-35.
2. Axelsson P. Current role of pharmaceuticals in prevention of caries and periodontal disease. *Int Dental J.* 1993;43(3):473-82.
3. Axelsson P, Lindhe J. Efficacy of mouthrinses in inhibiting dental plaque and gingivitis in man. *J Clin Periodontol.* 1987;14:205-12.
4. Bacchi EOS, Prates NS, Attizzani A. Profilaxia buco-dental em ortodontia. *Rev Gaúcha Odontol.* 1997;45(6):342-46.
5. Bastos JRM, Henriques JFC, Olympio KPK. Prevenção de cárie e doença periodontal em pacientes sob tratamento ortodôntico. Manual didático. Bauru: Universidade de São Paulo; 2001.
6. Bastos JRM, Lopes ES, Ramires I. Odontologia social e preventiva. Manual didático. Faculdade de Odontologia de Bauru, Universidade de São Paulo, Bauru, 2001.
7. Bastos JRM, Sales-Peres SHC, Ramires I. Educação para a saúde. In: Pereira AC. Odontologia em saúde coletiva: planejando ações e promovendo saúde. Porto Alegre: Artmed; 2003. p.117-39.
8. Berglund LJ, Small CL. Effective oral hygiene for orthodontic patients. *J Clin Orthod.* 1990;24:315-20.
9. Boyd RL. Enhancing the value of orthodontic treatment: incorporating effective preventive dentistry into treatment. *Am J Orthod Dentofacial Orthop.* 2000;117(5):601-3.
10. Carvalho LEP, Granjeiro JM, Bastos JRM, Henriques JFC, Tarzia O. Clorexidina em Odontologia. *Rev Gaúcha Odontol.* 1991;39(6):423-7.
11. Couto JL, Couto RS, Duarte CA. A motivação do paciente: avaliação dos recursos didáticos de motivação para prevenção da cárie e doença periodontal. *Rev Gaúcha Odontol.* 1992;40:143-59.
12. Davies GM, Worthington HV, Ellwood RP, Bentley EM, Blinkhorn AS, Taylor GO, et al. A randomised controlled trial of the effectiveness of providing free fluoride toothpaste from the age of 12 months on reducing caries in 5-6 year old children. *Community Dent Health.* 2002;19(3):131-6.
13. Depaola IG. Chemotherapeutic inhibition of supragingival dental plaque and gingivitis development. *J Clin Periodontol.* 1989;16:311-5.
14. Denes J, Gábris K. Results of a 3-year oral hygiene programme including amine fluoride products in patients treated with fixed orthodontic appliances. *Eur J Orthod.* 1991;13(2):129-33.
15. Derks A, Katsaros C, Frencken JE, van't Hof MA, Kuijpers-Jagtman AM. Caries-inhibiting effect of preventive measures during orthodontic treatment with fixed appliances. *Caries Res.* 2004;38(5):413-20.
16. Diamanti-Kipioti A, Gusberti FA, Lang NP. Clinical and microbiological effects of fixed orthodontic appliances. *J Clin Periodontol.* 1987;14(6):326-33.
17. Dubey R, Jalili VP, Garg S. Oral hygiene and gingival status in orthodontic patients. *J Pierre Fauchard Acad.* 1993;7(2):43-54.
18. Feliu JL. Long-term benefits of orthodontic treatment on oral hygiene. *Am J Orthod Dentofacial Orthop.* 1982;82(6):473-7.
19. Glans R, Larsson E, Ogaard B. Longitudinal changes in gingival condition in crowded and noncrowded dentitions subjected to fixed orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 2003;124(6):679-82.
20. Heintze SD. A profilaxia individual em pacientes com aparelhos fixos: recomendações para o consultório. *Ortodontia.* 1996;29(2):4-15.
21. Heintze SD, Finke C, Jost-Brinkman PG, Miethke RR. Home-care measures for reducing oral bacteria. In: Heintze SD, Finke C, Jost-Brinkman PG, Miethke RR. Oral health for the orthodontic patient. Illinois: Quintessence; 1998. Cap. 4. p. 66-70.
22. Inglehart M, Tedesco LA. Behavioral research related to oral hygiene practices: a new century model of oral health promotion. *Periodontol 2000.* 1995;8:15-23.
23. Kay A. The prevention of dental disease: changing your patient's behavior. *Dental Update.* 1991;7:245-8.
24. Kon S. Controle da placa bacteriana. In: Garone Filho W. Atualização em odontologia clínica. São Paulo: Medisa; 1980. p. 65-8.

25. Löe H, Silness J. Periodontal disease in pregnancy. *Acta Odontol Scand.* 1963;21:533-51.
26. Lucas GQ, Lucas ON. Efecto de la clohexidina em pacientes com aparatos de ortodoncia. *Rev Assoc Odontol Argentina.* 1997;85(4):355-60.
27. Lundström F, Hamp SE. Effect of oral hygiene education on children with and without subsequent orthodontic treatment. *Scand J Dental Res.* 1980;88:53-9.
28. Matos MS. Controle químico e mecânico de placa em pacientes ortodônticos. Uma análise por grupos de dentes de acordo com o acessório ortodôntico empregado. *Rev Dental Press Ortodon Ortop Facial.* 2003;8(1):87-93.
29. Oppermann RV, Rösing CK. *Periodontia: ciência e clínica.* São Paulo: Artes Médicas; 2001. p.5-9.
30. Owens J, Addy M, Faulkner J, Lockwood C, Adair R. A short-term clinical study design to investigate the chemical plaque inhibitory properties of mouthrinses when used as adjunct to toothpastes: applied to chlorhexidine. *J Clin Periodontol.* 1987;24(10):732-7.
31. Santos A. Evidence-based control of plaque and gingivitis. *J Clin Periodontol.* 2003;30(5):13-6.
32. Sekino S, Ramberg P, Uzel NG, Socransky S, Lindhe J. Effect os various chlorhexidine regimens on salivary bacteria and de novo plaque formation. *J Clin Periodontol.* 2003;30(10):919-25.
33. Silva Filho OG, Corrêa AM, Terada HH, Nary Filho H, Caetano MK. Programa supervisionado de motivação e instrução de higiene e fisioterapia bucal em crianças com aparelhos ortodônticos. *Rev Odontol Univ São Paulo.* 1990;4(1):11-9.
34. Souza FM. Prevenção de cáries e doenças periodontais em ortodontia corretiva: métodos simples para serem usados no consultório. *Ortodontia.* 1994;27(3):87-92.
35. Souza NM, Falcão AFP, Araújo TM. Higiene bucal no paciente ortodôntico. *Rev Fac Odontol Univ Fed Bahia.* 1999;18:60-7.
36. Sreenivasan PK, Tambs G, Gittins E, Nabi N, Gaffar A. A rapid procedure to ascertain the antimicrobial efficacy of oral care formulations. *Oral Microbiol Immunol.* 2003;18(6):371-8.
37. Tamburus VS, Bagatin CR, Silva Netto CR. Higiene bucal no tratamento ortodôntico: importância da motivação. *Rev Fac Odontol Lins.* 1998;11(1):51-7.
38. Torres MCM. Utilização da clorexidina em seus diversos veículos. *Rev Bras Odontol.* 2000;57(3):174-80.
39. Uetanabaro T, Martins JES, Andrade JLF. Acúmulo de placa bacteriana em pacientes portadores de colagem direta e anéis convencionais. *Rev Gaúcha Odontol.* 1984;32(2):161-6.

Submitted: November 2006
Revised and accepted: June 2008

Contact address

Priscila Ariede Petinuci Bardal
Rua Paes Leme, 1-41
CEP: 17.013-180 - Bauru / SP, Brazil
E-mail: priscilabardal@yahoo.com

Microbiological analysis of orthodontic pliers

Fabiane Azeredo*, Luciane Macedo de Menezes**, Renata Medina da Silva***, Susana Maria Deon Rizzato****, Gisela Gressler Garcia*****, Karen Revers*****

Abstract

Objective: To evaluate bacterial contamination of orthodontic pliers used in an academic setting. **Methods:** Thirty-four pliers were selected — 17 band remover pliers and 17 bird beak pliers. The control group was composed of 3 previously autoclaved pliers of each model. After use, the pliers in the experimental group were immersed in 10 ml of brain-heart infusion (BHI) culture medium for 2 minutes, incubated at 37° C for 24 to 48 h and seeded in duplicates in different agar-based solid culture media to detect and identify microbial agents. **Results:** Microbiological analyses revealed that there was contamination in both types of orthodontic pliers. Several bacteria were detected, predominantly staphylococcus and isolated Gram-positive (G+) cocci. The band remover pliers had a greater contamination rate and mean values of 2.83×10^9 and 6.25×10^9 CFU/ml, with variations according to the type of culture medium. The 139 pliers also had all types of bacteria from the oral microbiota at values that ranged from 1.33×10^8 to 6.93×10^9 CFU/ml. The highest mean value was found in the medium to grow staphylococci, which confirmed, in certain cases, the presence of *Staphylococcus aureus*, which are not part of the normal oral microbiota but are usually found in the nasal cavity and on the skin. **Conclusion:** Orthodontic pliers were contaminated as any other dental instrument after use in clinical situations. Therefore, they should undergo sterilization after each use in patients.

Keywords: Dental instruments. Orthodontics. Infection control. Contamination. Microbiology.

How to cite this article: Azeredo F, Menezes LM, Silva RM, Rizzato SMD, Garcia GG, Revers K. Microbiological analysis of orthodontic pliers. *Dental Press J Orthod.* 2011 May-June;16(3):103-12.

* Graduate student, Orthodontics, School of Dentistry, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.

** MSc and PhD in Orthodontics, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil. Professor, Orthodontics, PUCRS, Porto Alegre, Brazil.

*** MSc in Genetics and Molecular Biology, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Brazil. PhD in Microbiology, Universidade de São Paulo (USP), São Paulo, Brazil. Professor, Microbiology, School of Biosciences, PUCRS, Porto Alegre, Brazil.

**** MSc in Orthodontics from PUCRS, Porto Alegre, Brazil. Professor, Orthodontics, PUCRS, Porto Alegre, Brazil.

***** Undergraduate student, School of Biological Sciences, PUCRS, Porto Alegre, Brazil.

***** Graduate in Biological Sciences from Universidade do Oeste Catarinense (UNOESC), São Miguel do Oeste, Brazil. Specialist in Applied Microbiology, UNOESC, São Miguel do Oeste, Brazil.

INTRODUCTION

The oral cavity has a large variety of microorganisms that form a complex environment and a diverse and often pathogenic microbiota.²⁸ Therefore, special attention should be paid to infection control and biosafety in dentistry, and procedures should be adopted to prevent and significantly reduce the chances of cross infection between patients as well as between patient and dentist.¹⁴

Infections may be transmitted by direct contact with blood and oral fluids, or, indirectly, by contact with contaminated instruments or surfaces. Some of the potentially transmissible pathogens are hepatitis B and C (HBV and HCV), herpes simplex and human immunodeficiency (HIV) viruses, *Mycobacterium tuberculosis*, different *Staphylococcus* and *Streptococcus* strains, and other microorganisms responsible for upper respiratory tract infections.² Not all individuals with important diseases can be identified before a procedure is performed; therefore, all patients, indiscriminately, should be considered potentially contaminated, and, consequently, standard precautions should be taken in all procedures with all patients.¹¹

The terms “sterilization” and “disinfection”, although clearly different, are often confused and used incorrectly. The destruction of all forms of microbial life, including viruses, is obtained by means of sterilization. Disinfection, in turn, destroys pathogenic microorganisms but does not eliminate sporebearers and resistant microorganisms, such as the etiological agents of tuberculosis and hepatitis.^{3,16,10}

The instruments used in medical and dental practice are classified into three categories according to the risk of infection, the need to sterilize them between uses, and their level of contamination:^{20,29}

» Critical: They should be discarded or undergo sterilization because they penetrate soft tissue or bone.

» Semicritical: Instruments that touch oral tissues but do not penetrate hard or soft tissues. They should be sterilized after each use; if sterilization is not possible because the material is not heat resistant, the instruments should at least undergo high-level disinfection.

» Noncritical: They touch only intact skin and should only be disinfected or cleaned.

In orthodontics, concerns with infection control have intensified after the increase of cases of HIV infection, although hepatitis B and C infections, which have a high level of contamination, have been around for a long time.¹⁴ Of all dental healthcare personnel (DHCP), the rate of hepatitis B infection among orthodontists is very high,^{10,13,27} second only to oral surgery specialists,⁷ as saliva is as infectious as blood.¹³

Clinical orthodontics, a specialty that usually has more patients than other dental specialties, demands planning and organization of sterilization and disinfection procedures to ensure greater protection to both patients and DHCP.^{18,30} Disinfection does not replace sterilization and, therefore, all material that can undergo sterilization should never be only disinfected.^{9,10} However, a common error among orthodontists is to see disinfection as an alternative to sterilization.¹⁰

This study evaluated bacterial contamination in the active tip of orthodontic pliers used in patient care by orthodontics graduate students using a microbiological method and the identification of bacterial agents.

MATERIAL AND METHODS

Sample selection

Instruments ready for clinical use were collected to analyze the potential of microbial contamination of orthodontic pliers. Sample selection was random and took the students by surprise during their clinical practice classes. Therefore, they had not time to perform procedures that might change statistical data or

microscopic findings. The sample comprised 17 samples of bird beak pliers, type 139 and 17 of band remover pliers, type 347. The control group had 3 samples of 139 pliers and 3 of the 347 pliers, at a total of 6 previously sterilized pliers (autoclave) not used in any clinical procedure. These instruments were chosen because they are widely used in everyday orthodontic procedures: The 139 plier because it is made of metal only, and the band remover pliers (347), because they have a plastic component in its structure that, when pliers are used, is directly in contact with oral tissues.

Culture media

The brain-heart infusion (BHI) medium used for the immersion of pliers is a liquid medium for the enrichment and proliferation of microbial cells to increase the number of bacteria in the sample. After dilution, cultures were seeded in duplicates in the following solid culture media with 2% agar: blood agar (BA) and nutrient agar (NA) for total count of grown colonies; eosin methylene blue agar (EMB) for the selection of gram-negative bacteria; mitis-salivarius agar (MS), for the selection of Streptococci; and mannitol salt agar (Chapman), for the selection of Staphylococci. Culture media used in this study were produced by Vetec Química Fina Ltda (Duque de Caxias, Brazil).

Microbiological analysis

The orthodontic pliers under analysis, as well as the control instruments, had their active tips immersed for 2 minutes in 10 ml BHI. Immediately after that, the samples were incubated for 24 to 48 hours at 37°C. The samples containing BHI inoculated by the pliers underwent successive dilutions in inert saline solution (0.9% NaCl) to obtain different concentrations for each sample until a dilution of 10^{-5} was obtained. The purpose of dilution was to reduce bacterial cell concentration in liquid medium for later counting.

Immediately after dilution, the samples were seeded in the different solid media described before and later incubated for 24 to 48 hours at 37°C. After that, colony forming units (CFU) in the Petri dishes were counted for comparisons and statistical analyses. Dishes with very high bacterial growth, which made counting impossible, were classified as "uncountable" ($>10^{10}$ CFU/ml). The few cultures where no colonies were found were called "null". A final mean number of bacterial cells per BHI milliliter was calculated using the two counts for each dilution, as long as there was no significant differences between the duplicates. Counts for the same dilution and medium that had great differences in the number of colonies were excluded from the study. Therefore, only the duplicates whose scores were equivalent were kept in the study, which ensured the reliability of results. Using the individual mean CFU/ml for each dilution, the general mean for each culture medium was calculated according to the type of pliers.

The shape and color of colonies for each culture medium were analyzed; bacteria in those colonies were examined under light microscopy and classified using Gram staining.

Result analysis

Results of total number of grown colonies for each instrument were recorded and compared with results of the different pliers under study and between the different culture media. For those purposes, the Student t test and analysis of variance (ANOVA) were used. The level of significance was set at 5%. The SPSS 15.0 software was used for data analysis.

RESULTS

Growth in enrichment and seeding medium

After the pliers were immersed in 10 ml of BHI (enrichment medium), stored and incubated at 37°C for 24 to 48 hours, the liquid medium was turbid and microbial cells were deposited

on the bottom of the test tubes in 32 of the 34 samples. This indicated that there was proliferation of the microorganisms collected from the instrument surfaces and that they had microbial contamination. The fact that BHI remained clear and clean, as in the control group, in two samples, one of the 139 plier and one of the 347 plier, indicated that the instruments had been previously sterilized. After dilution, the BHI samples were seeded in duplicates in the Petri dishes containing agar. After the 24 to 48 h incubation time at 37°C, colonies were found in most cultures.

Number of CFU per milliliter

For statistical and comparative analyses, CFU were counted whenever possible.

Table 1 shows that the greatest discrepancy of mean CFU/ml values between instruments was found in NA, a nonselective and nondifferential medium. Band remover pliers had a mean contamination rate 10 times greater than that of 139 pliers, and the differences between the two types of pliers were statistically significant ($p=0.008$).

In MS and Chapman media, differences were also found in mean values between the pliers, and these findings may be correlated with practical activities. The significantly greater mean ($p=0.009$) number of colonies in Chapman culture, a selective medium for *Staphylococcus* sp and a differential medium for *S. aureus*, obtained in the 139 plier group suggests a greater contact of this type of pliers with the skin. These bacteria colonize the surface of human skin and the nasal cavity mucosa¹⁵. Such findings may suggest that the pliers were used to produce other orthodontic devices, that is, in laboratory. Moreover, in the 139 group, ANOVA results revealed that the Chapman medium was the only one that had a significant difference from the NA medium, which had the lowest number of CFU/ml.

In contrast, the MS medium had a high, but not significantly different, mean CFU/ml value for the band remover pliers, which indicates a greater trend towards contamination of this type of pliers. As this medium is selective for *Streptococcus* and differential for *S. mutans*, this result may be explained by the direct contact of the instrument with the surfaces of

TABLE 1 - Mean CFU/ml in samples collected from 139 and 347 pliers, grown in BHI and seeded in different solid culture media.

Culture media	Brief description	Number of samples		CFU/ml		t Test
		model 139	model 347	model 139	model 347	
Nutrient agar (NA)	Rich medium	21	19	1.33×10^9	2.83×10^9	0.008*
Blood agar (BA)	Rich medium	26	22	3.66×10^9	4.65×10^9	0.492
Eosin methylene blue agar (EMB)	Gram-negative selective medium	24	22	3.00×10^9	2.99×10^9	0.992
Mannitol salt agar (Chapman)	Gram-positive selective medium (<i>Staphylococcus</i> sp.)	26	22	6.93×10^9	3.19×10^9	0.009*
Mitis salivarius agar (MS)	Gram-positive selective medium (<i>Streptococcus</i> sp.)	6	8	3.34×10^9	6.25×10^9	0.317

* Statistically significant results of comparisons between 139 and 347 models of pliers using t test (level of significance = 5%).

teeth, gingiva and mucosa in the posterior region of the oral cavity, where bacterial plaque often accumulates. These bacteria are part of the oral microbiota and are classified as substantially more carcinogenic.⁶

Finally, in the EMB, a selective medium for Gram-negative bacteria, and the BS cultures, a rich medium, mean number of CFU/ml in BHI was similar for 139 pliers and band remover pliers.

General morphological characteristics of colonies and microorganisms grown in each culture medium

The microbial colonies had variable shapes, sizes and colors. For the analysis under light microscopy, 41 Petri dishes of all types of media were selected to include the greatest variety of samples of grown colonies. The Gram method was used for slide staining.

Table 2 and Figure 1 describe the most frequent shape of the colonies and the type of

bacteria in them. In the dishes with NA, yellow colonies were predominant. According to microscopic analysis, they were primarily composed of staphylococci or Gram-positive bacilli. In BA, the most common bacterial types were staphylococci and G+ streptobacilli, found in white and light yellow colonies with smooth or rough surfaces. Moreover, some colonies had microorganisms that could destroy the blood cells found in the BA cultures. The translucent or greenish halos around the different colonies seen in dishes with that agar confirmed the presence of hemolytic bacteria. Streptococci found in the oropharynx, in pharyngeal inflammations and in skin infections are examples of hemolytic microorganisms.¹⁹ In EMB medium, several types of bacteria were visualized, and there was a predominance of isolated cocci and G+ streptobacilli. Isolated G+ and G- bacilli were also found; they formed purplish colonies with an irregular surface and

TABLE 2 - Colonies, shape organization and classification of most frequent bacteria in different culture media according to Gram staining.

Culture media	Most common colony configuration	Shape, organization and classification of bacteria according to Gram staining
Nutrient agar (NA)	Yellow, smooth	G+ staphylococci *, isolated G+ bacilli
	White, smooth	Isolated G+ cocci, G+ coccobacilli, G- streptobacilli **
	Orange, smooth	G+ staphylococci, G+ coccobacilli
Blood agar (BA)	Yellow, smooth	G+ staphylococci, G- sarcinae, isolated G+ bacilli, G+ coccobacilli
	White, smooth	G+ staphylococci, G+ streptobacilli, isolated G+ cocci, G+ streptococci
	Rough, white	G+ streptobacilli, isolated G+ bacilli, isolated G+ cocci, G+ streptococci, G+ coccobacilli, G+ diplococci
Eosin methylene blue agar (EMB)	Purple, rough	Isolated G+ cocci, isolated G+ and G- bacilli, G+ streptobacilli
	Pinkish, smooth	Isolated G+ cocci, isolated G+ bacilli, G+ diplococci, G+ diplobacilli
Mannitol salt agar (Chapman)	Yellow, smooth	G+ staphylococci, isolated G+ cocci, G+ streptobacilli, isolated G+ bacilli, G+ tetrad-forming organisms
	Pinkish, smooth	G+ staphylococci *, isolated G+ cocci
Mitis salivarius agar (MS)	Blue, smooth	Isolated G+ cocci, isolated G+ and G- bacilli, G- sarcinae
	Clear, smooth	Isolated G+ cocci *, G+ streptobacilli

* G+ = Gram positive; ** G- = Gram negative.

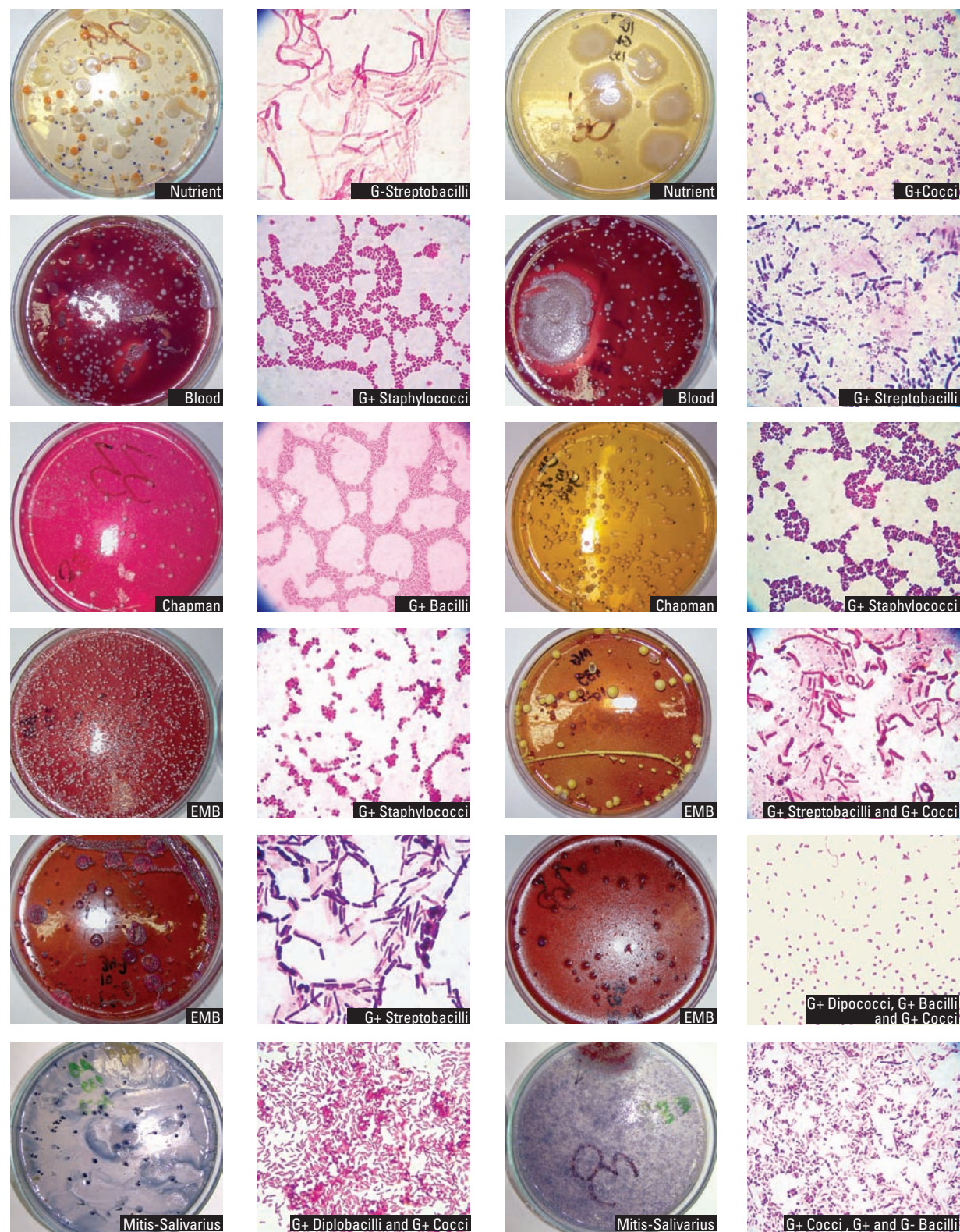


FIGURE 1 - Microbial colonies grown in different culture media and microscopic aspect (Gram staining; 1000 X magnification) of bacteria found in most frequent colonies of each medium.

outline. In the Chapman cultures, G+ staphylococci were prevalent in yellow and pinkish colonies, which indicated, in several cases, the presence of *Staphylococcus aureus*, confirmed by the change of agar color. MS had G+ cocci, and isolated G+ and G- bacilli; bluish, round and small colonies were predominant.

DISCUSSION

Over 300 bacterial species have already been described in oral microbiota.²⁶ In healthy individuals, these microorganisms coexist in equilibrium with the host, but environmental changes and microbial imbalances may originate infections.¹ For example, brackets and orthodontic bands induce specific changes in the oral environment, such as a lower pH and an increase of bacterial plaque,¹ higher levels of *S. mutans*^{1,22} and an increase in the number of *Lactobacilli* species.^{1,24}

This study found that biosafety procedures adopted in academic settings are not efficient to reduce the risk of infection. The term "cross infection" refers to the transfer of microorganisms from one person or object to another person and the resulting infection. It should be distinguished from cross contamination, which refers to the transfer of microorganisms from one person or object to another person which may or may not result in infection.

Of the several types of bacteria found in this study using light microscopy, isolated G+ cocci and microorganisms arranged as staphylococci were the most frequent. Such microorganisms may belong to different bacterial species that may cause several diseases. As in several infectious diseases, immunodepression is an important factor in an individual's susceptibility to infection.¹⁹ Both types of pliers under analysis presented bacterial contamination. Band remover pliers had the most contamination, and most bacteria were those that are found in the oral microbiota. This may be assigned to the

direct contact of this instrument with intraoral structures and to the presence of plastic material in its tip, which may favor the retention of microorganisms. The 139 pliers, in addition to contamination by microorganisms found in the oral cavity, had a high rate of contamination by staphylococci, which are bacteria that colonize the nasal mucosa and the skin. This finding may be explained by the use of this instrument during the manufacture of orthodontic appliances, because, in theory, these pliers are not supposed to be placed directly in the mouth.

The *Staphylococcus* genus has more than fifteen different species, and *S. aureus*, *S. epidermidis* and *S. saprophyticus* are the most important in healthcare settings.²⁵ These microorganisms, responsible for nosocomial infections, are some of the most resistant pathogenic bacteria and may survive for months in dry surfaces at temperatures higher than 60°C.²⁹ Some of the diseases caused by staphylococcal enzymes and toxins are superficial infections, such as furuncles, carbuncles, pustules, abscesses, conjunctivitis and angular cheilitis, as well as more severe diseases, such as toxic shock syndrome, osteomyelitis, pneumonia,²⁵ bacterial endocarditis and septicemia.^{25,29} Some of the important diseases caused by *Streptococcus* species are respiratory tract infections, such as pharyngitis and tonsillitis, which may be accompanied by scarlet and rheumatic fever.²⁵ One of the complications of acute pharyngitis may be the dissemination of infection into the ear (otitis media), the mastoids, the base of the tongue or the floor of the mouth.²⁵ Other diseases caused by streptococci are infections of soft tissues in the oral cavity or the skin, as well as caries, primarily caused by mutans microorganisms.²⁵

Pathogens may be transmitted from one patient to another by direct or indirect contact with reused instruments inadequately prepared, and with contaminated surfaces or hands.²¹

Several studies found contamination after inadequate disinfection of instruments used in patients, which stresses the need to follow adequate disinfection procedures.^{14,23} Sterilization or high-level disinfection is the recommended procedure against HBV and HIV. However, disinfection efficacy is affected by factors such as the nature of the object (type of slots and hinges) and by duration of exposure to disinfecting products.¹⁴ All materials that can be sterilized should never be only disinfected. According to some authors, infection control methods currently adopted in some orthodontic offices are not satisfactory, maybe because it is believed that this specialty has a low risk of contamination.^{8,18}

A survey conducted with a group of orthodontists found that 49% sterilized their pliers, whereas 49% disinfected them. One reason for the high usage of disinfection methods may be the cost of sterilization, as the orthodontist should have several pliers if each instrument is to be sterilized. Other reasons mentioned are the fact that sterilization shortens the useful life of materials, the large number of patients per day, and the shorter duration of appointments. Moreover, orthodontists may be more flexible in terms of infection control than dentists in other specialties because they may believe that their young population is less likely to be infected with HIV or HBV.³⁰ However, recent studies showed that there has been an increase in HIV infection among individuals younger than 20 years.¹⁷ Woo et al³⁰ reported that, of the total number of patients seen in orthodontic clinics, 21% were children, 52% were teenagers, and 27%, adults. Adolescents or adults account for the largest percentage of patients receiving orthodontic treatment. In addition, all patients should be treated as if they were potentially infective. Because most patients with HBV and HIV infection are asymptomatic, they may disseminate the virus in offices.¹⁰

Of the many viral diseases that may be acquired in a dental office, the most often mentioned are hepatitis (B, C and D), herpetic conjunctivitis, herpes simplex, herpes zoster, measles, chickenpox, rubella, mumps and AIDS. The most important infections caused by bacteria, according to the literature, are tuberculosis, syphilis, pneumonia, infections by streptococci and staphylococci.¹²

The incidence of hepatitis B after accidental exposure to contaminated materials or due to lesions caused by sharp instruments used in patients that have HBsAg antigens is about 20%. In the same circumstances, the risk of HIV transmission is between 0 and 0.5%.¹⁹ An aggravating factor in HBV transmissibility is its high resistance and its high infectious capacity, as it has been shown to remain infective up to six months at room temperature and up to seven days when exposed to surfaces.^{4,10} In less than 0.00000001 ml of blood, hepatitis B virus is potentially infective for 7 days after the surface is dried.¹⁰

This study showed orthodontic pliers have great contamination rates and that, by means of contaminated instruments, several types of microorganisms may be transmitted between individuals. This is a truly relevant fact because of the immense number of bacteria and, particularly, viral particles that are secreted in oral fluids, and a small amount of saliva has the potential to cause severe diseases, such as hepatitis B. Therefore, virus dissemination should not be overlooked, although this study focused on the identification of contaminating bacteria.

The prevention and control of cross infection in the dental office are current patient demands and rights. Therefore, all dental health-care personnel should be aware of these facts. Such knowledge will help them to change their procedures and adopt correct biosafety measures for all patients as a way to stop the propagation of infections.

CONCLUSION

This study found high rates of bacterial contamination in the two types of orthodontic pliers selected for investigation. Data showed that band remover pliers had greater contamination rates, probably because of their direct contact with intraoral structures and tissues. The 139 pliers also showed high contamination by agents found in the oral microbiota, but mean CFU/ml was relatively greater in the Chapman

agar cultures, a medium to grow staphylococci, which are microorganisms found not in the oral cavity, but, rather, on the surfaces of human skin and in the nasal mucosa.

The disinfection procedures adopted did not seem to be effective to reduce contamination. More efficient measures should be adopted to control infection, so that microorganisms are not transmitted to patients or between patients and the members of the orthodontic team.

REFERENCES

1. Anhoury P, Nathanson D, Hughes CV, Socransky S, Feres M, Chou LL. Microbial profile on metallic and ceramic bracket materials. *Angle Orthod.* 2002;72(4):338-43.
2. Araujo MW, Andreana S. Risk and prevention of transmission of infectious diseases in dentistry. *Quintessence Int.* 2002;33(5):376-82.
3. Buckthal JE, Mayhew MJ, Kusy RP, Crawford JJ. Survey of sterilization and disinfection procedures. *J Clin Orthod.* 1986;20(11):759-65.
4. Consolaro A, Pinzan A, Ursi WJS, Cuoghi AO, Pinto PRS, Diaz MCA. A hepatite B e a clínica ortodôntica. *Ortodontia.* 1991;24(2):53-8.
5. Cunha ACA, Zöllner MSA. Presença de microorganismos dos gêneros *Staphylococcus* e *Candida* aderidos em máscaras faciais utilizadas em atendimento odontológico. *Biociências.* 2002;8(1):95-101.
6. De Lorenzo JL. Microbiologia para o estudante de Odontologia. 1ª ed. São Paulo: Atheneu; 2004.
7. Feldman RE, Schiff ER. Hepatitis in dental professionals. *JAMA.* 1975;23(232):1228-30.
8. Freitas MPM, Menezes LM, Rizzato SMD, Feldens JA. Protocolo básico de biossegurança na clínica ortodôntica. *Rev Clín Ortod Dent Press.* 2006;5(2):78-86.
9. Gandini Júnior LG, Souza RS, Martins JC, Sakima T, Gandini MR. Controle da infecção cruzada em Ortodontia: Parte 2: processamento, esterilização e controle de corrosão. *Rev Dental Press Ortodon Ortop Facial.* 1997;2(3 Pt 2):80-7.
10. Gandini LG Júnior, Souza RS, Martins JC, Sakima T, Gandini MR. Controle da infecção cruzada em Ortodontia: Parte 1: Hepatite B, desinfecção e aparatologia pessoal. *Rev Dental Press Ortodon Ortop Facial.* 1997;2(2):77-82.
11. Hamory BH, Whitener CJ. Nosocomial infections in dental, oral, and maxillofacial surgery. In: Mayhall CG. *Hospital Epidemiology and Infection Control.* 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999. p. 719-28.
12. Jorge AOC. Princípios de biossegurança em Odontologia. [Acesso 2006 Jun 4] 2002. Available in: <http://www.unitau.br/prppg/publica/biocienc/downloads/principiosbio-N1-2002.pdf>.
13. Kirchhoff ST, Sekijima RK, Masunaga MI, Alizadeh CM. Sterilization in Orthodontics. *J Clin Orthod.* 1987;21(5):326-36.

14. Knorst ME, Asensi MD, Moraes BA, Yoshida CF, Finizola Filho A, Salgado Júnior LP, et al. Desinfecção em ortodontia: estudo de um método alternativo utilizando o lenço Bacti Buster Stepac L.A. em alicates ortodônticos e em superfície do mobiliário contra o vírus da hepatite B e a bactéria *S. aureus* metilicilino-resistente. *J Bras Ortodon Ortop Facial*. 1999;4(21):265-70.
15. Marsh P, Martin MV. *Microbiologia Oral*. 4ª ed. São Paulo: Santos; 2005.
16. Matlack RE. Instrument sterilization in orthodontic offices. *Angle Orthod*. 1979;49(3):205-11.
17. McCarthy GM, Mamandras AH, MacDonald JK. Infection control in the orthodontic office in Canada. *Am J Orthod Dentofacial Orthop*. 1997;112(3):275-81.
18. Mulick JF. Upgrading sterilization in the orthodontic practice. *Am J Orthod*. 1986;89(4):346-51.
19. Nisengard RJ, Newman MG. *Microbiologia oral e Imunologia*. 2ª ed. Rio de Janeiro: Guanabara Koogan; 1997.
20. Orthodontic Instrument Sterilization: making the right choice in sterilization techniques. *American Orthodontics - The Assistant*. 2002;1(1):2-7.
21. Palenik CJ, Burke FJ, Miller CH. Strategies for dental clinic infection control. *Dent Update*. 2000;27(1):7-15.
22. Rosenbloom RG, Tinanoff N. Salivary *S* mutans levels in patients before, during, and after orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1991;100(1):35-7.
23. Rutala WA. Draft APIC Guideline for selection and use of disinfectants. *Am J Infect Control*. 1990;18(2):99-117.
24. Sakamaki ST, Bahn AN. Effect of orthodontic banding on localized oral lactobacilli. *J Dent Res*. 1968;47(2):275-9.
25. Samaranayake LP. *Essential microbiology for dentistry*. 2nd ed. London: Churchill Livingstone; 2002.
26. Souto R, Andrade AF, Uzeda M, Colombo AP. Prevalence of non-oral pathogenic bacteria in subgingival biofilm of the subjects with chronic periodontitis. *Braz J Microbiol*. 2006;37:208-15.
27. Starnbach H, Biddle S. A pragmatic approach to asepsis in the orthodontic office. *Angle Orthod*. 1980;50(1):63-6.
28. Thylstrup A, Fejerskov O. *Cariologia Clínica*. 2ª ed. São Paulo: Ed. Santos; 2001.
29. Wichelhaus A, Bader F, Sander FG, Krieger D, Mertens T. Effective disinfection of orthodontic pliers. *J Orofac Orthop*. 2006;67(5):316-36.
30. Woo J, Anderson R, Maguire B, Gerbert B. Compliance with infection control procedures among California orthodontists. *Am J Orthod Dentofacial Orthop*. 1992;102(1):68-75.

Submitted: December 2007
Revised and accepted: October 2008

Contact address

Fabiane Azeredo
Pontifícia Universidade Católica do Rio Grande do Sul
Faculdade de Odontologia – Departamento de Ortodontia
Av. Ipiranga, 6681
CEP: 90.619-900 – Porto Alegre / RS, Brazil
E-mail: fabianeazeredo@hotmail.com

Cephalometric evaluation of the effects of the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance on the skeletal structures of patients with Angle Class II, division 1 malocclusion

Emmanuelle Medeiros de Araújo*, Rildo Medeiros Matoso**, Alexandre Magno Negreiros Diógenes***, Kenio Costa Lima****

Abstract

Objective: This study aimed to perform a cephalometric evaluation of the skeletal responses triggered by the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance for correction of Class II, division 1 malocclusion in young Brazilian patients. **Methods:** The sample consisted of 56 lateral cephalograms of 28 patients (16 women and 12 men). The initial mean age was 13.06 years and mean duration of therapy with MPA was 14.43 months. The lateral radiographs were obtained before and after treatment and were compared by two calibrated examiners to identify the skeletal changes induced by the MPA using 16 linear and angular cephalometric measures. Some independent variables (patient age, sex, facial pattern, MPA model, total use time, archwire and technique used during therapy with MPA) were considered and related to those measures in order to demonstrate the influence of these variables on them. Responses to treatment were analyzed and compared by the Wilcoxon Signed Ranks test and Mann-Whitney test at a significance level of 5%. **Results:** The results showed restricted anterior displacement of the maxilla, increased mandibular protrusion, improved anteroposterior relationship of the basal bones and stability of the mandibular plane relative to the cranial base. The influence of variables age, facial pattern and MPA type was also noted. **Conclusions:** MPA proved an effective alternative in the treatment of Class II, division 1 malocclusion, inducing changes in the skeletal component with satisfactory clinical results.

Keywords: Cephalometry. Functional orthodontic appliances. Angle Class II malocclusion. Mandibular protraction appliance.

How to cite this article: Araújo EM, Matoso RM, Diógenes AMN, Lima KC. Cephalometric evaluation of the effects of the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance on the skeletal structures of patients with Angle Class II, division 1 malocclusion. *Dental Press J Orthod*. 2011 May-June;16(3):113-24.

* Specialist in Orthodontics, ABO-EAP/RN.

** MSc in Orthodontics, USP. Head Professor of Orthodontics, UFRN. Professor of the Specialization Course, ABO-EAP/RN.

*** Specialist in Orthodontics, ABO-EAP/RN.

**** Professor, Department of Orthodontics and Graduated Course in Dentistry and Health Sciences, UFRN.

INTRODUCTION AND LITERATURE REVIEW

Angle Class II, division 1 malocclusion is a frequent problem affecting about 55% of the Brazilian population.² It has a multifactorial etiology, and from a skeletal point of view, may be due to maxillary protrusion, mandibular retrusion or a combination of both.¹⁶

The literature is rich in treatment methods for this malocclusion, which traditionally rely on patient cooperation in wearing removable functional appliances (Activator, Balters' Bionator, Frankel appliance), using Class II elastics and/or extraoral traction appliances. Among the appliances used in Class II, division 1 cases are those which have as their key objective restricting the anterior displacement of the maxilla, those that push the mandible towards a more anterior position in order to redirect growth and lead to an appropriate morphological development, and those that induce changes in both arches.¹²

In recent decades, several authors began to develop fixed intraoral orthopedic appliances capable of correcting Class II molar relationship with mandibular retrognathism, since these appliances promote changes in mandibular posture, positioning it forward with the aim of stimulating its growth.^{24,25} Since these appliances are fixed (Herbst,²⁵ Jasper Jumper,^{17,18} Universal Bite Jumper,^{4,28} Eureka Spring,¹³ MARA,¹ Churro Jumper⁵ and Superspring¹⁹) they are instrumental in decreasing the need for patient compliance during treatment.

However, the lack of specialized laboratories to fabricate these appliances, their high cost and scarcity of information about the installation of most of them led Coelho Filho⁶ to design the Mandibular Protraction Appliance 1, also known as MPA 1, whose characteristics, at first quite simple, soon evolved into a more advanced version. In 1995, the inventor presented the clinical results achieved with his appliance as an alternative to Herbst,^{6,20,21,22,23,26,27} rein-

troduced by Pancherz (1979), since the former uses the same mechanical design as the latter.

Some of the advantages of MPA over Herbst are that (a) it can be fabricated by professionals themselves, without the need for laboratory work, (b) it is affordable, (c) it is easy to insert, and (d) as it is less bulky, it provides greater patient comfort.^{10,11,30}

MPA 1 was initially made with 0.032-in (0.9 mm) wire and consisted of a steel rod with a round loop at each end. In this first version, rectangular wires had to be in place and due to the conformation of the appliance only canine to canine brackets could be bonded. Moreover, the lower arch needed to have a strong torque in the anterior region to resist buccal displacement of lower incisors resulting from the protrusive forces generated by the appliance. Additionally, bends had to be applied on the distal side of lower molar tubes to enhance anchorage and prevent mesial drift of lower teeth.^{6,8}

Although the clinical results achieved with MPA 1 were extremely positive, limitations in mouth opening caused frequent breakages.⁷ Therefore, in 1997, the second MPA version was launched, featuring increased mouth opening, greater patient comfort and less frequent breakages. Besides all the installation details described for an MPA 1, the author emphasized insertion of anterosuperior buccal torque and two circular loops positioned mesial to the upper molars and distal to the lower canines to facilitate appliance installation. Also noteworthy was the fact that with this second version brackets could be bonded to premolars.

In contrast to these upsides, MPA 2 also showed some shortcomings. To address these issues the author created a fully modified third version termed MPA 3,^{7,9,10} which had a completely different configuration from earlier versions, including telescopic stainless steel tubes through which ran 0.9 mm wire rods. The method of insertion in the lower

arch was redesigned. All these improvements ensured greater appliance balance when patients opened and closed their mouth. The author also discussed the use of the appliance in cases of Class III malocclusion and anterior crossbite. To do so would require reversing the direction of the appliance.^{7,9}

In 2001 and 2002, Coelho Filho introduced the latest version: MPA 4. The author reported that this new model seemed to surpass all previous models in terms of both shear strength and ease of installation. Furthermore, MPA 4 adaptation to the upper arch was modified to impart greater functional stability to the appliance.¹¹ The author also pointed out that MPA model did not determine differences in the outcome. All models feature the same mechanical principles. What makes each different is fabrication method, installation and patient comfort.⁷

Given their numerous advantages, as stated above, in addition to being versatile and featuring a wide range of applications, orthodontists were driven to study MPA treatment effects, prompting some to go as far as to propose other appliance models with similar mechanisms.^{15,22} Thus, the purpose of this study was to analyze and determine skeletal changes in patients with Angle Class II, division 1 malocclusion resulting from treatment with MPA during the phase of active growth.

METHODS

This study can be defined as an uncontrolled, nonrandomized clinical trial. To conduct it, a sample was selected comprising 56 lateral cephalograms of 28 Brazilian youths of both sexes — 16 women and 12 men — according to the following criteria: Angle Class II, division 1 malocclusion with mandibular retrognathism, as assessed by study models, photographs and radiographs with a clear visualization of the structures of interest. Exclusion criteria were as follows: Agenesis, ex-

traction or loss of permanent teeth; patients undergoing orthodontic treatment prior to MPA installation, since prior therapy would alter the Class II, division 1 malocclusion; and significant overjet.

Clinical records included the following clinical variables: Patient age, sex, facial pattern (dolichofacial, mesofacial and brachyfacial, but the latter was excluded during sample selection as only one case had this facial type, which might yield statistical results with a higher margin of error), MPA model (types 1, 2, 3 and 4; type 1 was associated with type 2, and type 3 with type 4, since only one patient was treated with MPA 1, and only 5 cases with MPA 3), total time of appliance use, archwires used during treatment with MPA (0.019x0.025-in, 0.021x0.025-in and 0.018x0.025-in stainless steel wires, with the latter two grouped together, totaling 12 cases, compared to 16 patients with 0.019x0.025-in stainless steel wire) and orthodontic technique (Standard Edgewise and Straight Wire).

The cephalograms used in this study were selected from the archives of Professor Carlos Martins Coelho Filho's private clinic (in the city of São Luís, Maranhão state, Brazil), and obtained with Funk Orbital X15 X-ray device, with a magnification factor of 9%, and operated by one and the same examiner.

Two lateral cephalograms of each of the 28 patients were used, referred to as T1 (initial) and T2 (final). The cephalograms were traced manually on a light box by two calibrated examiners in a darkened room at Professor Carlos Martins' private clinic in São Luís, Maranhão state.

Examiner calibration was performed approximately three months earlier, when 30 randomly selected cephalograms were retraced until minimum error was attained.

To obtain the cephalograms the authors used transparent Ultraphan acetate paper (Cephalometric Tracing Paper, GAC), Pentel pencil holder

with a 0.3 mm tip, tape, soft rubber, template (Tracing Template, Unitek Corp.), and a light box. When double images of the anatomical design of bony structures were visualized both images were traced and a mean value was found between cephalometric points.

In the next step the images were imported via a scanner into a microcomputer containing the Radiocef Studio Cephalometry program (No. 020576, version 4.0, release 3 - Belo Horizonte/MG, Brazil), where values were obtained for T1 and T2 and their respective repetitions.

From then on, the following landmarks were identified to obtain angular and linear measurements: S (sella turcica), N (nasion), A (subspinale), B (supramentale), Pog (pogonion), Me (menton), Go (gonion), Gn (gnathion), Ar (articulare), ANS (anterior nasal spine) and PNS (posterior nasal spine) (Fig 1).

The reference planes used in this study were, as shown in Figure 2: a modified Frankfort Horizontal Plane (FHP)²⁹ (1), composed of a line that forms with the SN line a 7° angle

down through point S; Mandibular planes Go-Me (2) and Go-Gn (3); Palatal Plane (PP) (4), formed by points ANS and PNS; lines SN (5), NA (6), NB (7), APog (8) and S-HFp (9).

Angular variables included, as shown in Figure 3: SN.PP (10), SN.GoGn (11), SN.GoMe (12), SNA (13), SNB (14), ANB (15) and NAPog (16); and the linear variables were, as shown in Figure 4: Go-Gn (17), ANS-FHP (18), Pog-FHP (19), A-FHP (20), B-FHP (21), ASFH (22), PFH (23), LPFH (24) and LAFH (25).

RESULTS

This study used a sample of 56 lateral cephalograms of 28 young Brazilian of both sexes comprising 16 women (57.1%) and 12 men (42.9%) (Table 1).

Mean age was 13.06 years, with a standard deviation of 1.3 years, with a minimum of 10.33 years and a maximum of 16.58 years, respectively.

As regards facial pattern, 39.3% (11 patients) were dolichofacial while 60.7% (17 patients)

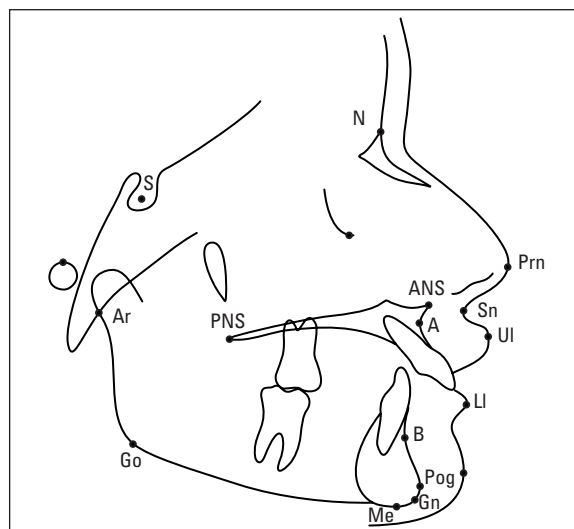


FIGURE 1 - Cephalometric points (landmarks).

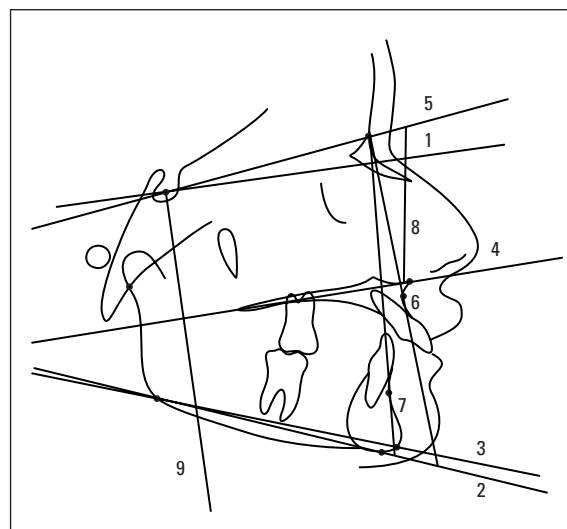


FIGURE 2 - Reference planes and lines.

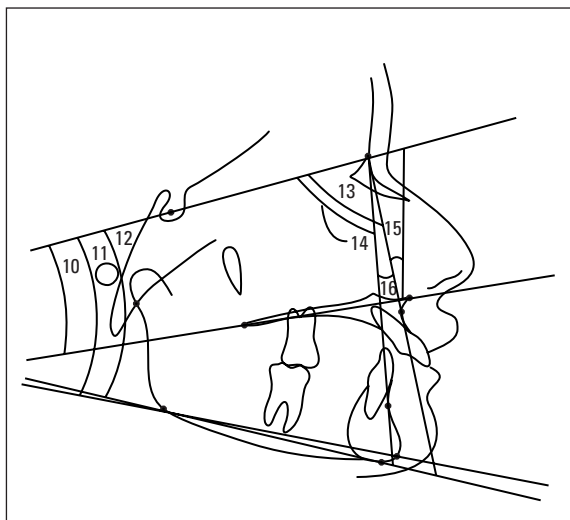


FIGURE 3 - Skeletal angular variables.

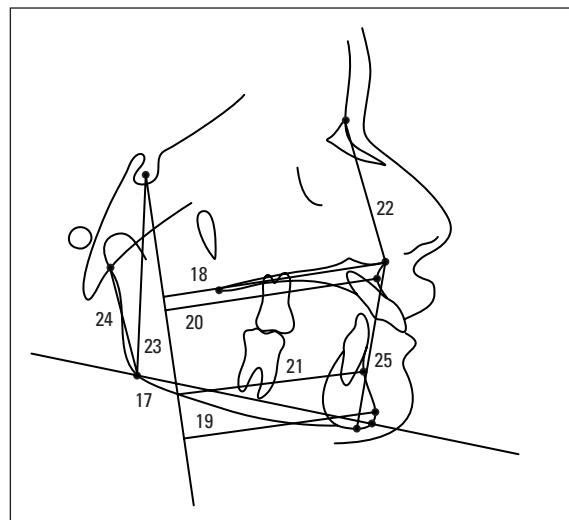


FIGURE 4 - Skeletal linear variables.

were mesofacial. As explained before, during sample selection the brachyfacial pattern was excluded as only one case had this facial type, which might yield unreliable statistical results.

Similarly, under variable MPA model, MPA type 1 was associated with MPA type 2, and type 3 with type 4, since only one patient (3.6%) had been treated with MPA 1 and 5 cases (17.9%) with MPA 3. The remaining percentages corresponded to 35.7% (10 cases) and 42.9% (12 cases) of MPAs 2 and 4, respectively.

For the variable archwire, the following types were noted: 0.019x0.025-in stainless steel (57.1% or 16 patients), 0.021x0.025-in stainless steel (10.7% or 3 patients) and 0.018x0.025-in stainless steel (32.1% or 9 patients). The latter two archwires were also grouped into a total of 12 cases.

The variable technique showed a frequency of 12 cases (42.9%) for the Straight Wire technique and a total of 16 cases (57.1%) for the Standard Edgewise technique.

The result achieved for the variable total MPA use time was 14.43 months, with a minimum of 3 months and maximum of 33 months, and a standard deviation of 9.33 months.

Table 2 shows the means for initial and final cephalometric measurements of patients of both sexes, their medians, quartiles 25 and 75, and statistical significance value (p), obtained with the Wilcoxon Signed Ranks Test. As can be observed, of all the skeletal cephalometric measures employed in this study, only SNA, SNB, ANB, NAPog, Go-Gn, Pog-FHP, FHP-B, ASFH, PFH, LPFH and LAFH were influenced by treatment with MPA, i.e., showed statistically significant values ($p < 0.05$).

Among the seven independent variables, statistically significant results were found only for age, sex, facial pattern and MPA model. Tables 3 and 4 show differences between cephalometric measurements before and after treatment with MPA related to such variables, including their medians, quartiles 25 and 75,

Variables		Frequency	
		n	%
Age	≤ 13.06 years	14	50
	≥ 13.06 years	14	50
Sex	Female	16	57.1
	Male	12	42.9
Facial Pattern	Dolicho	11	39.3
	Meso	17	60.7
MPA Type	1+2	11	39.3
	3+4	17	60.7
Archwire	0.019x0.025-in SS	16	57.1
	0.021x0.025-in + 0.018x0.025-in SS	12	42.9
Technique	Straight Wire	12	42.9
	Standard Edgewise	16	57.1

TABLE 1 - Relationship between variables and sample distribution. Natal, Rio Grande do Norte State, Brazil, 2005.

and significance value (p) for each individual measure. For sex, only Go-Gn and LAFH showed a statistically significant results, and for age, only ANB. As for facial pattern, the only quantities that showed significant differences were PFH and LPFH. Regarding MPA type, statistical differences were found for Go-Gn, ANS-FHP, Pog-FHP, A-FHP, B-FHP, ASFH, PFH and LAFH.

Tables 5 and 6 show the variables associated with the skeletal cephalometric measures that exhibited changes after treatment. The variables were related to these measures prior to treatment. This revealed the influence that they exerted on these measures and whether differences existed in relation to these variables even before starting therapy with MPA. To obtain these results, the Mann-Whitney Test was employed.

As can be seen in Tables 5 and 6, only Go-Gn and LAFH showed statistical relevance even before starting treatment, when related

TABLE 2 - Medians and 25/75 quartiles of initial and final skeletal cephalometric measurements and value of statistical significance. (Natal, Rio Grande do Norte state, Brazil, 2005).

Skeletal cephalometric measures	Median	$Q_{25} - Q_{75}$	P
Initial SN.PP Final SN.PP	6.67 6.77	4.58 - 9.00 4.88 - 9.03	0.608
Initial SN.GoGn Final SN.GoGn	29.47 29.69	27.74 - 34.35 26.30 - 32.63	0.374
Initial SN.GoMe Final SN.GoMe	31.19 30.99	29.53 - 36.16 28.03 - 34.10	0.219
Initial SNA Final SNA	89.86 81.95	80.07 - 86.03 79.26 - 84.24	0.018*
Initial SNB Final SNB	77.25 78.07	75.74 - 78.91 76.36 - 80.03	0.032*
Initial ANB Final ANB	5.88 3.92	3.59 - 7.49 1.91 - 5.54	0.000*
Initial NAPog Final NAPog	11.00 7.17	3.95 - 14.15 3.03 - 9.63	0.009*
Initial Go-Gn Final Go-Gn	70.44 76.35	39.23 - 79.62 45.30 - 84.19	0.000*
Initial ANS-FHP Final ANS-FHP	75.49 77.67	43.15 - 84.63 44.79 - 86.14	0.187
Initial Pog-FHp Final Pog-FHp	64.78 65.75	37.66 - 72.68 38.80 - 77.38	0.024*
Initial A-FHp Final A-FHp	71.45 71.97	40.86 - 81.40 41.70 - 82.30	0.255
Initial B-FHp Final B-FHp	63.84 63.84	35.61 - 71.44 36.75 - 72.95	0.027*
Initial ASFH Final ASFH	51.48 53.48	29.93 - 55.90 30.79 - 57.68	0.002*
Initial PFH Final PFH	71.24 76.23	40.79 - 83.02 43.15 - 83.91	0.001*
Initial LPFH Final LPFH	42.26 45.16	22.79 - 49.42 24.94 - 51.85	0.004*
Initial LAFH Final LAFH	59.85 62.72	35.43 - 72.56 36.25 - 71.05	0.001*

*Significant difference (p<0.05) based on Wilcoxon test.

to variable sex. All other measures, which were influenced by treatment with MPA, exhibited no statistically significant values in this pre-treatment phase.

TABLE 3, 4 - Medians, 25/75 quartiles and significance of cephalometric measurements related to independent variables. (Natal, RN, Brazil, 2005).

Difference between T1 and T2 cephalometric measurements	ANB			Go-Gn			ANS-FHP			Pog-FHP			A-FHP		
	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p
Sex n															
Female (16)	2.24	1.12/2.96	0.246	-1.19	-3.76/-0.82	0.029	0.04	-1.76/1.27	0.194	-1.15	-6.13/1.67	0.194	-0.29	-1.02/1.19	0.114
Male (12)	1.18	0.04/3.00		-4.20	-11.44/-2.31		-1.11	-6.48/0.75		-6.13	-10.26/0.51		-1.48	-4.75/0.44	
Age (n)															
≤ 13.06 (14)	2.65	1.07/3.45	0.035*	-3.72	-13.11/-1.14	0.183	-0.42	-2.64/0.38	0.748	-4.18	-9.66/1.65	0.383	-0.40	-2.37/1.67	1.000
>13.06 (14)	1.29	0.04/2.40		-1.66	-4.16/-0.80		-0.13	-4.89/1.02		0.79	-5.85/0.87		-0.34	-3.21/1.09	
Facial Pattern (n)															
Dolichofacial (11)	1.13	0.53/2.98	0.410	-2.83	-17.47/-1.23	0.312	-0.82	-4.66/0.78	0.335	-5.09	-9.35/1.84	0.621	-1.07	-3.58/1.24	0.556
Mesofacial (17)	2.37	0.78/3.03		-2.08	-6.31/0.83		0.06	-3.33/1.04		-1.20	-7.28/0.47		-0.37	-1.80/0.80	
MPA type (n)															
1 + 2 (11)	2.98	0.31/3.61	0.335	-4.83	-17.47/-3.65	0.003*	-1.64	-5.02/-0.03	0.018*	-7.19	-10.58/-1.95	0.001*	-1.26	-3.74/-0.43	0.006*
3 + 4 (17)	1.74	0.75/2.44		-1.23	-3.13/-0.61		0.67	-1.89/1.21		0.39	-3.25/3.30		0.56	-1.27/2.15	

*Significant difference (p<0.05).

Difference between T1 and T2 cephalometric measurements	B-FHP			ASFH			PFH			LPFH			LAFH		
	Mediana	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p
Sex (n)															
Female (16)	-0.84	-5.49/1.14	0.265	-0.89	-1.66/-0.14	0.057	-2.33	-5.50/-0.24	0.210	-2.27	-4.49/-0.27	0.430	-1.44	-2.98/-0.52	0.010*
Male (12)	-5.44	-10.39/0.81		-2.38	-5.75/-0.53		-4.95	-7.65/-1.37		-4.39	-5.90/0.80		-5.13	-8.56/-3.11	
Age (n)															
≤ 13.06 (14)	-3.74	-7.91/1.14	0.312	-1.30	-3.74/0.76	0.963	-5.53	-8.64/-1.30	0.081	-4.43	-6.60/-0.68	0.154	-2.83	-5.85/-1.07	0.566
>13.06 (14)	-0.43	-5.15/1.01		-1.32	-2.50/-0.23		-2.33	-4.74/-0.01		-1.29	-4.35/-0.56		-2.57	-5.33/-0.47	
Facial Pattern (n)															
Dolichofacial (11)	-4.59	-6.93/1.29	0.724	-1.65	-4.84/-0.24	0.384	-5.54	-11.09/-2.99	0.041*	-4.34	-8.00/-0.99	0.046*	-3.41	-5.71/-0.93	0.371
Mesofacial (17)	-0.96	-6.37/0.70		-1.10	-2.38/0.16		-2.31	-5.38/0.28		-2.04	-4.53/-1.97		-2.62	-5.03/-0.58	
APM type (n)															
1 + 2 (11)	-6.29	-10.85/-1.74	0.002*	-2.32	-6.09/-0.94	0.048*	-5.67	-11.09/-3.37	0.015*	-4.52	-8.00/-1.60	0.063	-5.21	-7.57/-2.00	0.041*
3 + 4 (17)	0.49	-3.06/2.70		-0.85	-1.91/0.16		-2.31	-4.59/0.03		-0.99	-3.79/0.82		-1.12	-4.69/-0.47	

*Significant difference (p<0,05).

TABLE 5, 6 - Values of cephalometric measurements that showed statistically significant changes after treatment - related to independent variables - before starting treatment with MPA. (Natal, RN, Brazil, 2005).

	ANB			Go-Gn			ANS-FHP			Pog-FHP			A-FHP		
	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p
Sex (n)															
Female (16)				44.14	27.51/66.57	0.003*									
Male (12)				75.39	71.04/91.29										
Age (n)															
≤ 13.06 (14)	5.57	3.26/7.23	0.730												
>13.06 (14)	6.04	3.95/7.84													
Facial Pattern (n)															
Dolichofacial (11)															
Mesofacial (17)															
MPA type (n)															
1 + 2 (11)				70.44	28.51/94.09	1.000	78.39	28.55/102.20	0.410	68.84	22.79/78.16	0.655	74.68	27.14/97.74	0.359
3 + 4 (17)				70.44	44.14/75.43		72.95	43.47/80.19		62.48	37.72/70.58		69.37	41.17/77.70	

*Significant difference (p<0.05).

	B-FHP			ASFH			PFH			LPFH			LAFH		
	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p	Median	Q ₂₅ /Q ₇₅	p
Sex (n)															
Female (16)													36.38	26.94/58.82	0.001*
Male (12)													69.29	62.43/79.77	
Age (n)															
≤ 13.06 (14)															
>13.06 (14)															
Facial Pattern (n)															
Dolichofacial (11)							78.12	39.86/89.06	0.525	45.62	23.68/55.61	0.269			
Mesofacial (17)							70.66	40.83/80.62		40.50	22.42/47.09				
MPA type (n)															
1 + 2 (11)	66.90	23.38/76.33	0.466	52.58	21.36/63.91	0.438	77.53	27.53/89.06	0.466				63.16	26.87/81.10	0.384
3 + 4 (17)	61.15	35.53/68.08		44.20	30.02/55.04		69.16	40.83/82.33					53.83	35.54/69.29	

*Significant difference (p<0.05).

DISCUSSION

Angle Class II, division 1 malocclusion is a frequent problem since for its interception and/or correction a wide range of appliances have been proposed. Moreover, the literature is still scarce in studies that pinpoint which changes result from MPA use, be they skeletal, dental or cutaneous changes. Thus, this study sought to evaluate the skeletal changes triggered by the use of mandibular protraction appliances in patients with Class II, division 1 malocclusion associated with a corrective orthodontic appliance.

As for the sagittal maxillomandibular relationship, only measures ANB and NAPog were verified. The following measures were used to observe vertical changes: SN.PP, SN.GoGn, SN.GoMe, ASFH, PFH, LPFH and LAFH.

According to the results shown in Table 2, only SNA showed statistical significance for the maxillary component, suggesting that MPA acted by hindering anterior maxillary displacement, causing a reduction of 1.91° . It is known that during growth the maxilla moves forward and downward. In patients with Class II growth pattern it is common for point A to be positioned more anteriorly. Thus, when associated with the growth tendency observed in the maxilla of untreated patients, SNA often experiences an increase.¹⁴ In this study, reduction in this skeletal cephalometric measurement can therefore be attributed to the use of the appliance favored by the growth factor, since the treated group had a mean age of 13.06 years.

Concerning mandibular changes, all measures showed significant differences and increased protrusion when MPA was used, but this fact does not warrant one to assert that protrusion was solely due to the MPA as this age group shows a predominance of mandibular growth. Cephalometric measurements correspond to SNB, GoGn, B-FHp and Pog-FHp (Table 2).

The measures used to verify the sagittal maxillomandibular relationship yielded statistically

significant results. After using the appliance, an improved relationship was noted between the maxilla and mandible in the anteroposterior direction, with a more posterior positioning of the maxilla and more anterior positioning of the mandible. There was a decrease in maxillo-mandibular relationship values (ANB, NAPog) which resulted in the correction of the skeletal Class II (Table 2).

In observing the vertical changes resulting from therapy with MPA, it was found that the angular measures SN.PP, SN.GoGn and SN.GoMe showed no statistically significant differences after MPA use. The former two measures remained fairly constant and the latter experienced a slight downturn. Linear measures ASFH, PFH, LPFH and LAFH showed significant increases (Table 2). Once again the results reinforce Coelho Filho's finding that despite increases in antero-inferior and posterior facial height, the mandibular plane angle is not negatively affected when treatment induces the mandible to move to a more anterior position.

Tables 3 and 4 show the difference ratio between cephalometric initial and final measures, and independent variables. Only variables sex, age, facial pattern and MPA model influenced the final cephalometric measures. The other variables used in this research — total use time, archwire and technique used during treatment — showed no statistically significant results and do not seem to exert any influence on the skeletal cephalometric measures targeted in this study.

Regarding sex, there was a significant difference for GoGn and LAFH, and in both there was a larger increase for males and smaller increase for females since males exhibit greater growth potential (Tables 3 and 4). These measurements, however, were already different in relation to sex before treatment, suggesting that sex did not directly interfere with the outcome of therapy using MPA (Tables 5 and 6).

As regards age, the only measurement that showed significant alteration was ANB, and the difference between T1 and T2 was higher in the group aged ≤ 13.06 years and lower in the group aged > 13.06 years, whose values correspond to 2.65 and 1.29, in the order given, due to greater growth potential with more significant skeletal changes at younger ages (Tables 3 and 4). However, this measure was not initially altered, suggesting that age influenced the treatment (Tables 5 and 6).

According to Enlow,¹⁴ during puberty the growth velocity curve rises to a peak and then begins to fall rapidly. Peak velocity is called maximum height growth speed. Pubertal growth spurt occurs on average two years earlier in girls than in boys. Spurt initiation, i.e., the age at which the curve shows a steady increase, represents an age of 10.04 ± 1.26 years for girls and 12.08 ± 1.20 years for boys. As for spurt duration there seems to be no significant difference between the sexes (4.73 and 4.91 years for girls and boys, respectively). In this study, the group that exhibited the most significant changes had a mean age ≤ 13.06 years, with a decrease in ANB, as can be seen in Table 4. This can be explained both by the growth factor, since the group in question was experiencing maximum spurt, but also by the mechanics produced by the MPA, confirming once again studies by Coelho Filho which show satisfactory results from the use MPAs for facial convexity reduction and correction of the maxillomandibular relationship.

In analyzing facial pattern, only PFH and LPFH showed enhanced values, with dolichofacial patients showing slightly more changes than mesofacial patients (Tables 3 and 4). However, these measures showed no significant changes before starting therapy with the MPA, which may lead one to reason that facial pattern exerted some influence on the treatment (Tables 5 and 6).

Facial growth plays a significant role in the prognosis of patients treated orthodontically. A major goal in treating young patients during the active growth phase is to control facial growth direction. According to Björk,³ Frankel and Frankel¹⁵ and Vasconcelos³⁰ increases in the vertical facial factor are deleterious for patients with skeletal Class II malocclusion as the mandible rotates posteriorly, further worsening the sagittal malocclusion. In dolichofacial types, treatment of Class II should check anteroinferior facial height growth and posterior facial height growth. In this study, measures PFH and LPFH — after treatment with MPA — showed increases that were higher for the dolichofacial than for the mesofacial group. The other measures were correlated with the facial pattern and displayed no statistically significant results. This finding has major clinical bearing as it shows an improved profile, control over vertical facial increase and mandibular plane angle, or the latter's anterior rotation, improving the sagittal maxillomandibular relationship.

Regarding MPA type, in all that experienced changes (Go-Gn, ANS-FHP, Pog-FHP, A-FHP, B-FHP, ASFH, PFH, and LAFH) greater changes in measurements were observed in the group using MPA type 1 and 2 than in the second group using MPAs 3 and 4 (Tables 3 and 4). But this difference was not present prior to treatment (Tables 5 and 6). Such changes may be associated with the fact that MPAs type 1 and 2 showed more limited mouth opening, greater rigidity, longer-acting time and therefore greater effectiveness.

However, these findings cannot be considered fully conclusive due to some limitations in this study, among which are a small sample size, absence of a control group and the fact that patients were not randomly assigned. Thus, further studies need to be conducted, including assessment of variables that could influence the results.

CONCLUSIONS

Given the methods employed and the results obtained in this study, it can be concluded that treatment with MPA:

1. Worked by restricting anterior maxillary displacement, with decreased SNA.
2. Influenced the anterior-most mandibular position (SNB, Go-Gn, B-FHp and Pog-FHp).
3. Was effective in reducing facial convexity and correcting the maxillomandibular relationship.
4. Did not influence mandibular vertical growth

since the angular variables showed no significant posttreatment behavior (SN.PP, SN.GoGn, SN.GoMe). However, anterior and posterior facial heights increased significantly, despite the fact that the mandibular plane angle remained stable. The following influences were noteworthy: (a) variable age (the sample was experiencing pubertal growth spurt), (b) variable facial pattern (dolichofacial patients benefited most), and (c) variable MPA type (probably due to the greater stiffness of types 1 and 2).

REFERENCES

1. Allen-Noble, P. Clinical management of the MARA. *Orthodontic CyberJournal*, Auburn, ME, p.1-17, Feb. 1999.
2. Almeida-Pedrin RR, Pinzan A, Almeida RR, Almeida MR, Henriques JFC. Efeitos do AEB conjugado e do Bionator no tratamento da Classe II, 1ª divisão. *Rev Dental Press Ortodon Ortop Facial*. 2005;10(5):37-54.
3. Björk A. Prediction of mandibular growth rotation. *Am J Orthod*. 1969;55(6):39-53.
4. Calvez X. The universal bite jumper. *J Clin Orthod*. 1998;32(8):493-500.
5. Castanon R, Waldez M, White LW. Clinical use of the Churro jumper. *J Clin Orthod*. 1998;32(12):731-45.
6. Coelho Filho CM. Mandibular Protraction Appliance for Class II treatment. *J Clin Orthod*. 1995;29(5):319-36.
7. Coelho Filho CM. Emprego do Aparelho de Protração Mandibular. In: Grupo Brasileiro de Professores de Ortodontia e Odontopediatria. 9º Livro Anual do Grupo Brasileiro de Professores de Ortodontia e Odontopediatria. 1ª ed. São Paulo: IMC- Image Maker Comunicações; 2000. p. 122-9.
8. Coelho Filho CM. Clinical application of the Mandibular Protraction Appliance. *J Clin Orthod*. 1997;31(2):92-102.
9. Coelho Filho CM. The Mandibular Protraction Appliance n 3. *J Clin Orthod*. 1998;32(6):379-84.
10. Coelho Filho CM. Emprego clínico do aparelho para projeção da mandíbula. *Rev Dental Press Ortodon Ortop Facial*, 1998;3(5):69-130.
11. Coelho Filho CM. O Aparelho de Protração Mandibular IV. *Rev Dental Press Ortodon Ortop Facial*. 2002;7(2):49-60.
12. Coelho Filho CM. O Aparelho de Protração Mandibular (APM) no tratamento de pacientes adultos. In: Sakai E. et al. *Nova visão em Ortodontia-Ortopedia Facial*. 1ª ed. São Paulo: Ed. Santos; 2002. p.457-63.
13. De Vicenzo J. The Eureka Spring: a new interarch force delivery system. *J Clin Orthod*. 1997;31(7):454-67.
14. Enlow DH. *Crescimento facial*. 3ª ed. São Paulo: Artes Médicas; 1993.
15. Fränkel R, Fränkel C. *Ortopedia orofacial com o regulador de função*. 2ª ed. Rio de Janeiro: Guanabara Koogan; 1996.

16. Gandini Junior LG, Martins JCR, Gandini MREAS. Avaliação cefalométrica do tratamento da Classe II, divisão 1ª, com aparelho extrabucal de Kloehe e aparelho fixo: alterações esqueléticas (Parte I). *Rev Dental Press Ortodon Ortop Maxilar*. 1997;2(6 Pt 1):75-87.
17. Garcia C. Jasper Jumper: alternativa para a correção da Classe II. *Ortodontia*. 1998;3(2):93-100.
18. Jasper JJ. The correction of interarch malocclusions using a fixed force module. *Am J Orthod Dentofacial Orthop*. 1995;108(6):641-50.
19. Klapper L. The Superspring II: a new appliance for non-compliant patients. *J Clin Orthod*. 1999;33(1):50-4.
20. Konik M, Pancherz H, Hansen K. The mechanism of Class II correction in late Herbst treatment. *Am J Orthod Dentofacial Orthop*. 1997;112(1):87-91.
21. Lai M. Molar distalization with the Herbst appliance. *Semin Orthod*. 2000;6(5):119-28.
22. Loiola AV, Ramos E, Sakima MT, Sakima T. Aparelho para a projeção da mandíbula modificado. *Rev Clin Ortod Dental Press*. 2002;1(4):31-7.
23. Manfredi C, Cimino R, Trani A, Pancherz H. Skeletal changes of Herbst appliance therapy investigated with more conventional cephalometrics an European norms. *Angle Orthod*. 2001;71(3):170-6.
24. Pancherz H. The Herbst appliance: its biologic effects and clinical use. *Am J Orthod Dentofacial Orthop*. 1985;87(1):1-20.
25. Pancherz H, Ruf S, Kohlhas P. Effective condylar growth and chin position changes in Herbst treatment: a cephalometric long-term study. *Am J Orthod Dentofacial Orthop*. 1998;114(4):437-46.
26. Sakima MT, Pinto AS, Raveli DB, Martins LP, Ramos AL. Estudo do ângulo nasolabial em indivíduos Classe II 1ª divisão com diferentes padrões faciais. *Rev Dental Press Ortodon Ortop Facial*. 2001;6(5):11-5.
27. Silva Filho OG, Freitas SF, Cavassan AO. Prevalência de oclusão normal e má oclusão em escolares na cidade de Bauru (São Paulo). Parte I: relação sagital. *Rev Odont USP*. 1990;4(2 Pt 1):130-7.
28. Silva Filho OG, Ozawa TO, Ferrari Júnior FM, Aiello CA. Aparelho de Herbst: variação para uso na dentição mista. *Rev Dental Press Ortodon Ortop Facial*. 2000;5(2):119-28.
29. Siqueira DF. Estudo comparativo, por meio de análise cefalométrica em norma lateral, dos efeitos dento-esqueléticos e tegumentares produzidos pelo aparelho extrabucal cervical e pelo aparelho de protração mandibular, associados ao aparelho fixo, no tratamento da Classe II, 1ª divisão de Angle [tese]. Bauru: Universidade de São Paulo; 2004.
30. Vasconcelos JCQ. Avaliação das alterações verticais da face proporcionadas pelo tratamento com o Bionator de Balters [monografia] Goiânia: Associação Brasileira de Odontologia; 2004.

Submitted: September 2007
Revised and accepted: February 2009

Contact address

Emmanuelle Medeiros de Araújo
Av. Lima e Silva, 1611, sala 206 - Lagoa Nova
CEP: 59.075-710 - Natal / RN, Brazil
E-mail: emmanuelle_rn@hotmail.com

Angle Class II, division 2 malocclusion treated with extraction of permanent teeth*

Sílvia Luís Dalagnol**

Abstract

This study describes the orthodontic treatment of a woman with Angle Class II, division 2 malocclusion, impacted maxillary third molars, periodontal pocket, gingival recession and tooth wear. Treatment consisted of extraction of maxillary second premolars and anchorage control. This case was presented to the Committee of the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) in the Free Case category as part of the requisites to obtain the BBO Diploma.

Keywords: Angle Class II malocclusion. Adult. Impacted tooth. Periodontal pocket. Tooth extraction. Orthodontic anchorage.

HISTORY AND ETIOLOGY

The patient, encouraged by her periodontist, sought orthodontic treatment at 28 years of age. Her main complaint was unsatisfactory dental esthetics. Her medical history was uneventful. Her dental history, however, reported by the periodontist, included a periodontal pocket in the mesial aspect of the right mandibular first molar (tooth #46), gingival recession in several teeth, tooth wear, and an indication for extraction of impacted maxillary third molars.

DIAGNOSIS

Facial evaluation revealed a harmonious, slightly concave profile, retruded lips, mild facial asymmetry, mandible shifted to the left and gingival display on the right side during smiling (Fig 1).

She presented an Angle Class II, division 2

malocclusion, with characteristic maxillary crowding and less marked mandibular crowding, mesial space in tooth #46 and a prosthesis, smaller when compared with its contralateral tooth. The maxillary gingival margins were uneven, there was discrete gingival recession in teeth #14, 22, 23 and 24, and the occlusal plane was uneven. Maxillary central incisors were retruded, inclined lingually and excessively worn, and lateral incisors were protruding and malformed. Maxillary second premolars had restorations and their size was disproportionate in comparison with the other teeth. The maxillary and mandibular canines had an edge-to-edge relation, marked overbite, and a functional displacement from centric relation (CR) to maximal intercuspation (MI). The upper part of the midline was shifted to the right in relation to the mid sagittal plane, and the lower, to the left (Figs 1 and 2).

How to cite this article: Dalagnol SL. Angle class II, division 2 malocclusion treated with extraction of permanent teeth. Dental Press J Orthod. 2011 May-June;16(3):125-35.

* Case Report, Free Choice Case Category, approved by the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

** MSc in Orthodontics, Federal University of Rio de Janeiro State, Brazil. Diplomate, Brazilian Board of Orthodontics and Facial Orthopedics.

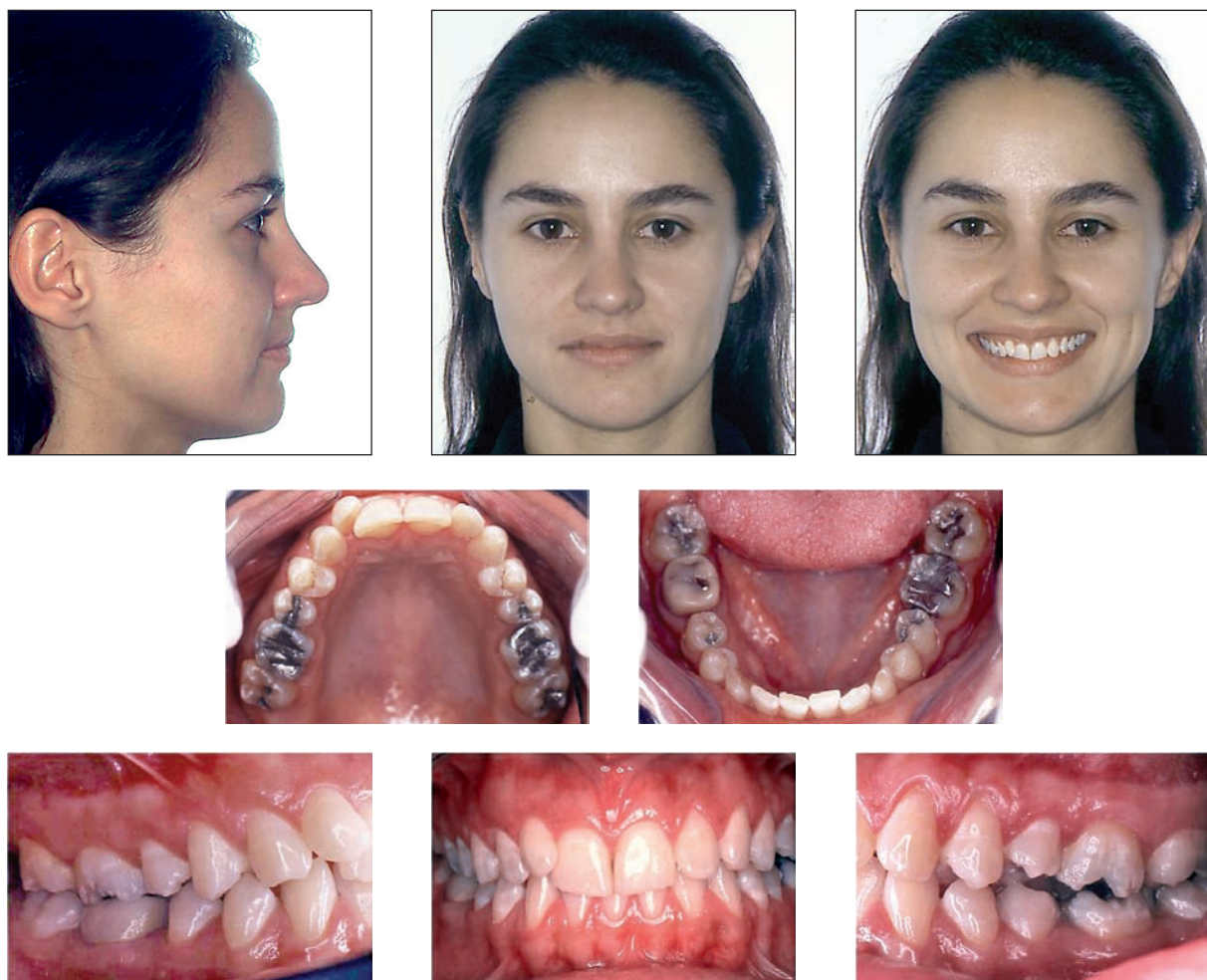


FIGURE 1 - Initial facial and intraoral photographs.

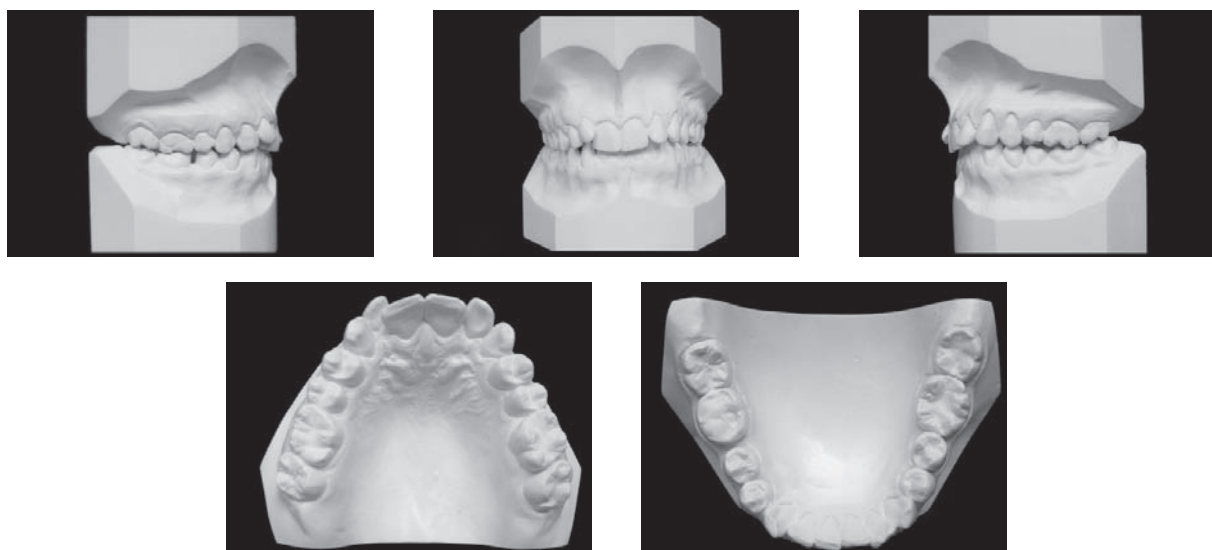


FIGURE 2 - Initial dental casts.

Radiographs showed a mesial periodontal pocket in tooth #46; teeth #38 and 48 were missing, and teeth #18 and 28 were impacted (Fig 3).

Cephalometric evaluation showed skeletal harmony: ANB was 3° , but the low values of the mandibular plane (SN-GoGn= 29° and FMA= 22°), the high value of the facial angle (89°) and the pogonion shape indicated a brachyfacial profile. Measurements to define dental pattern confirmed retrusion and lingual inclination of maxillary (I-NA= 15° and 3 mm) and mandibular (I-NB= 19° and 2.5 mm) incisors. Cephalometric measures are shown in Figure 4 and Table 1.

TREATMENT OBJECTIVES

As the main complaint was esthetical, the purpose of the treatment was to level maxillary gingival margins⁵ for esthetical and functional rehabilitation, and to extrude tooth #46 to reestablish normal periodontal space, as requested by the periodontist.

Specific objectives were to keep the harmonious facial profile, to improve maxillary occlusal

plane by extrusion in the left side but not on the right side, and to obtain a Class II relationship between molars and normal occlusion between canines according to Andrew's keys of occlusion, all under maximal anchorage control, as well as to correct upper and lower midlines, overbite, incisor tipping and leveling of the curve of Spee.

Therefore, at the end of the treatment, facial harmony was expected to be preserved, smile esthetics improved, and centric relation (CR), maximal intercuspation (MI) and normal excursion corrected.



FIGURE 3 - Initial panoramic radiograph.

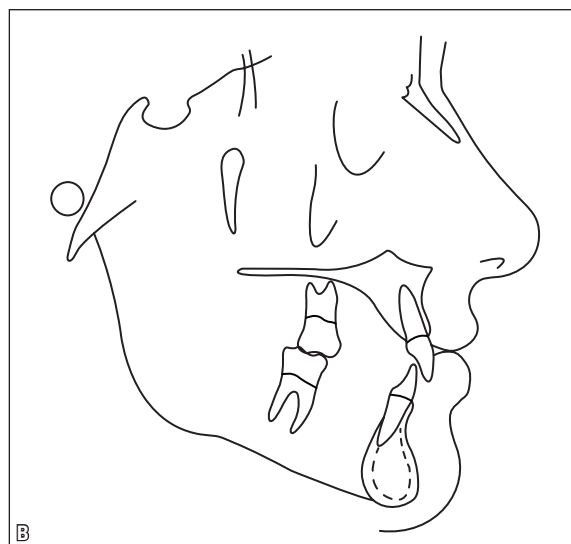


FIGURE 4 - Initial cephalometric profile radiograph (A) and cephalometric tracing (B).

TREATMENT PLAN

To achieve the treatment objectives, we chose to extract maxillary second premolars² because they were very small and had already been restored, although we were aware that this would complicate orthodontic mechanics. First, a fixed appliance would be placed in the upper arch, except for teeth #12 and 22 (Standard edgewise system, 0.018x 0.025-in slot) and a Kloehn extraoral appliance would be prepared for maximal anchorage. For maxillary leveling, 0.015-in round multistranded and 0.014 and 0.016-in stainless steel archwires would be used, but not for maxillary lateral incisors. After that, premolars and canines would be moved distally using chain elastics to create spaces for canines mesially. Then, lateral incisors would be bonded and leveled with nickel-titanium sectional archwires. The mandibular appliance would be mounted up to the second molars as soon as possible and according to the progression of maxillary incisor movement and creation of interocclusal spaces. The same sequence of archwires would be used to level the curve of Spee. Moreover, tooth #46 would be adjusted to enable its extrusion and the elimination of the periodontal pocket. After achieving normal canine occlusion according to Andrew's keys, the incisors would undergo retraction using a 0.017x 0.022-in stainless steel archwire with teardrop-loops. Finally, upper and lower continuous 0.017x 0.022-in stainless steel archwires would be used. According to gingival margin leveling and periodontal pockets in maxillary teeth, the appliance would be reassembled. After the removal of the fixed appliance, a wraparound retainer (full time wear) would be prescribed to be worn until esthetic and functional restorations were made, an intercanine arch would be bonded for mandibular retention, and the new maxillary retainer would be installed, in accordance with the new teeth shapes. The third molars would be fol-

lowed up to define whether they should be preserved or extracted later on.

TREATMENT PROGRESSION

The maxillary appliance was installed using orthodontic bands in the first molars, and 0.018x 0.025-in standard-Edgewise slot metal brackets were bonded on the other teeth except lateral incisors and second premolars. After that, the extraction of the second premolars was requested and the Kloehn extraoral appliance was adapted for nighttime wear. Individualized 0.015-in round multistranded and 0.014 and 0.016-in stainless steel archwires and elastic chains were used for maxillary alignment and leveling, including first premolars and canines, but not lateral incisors. After mesial spaces were created for the canines, lateral incisors were bonded and leveled using 0.012 to 0.016-in nickel-titanium wires and sectional archwires under straight wire. In the mandibular arch, brackets were bonded up to the second molars. Alignment and leveling were achieved using straight wires in the same sequence as in the maxillary arch. A small retraction of the maxillary incisors was necessary; for that, 0.017x0.022-in stainless steel archwire with teardrop-loops was used. To complement alignment and leveling, 0.017x0.022-in stainless steel coordinated wires were used. After that, a panoramic radiograph was obtained to evaluate root inclination, and the positions of some brackets were changed for leveling using 0.012 and 0.014-in nickel-titanium wires under rectangular wires. Finally, the same rectangular wires were used in association with elastics to achieve Class II occlusion on the left side. After evaluation by the periodontist, the appliance was removed and the wraparound retainers were installed for full time wear. As previously agreed on with the dentist, the patient was referred to a specialist for whitening and restorations and returned for a new maxillary retainer and bonding of the maxillary intercanine arch.



FIGURE 5 - Final facial and intraoral photographs.

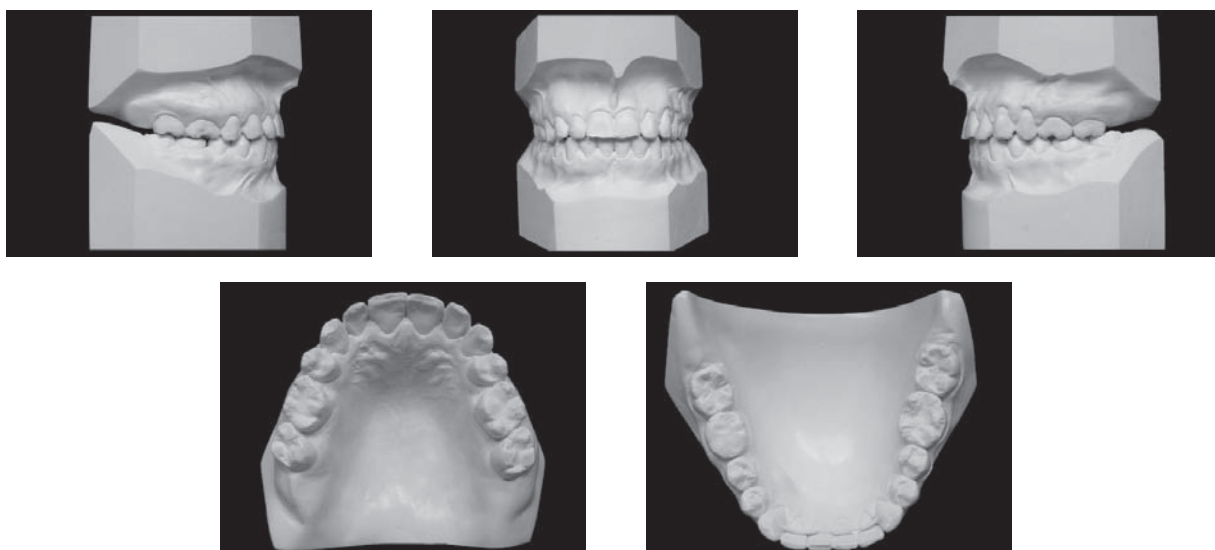


FIGURE 6 - Final casts.

TREATMENT RESULTS

The main treatment objectives were achieved, as confirmed by the patient's final examinations (Figs 5-8).

In the maxilla, the SNA angle was reduced in 1 degree because of bone remodeling resulting from the correction of incisor tipping.¹ In the mandible, the mandibular plane angles (SN-GoGn and FMA) and Y axis were reduced, and the facial angle increased, although a Kloehe extraoral appliance was used. The analysis of dental pattern confirmed that there were positive changes in incisor position and tipping, as well as a better leveling of gingival margins. The evaluation of total cephalometric comparison confirmed profile, maxillary and dental changes. The partial comparison showed changes in A point¹ and dental changes (Fig 9).

A Class II relation was achieved between molars, together with intentional maxillary premolar and molar rotation to improve intercuspation and normal canine occlusion according to Andrews' keys. Dental midlines coincided with the facial midline. Overbite was corrected as the maxillary and mandibular incisors were

intruded and the curve of Spee was leveled. Gingival recessions did not change because tooth #22 recession did not allow for the definition of a better contour for the gingival margins (Figs 5 and 6).



FIGURE 7 - Final panoramic radiograph.

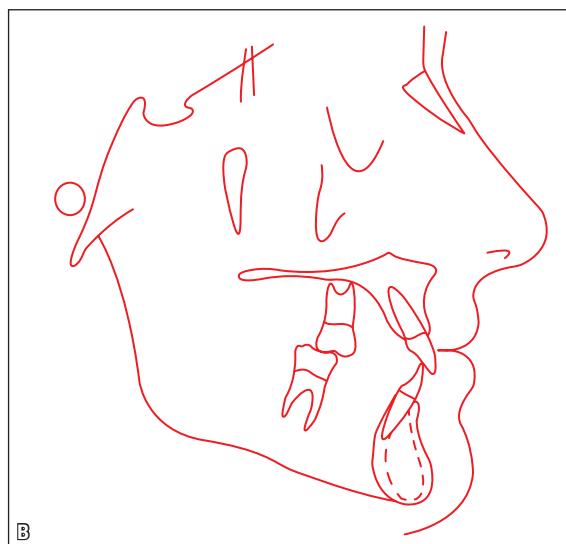


FIGURE 8 - Final cephalometric profile radiograph (A) and cephalometric tracing (B).

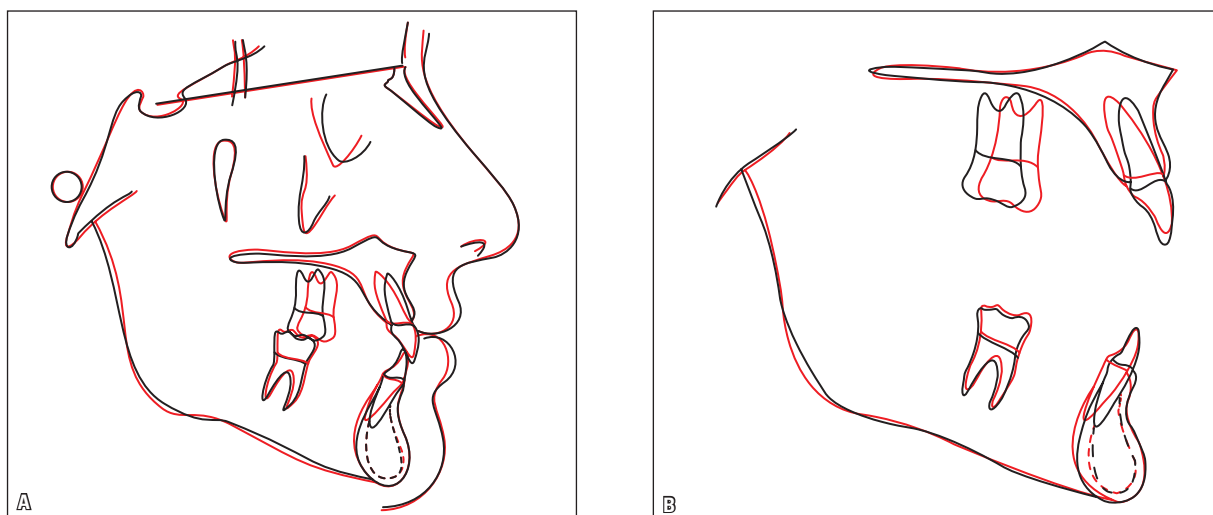


FIGURE 9 - Total (A) and partial (B) comparisons of initial (black) and final (red) cephalometric tracings.



FIGURE 10 - Facial and intraoral photographs four years and five months after treatment completion.

Intercanine and intermolar distances remained unaltered. Maxillary intercanine distance increased 3.7 mm as a result of canine distal movement, and maxillary intermolar distance decreased 4.1 mm due to the loss of anchorage and the intentional mesial rotation of molars (Table 2).

The analysis of radiographs revealed bone leveling in tooth #46, and root dilacerations, mostly in the canines, which were visible only after rotations were corrected. Despite these dilacerations, roots were parallel and root rounding was compatible with the great amount of movement of maxillary central incisors. Root resorption, more marked in tooth #12⁶, occurred primarily in the last phase of the treatment, and will be followed up. The progression of third molar eruption was small and will continue under observation (Fig 7).

Facial profile remained harmonious despite slight lip retrusion,³ the smile was significantly

improved after the correction of the maxillary occlusal inclination and the adequate alignment and leveling of anterior teeth, and the esthetic and functional rehabilitation desired by the patient was achieved.

The evaluation of control examinations (Figs 10-14) performed 4 years and 5 months after treatment completion showed esthetic and functional resin restorations in the anterior teeth, the metal-ceramic prosthesis of tooth #46, and other restorations that had been made by her clinical dentist. Occlusion remained balanced, there were no shifts in CR or MI, and intercanine and intermolar distances remained stable. Cephalometric measures either remained stable or had minor changes. Radiographs confirmed the apparent stability of root resorptions and the good progression of maxillary third molar eruption. In this phase, the maxillary retainer was changed to include buccal springs in teeth #18 and 28 to help correcting their position.

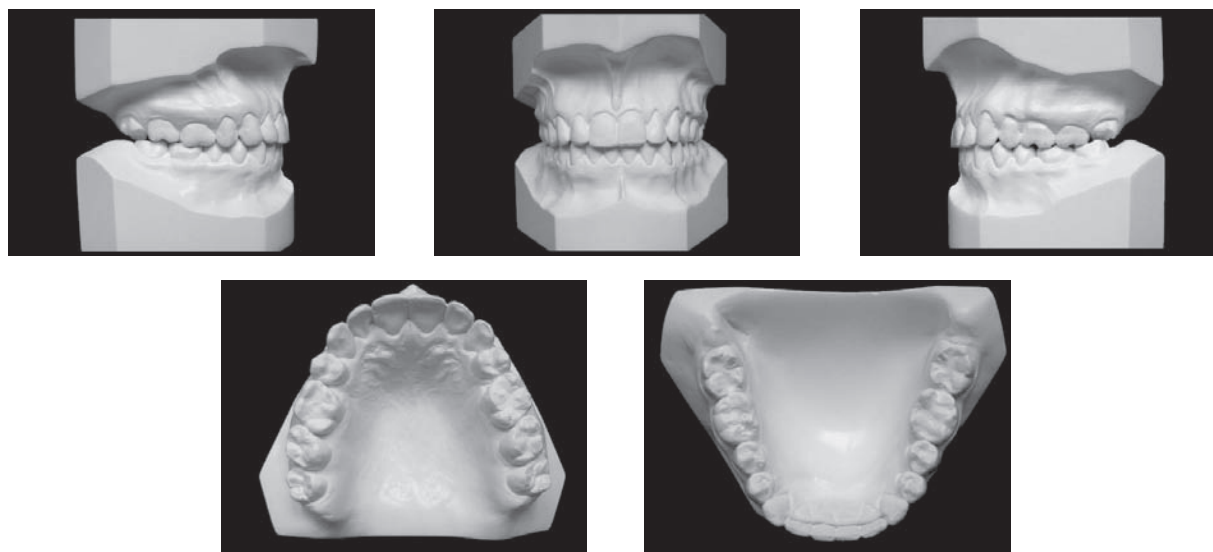


FIGURE 11 - Control dental casts four years and five months after treatment completion.



FIGURE 12 - Control panoramic radiograph four years and five months after treatment completion.



FIGURE 13 - Control cephalometric profile radiograph (A) and cephalometric tracing (B) four years and five months after treatment completion.

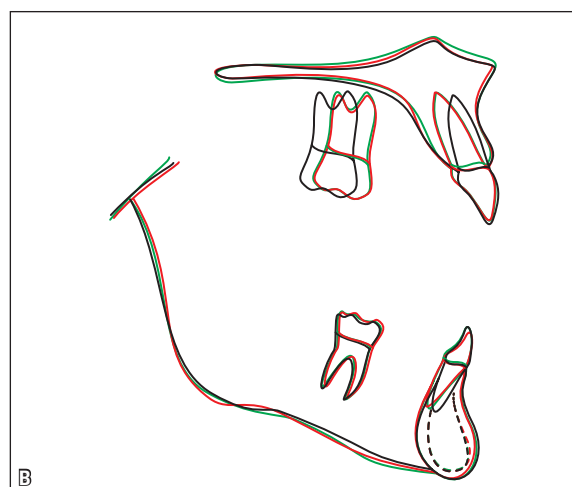


FIGURE 14 - Total (A) and partial (B) comparisons of cephalometric tracings at initial (black), final (red) and four years and five months after treatment completion (green).

TABLE 1 - Summary of cephalometric measurements.

MEASUREMENTS		Normal	A	B	A/B DIFFERENCE	C
Skeletal Pattern	SNA (Steiner)	82°	81°	80°	-1	80°
	SNB (Steiner)	80°	78°	78°	0	78°
	ANB (Steiner)	2°	3°	2°	-1	2°
	Convexity angle (Downs)	0°	0.5°	0°	-0.5	0.5°
	Y axis (Downs)	59°	59°	58°	-1	58°
	Facial angle (Downs)	87°	89°	90°	1	90°
	SN-GoGn (Steiner)	32°	29°	28°	-1	28°
	FMA (Tweed)	25°	22°	20°	-2	20°
Dental Pattern	IMPA (Tweed)	90°	93°	99°	6	99°
	$\underline{1}$ – NA (degrees) (Steiner)	22°	15°	23°	8	22°
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	3 mm	4 mm	1	4 mm
	$\bar{1}$ – NB (degrees) (Steiner)	25°	19°	25°	6	26°
	$\bar{1}$ – NB (mm) (Steiner)	4 mm	2.5 mm	3 mm	0.5	3 mm
	$\frac{1}{\bar{1}}$ – Interincisal angle (Downs)	130°	142°	128°	-14	130°
	$\bar{1}$ – APo (mm) (Ricketts)	1 mm	-1.5 mm	-0.5 mm	1	-0.5 mm
Facial Profile	Upper lip – S line (Steiner)	0 mm	-3 mm	-4.5 mm	-1.5	-4.5 mm
	Lower lip – S line (Steiner)	0 mm	-2 mm	-3.5 mm	-1.5	-3.5 mm

TABLE 2 - Transverse distances of dental arches.

MEASUREMENTS	A	B	A/B DIFF.	C
Mandibular intercanine distance	25.6 mm	25.6 mm	0	25.6 mm
Mandibular intermolar distance	43.6 mm	43.6 mm	0	43.1 mm
Maxillary intercanine distance	33 mm	35.6 mm	+2.6	35.6 mm
Maxillary intermolar distance	48.8 mm	44.7 mm	-4.1	44.7 mm

FINAL CONSIDERATIONS

As the patient's main complaint was about dental esthetics, the main treatment objectives have been achieved. Correct incisor alignment and leveling resulted in the desired esthetic and functional rehabilitation.

In adult patients, the plan to treat Angle Class II, division 2 malocclusion often includes the extraction of the maxillary first premolars to facilitate anchorage and reduce treatment time. In this case, because of the size and clinical condition of

the second premolars, we chose to extract them, although we were aware that this would make anchorage more difficult.

The evaluation of total cephalometric comparison (Fig 14) confirmed the preservation of the skeletal pattern and the changes in dental pattern and facial profile. Bone remodeling due to the correction of maxillary incisor tipping and associated with the marked retraction of maxillary lateral incisors was confirmed in the partial

comparison of the maxilla. As maxillary lateral incisors worked as support for the lips in the beginning of the treatment, those changes might have resulted in a slight lip retrusion and made the profile more concave.

Control examinations (Figs 10-14) showed that the smile improved, the profile remained harmonious and occlusion remained stable, which confirms that the treatment objectives have been achieved.

REFERENCES

1. Tien An TL, Cuoghi OA, Mendonça MR, Bertoz FA. O efeito da retração dos dentes anteriores sobre o ponto A em pacientes submetidos ao tratamento ortodôntico corretivo. *Rev Dental Press Ortod Ortop Facial*. 2008 mar-abr;13(2):115-23.
2. Brandt S, Safirstein R. Different extractions for different malocclusions. *Am J Orthod*. 1975 Jul;68(1):15-41.
3. Hershey HG. Incisor tooth retraction and subsequent profile change in postadolescent female patients. *Am J Orthod*. 1972 Jan;61(1):45-54.
4. Kloehe SJ. Evaluation of cervical anchorage force in treatment. *Angle Orthod*. 1961 Apr; 31(2):91-104.
5. Kokich VG. Esthetics: the orthodontic-periodontic restorative connection. *Semin Orthod*. 1996;2(1):21-30.
6. Mirabella AD, Artun J. Risk factors for apical root resorption of maxillary anterior teeth in adult orthodontic patients. *Am J Orthod Dentofacial Orthop*. 1995 Jul;108(1):48-55.

Submitted: April 2011
Revised and accepted: May 2011

Contact address

Silvio Luís Dalagnol
Av. Batel, 1230, Cj. 706, Batel
CEP: 80.420-906 - Curitiba / PR, Brazil
E-mail: silvio@dalagnolortodontia.com.br

Criteria for diagnosing and treating anterior open bite with stability

Alderico Artese*, Stephanie Drummond**,
Juliana Mendes do Nascimento***, Flavia Artese****

Abstract

Introduction: Anterior open bite is considered a malocclusion that still defies correction, especially in terms of stability. The literature reports numerous studies on the subject but with controversial and conflicting information. Disagreement revolves around the definition of open bite, its etiological factors and available treatments. It is probably due to a lack of consensus over the etiology of anterior open bite that a wide range of treatments has emerged, which may explain the high rate of instability following the treatment of this malocclusion. **Objective:** Review the concepts of etiology, treatment and stability of anterior open bite and present criteria for diagnosing and treating this malocclusion based on its etiology, and provide examples of treated cases that have remained stable in the long term.

Keywords: Open bite. Etiology. Treatment. Stability.

INTRODUCTION

The term “open bite” was coined by Caravelli in 1842 as a distinct classification of malocclusion¹ and can be defined in different manners.² Some authors have determined that open bite, or a tendency toward open bite, occurs when overbite is smaller than what is considered normal. Others argue that open bite is characterized by end-on incisal relationships. Finally, others require that no incisal contact be present before diagnosing open bite. For semantic reasons, and because it is in agreement with most definitions

in the literature,^{2,3,4,5} anterior open bite (AOB) is herein defined as the lack of incisal contact between anterior teeth in centric relation.

Given these different definitions for AOB, its prevalence varies considerably among studies depending on how authors define it. Prevalence in the population ranges from 1.5% to 11%.⁶ The age factor, however, affects prevalence, since sucking habits decrease and oral function matures with age. At six years old 4.2% present with AOB whereas at age 14 the prevalence decreases to 2%.⁵ In the US population, differences in prev-

How to cite this article: Artese A, Drummond S, Nascimento JM, Artese F. Criteria for diagnosing and treating anterior open bite with stability. Dental Press J Orthod. 2011 May-June;16(3):136-61.

* MSc in Orthodontics, University of Washington. Associate Professor of Orthodontics, UFRJ (Retired).

** Specialist and Masters Student in Orthodontics, UERJ.

*** Specialist in Orthodontics, UERJ.

**** MSc and PhD in Orthodontics, UFRJ. Associate Professor of Orthodontics, UERJ. Brazilian Board of Orthodontics and Facial Orthopedics Diplomate.

alence were detected between the different ethnicities, with 3.5% occurring in Caucasian children and 16.5% in Afro-descendant children.⁵ Despite its low prevalence, the demand for treatment of this malocclusion is very common as approximately 17% of orthodontic patients have AOB,⁶ which means that professionals should treat it in an effective and stable manner.

AOB ETIOLOGICAL FACTORS: FUNCTIONAL OR SKELETAL?

Teeth and alveolar bones are exposed to antagonistic forces and pressures stemming mostly from muscle function, which may partly determine the position of the teeth. On the other hand, the intrinsic forces of the lips and tongue at rest generate the balance required to position the teeth (Fig 1). By definition, balance

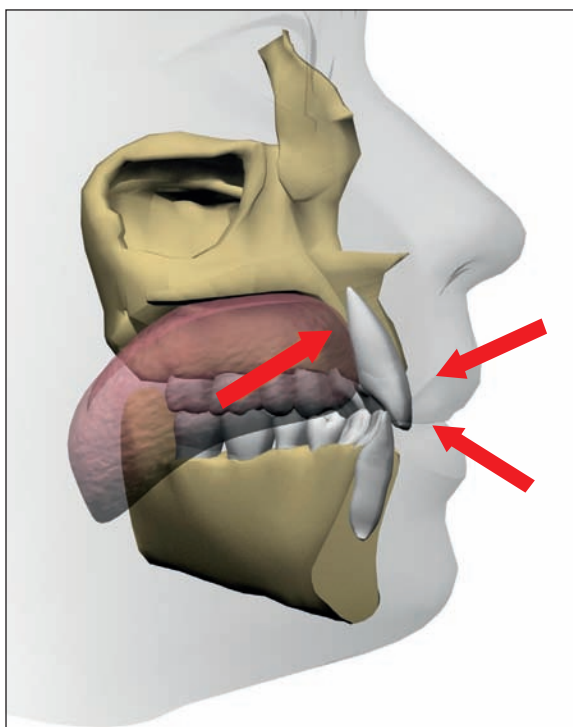


FIGURE 1 - Schematic illustrating balance between forces of lips and tongue (arrows), allowing contact of maxillary incisor and therefore achieving normal overbite.

occurs when a body at rest is subjected to forces in various directions but does not undergo acceleration or — in the case of teeth — is not displaced.⁷ Every time this balance is altered, changes occur, such as for example contraction of the dental arches in animals subjected to glossectomy when compared to control animals.⁸ Thus, when a tooth is extracted its antagonist continues the process of passive eruption, indicating that the mechanism of eruption remains basically unchanged throughout life and that the tooth seeks occlusal or incisal contact until balance is reached.⁷

Based on this idea of balance several etiological factors related to oral function have been associated with AOB. For example, sucking habits, presence of hypertrophic lymphoid tissues, mouth breathing, atypical phonation and swallowing, and anterior posture of the tongue at rest.^{2,3,9,10,11} It should be noted, however, that not all of these etiological factors exhibit a perfectly clear cause and effect relationship.

The causal relationship between AOB and nonnutritive sucking habits, such as the sucking of fingers and pacifiers, has been very well established.¹² In such cases, AOB self-corrects consistently after removal of the sucking habit, provided that no other secondary dysfunctions have set in² (Fig 2). These secondary dysfunctions may develop from maxillary incisor protrusion generated by the sucking habit, thereby hindering the lip seal required for swallowing, and causing the tongue to be abnormally positioned, especially at rest.¹¹

During childhood the tongue is proportionally larger than the oral cavity and it therefore protrudes beyond the alveolar ridges. The jaw bones grow faster than the tongue during childhood and eventually the size of the oral cavity adapts to tongue size.¹⁰ In fact, longitudinal studies in children showed that the prevalence of tongue protrusion in speech and swallowing is significantly reduced starting at 8 years of

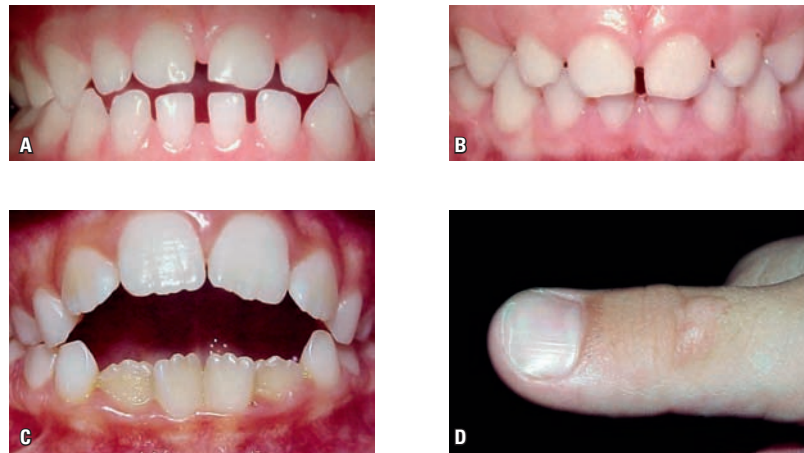


FIGURE 2 - **A)** AOB in primary teeth caused by pacifier sucking and **B)** spontaneous correction after removal of habit. **C)** AOB in mixed dentition caused by thumb sucking. It is noteworthy how AOB morphology differs according to causative agent. Pacifier is soft and deformable, creating more elongated and narrow open bite, whereas finger is stiffer and larger, creating wider, rounded open bite with protruded maxillary incisors and deficient eruption in mandibular incisors. **D)** When thumb sucking habit is so intense the back of the finger may become callous.

age. It is approximately 51.7% at 4 years of age and 38.9% at age 12.¹⁴

Some authors believe that the forces generated during swallowing and phonation can cause changes in the shape of the dental arches.⁴ Although these disorders are associated in the literature with AOB etiology, other studies show that these functions are short lived and not sufficient to cause dental changes.^{7,11} Frequency of atypical speech and swallowing is much higher than AOB prevalence, which may explain the tenuous causal link between the presence of atypical speech and swallowing, and the presence of this malocclusion.¹¹

Hypertrophic adenoids and tonsils are the most common cause of nasal obstruction and, consequently, mouth breathing in children.⁴ The effect of airway obstruction on the occlusion was demonstrated by Harvold et al¹⁶ who, after placing acrylic blocks in the posterior region of the palate of rhesus monkeys, found that AOB had developed. Induced nasal obstruction was also performed using nasal splints in rhesus

monkeys, which, in an attempt to secure an oral air passage, developed open mouth posture and protruded tongue.¹⁷

Therefore, hypertrophic lymphoid tissues and nasal obstruction may force the tongue to remain in a position designed to allow breathing to occur through the oropharyngeal rather than nasopharyngeal space.^{12,18} In general, lymphoid tissues undergo involution during puberty, allowing the tongue to adopt a position more posterior than what is deemed normal.² However, Linder-Aronson et al¹⁹ found that dentoalveolar response to adenoidectomy is highly variable and therefore should not be considered as a prophylactic procedure for the development of AOB. Indeed, not all patients with mouth breathing due to partial nasal blockage develop AOB.⁴

Most investigations of AOB etiology agree on the existence of secondary dysfunctions, which remain after the correction of an abnormal function, such as, especially, poor tongue posture at rest.^{4,7,12} It is believed that a gentle but continuous

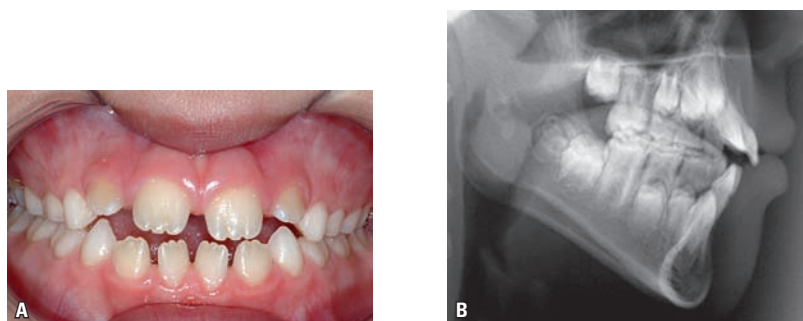


FIGURE 3 - AOB caused by poor posture of the tongue at rest and lip interposition (**A**). Cephalometric radiograph contrast allows the tongue to be viewed in its resting position, supported by the mandibular incisors, preventing their proper eruption, and the interposition of the lower lip between the incisors, preventing the proper eruption of the maxillary incisors is also visible (**B**).

pressure exerted by the tongue against the teeth can move such teeth, yielding significant effects. If a patient has a previous posture in which they have positioned their tongue, the duration of this pressure — even if very light — can affect the eruption process, or move anterior teeth, resulting in an open bite.^{10,11}

Tongue posture at rest is long lasting (several hours a day), which makes it clinically important as it can prevent the eruption of incisors, thereby causing and maintaining AOB (Fig 3). In addition, a low tongue posture may encourage the eruption of posterior teeth and constrict the upper arch since the tongue does not touch the palate.⁷ This etiological factor has not been studied enough and is generally overlooked during AOB treatment. Failure to eliminate this factor may be the primary reason of AOB relapse.¹⁰

In 1964, Subtelny and Sakuda² published an article on the diagnosis and treatment of AOB. Based on the premise that abnormal functional habits either decrease or are absent in adolescents, these authors sought out an explanation for the existence of what they called “persistent open bites,” i.e., those that persist after childhood. They conducted a cephalometric study in 25 patients with “persistent open bite” and compared them with 30 patients with normal

occlusion. All subjects were over 12 years of age. Basically, in cases of open bite the following significant differences were found: Greater eruption of maxillary molars, extrusion of maxillary incisors and overly increased mandibular planes and gonial angles. This facial pattern was named “skeletal open bite.” Its primary etiological factor is an unfavorable growth pattern with divergent basal bones and therefore no contact between the incisors. These etiological factors are associated with growth and not function, and can thus be defined as skeletal factors.

Over the years, vertical facial pattern was ultimately considered as the main risk factor for AOB and its treatment instability. However, other studies^{10,20} have reported that most hyperdivergent patients exhibit a normal or excessive overbite (Fig 4) while patients with normal facial patterns display a “persistent open bite”⁴ (Fig 5).

One can therefore infer that skeletal pattern per se cannot be the cause of AOB.⁷ In revisiting the aforementioned idea of balance of forces between teeth, the presence of a physical barrier prevents the incisors from coming into occlusal contact. Since an abnormal posture of the tongue at rest may occur in different situations,^{4,10} this may be the key etiological factor in AOB.

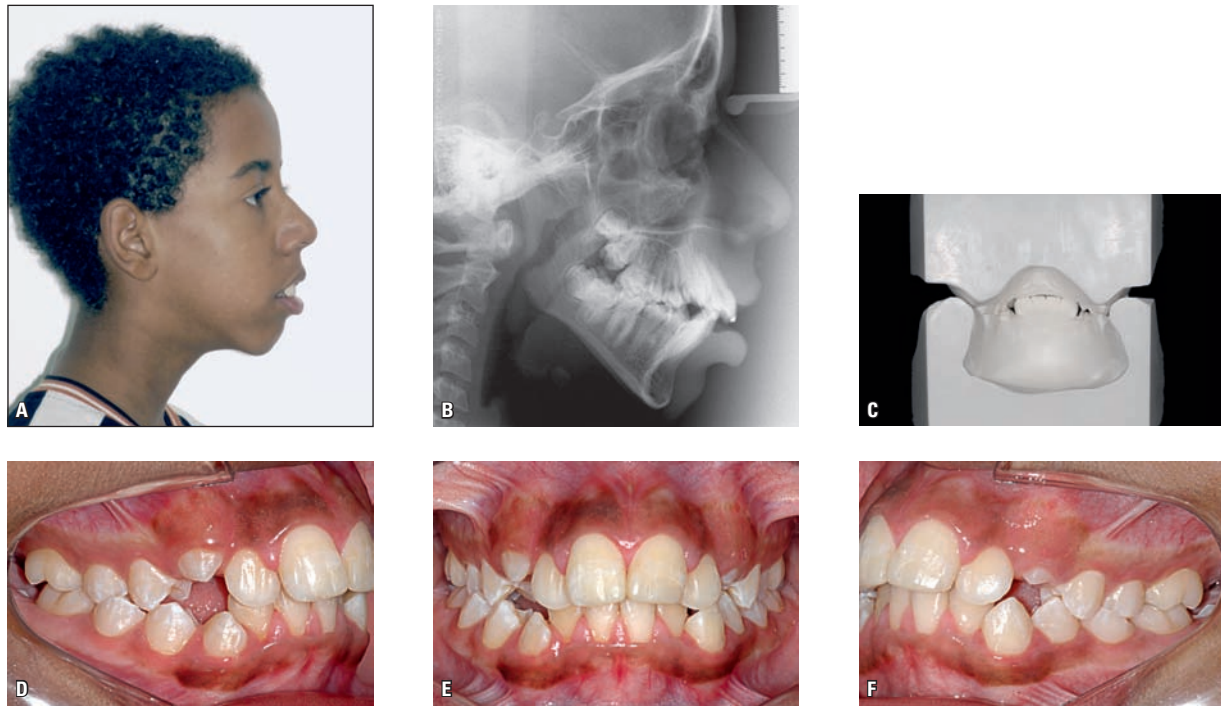


FIGURE 4 - Profile photograph (A), cephalometric radiograph (B), casts (C) and intraoral photographs (D, E and F) of a patient with hyperdivergent facial pattern (SNGoGn=49°), showing excessive overbite, which can be seen more clearly in a posterior view of the plaster casts in occlusion. The lower incisors touch the palate seeking occlusal contact since there is no structure preventing its eruption.

AOB TREATMENT AND STABILITY

Due to numerous etiological factors described in the literature various types of treatment have been postulated for correcting AOB. No consensus has been reached, however, as to what would be the best treatment for this malocclusion:⁶ (a) Changes in behavior to eliminate habits or abnormal functions, (b) Orthodontic movement by extruding the anterior teeth or intruding the molars, or (c) Surgical treatment of the basal bones.²¹ The only consensus that seems to exist is that AOB treatment is challenging^{3,6} and has poor stability.^{6,9,22}

Functional treatments

Myofunctional therapy is used to alter function and consists of a set of exercises to reeducate orofacial muscles in swallowing, speech and

resting posture.^{11,12,15} It is believed that voluntary activities such as swallowing and speech are easier to correct using myofunctional exercises while involuntary activities such as tongue posture habits are hard to automate.^{11,14}

Another way to correct functional habits is through mechanisms that prevent the tongue from resting on the teeth.²³ The best known are palatal or lingual cribs²⁴ and spurs^{10,25} There is a consensus that these devices should be fixed with the purpose of re-educating the function until automatic movements are attained.^{25,26}

Palatal or lingual cribs are aimed at correcting AOB by preventing the tongue from resting on the teeth. They must be long to prevent the tongue from positioning itself below them.²⁴ However, such structures are smooth and deliberately allow the tongue to rest on them so

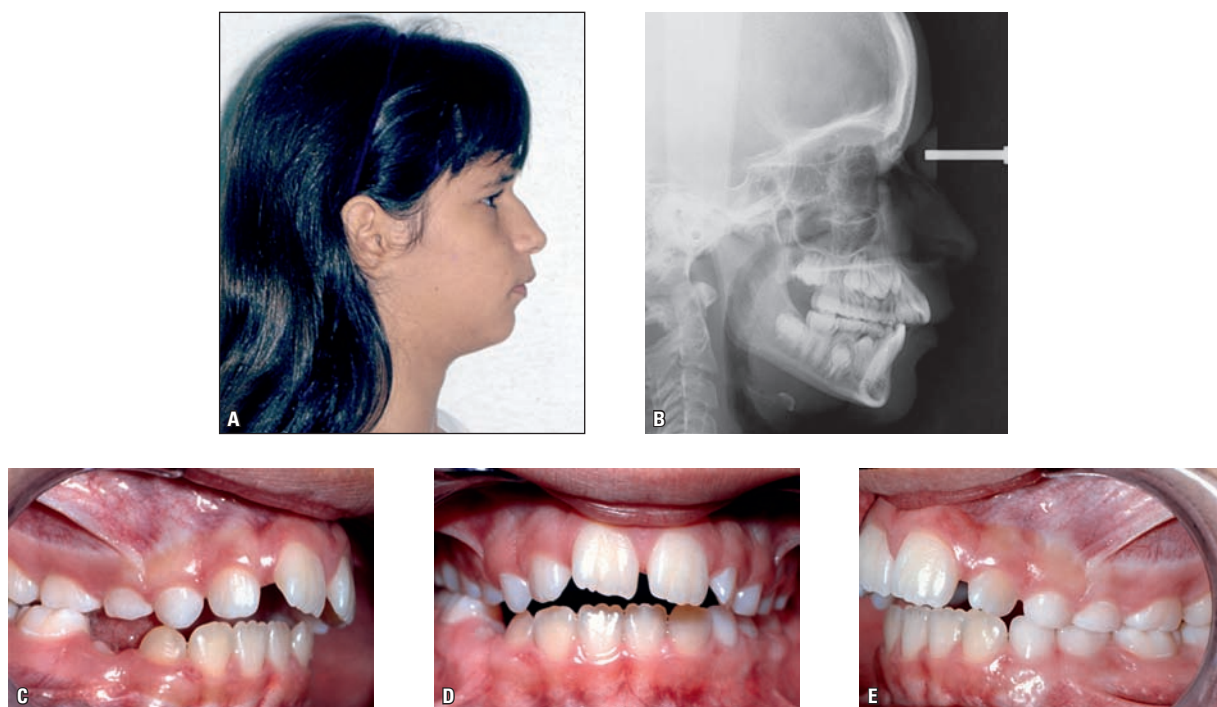


FIGURE 5 - Profile photograph (A), cephalometric radiograph (B) and intraoral photographs (C, D and E) of a patient with normal facial pattern (SNGoGn=34°), with AOB. The incisors are not in contact due to mechanical obstruction, possibly due to tongue posture since the patient reported no sucking habits.

that in some cases this may prevent the functional re-education of the tongue. In these cases, the tongue returns to its original position as shown by the cinefluoroscopic method,²⁸ thus leading to AOB relapse.

The use of spurs was described by Rogers²⁸ in 1927 in the treatment of three AOB cases. The spurs were welded to a palatal arch and placed from canine to canine. All cases were corrected by normalizing the tongue posture. Several types of similar devices were later described in which spurs can be soldered to the lingual surfaces of maxillary incisor bands or attached to palatal¹⁰ or lingual²⁹ arches or, alternately, bonded to the lingual or palatal surfaces of the incisors.²⁶

Despite their efficacy, treatments using spurs are sometimes regarded as punitive,^{1,2} although there are no reports of pain or injury to the

tongue.¹⁰ Furthermore, Haryett et al²³ concluded that any type of device used to break the finger sucking habit, including spurs, can cause psychological disorders.

Spurs induce a change in the resting position of the tongue, thus allowing tooth eruption and open bite closure. This change in tongue position alters sensory perception by the brain, thereby producing a new motor response. This response can be imprinted permanently in the brain, which explains the permanent change in tongue posture produced by spurs. This is one of the factors responsible for AOB treatment stability.^{10,25}

Huang et al³ evaluated AOB treatment stability using cribs or spurs in 33 patients divided into two groups, one with and one without growth. These authors found that AOB

correction occurred in both groups but 17.4% of cases showed relapse. Since no comparison between different treatment types was performed, one could argue that patients whose overbite is corrected with the use of cribs or spurs stand a good chance of maintaining long-term treatment outcome. However, comparative studies between these two types of treatment would be invaluable for the prognosis of AOB treatment.

Orthodontic treatments

There are several types of treatment involving orthodontic movement for correction of open bite, with different therapeutic goals. Extraoral appliances, vertical chincups, bite-blocks and functional appliances are designed to reduce the extrusion of molars, allowing a counterclockwise rotation of the mandible.^{6,9,22} More recently, the same mechanism was implemented with the aid of anchorage to intrude molars.^{6,21} Mechanics with intraoral elastics are used both for incisor extrusion² and molar intrusion, as well as for rotation of the occlusal plane combined with multiloop archwires.³⁰ Although there are many successful reports of these therapies few studies have been conducted to investigate their long-term stability, which precludes any reliable prognoses for these treatments.^{4,6,22}

Stability in the correction of AOB in patients treated orthodontically with fixed appliances associated with high-pull and combined headgear was evaluated 10 years after treatment.⁹ AOB relapse was greater than 3 mm in 35% of the cases. The sample was then stratified into stable and relapse groups for comparison of cephalometric variables. All variables were similar between the groups at the beginning of treatment, except for anterior dental height in the mandibular arch, which was lower in the relapse group at all treatment times.

Zuroff et al⁶ assessed AOB stability 10 years after treatment. Sixty-four patients were divided into three groups: One with incisal

contact, one with open bite and overlap, and one with open bite. All patients were only treated orthodontically. After treatment, 4% of the group with incisal contact had overjet relapse; 20% of the group with open bite and overlap had overjet relapse but preserved incisal contact; and 40% of the open bite group had overjet, with 60% displaying no incisal contact. These results indicate that a lack of vertical overlap prior to treatment exerts a greater adverse effect on AOB stability compared to open bite with overlap.

Surgical Treatments

Surgical treatments for AOB began in the 70s and were indicated for extremely severe cases with mandibular plane above 50 degrees. Thereafter, these treatments have become more common and usually include LeFort I osteotomy for superior repositioning of the maxilla. This allows a counterclockwise rotation of the mandible, thus correcting AOB.²²

Denison et al²² assessed the stability of AOB surgical treatment in 66 adult patients followed up for at least 1 year after surgery. These patients were stratified according to preoperative vertical overlap, namely: Open bite, open bite with overlap, and normal overlap. Open bite recurred in 42.9% of cases in the open bite group while the groups with open bite and overlap, and normal overlap showed no changes in postoperative overbite. It was found that the instability found in patients in the open bite group was due to dentoalveolar changes and not to skeletal changes.

Once it has been eliminated in surgical patients, one cannot claim that hyperdivergence is an etiological factor since these patients are adults and exhibit little or no growth. Therefore, it is believed that the relapses found in the study described above are of dentoalveolar origin, generated by oral disorders overlooked in the pretreatment phase.¹⁰

Greenlee et al²¹ published a meta-analysis which evaluated AOB treatment stability in surgical and nonsurgical studies. A 75% stability rate was found in both types of treatment. However, these results should be viewed with caution since these various treatments were examined in different studies and applied to different populations. Moreover, these studies lacked control groups.

Nowadays there are not enough evidence-based findings to support the effectiveness of AOB²¹ treatment or stability of AOB correction. Randomized trials evaluating different therapies are thus necessary.⁵ However, the outcomes of the stability studies described above indicate that AOB relapse is linked to two factors: Dentoalveolar changes and open bites with no vertical overlap prior to treatment.^{3,6,9,22} These data suggest that AOB relapse is generally caused by the anterior position of the tongue at rest, an etiological factor that has not merited due attention in both orthodontic and surgical treatment.^{3,10}

DIFFERENT POSTURES OF THE TONGUE AT REST

AOB morphology is directly associated with etiological factors,⁷ which differ for each type of habit (Fig 2). In AOB cases that do not result from sucking habits one can use this logic to differentiate between the resting positions of the tongue, as there may be more than one type of resting position.

The position considered normal for the tongue at rest is one in which the tip of the tongue rests on the incisal papilla and its back lies along the palate (Figs 1 and 6A), keeping the anterior teeth in balance while preserving the transverse dimension of the upper arch.⁷ However, some AOBs show changes in the positions assumed by maxillary incisors and others display changes in the positions of mandibular incisors. Based on these morphological

characteristics some different resting positions of the tongue are suggested: High, horizontal, low and very low (Fig 6).

A high posture of the tongue at rest is associated with slightly protruded maxillary incisors and AOB may exhibit vertical overlap and positive horizontal overlap. Since the tongue rests on the palatal surface of the incisors, beneath the incisal papilla, upper incisors are positioned above the occlusal plane. Leveling of the mandibular arch is unaffected and displays a single occlusal plane (Fig 7). Posterior crossbites are not present as the back of the tongue rests on the palate while maintaining the transverse dimension of the upper arch.

In the horizontal posture of the tongue at rest, the tongue appears lower than in the high position, although with greater protrusion, resting on the palatal surface of the upper incisors and on the incisal edges of the lower incisors. The major effect in this case can only be seen in the upper arch, where protrusion of maxillary incisors was more prominent, which prevented their extrusion, thereby causing AOB. Also due to the greater protrusion of the incisors, a positive and increased horizontal overlap was noted. As the tongue positions itself lower, its back turns away from the palate allowing transverse changes to occur in the maxillary arch, which may cause posterior crossbites (Fig 8).

As the tongue assumes a lower position, pressure begins to be exerted on mandibular teeth. In the low posture of the tongue, it rests on the lingual surface of the crowns of mandibular incisors, thereby protruding these teeth and preventing their eruption, which establishes a moderate open bite. Due to protrusion in the lower incisors, horizontal overlap may be zero or negative. A gap can be seen between the occlusal surfaces of posterior teeth and the incisal surfaces of anterior teeth in the lower arch only, with lower incisors positioned below the occlusal level. Posterior crossbites may be present for the same reason mentioned above (Fig 9).

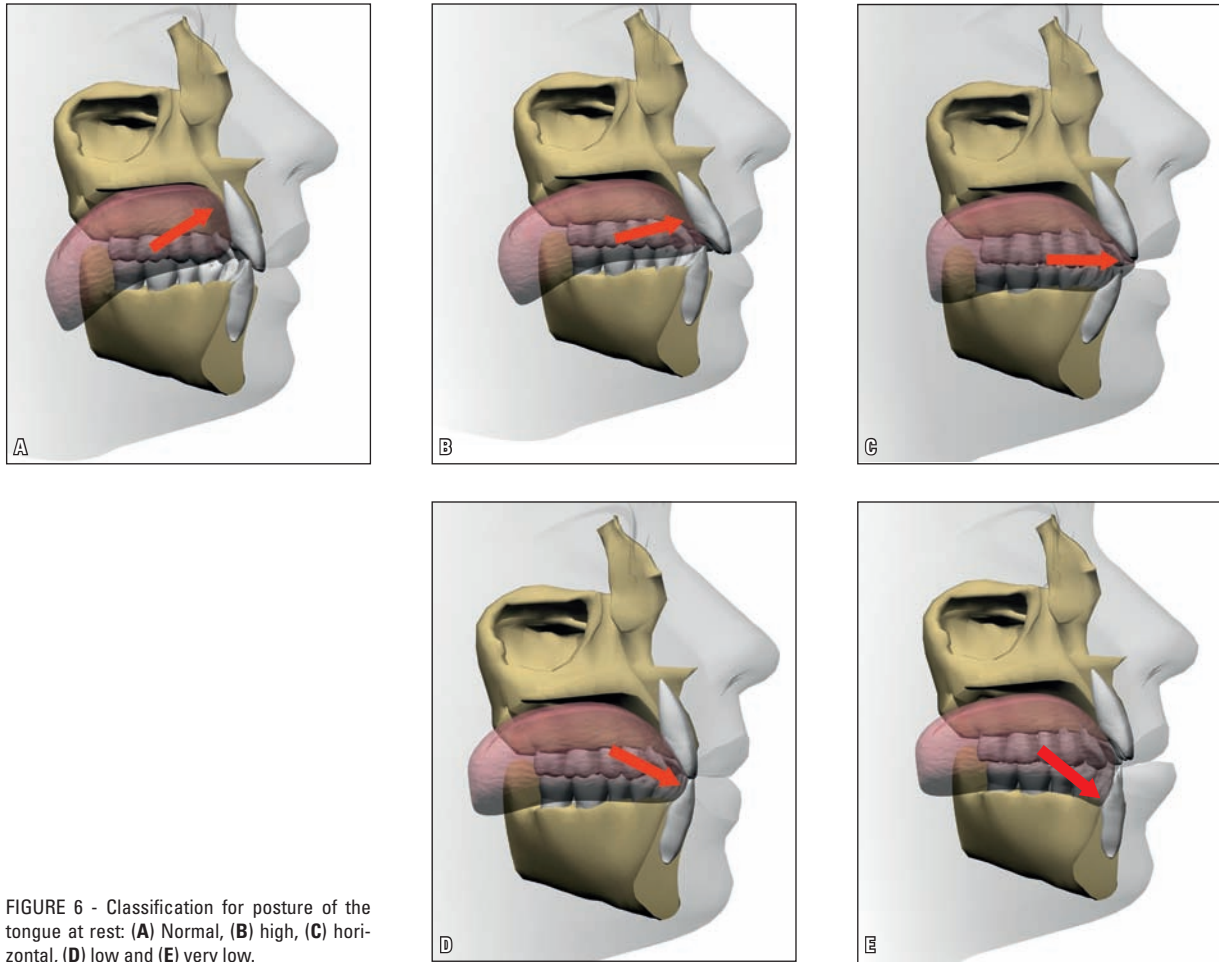


FIGURE 6 - Classification for posture of the tongue at rest: (A) Normal, (B) high, (C) horizontal, (D) low and (E) very low.



FIGURE 7 - Schematic (A) and photographs (B and C) of high posture of the tongue at rest, associated with a mild AOB; may exhibit vertical overlap. The maxillary incisors are protruded and lower arch leveling is unchanged. No posterior crossbite was observed. The arrows represent the direction of the force exerted by the tongue.

A very low tongue posture occurs when the tongue rests below the crowns of the mandibular incisors in the lingual region of the lower alveolar ridge. The direction of tongue pressure produces retroclination of mandibular incisors and prevents their eruption, positioning them below the occlusal level. The open bite is more severe and associated with posterior crossbite due to the fact that the tongue moves away from the palate. The tongue sprawls across the mouth floor, expanding the lower arch in the transverse direction (Fig 10).

TREATMENT CHOICE BASED ON TONGUE POSITION AT REST: RESTRAINING AND ORIENTING TREATMENTS

Understanding AOB etiology in each patient may help in their treatment and long-term stability.⁴ These various postures of the tongue at rest will guide orthodontists in choosing the treatment capable of bringing the tongue back to a correct resting posture, thus removing the causative agent of the malocclusion.

Once the AOB causative agent has been iden-

tified and ascribed to an abnormal posture of the tongue, orthodontists should classify tongue posture through an analysis of the morphological features of the malocclusion.

High and horizontal tongue postures are positioned very close to normal posture and require control in the horizontal direction only. It is suggested that blocking mechanisms such as cribs are sufficient to produce this tongue retraction and adapt it to its correct posture at rest. This type of treatment will be referred to as restraining treatment.

However, in the low and very low tongue postures, the tongue is not only protruded but it is positioned below its correct position and needs to be retracted and elevated. This process is difficult to learn and automate,²⁵ requiring educating devices which force the direction of the tongue, such as spurs. This type of treatment will be referred to as orienting treatment.

To illustrate these types of treatment, and in particular their stability, AOB cases caused by each type of tongue posture at rest, which were monitored in the long-term, will be presented.

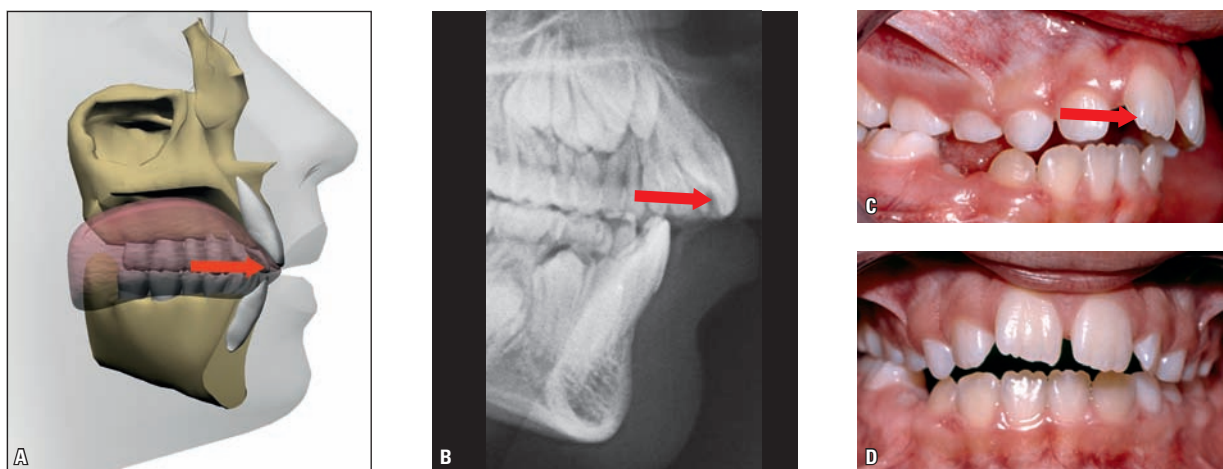


FIGURE 8 - Schematic (A), radiograph (B) and photographs (C and D) of horizontal posture of the tongue at rest, associated with a moderate AOB; may exhibit vertical overlap. The maxillary incisors are markedly protruded and above the occlusal plane. Lower arch leveling is unchanged. Due to the distance between the back of the tongue and the palate, posterior crossbites may emerge. The arrows represent the direction of the force exerted by the tongue.

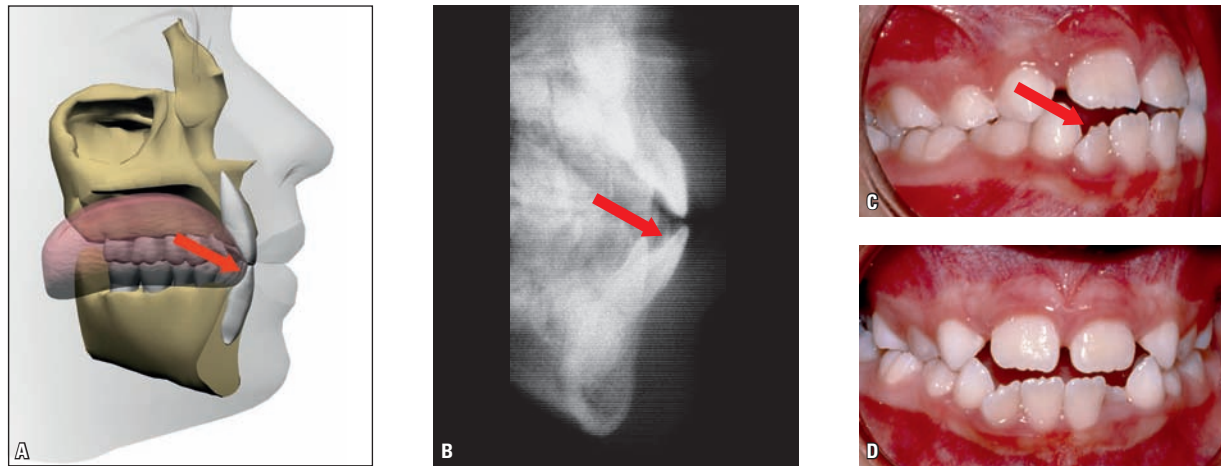


FIGURE 9 - Schematic (A), radiograph (B) and photographs (C and D) of low posture of the tongue at rest, associated with a moderate AOB. The mandibular incisors display a pronounced protrusion. Lower arch leveling is changed, with mandibular incisors positioned below the occlusal level. Due to the distance between the back of the tongue and the palate, posterior crossbites may emerge. The arrows represent the direction of the force exerted by the tongue.



FIGURE 10 - Schematic (A), radiograph (B) and photographs (C and D) of very low posture of the tongue at rest, associated with a severe AOB. The mandibular incisors appear uprighted or retroclined. Lower arch leveling is changed, with mandibular incisors well below the occlusal level. Due to the distance between the back of the tongue and the palate, posterior crossbites are bound to emerge. The arrows represent the direction of the force exerted by the tongue.

APPLYING CRITERIA FOR AOB DIAGNOSIS AND TREATMENT: CASE REPORTS

Case 1: High Posture of Tongue at Rest

This is an 8-year-old female patient in the mixed dentition stage. She presented with an Angle Class I malocclusion with AOB, slightly increased overjet, protruded maxillary incisors and interincisal diastemas in the upper arch. The

lower arch was normal. The face was symmetrical with a slightly convex facial profile (Fig 11).

Patient history did not reveal sucking habits, indicating that AOB was caused by an abnormal posture of the tongue at rest. AOB morphological characteristics indicated that the patient had a high tongue posture as it did not change the occlusal plane in the lower arch. However,

the maxillary incisors were protruded and positioned above the occlusal plane (Figs 11C, D and E). Since the treatment goal was to restrain the tongue in the horizontal direction, placing it further back, restraining treatment was preferred and a Hawley retainer was therefore used, combined with a crib (Fig 12A).

The retainer was used for a period of two years until the patient was in the final stage of mixed dentition (Fig 12B). She was monitored until the permanent dentition phase. The open bite was

closed, overjet and interincisal diastemas reduced (Figs 13C, D and E). No other treatment was performed on this patient, who achieved a stable result as can be seen from the records obtained 32 years after treatment (Fig 14).

It was only thanks to the removal of a poor tongue posture that establishing a normal horizontal overlap became possible and, more importantly, the AOB etiological factor was eliminated, thus ensuring a stable result for many years (Fig 15).

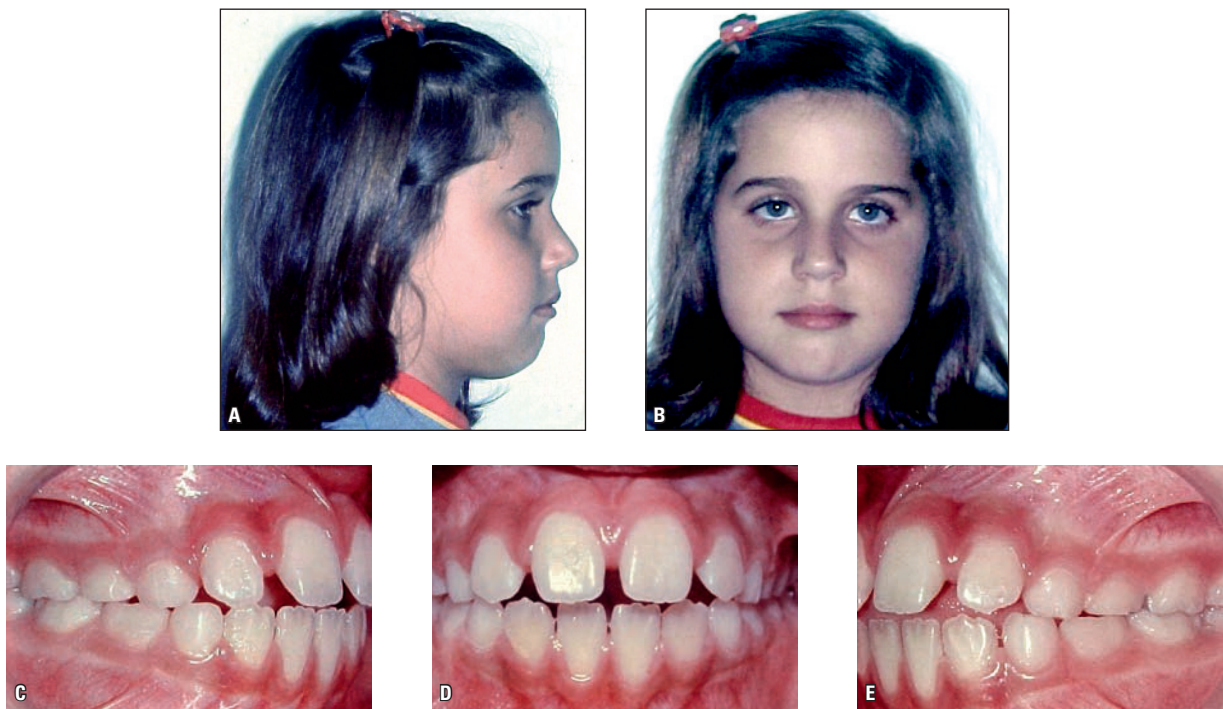


FIGURE 11 - Initial facial (A and B) and intraoral photographs (C, D and E).

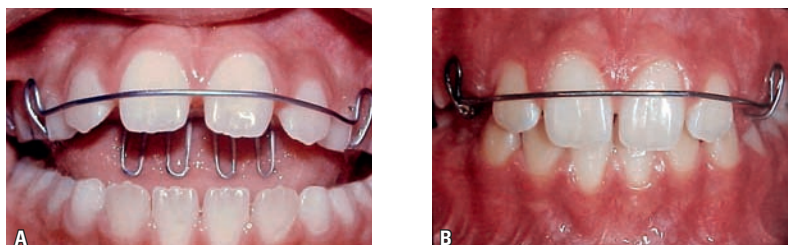


FIGURE 12 - Hawley retainer with crib (A) used to treat patients for a two-year period until a normal overbite was attained (B).



FIGURE 13 - Extraoral (A and B) and intraoral photographs (C, D and E) at the end of treatment. The patient was not subjected to any other type of orthodontic treatment.



FIGURE 14 - Extraoral and intraoral photographs 32 years after treatment.



FIGURE 15 - **A)** Initial AOB condition, **B)** during treatment with Hawley retainer with crib, **C)** end of treatment and **D)** 32 years after treatment, demonstrating stability of AOB correction.

Case 2:

Horizontal Posture of Tongue at Rest

A female patient aged 9 years, in the mixed dentition period presenting with an Angle Class II, Division 1 malocclusion, 8 mm overjet, cross bite of teeth 16 and 46, AOB and less than 2 mm midline shift to the right (Figs 16E, F and G). She had a Class II skeletal pattern with 10° ANB ($SNA=88^\circ$ and $SNB=78^\circ$) and normal mandibular plane ($SNGoGn=34^\circ$) (Fig 16D). Facial evaluation showed a symmetrical face and convex profile (Figs 16A, B and C).

Patient history revealed that she had no sucking habits, suggesting that AOB etiology was related to abnormal tongue posture. To determine what sort of tongue posture the patient had it was observed that lower arch leveling was normal while the upper incisors were protruded and positioned above the occlusal level. These features suggest a horizontal posture of the tongue associated with marked overjet. Therefore, restraining treatment would be indicated in this case.

It was decided the use of a modified Thuro appliance with expansion screw and pala-

tal crib (Fig 17), which was worn for six consecutive months. After this period, an Angle Class I molar relationship was attained with 3 mm overjet, the crossbite was corrected as well as the AOB (Figs 18E, F and G) and there was improvement in the skeletal relationship ($SNA=83^\circ$, $SNB=78^\circ$ and $ANB=5^\circ$) (Fig 18D). The face remained symmetrical and the profile slightly convex (Figs 18A, B and C). The appliance was then worn only at night for another six months for retention purposes.

At age 12 the second phase of treatment was initiated with the placement of a fixed metallic orthodontic appliance. Due to the correction of tongue posture the upper incisors extruded (Fig 19), reaching a situation of excessive overbite, as shown in Figures 18E, F and G. It was therefore necessary to employ utility archwires to intrude the incisors and attain a normal overbite. The second phase of treatment was completed by correcting the horizontal and vertical overlaps, and the Class I molar relationship was maintained (Figs 20D, E and F). The face remained symmetrical with a balanced facial profile (Figs 20A, B and C).



FIGURE 16 - Initial extraoral photographs (A, B, C), cephalometric radiograph (D) and intraoral photographs (E, F and G).



FIGURE 17 - Modified Thurow headgear used in the first treatment phase containing a posterior maxillary splint with an expansion screw, lingual crib and Hawley clasp.

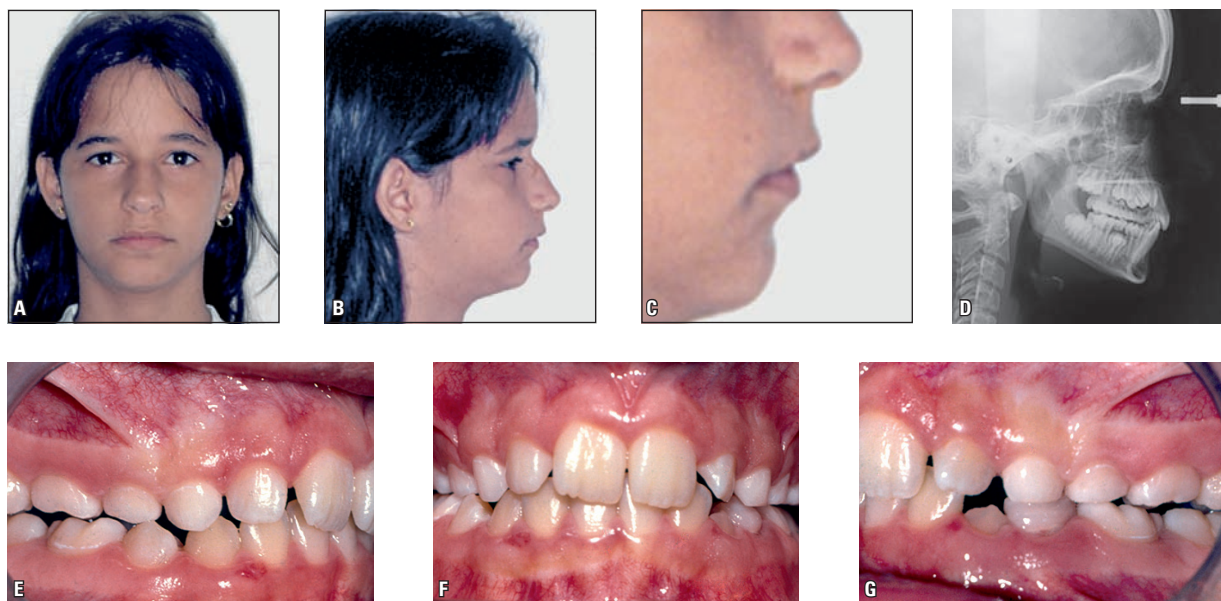


FIGURE 18 - Extraoral photographs (A, B, and C), cephalometric radiograph (D) and intraoral photographs (E, F and G) at the end of the first treatment phase.

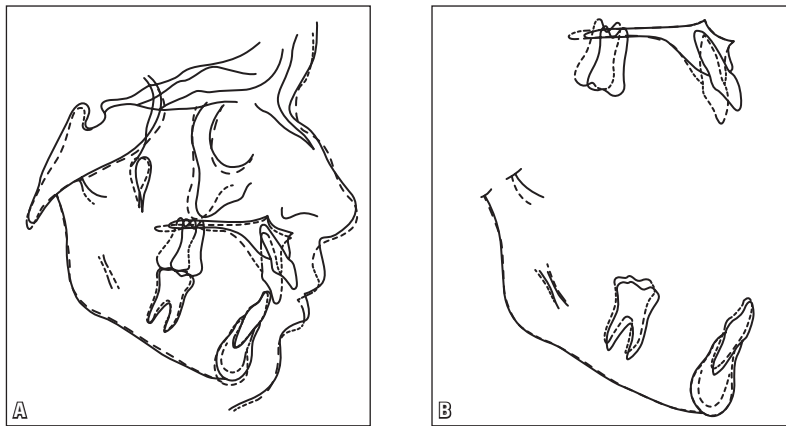


FIGURE 19 - Total (A) and partial (B) cephalometric superimpositions comparing the beginning and end of the first treatment phase. It is noteworthy that AOB correction occurred by extrusion of the maxillary incisors.



FIGURE 20 - Extraoral (A, B and C) and intraoral photographs (D, E and F) at the end of the second treatment phase.

In this case, AOB correction occurred thanks to a spontaneous extrusion of the incisors (Fig 19) after using a palatal crib and correcting the tongue posture. The results were stable as can be seen in the follow-up photographs 10 years after treatment (Fig 21). Stability of AOB correction was accomplished because the etiological factor

was eliminated and, in this case, it was curious to note that the AOB evolved into an excessive overbite (Fig 22). This suggests that after removing the AOB etiological factor one can develop any degree of overbite (normal or excessive) and, therefore, it is advisable to use plates with stops as a retention mechanism like the ones used in this patient.



FIGURE 21 - Extraoral (A, B and C) and intraoral photographs (D, E and F) 10 years after treatment.



FIGURE 22 - Degrees of vertical overlap at the beginning of treatment showing AOB (A), after the first treatment phase with excessive overbite (B), at the end of treatment (C) and 10 years after treatment, with adequate vertical overlap (D).

Case 3: High Posture of Tongue at Rest

A 7-year-old female patient with mixed dentition presented with a Class I molar relationship, without horizontal overlap, with AOB and tendency toward posterior crossbite (Figs 23E, F and G). No sucking habit was reported. She had a typical skeletal Class I ($SNA=78^\circ$, $SNB=77^\circ$ and $ANB=1^\circ$) with increased mandibular plane ($SNGoGn=37$) (Fig 23D). The face was balanced with no apparent asymmetries, with lip incompetence and a convex profile (Figs 23A, B and C).

The morphological features of this AOB included slightly protruded maxillary incisors with deficiently erupted and protruded mandibular incisors ($IMPA=100^\circ$) (Figs 23D and F). These effects in the lower arch suggest a low posture of the tongue at rest. Since this tongue had to be retracted and elevated, it was decided to conduct orienting treatment with spurs on the lingual arch (Fig 24).

The spurs were worn for a period of two years and the patient monitored for another two years until the permanent dentition stage. By then the patient had developed a Class I molar relationship, severe lack of space in both arches, posterior crossbite on the right side, and normal overbite (Fig 25). The mandibular incisors were uprighted and extruded through the use of spurs ($IMPA=92^\circ$) (Fig 26). The skeletal Class I relationship was maintained ($ANB=1^\circ$). Corrective treatment was then initiated with extraction of first premolars.

Corrective treatment was performed with canine distalization followed by retraction of the incisors. No anchorage mechanism was used, nor any vertical elastics, which attests to the stability of the AOB correction. Dental alignment was attained as well as vertical and horizontal overlaps, and adequate intercuspation. The profile remained balanced (Fig 27).



FIGURE 23 - Initial extraoral photographs (A, B, C), cephalometric radiograph (D) and intraoral photographs (E, F and G).



FIGURE 24 - Panoramic radiograph of patient with spurs in place, reorienting the tongue backwards and upwards.



FIGURE 25 - Extraoral photographs (A, B and C), cephalometric radiograph (D) and intraoral photographs (E, F and G) after use of spurs in permanent dentition.

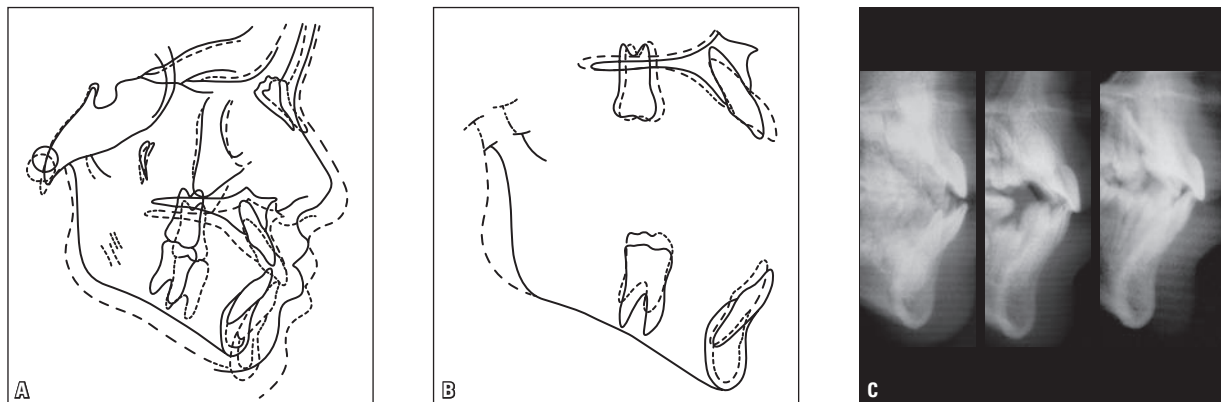


FIGURE 26 - Total (A) and partial (B) cephalometric superimpositions comparing the initial phase with the phase prior to corrective treatment. It is noteworthy that in the radiographs (C) uprighting and extrusion were attained in the lower incisors with the use of spurs alone, and the stable outcome was monitored over 5 years.



FIGURE 27 - Extraoral (A, B and C) and intraoral photographs (D, E and F) at the end of corrective treatment after 7 years of spur use, showing stability of AOB correction.

Case 4: Very Low Posture of Tongue at Rest

A female patient aged 9 years, showing severe anterior open bite and severe lack of space in the lower arch (Figs 28E, F and G). The patient was a mouth breather and undergoing speech therapy. She had a Class III skeletal pattern ($ANB=-1^\circ$), a tendency toward vertical growth, and an increased mandibular plane ($SNGoGn=49^\circ$) (Fig 28D). The face showed no clear asymmetry and had an adequate profile (Figs 28A, B and C).

According to the morphological characteristics of the open bite, the patient had a very low position of the tongue at rest, clearly characterized by retroclination of mandibular incisors ($IMPA=70^\circ$) and posterior crossbite. To perform the correction it would be necessary to move the tongue upward and backward with orienting treatment. The appliance of choice was a lower lingual arch with spurs. Firstly, a

single spur was placed in the midline region, then other spurs were gradually inserted in the canine-to-canine region (Fig 29).

Use of lingual arch with spurs was suspended four years later. At this time a significant improvement in vertical overlap was observed as well as the presence of diastemas in the mandibular incisor region (Figs 30D, E and F) due to the protrusion of these teeth. The profile remained balanced and the face symmetrical (Figs 30A, B and C). At this stage, it was decided to place a fixed orthodontic appliance in the mandibular arch in order to close spaces.

The upper arch received no appliances and was monitored for a period of one year to assess stability of AOB correction. Should the AOB have relapsed it would have meant that the tongue posture had not been corrected. An adequate vertical overlap was achieved and the posterior crossbite corrected (Figs 31C, D and E).

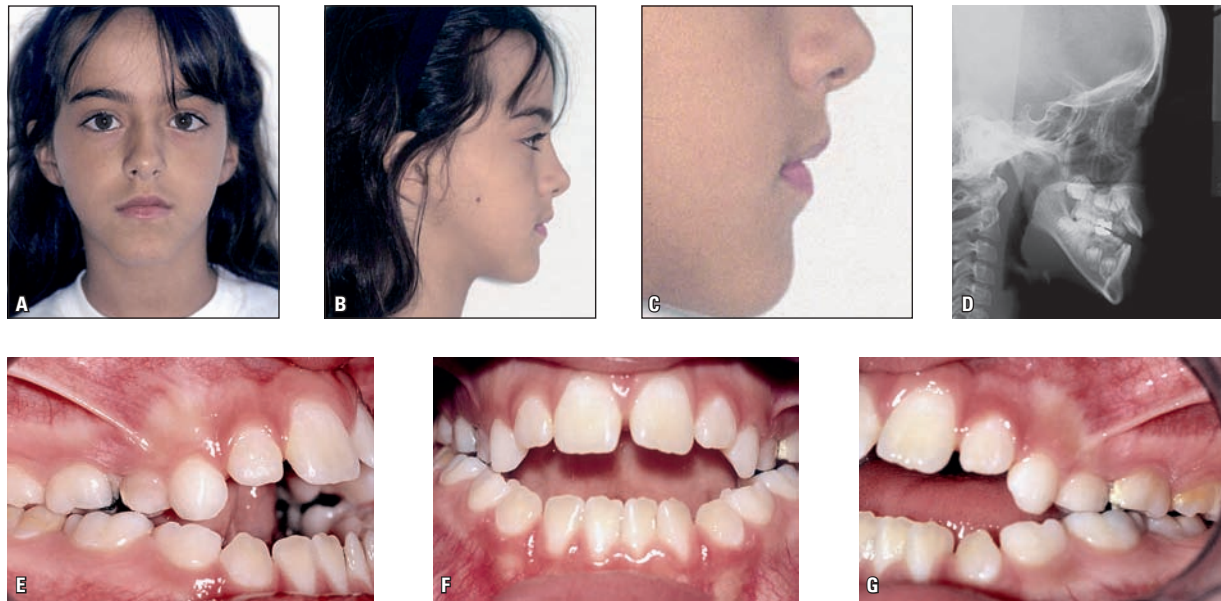


FIGURE 28 - Initial extraoral photographs (A, B, C), lateral cephalometric radiograph (D) and intraoral photographs (E, F and G).

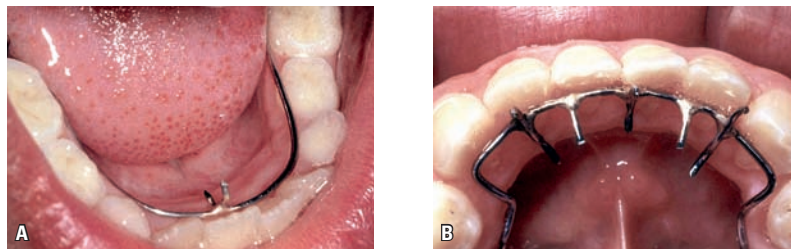


FIGURE 29 - Spurs used on lingual arch, starting with one spur at arch center (A) and increasing number and size of spurs (B) in order to reorient tongue posture backwards and upwards.

No expansion was performed in the upper arch and crossbite was corrected by positioning the tongue higher, thus changing the transverse dimension of the arch. The face remained symmetrical with a balanced facial profile (Figs 31A, B and C). At this stage, fixed appliances were installed in the upper jaw to finish the case.

At the end of treatment an excellent occlusal outcome was accomplished, with the establishment of a Class I relationship and correct horizontal and vertical overlap (Figs 32E, F and G). A skeletal Class I relationship was attained ($ANB=1^\circ$) (Fig 31D). Despite the high mandibular plane ($SNGoGn=50$) the face was balanced

with a good profile and adequate lip seal (Figs 32A, B and C).

Correction of this AOB was achieved mostly by a significant extrusion of the mandibular incisors (Figs 33A and B). The backward and upward change in tongue posture allowed eruption of the incisors, thereby lengthening the alveolar process (Figs 33C, D, E and F), as reported by Meyer-Marcotty et al.²⁵ The skeletal features of this face would have one believe that the cause of the AOB might be an unfavorable growth pattern.² However, this case suggests that AOB occurs — even in hyperdivergent faces — when the eruptive process is hampered by a mechanical obstruction (in this case the tongue), and thus,

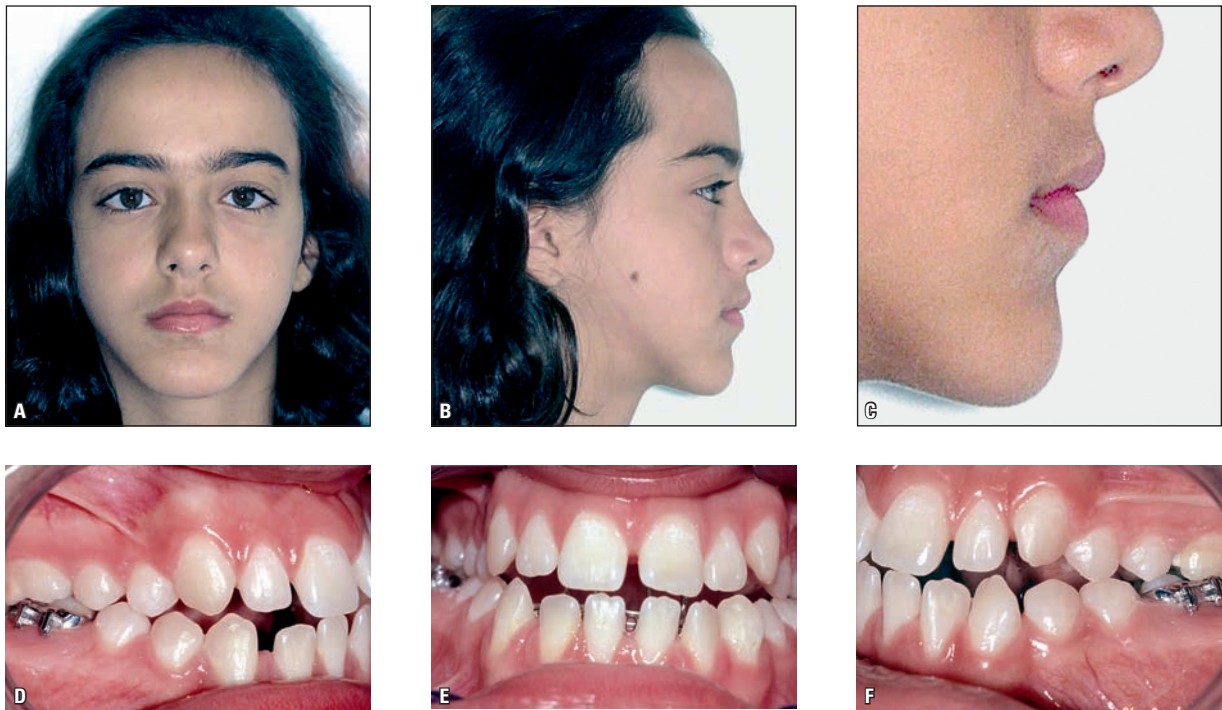


FIGURE 30 - Extraoral (A, B and C) and intraoral (D, E and F) photographs after 4 years of spur use.



FIGURE 31 - Extraoral (A, B and C) and intraoral (D, E and F) photographs after placement of appliance in the lower arch.

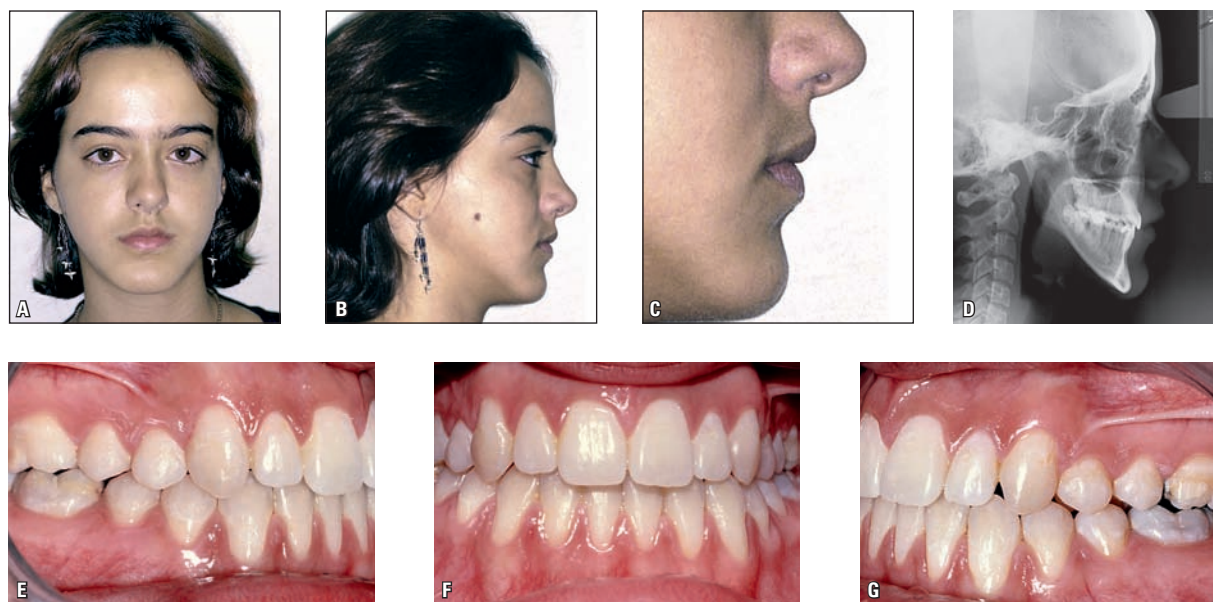


FIGURE 32 - Extraoral photographs (A, B and C), lateral cephalometric radiograph (D) and intraoral photographs (E, F and G) at the end of treatment.

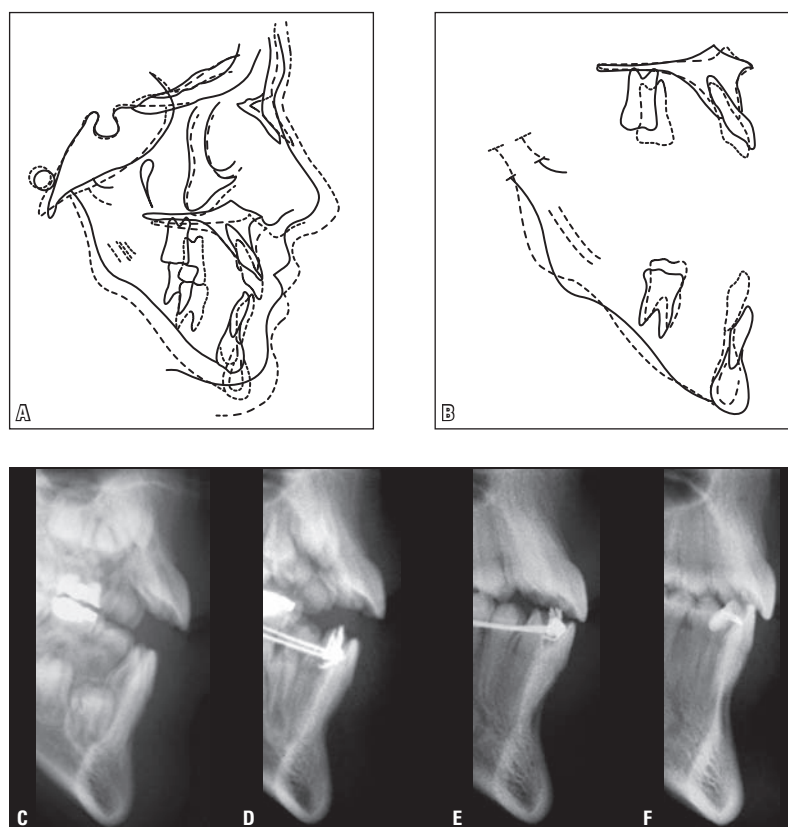


FIGURE 33 - Total (A) and partial (B) cephalometric superimpositions comparing initial and final treatment phases. Radiographs (C, D, E and F) show protrusion and marked extrusion of incisors obtained with the use of spurs only.

skeletal pattern would not play an etiological role in AOB.

Removal of the causative agent of this AOB ensured outcome stability 10 years after treatment, as shown in Figure 34. Treatment of these cases requires patience and the long-term use

of spurs, which in this case lasted for 4 years. Due to AOB severity, the amount of extrusion required for incisors to attain vertical overlap is considerable (Fig 35). Moreover, the process of automating tongue posture is slow, demanding time for neuromuscular restructuring.^{10,25}



FIGURE 34 - Extraoral (A, B and C) and intraoral (D, E and F) photographs 10 years after treatment.

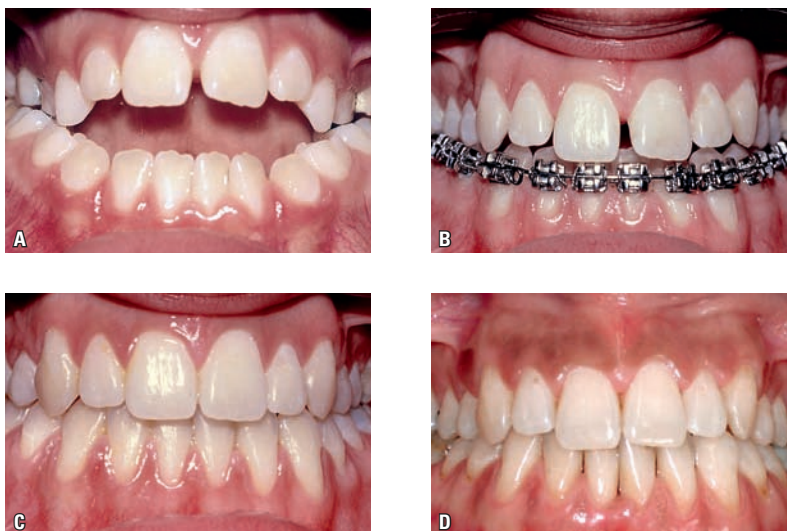


FIGURE 35 - A) Initial open bite position, B) Intermediate treatment stage after adjusting overbite with spurs and placement of appliance in the lower arch, C) Overbite achieved after corrective treatment and D) Overbite stability 10 years after treatment.

FINAL CONSIDERATIONS

The difficulties encountered in obtaining stable results for AOB correction can be justified by the fact that their true etiology still defies understanding. The posture of the tongue at rest is not highly regarded in AOB treatments. Some evidence suggests that the posture of the tongue may be one of the most important etiological factors in AOB. Therefore, it must be analyzed and addressed when it is abnormal.

There is more than one possible resting position for the tongue. It can position itself on a higher or lower level, producing open bite with different morphological characteristics and severity.

Appropriate treatment should be selected based on these characteristics, and can be conducted by either restraining or orienting the tongue. Once the posture of the tongue has been corrected, the etiological factor is extinguished and treatment stability is ensured.

Clinical studies of AOB are generally case-control experimental models with small samples and lack of control groups. This fact makes the information available about this malocclusion incomplete and therefore inconclusive. Further research is warranted, particularly to reassess whether or not tongue posture and a hyperdivergent facial growth can be considered as an etiological factor of AOB.

REFERENCES

1. Parker JH. The interception of the open bite in the early growth period. *Angle Orthod.* 1971 Jan;41(1):24-44.
2. Subtelny HD, Sakuda M. Open bite: diagnosis and treatment. *Am J Orthod.* 1964 May;50(5):337-58.
3. Huang GJ, Justus R, Kennedy DB, Kokich VG. Stability of anterior openbite treated with crib therapy. *Angle Orthod.* 1990 Jun;10(1):17-24.
4. Shapiro PA. Stability of open bite treatment. *Am J Orthod Dentofacial Orthop.* 2002 June;121(6):566-8.
5. Cozza P, Mucedero M, Baccetti T, Franchi L. Early orthodontic treatment of skeletal open bite malocclusion: a systematic review. *Angle Orthod.* 2005 Sept;75(5):707-13.
6. Zuroff JP, Chen SH, Shapiro PA, Little RM, Joondeph DR, Huang GJ. Orthodontic treatment of anterior open-bite malocclusion: stability 10 years postretention. *Am J Orthod Dentofacial Orthop.* 2010 Mar;137(3):302.e1-302.e8.
7. Proffit WR. Equilibrium theory revisited: factors influencing position of the teeth. *Angle Orthod.* 1978 July;48(3):175-86.
8. Negri PL, Croce G. Influence of the tongue on development of the dental arches. *Dental Abstr.* 1965;10:453.
9. Lopez-Gavito G, Wallen T, Little RM, Joondeph DR. Anterior open-bite malocclusion: a longitudinal 10-year postretention evaluation of orthodontically treated patients. *Am J Orthod.* 1985 Mar;87(3):175-86.
10. Justus R. Correction of anterior open bite with spurs: long-term stability. *World J Orthod.* 2001;2(3):219-31.
11. Franco FC, Araújo TM, Habib F. Pontas ativas: um recurso para o tratamento da mordida aberta anterior. *Ortodon Gaúch.* 2001 jan-jun;5(1):5-12.
12. Miller H. The early treatment of anterior open bite. *Int J Orthod.* 1969 Mar;7(1):5-14.
13. Andrianopoulos MV, Hanson ML. Tongue-thrust and the stability of overjet correction. *Angle Orthod.* 1987 Apr;57(2):121-35.
14. Yashiro K, Takada K. Tongue muscle activity after orthodontic treatment of anterior open bite: a case report. *Am J Orthod Dentofacial Orthop.* 1999 June;115(6):660-6.
15. Subtelny JD, Subtelny JD. Malocclusion, speech, and deglutition. *Am J Orthod.* 1962 Sept;48(9):685-97.
16. Harvold EP, Vagervik K, Chierici G. Primate experiments on oral sensation and dental malocclusion. *Am J Orthod.* 1973 May;63(5):494-508.
17. Harvold EP, Tomer BS, Vagervik K, Chierici G. Primate experiments on oral respiration. *Am J Orthod.* 1981 Apr;79(4):359-72.
18. Brauer JS, Holt TV. Tongue thrust classification. *Angle Orthod.* 1965 Apr;35(2):106-12.
19. Linder-Aronson S, Woodside D, Hellsing E, Emerson W. Normalization of incisor position after adenoidectomy. *Am J Orthod Dentofacial Orthop.* 1993 May;103(5):412-27.
20. Dung J, Smith R. Cephalometric and clinical diagnosis of open bite tendency. *Am J Orthod.* 1998 Dec;94(6):484-90.
21. Greenlee GM, Huang GJ, Chen SS, Chen J, Koepsell T, Hujuel P. Stability of treatment for anterior open-bite malocclusion: a meta-analysis. *Am J Orthod Dentofacial Orthop.* 2011 Feb;139(2):154-69.
22. Denison TF, Kokich VG, Shapiro PA. Stability of maxillary surgery in openbite versus nonopenbite malocclusions. *Angle Orthod.* 1989 Spring;59(1):5-10.
23. Haryett RD, Hansen FC, Davidson PO, Sandilands ML. Chronic thumb-sucking: the psychologic effects and the relative effectiveness of various methods of treatment. *Am J Orthod.* 1967 Aug;53(8):569-85.
24. Subtelny JD. Examination of current philosophies associated with swallowing behavior. *Am J Orthod.* 1965 Mar;51(3):161-82.
25. Meyer-Marcotty P, Hartmann J, Stellzig-Eisenhauer A. Dentoalveolar open bite treatment with spur appliances. *J Orofac Orthop.* 2007 Nov;68(6):510-21.
26. Nogueira FF, Mota LM, Nouer PRA, Nouer DF. Esporão lingual colado Nogueira®: tratamento coadjuvante da deglutição atípica por pressionamento lingual. *Rev Dental Press Ortod Ortop Facial.* 2005 mar-abr;10(2):129-56.
27. Cleall JF. Deglutition: a study of form and function. *Am J Orthod.* 1965 Aug;51(8):587-94.
28. Rogers AP. Open bite cases involving tongue habits. *Int J Orthod.* 1927;13:837-44.
29. Hickham JH. Maxillary protraction therapy: diagnosis and treatment. *J Clin Orthod.* 1991 Feb;25(2):102-13.
30. Kim YH, Han UK, Lim DD, Serraon ML. Stability of anterior openbite correction with multiloop edgewise archwire therapy: a cephalometric follow up study. *Am J Orthod Dentofacial Orthop.* 2000 July;118(1):43-54.

Submitted: April 2011

Revised and accepted: May 2011

Contact address

Flavia Artese

Rua Santa Clara, 75/1110

CEP: 22.041-011 - Copacabana / RJ, Brazil

E-mail: flaviaartese@gmail.com

- 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.dentalpressjournals.com
- Please send all other correspondence to:
Dental Press International
Av. Euclides da Cunha 1718, Zona 5
ZIP CODE: 87.015-180, Maringá/PR, Brazil
Phone. (55 044) 3031-9818
E-mail: artigos@dentalpress.com.br
- The statements and opinions expressed by the author(s) do not necessarily reflect those of the editor(s) or publisher, who do not assume any responsibility for said statements and opinions. Neither the editor(s) nor the publisher guarantee or endorse any product or service advertised in this publication or any claims made by their respective manufacturers. Each reader must determine whether or not to act on the information contained in this publication. The Journal and its sponsors are not liable for any damage arising from the publication of erroneous information.
- To be submitted, all manuscripts must be original and not published or submitted for publication elsewhere. Manuscripts are assessed by the editor and consultants and are subject to editorial review. Authors should follow the guidelines below.
- All articles must be written in English.

GUIDELINES FOR SUBMISSION OF MANUSCRIPTS

- Manuscripts must be submitted via www.dentalpressjournals.com. Articles must be organized as described below.

1. Title Page

- Must comprise the title, abstract and keywords.
- Don't include information about the authors (e.g., authors' full names, academic degrees, institutional affiliations and administrative positions). They should be included only in the specific fields of the site for article submission. Thus, this information will not be available to reviewers.

2. Abstract

- Preference is given to structured abstracts with 250 words or less.
- The structured abstracts must contain the following sections: INTRODUCTION, outlining the objectives of the study; METHODS, describing how the study was conducted; RESULTS, describing the primary results; and CONCLUSIONS, reporting the authors' conclusions based on the results, as well as the clinical implications.
- Abstracts must be accompanied by 3 to 5 keywords, or descriptors, which must comply with MeSH.

3. Text

- The text must be organized in the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, References and Figure legends.
- Texts must contain no more than 4,000 words, including captions, abstract and references.
- Figures and tables must be submitted in separate files (see below).
- Insert the Figure legends also in the text document to help with the article layout.

4. Figures

- Digital images must be in JPG or TIF, CMYK or grayscale, at least 7 cm wide and 300 dpi resolution.
- Images must be submitted in separate files.
- In the event that a given illustration has been published previously, the legend must give full credit to the original source.
- The author(s) must ascertain that all figures are cited 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 (non-editable).

- Drawings may be improved or redrawn by the journal's production department at the criterion 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. Ethics Committees

- Articles must, where appropriate, refer to opinions of the Ethics Committees.

8. Statements required

All manuscripts must be accompanied with the following statements, to be filled at the time of submission of the article:

- **Assignment of Copyright**
Transferring all copyright of the manuscript for Dental Press International if it is published.
- **Conflict of Interest**
If there is any commercial interest of the authors in the research subject of the paper, it must be informed.
- **Human and Animals Rights Protection**
If applicable, inform the implementation of the recommendations of international protection entities and the Helsinki Declaration, respecting the ethical standards of the responsible committee on human /animal experimentation.
- **Informed Consent**
Patients have a right to privacy that should not be violated without informed consent.

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 following examples should be used:

Articles with one to six authors

Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. *J Clin Periodontol*. 1999 Mar;26(3):153-7.

Articles with more than six authors

De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. *J Dent Res*. 2005 Feb;84(2):118-32.

Book chapter

Higuchi K. Osseointegration and orthodontics. In: Branemark PI, editor. *The osseointegration book: from calvarium to calcaneus*. 1. Osseointegration. Berlin: Quintessence Books; 2005. p. 251-69.

Book chapter with editor

Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wiczorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper

Kuhn RJ. Force values and rate of distal movement of the mandibular first permanent molar. [Thesis]. Indianapolis: Indiana University; 1959.

Digital format

Oliveira DD, Oliveira BF, Soares RV. Alveolar corticotomies in orthodontics: Indications and effects on tooth movement. *Dental Press J Orthod*. 2010 Jul-Aug;15(4):144-57. [Access 2008 Jun 12]. Available from: www.scielo.br/pdf/dpjo/v15n4/en_19.pdf

* To submit new manuscripts access the site:
www.dentalpressjournals.com

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

Imaging from temporomandibular joint during orthodontic treatment: a systematic review

Eduardo Machado*, Renésio Armindo Grehs**, Paulo Afonso Cunali***

Abstract

Introduction: The evolution of imaging in dentistry has provided several advantages for the diagnosis and development of treatment plans in various dental specialties. Examinations as nuclear magnetic resonance, computed tomography and cone beam volumetric tomography, as well as 3D reconstruction methods, have enabled a precise analysis of orofacial structures. Allied to this fact, the effects of orthodontic treatment on temporomandibular joint (TMJ) could be evaluated with the accomplishment of clinical studies with appropriate designs and methodologies. **Objective:** This study, a systematic literature review, had the objective of analyzing the interrelation between orthodontic treatment and TMJ, verifying if orthodontic treatment causes changes in the internal structures of TMJ. **Methods:** Survey in research bases MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs and BBO, between the years of 1966 and 2009, with focus in randomized clinical trials, longitudinal prospective nonrandomized studies, systematic reviews and meta-analysis. **Results:** After application of the inclusion criteria 14 articles were selected, 2 were randomized clinical trials and 12 longitudinal nonrandomized studies. **Conclusions:** According to the literature analysis, the data concludes that orthodontic treatment does not occur at the expense of unphysiological disc-condyle position. Some orthodontic mechanics may cause remodeling of articular bone components.

Keywords: Temporomandibular joint. Temporomandibular joint dysfunction syndrome. Temporomandibular joint disorders. Orthodontics. Magnetic resonance imaging. Tomography.

How to cite this article: Machado E, Grehs RA, Cunali PA. Imaging from temporomandibular joint during orthodontic treatment: a systematic review. Dental Press J Orthod. 2011 May-June;16(3):54.e1-7.

* Specialist in TMD and Orofacial Pain, UFPR. Graduate in Dentistry, UFSM.

** PhD in Orthodontics and Dentofacial Orthopedics, UNESP/Araraquara – SP. Professor of Graduate and Post-graduate Dentistry course, UFSM.

*** PhD in Sciences, UNIFESP. Professor of Graduate and Post-graduate Dentistry course, UFPR. Head of the Specialization Course in TMD and Orofacial Pain, UFPR.

INTRODUCTION

The effects of orthodontic treatment on Temporomandibular Joint (TMJ) are still subject to doubts and discussions. The use of complementary exams has always been a constant in the evaluation of this interrelation and can be exemplified by conventional radiographic examinations that were widely used to assess the implications of orthodontic treatment on the TMJ. However, this modality of imaging examination has limitations, because the TMJ is one of the structures of the human body more difficult to be well visualized radiographically due to overlapping of several adjacent bony structures. Thus, the effects of orthodontics on TMJ structures are still controversial.

With the advent of imaging examinations with specificity, sensitivity and greater accuracy in the reproduction of articular anatomic structures, such as magnetic resonance imaging (MRI), computed tomography and cone-beam volumetric computed tomography as well as 3D reconstruction methods, this interrelationship can be evaluated with greater exactness. Added to this fact, there was accomplishment of clinical studies with designs and more rigorous methodological criteria, generating higher levels of evidence.

Thus, the general aim of this study, through a systematic literature review was to analyze within a context of a scientific evidence based dentistry, the implications of orthodontics to the TMJ and check specifically what changes in condylar and articular disc position and joint morphological changes that occur due to orthodontic treatment.

MATERIAL AND METHODS

We performed a computerized search in MEDLINE, Cochrane, EMBASE, PubMed, Lilacs and BBO in the period from 1966 through February 2009. The research descriptors used were “orthodontics”, “orthodontic treatment”, “temporomandibular disorder”, “temporomandibular joint”, “cranio-mandibular disorder”, “TMD”, “TMJ”, “magnetic

resonance imaging” and “tomography”, which were crossed in search engines. The initial list of articles was submitted to review by two reviewers, who applied inclusion criteria to determine the final sample of articles, which were assessed by their title and abstract. If there was any disagreement between the results of the reviewers, a third reviewer would be consulted by reading the full version of the article.

Inclusion criteria for selecting articles were:

- » Studies based on magnetic resonance imaging (MRI), computed tomography (CT) and/or volumetric cone-beam tomography, which assessed the effects of orthodontic treatment in TMJ. Studies based only on electromyography, cephalometric radiographs and conventional radiographs were excluded, as well as studies involving orthognathic surgery.
- » Randomized clinical trials (RCT), non-randomized prospective longitudinal studies, systematic reviews and meta-analysis.
- » Studies in which orthodontic treatment is already completed in the assessed samples.
- » Studies written in English and Spanish, and published between 1966 and February 2009.

Thus, we excluded cross-sectional studies, clinical case reports, case series, simple reviews and opinions papers, as well as studies in which orthodontic treatment had not yet been completed.

RESULTS

After applying the inclusion criteria 14 studies were selected and the Kappa index of agreement between reviewers was 1.00. Among these studies, two were randomized clinical trials and 12 were longitudinal studies without randomization criteria (Fig 1).

Among the selected studies, 11 were based on magnetic resonance imaging and 3 in computed tomography images, as shown in Figure 2. None of the selected studies used cone-beam computed tomography for evaluation of the TMJ.

The sample of articles selected by the methodological criteria of this systematic review is available in Table 1.

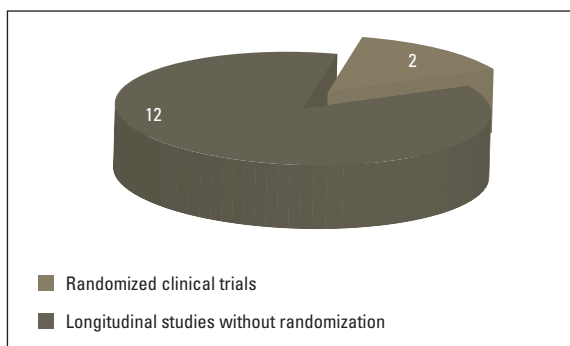


FIGURE 1 - Design of included studies.

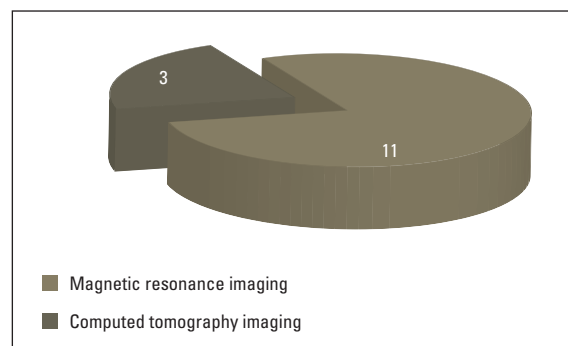


FIGURE 2 - Studies characteristics.

TABLE 1 - Studies based on imaging examination of magnetic resonance imaging, computed tomography and/or cone-beam computed tomography.

Authors	Year of publication	Design	Sample size	Imaging Examinations	Orthodontic Appliance Used	Changes in TMJ
Major et al. ²³	1997	P, L	35 tt	CT	F	Increase in An JS
Ruf, Pancherz ²⁶	1998	P, L	15 tt	MRI	Herbst	Remodeling of condylar and glenoid fossa
Ruf, Pancherz ²⁷	1999	P, L	39 tt	MRI	Herbst	Remodeling of condylar and glenoid fossa
Carlton, Nanda ⁶	2002	P, L	106 tt	CT	F, FA	No adverse effects
Franco et al. ⁹	2002	RCT	28 tt 28 no tt	MRI	FA	No adverse effects
Gokalp, Kurt ¹²	2005	P, L	13 tt 7 no tt	MRI	CC	Condylar remodeling
Kinzinger et al. ²¹	2006	P, L	20 tt	MRI	FA	No adverse effects
Kinzinger et al. ²²	2006	P, L	20 tt	MRI	FA	No adverse effects
Kinzinger et al. ¹⁹	2006	P, L	15 tt	MRI	FA	No adverse effects
Kinzinger et al. ²⁰	2007	P, L	20 tt	MRI	FA	No adverse effects
Arici et al. ³	2008	RCT	30 tt 30 no tt	CT	FA	Changes in An and Po joint spaces
Arat et al. ¹	2008	P, L	18 tt	MRI	F (RME)	No adverse effects
Arat et al. ²	2008	P, L	18 tt	MRI	F (RME)	No adverse effects
Wadhawan et al. ³⁰	2008	P, L	12 tt	MRI	F, FA	No adverse effects

P= prospective; L= longitudinal; RCT= randomized clinical trial; tt= treatment; MRI= magnetic resonance imaging; CT= computed tomography; F= fixed appliances; FA= functional appliances; CC= chin cup; JS= joint space; An= anterior; Po= posterior; RME= rapid maxillary expansion.

DISCUSSION

It becomes increasingly important to analyze the current literature in a critical and rigorous way to verify what level of scientific evidence that the information generates. The application of methodological considerations for research — such as sample size calculation, randomization, calibration, blinding and control of involved factors — are extremely important to qualify the level of evidence generated. And this information must be available for examination and discussion for the reader.²⁸

Currently, the access to scientific evidences is available through many different ways. Because of this facility, the knowledge about the hierarchy of the scientific evidence levels is essential for assessing the quality of the study. Thus, meta-analysis, systematic reviews and randomized clinical trials receive the best concepts. Being aware of this fact is important, since the vast majority of articles published in Brazilian journals correspond to studies of low potential for direct clinical application.

Magnetic resonance imaging and computed tomography are methods with higher diagnostic accuracy compared with conventional radiology, because of greater anatomic resolution they provide. CT is the ideal method for assessment of bone structures, whereas MRI allows the study of soft tissues, including intra-articular disc. Both methods often complement the study of abnormalities of the temporomandibular joint (TMJ), thus becoming important tools in the differential diagnosis of various diseases in this region.¹¹

Computed tomography is the examination of choice to evaluate TMJ bony structures, especially for the diagnosis of fractures, joint deformities, ankylosis and tumors. There is no overlapping of any other structure, enabling assessment of the quality and bone density.⁵ Similarly, MRI is the gold standard for the representation of soft tissue and positioning of the TMJ articular disc,¹⁷ allowing information about the position, function and form of the articular disc and conditions of muscle tissues

and ligaments, as well as assessment of severity of various disorders: trauma, arthritis, arthrosis and neoplastic degeneration.¹⁰

Also, the cone-beam computed tomography allows visualization of structures of reduced dimensions with minimal radiation exposure for patients and less operating time than conventional CT. This imaging modality has several applications, assisting in the diagnosis and in the treatment plan in different dental specialties.²⁹ The cone-beam tomography has a relevant importance in diagnosis, localization and reconstruction of tomographic images with excellent precision, aiding in therapeutic decisions.⁴

Clinically, the scientific evidences indicate for a tendency of no association between orthodontic treatment and temporomandibular disorders (TMD), in other words, orthodontics does not increase the prevalence of signs and symptoms of TMD, with longitudinal and experimental-interventionist studies,^{7,8,13-16,25} systematic review²⁴ and meta-analysis¹⁸ corroborating that. Also, with the analysis of imaging studies, according to the methodological criteria adopted by this systematic review, it appears that orthodontic movement does not cause adverse effects to the TMJ.^{6,9,19-22}

The systematic literature review shows that the correct occlusal relationship between the teeth did not cause a change in the physiological position of the condyles and articular discs in TMJ when MRI and CT were examined,^{19,21,22} whereas in some cases of TMD an improvement can be obtained as a result of orthodontic treatment.^{9,19,22} Some studies found changes in condylar position³ and in the volumes of the anterior and posterior joint spaces^{3,23} due to applied orthodontic mechanics. Furthermore, the use of the chincup caused a morphological change in condylar growth, which may be associated with correction of skeletal malocclusion in conjunction with remodeling in the jaw,¹² as well as the Herbst appliance.^{26,27}

The application of different orthodontic mechanics did not cause incorrect positioning on the articular disc-condyle relationship. Elastics mechanics,^{6,23} headgear,⁶ rapid maxillary expansion,^{1,2} Frankel functional appliance,⁹ Bionator,³⁰ fixed functional orthopedic appliances,^{20,21,22} Twin Block³⁰ and functional mandibular advancement appliance¹⁹ did not cause physiological changes in the positioning of the condyle and articular disc, whereas the implementation or not of extraction protocols did not change this situation.^{6,23}

Great provider of scientific evidence, randomized clinical trials were found in low number in this systematic review: only two studies.^{3,9} This fact is associated with difficulties in accomplishment of this type of study in patients undergoing orthodontic treatment due to ethical and practical questions.¹⁸ Likewise, there

were no selected meta-analysis and systematic reviews after application of the inclusion criteria. It is important to be noted that all the selected studies presented longitudinal assessments, which is the ideal study design to check for risk factors, due to its temporal component.²⁸

The use of imaging examinations — CT, cone-beam CT and MRI — in orthodontic practice, not only for evaluating the occlusal criteria, but also for adjacent structures, tends to become a useful tool. Through 3D reconstruction of the surfaces of condyle and their overlaps, detailed views of adaptive mechanisms and its non-invasive assessment may become possible in routine clinical orthodontics.²⁰ Through these examinations modalities, allied to scientific knowledge, diagnosis and therapeutic decision can be guided and based on scientific evidence, in order to provide most appropriate and safe treatment for patient.

CONCLUSIONS

- » This systematic literature review finds that the correct occlusal relationship as a result of orthodontic treatment is not obtained at the expense of non-physiological positioning of both the condyle and the articular disc. Thus, when orthodontics is used correctly does not cause adverse effects in the TMJ.
- » The application of forces during certain orthodontic mechanics, especially orthopedic situations, can cause alterations in condylar growth and bone structures of the TMJ. Thus, the mechanics application should be performed properly and the professional

must have knowledge of these impacts.

- » In some studies by analysis of imaging examinations, it was observed that there were improvements in situations of pre-existing TMD at the beginning of orthodontic therapy. However, these data are only suggestive and more randomized clinical trials are necessary to obtain more precise conclusions.
- » Further randomized controlled clinical trials, with longitudinal and interventional nature are necessary, for the determination of more precise causal associations, within a context of a scientific evidence based dentistry.

REFERENCES

1. Arat FE, Arat ZM, Tompson B, Tanju S, Erden I. Muscular and condylar response to rapid maxillary expansion. Part 2: magnetic resonance imaging study of the temporomandibular joint. *Am J Orthod Dentofacial Orthop.* 2008;133(6 Pt 2):823-9.
2. Arat FE, Arat ZM, Tompson B, Tanju S. Muscular and condylar response to rapid maxillary expansion. Part 3: magnetic resonance assessment of condyle-disc relationship. *Am J Orthod Dentofacial Orthop.* 2008;133(6 Pt 3):830-6.
3. Arici S, Akan H, Yakubov K, Arici N. Effects of fixed functional appliance treatment on the temporomandibular joint. *Am J Orthod Dentofacial Orthop.* 2008;133(6):809-14.
4. Bissoli CF, Ágreda CG, Takeshita WM, Castilho JCM, Medici Filho E, Moraes ML. Importancia y aplicaciones del sistema de tomografía computarizada cone-beam (cbct). *Acta Odontol Venez.* 2007;45(4):589-92.
5. Bumann A, Lotzmann U. Disfunção temporomandibular: diagnóstico funcional e princípios terapêuticos. Porto Alegre: Artmed; 2003.
6. Carlton KL, Nanda RS. Prospective study of posttreatment changes in the temporomandibular joint. *Am J Orthod Dentofacial Orthop.* 2002;122(5):486-90.
7. Egermark I, Carlsson GE, Magnusson T. A prospective long-term study of signs and symptoms of temporomandibular disorders in patients who received orthodontic treatment in childhood. *Angle Orthod.* 2005;75(4):645-50.
8. Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. *Angle Orthod.* 2003;73(2):109-15.
9. Franco AA, Yamashita HK, Lederman HM, Cevidanes LH, Proffit WR, Vigorito JW. Fränkel appliance therapy and the temporomandibular disc: a prospective magnetic resonance imaging study. *Am J Orthod Dentofacial Orthop.* 2002;121(5):447-57.
10. Freitas A. Radiologia odontológica. 6ª ed. São Paulo: Artes Médicas; 2004.
11. Garcia MM, Machado KFS, Mascarenhas MH. Ressonância magnética e tomografia computadorizada da articulação temporomandibular: além da disfunção. *Radiol Bras.* 2008;41(5):337-42.
12. Gokalp H, Kurt G. Magnetic resonance imaging of the condylar growth pattern and disk position after chin cup therapy: a preliminary study. *Angle Orthod.* 2005;75(4):568-75.

13. Henrikson T, Nilner M. Temporomandibular disorders and need of stomatognathic treatment in orthodontically treated and untreated girls. *Eur J Orthod.* 2000;22(3):283-92.
14. Henrikson T, Nilner M. Temporomandibular disorders, occlusion and orthodontic treatment. *J Orthod.* 2003;30(2):129-37.
15. Henrikson T, Nilner M, Kurol J. Symptoms and signs of temporomandibular disorders before, during and after orthodontic treatment. *Swed Dent J.* 1999;23(5-6):193-207.
16. Imai T, Okamoto T, Kaneko T, Umeda K, Yamamoto T, Nakamura S. Long-term follow-up of clinical symptoms in TMD patients who underwent occlusal reconstruction by orthodontic treatment. *Eur J Orthod.* 2000;22(1):61-7.
17. Kamelchuk L, Nebbe B, Baker C, Major P. Adolescent TMJ tomography and magnetic resonance imaging: a comparative analysis. *J Orofac Pain.* 1997;11(4):321-7.
18. Kim MR, Graber TM, Viana MA. Orthodontics and temporomandibular disorder: a meta-analysis. *Am J Orthod Dentofacial Orthop.* 2002;121(5):438-46.
19. Kinzinger G, Gulden N, Roth A, Diedrich P. Disc-condyle relationships during Class II treatment with the Functional Mandibular Advancer (FMA). *J Orofac Orthop.* 2006;67(5):356-75.
20. Kinzinger G, Kober C, Diedrich P. Topography and morphology of the mandibular condyle during fixed functional orthopedic treatment: a magnetic resonance imaging study. *J Orofac Orthop.* 2007;68(2):124-47.
21. Kinzinger G, Roth A, Gulden N, Bucker A, Diedrich P. Effects of orthodontic treatment with fixed functional orthopaedic appliances on the condyle-fossa relationship in the temporomandibular joint: a magnetic resonance imaging study (Part I). *Dentomaxillofac Radiol.* 2006;35(5 Pt 1):339-46.
22. Kinzinger G, Roth A, Gulden N, Bucker A, Diedrich P. Effects of orthodontic treatment with fixed functional orthopaedic appliances on the disc-condyle relationship in the temporomandibular joint: a magnetic resonance imaging study (Part II). *Dentomaxillofac Radiol.* 2006;35(5 Pt 2):347-56.
23. Major P, Kamelchuk L, Nebbe B, Petrkowski G, Glover K. Condyle displacement associated with premolar extraction and nonextraction orthodontic treatment of Class I malocclusion. *Am J Orthod Dentofacial Orthop.* 1997;112(4):435-40.
24. Mohlin B, Axelsson S, Paulin G, Pietila T, Bondemark L, Brattstrom V, et al. TMD in relation to malocclusion and orthodontic treatment. *Angle Orthod.* 2007;77(3):542-8.
25. Mohlin BO, Derweduwen K, Pilley R, Kingdon A, Shaw WC, Kenealy P. Malocclusion and temporomandibular disorder: a comparison of adolescents with moderate to severe dysfunction with those without signs and symptoms of temporomandibular disorder and their further development to 30 years of age. *Angle Orthod.* 2004;74(3):319-27.
26. Ruf S, Pancherz H. Temporomandibular joint growth adaptation in Herbst treatment: a prospective magnetic resonance imaging and cephalometric roentgenographic study. *Eur J Orthod.* 1998;20(4):375-88.
27. Ruf S, Pancherz H. Temporomandibular joint remodeling in adolescents and young adults during Herbst treatment: a prospective longitudinal magnetic resonance imaging and cephalometric radiographic investigation. *Am J Orthod Dentofacial Orthop.* 1999;115(6):607-18.
28. Susin C, Rosing CK. *Praticando odontologia baseada em evidências.* 1ª ed. Canoas: ULBRA; 1999.
29. Xaves ACC, Sena LEC, Araújo LF, Nascimento Neto JBS. Aplicações da tomografia computadorizada de feixe cônico na odontologia. *Int J Dent.* 2005;4(3):80-124.
30. Wadhawan N, Kumar S, Kharbada OP, Duggal R, Sharma R. Temporomandibular joint adaptations following two-phase therapy: an MRI study. *Orthod Craniofac Res.* 2008;11(4):235-50.

Submitted: February 2009
 Revised and accepted: May 2010

Contact address

Eduardo Machado
 Rua Francisco Trevisan 20, Nossa Sra. de Lourdes
 CEP: 97.050-230 - Santa Maria / RS, Brazil
 E-mail: machado.rs@bol.com.br

Cytotoxicity of electric spot welding: an in vitro study

Rogério Lacerda dos Santos*, Matheus Melo Pithon**, Leonard Euler A. G. Nascimento***, Fernanda Otaviano Martins****, Maria Teresa Villela Romanos*****, Matilde da Cunha G. Nojima*****, Lincoln Issamu Nojima*****, Antônio Carlos de Oliveira Ruellas*****

Abstract

Objective: The welding process involves metal ions capable of causing cell lysis. In view of this fact, the aim of this study was to test the hypothesis that cytotoxicity is present in different types of alloys (CrNi, TMA, NiTi) commonly used in orthodontic practice when these alloys are subjected to electric spot welding. **Methods:** Three types of alloys were evaluated in this study. Thirty-six test specimens were fabricated, 6 for each wire combination, and divided into 6 groups: Group SS (stainless steel), Group ST (steel with TMA), Group SN (steel with NiTi), Group TT (TMA with TMA), Group TN group (TMA with NiTi) and Group NN (NiTi with NiTi). All groups were subjected to spot welding and assessed in terms of their potential cytotoxicity to oral tissues. The specimens were first cleaned with isopropyl alcohol and sterilized with ultraviolet light (UV). A cytotoxicity assay was performed using cultured cells (strain L929, mouse fibroblast cells), which were tested for viable cells in neutral red dye-uptake over 24 hours. Analysis of variance and multiple comparison (ANOVA), as well as Tukey test were employed ($p < 0.05$). **Results:** The results showed no statistically significant difference between experimental groups ($P > 0.05$). Cell viability was higher in the TT group, followed by groups ST, TN, SS, NS and NN. **Conclusions:** It became evident that the welding of NiTi alloy wires caused a greater amount of cell lysis. Electric spot welding was found to cause little cell lysis.

Keywords: Toxicity. Cell culture techniques. Welding in dentistry.

How to cite this article: Santos RL, Pithon MM, Nascimento LEAG, Martins FO, Romanos MTV, Nojima MCG, Nojima LI, Ruellas ACO. Cytotoxicity of electric spot welding: an in vitro study. Dental Press J Orthod. 2011 May-June;16(3):57.e1-6.

* Specialist in Orthodontics, Federal University of Alfenas - UNIFAL. Master and Doctor in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Adjunct Professor of Orthodontics, Federal University of Campina Grande - UFCG.

** Specialist in Orthodontics, Federal University of Alfenas - UNIFAL. Master and Doctor in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Assistant Professor of Orthodontics, State University of Southwestern of Bahia - UESB.

*** Doctoral Student in Orthodontics, Federal University of Rio de Janeiro - UFRJ.

**** Graduated in Microbiology and Immunology, Federal University of Rio de Janeiro. Trainee of the Microbiology Institute of Prof. Paulo de Góes - UFRJ.

***** PhD in Sciences (Microbiology and Immunology) by the Federal University of Rio de Janeiro - UFRJ. Adjunct Professor, Federal University of Rio de Janeiro - UFRJ.

***** MSc and PhD in Orthodontics, Federal University of Rio de Janeiro - UFRJ. Adjunct Professor of Orthodontics, Federal University of Rio de Janeiro - UFRJ.

INTRODUCTION

The composition of most alloys used in orthodontics is similar to that of stainless steel (18/8, i.e., 18% chromium and 8% nickel), and the manufacturing process of many devices such as facial masks, orthodontic bands and brackets involve welding of some kind. Research has shown that some ions can be released in welding^{13,17,22,26,27,28} and this exposure may trigger a variety of adverse effects with direct toxic changes, be it acutely, or chronically.¹ The World Health Organization International Agency for Research on Cancer and the United States National Toxicology Program have determined that metal components in silver solder such as cadmium, copper, silver and zinc are potentially carcinogenic to humans.¹

However, welding is widely used in orthodontic practice as an aid in moving teeth. Electric spot welding is a time saving procedure that provides ease of use, lower cost, hygiene and pleasing aesthetics.⁵ However, this type of welding has been avoided due to poor mechanical strength when compared with silver solder.¹⁴

Type of welding machine, electrode shape and alloy wire are some of the factors that determine spot welding quality.⁷ The first spot welding machine was marketed in 1934. Currently, machines have been reported that offer resistance welds by means of functions that allow proper melting of materials, reduction in the amount of oxides capable of weakening wire joining, and absence of heat around electrode contacts, which allows wires made from different types of alloys to not lose their mechanical properties.

The use of stainless steel alloy (CrNi) prevailed in orthodontics for decades but the advent of new metal alloys diversified the universe of weldable wires.

Given the proven cytotoxic activity of silver solders, other joining methods, free from the metal ions found in silver solder, have been used to reduce cytotoxic effects. The aim of this study was to test the hypothesis that cytotoxicity is

present in different types of alloys (CrNi, TMA, and NiTi) subjected to electric spot welding in orthodontic practice.

MATERIAL AND METHODS

Cell culture

This study used a culture of L929 cells (mouse fibroblasts) obtained from the American Type Culture Collection (ATCC, Rockville, MD, USA), maintained in Eagle minimum essential medium (MEM-Eagle) (Cultilab, Campinas, Brazil) plus 0.03 mg/ml glutamine (Sigma, St. Louis, Missouri), 50 mg/ml Gentamicin Sulfate (Schering Plough, Kenilworth, New Jersey), 2.5 mg/ml fungizone (Bristol-Myers-Squibb, New York, USA), sodium bicarbonate solution at 0.25% (Merck, Darmstadt, Germany), 10 mM HEPES (Sigma, St. Louis, Missouri) and 10% fetal bovine serum (Cultilab, Campinas, Brazil) kept at 37°C in an environment containing 5% CO₂.

Test specimen fabrication

Three types of alloys were evaluated in this study. The test specimens were fabricated with rectangular wires (0.019x0.025-in), cut into segments of 25 mm, which were welded using combinations between stainless steel (CrNi), nickel-titanium (NiTi) and molybdenum-titanium (TMA) wires (Morelli, Sorocaba, Brazil). For the welding procedure the two wire segments were positioned one on top of the other forming an "X" and then placed in the electric spot welding machine (SMP-3000 Super Micro Point, Kernit, Indaiatuba, Brazil) and subjected to a single spot weld with power set at 30 W for all samples. After each weld, the ends of the electrodes were cleaned with 400 grit sandpaper (3M, Sumaré, São Paulo, Brazil).

Thirty-six test specimens were fabricated, 6 for each wire combination, and divided into: Group SS (steel with steel), Group ST (steel with TMA), Group SN (steel with NiTi), Group TT (TMA with TMA), Group TN (TMA with NiTi) and Group NN (NiTi with NiTi). After welding,

test specimen surfaces were cleaned with isopropyl alcohol and then sterilized by exposure to ultraviolet light (Labconco, Kansas, Missouri, USA) for 30 minutes along with the positive and negative controls. Preparation and welding of test specimens were performed by a single examiner.

Controls

To observe cellular responses to extremes, six additional groups were included, Group CC (cell control) where cells were not exposed to any material, Group C+ (positive control), consisting of a copper amalgam cylinder (Pratic NG 2, Vigodent, Rio de Janeiro, Brazil), group C- (negative control) consisting of a glass cylinder, and Group C- (steel), C- (TMA) and C- (NiTi) (negative control for each respective wire: stainless steel, TMA and NiTi) (Morelli, Sorocaba, São Paulo, Brazil), which remained in contact with the cells.

Cytotoxicity assay

After sterilization, the 6 samples of each material were placed in 24-well plates containing culture medium (MEM) (Cultilab, Campinas, São Paulo, Brazil). After 24 hours the culture medium was collected and evaluated for toxicity to L929 cells. Supernatants were placed in triplicate in a 96-well plate containing L929 confluent monolayer and incubated for 24 hours at 37°C in an environment containing 5% CO₂. After incubation, the effect on cell viability was determined using the dye-uptake technique described by Neyndorff et al¹⁶ with minor modifications. After 24 hours of incubation, 100 µl of neutral red at 0.01% were added (Sigma, St. Louis, Missouri, USA), in a culture medium, to the microplate wells and these were incubated at 37°C for 3 hours to allow penetration of vital dye into the living cells. After this period and after disposal of the dye, 100 µl of formaldehyde solution (Reagen) at 4% were added in PBS (NaCl 130 mM; KCl 2 mM; Na₂HPO₄ 2H₂O 6 mM; K₂HPO₄ 1mM, pH 7.2) for 5 min-

utes to promote cell attachment to the plates. Next, in order to extract the dye, a solution of 100 µl of acetic acid (Vetec, Rio de Janeiro, Brazil) at 1% was added along with methanol (Reagen, Rio de Janeiro, Brazil) at 50%. Twenty minutes later readings of the optical density of the experimental groups and positive and negative controls were performed in a spectrophotometer (Biotek, Winooski, Vermont, USA) at a wavelength of 492 nm ($\lambda = 492 \text{ nm}$).

Statistical analyses were conducted with the aid of the SPSS 13.0 software program (SPSS Inc., Chicago, Illinois). Data were compared by analysis of variance (ANOVA) and then Tukey's test for assessment between groups, with reliability set at 5% significance level.

RESULTS

The results showed no statistically significant difference between experimental groups (SS, ST, SN, TT, TN and NN) ($P > 0.05$). A statistically significant difference was found between groups CC and NN group ($P < 0.05$). Cell viability was higher in the TT group, followed by groups ST, TN, SS, SN and NN (Table 1).

TMA alloy showed greater cell viability than steel and NiTi alloys. The same results were found by means of the negative controls of these respective alloys which were not welded (Table 1).

DISCUSSION

Most orthodontic materials establish some type of interaction with the environment, which may compromise their use due to deterioration of their mechanical or physical properties, or their appearance. One of these degradation processes is corrosion.¹⁵

The ions released by the corrosion process have the potential to interact with tissues through different mechanisms. Biological reactions occur by the interaction of the released ions with a molecule in the host, and alloy composition is of paramount importance in this process. The effects

TABLE 1 - Dye-uptake technique. Statistical description of optical density for experimental groups (n=6).

Groups	N	Time (24 h)			Viable cells (%)
		Mean	Median	SD	
CC	6	1.107 ^a	0.989	0.119	100.0
C+	6	0.377	0.349	0.076	34.1
C-	6	1.098	0.991	0.129	99.2
C- (Steel)	6	1.052	0.960	0.076	95.1
C- (TMA)	6	1.092	0.946	0.139	98.8
C- (NiTi)	6	0.919	0.859	0.116	83.1
SS	6	0.927 ^a	0.889	0.129	83.8
ST	6	0.994 ^a	0.917	0.115	89.8
SN	6	0.897 ^a	0.829	0.123	81.1
TT	6	1.039 ^a	0.963	0.137	93.9
TN	6	0.943 ^a	0.891	0.125	85.2
NN	6	0.787 ^b	0.721	0.113	71.1

Values followed by identical letters do not show a statistically significant difference ($p>0.05$). SD= Standard deviation.

experienced by the body appear to be due to the influence of ions on the mechanisms of bacterial adhesion caused by toxicity, subtoxic effects or allergy to metal ions.¹⁵

One of the fundamental conditions for the use of metallic materials in the oral environment is that these materials resist the corrosive action of saliva and alkaline or acid foods^{4,8} as well as variations in pH and temperature. Silver solders are among the materials used in orthodontics, which are very susceptible to corrosion.¹⁰ These solders are used when one wishes to join stainless steel alloys or other alloys for the manufacture of orthodontic appliances.

Upon analysis of the biological aspects of silver solder, the results suggest that, contrary to routine orthodontic practice, silver solder should be used sparingly in the oral environment.^{18,19}

Based on this premise, attempts have been made to replace it with other welding methods^{27,28} — such as electric spot welding — that are free from the metal ions present in silver solder.^{13,22,26,17,27,28} This study was conducted in

order to investigate the behavior of CrNi, NiTi and TMA alloys subjected to spot welding, using a culture of fibroblasts.

Cell cultures have been used as part of a series of recommended tests for assessing the biological behavior of materials designed to be placed in contact with human tissue. In this study, copper amalgam was utilized as positive control, given its proven cytotoxicity,²³ and glass as negative control to validate the results.

The findings of this study showed low cell cytotoxicity in the experimental groups compared to the cell control groups and negative control group, with the sole exception of the NN group, which showed a statistically significant difference relative to the cell control group ($p<0.05$). This outcome can be explained by the considerable amount of nickel present in this alloy type compared to other types of alloys tested in this investigation.

The percentage of nickel in brackets, wires and auxiliary appliances used in orthodontic ranges from 8% (as in stainless steel) to more than 50% (as in the case of nickel-titanium).^{9,20}

Nickel is notorious for its allergenic potential.^{11,21,25} It is estimated that 4.5% to 28.5% of the population is hypersensitive to nickel,^{3,12,21,24} with a higher prevalence in females: only one man — compared to 10 women — is allergic to nickel.²¹ Given the presence of metal ions such as nickel in orthodontic appliances, this metal has been associated with hypersensitivity reactions in orthodontics.²

Groups NN and SN showed higher cytotoxicity compared to the groups that had titanium-molybdenum (TMA), but when negative controls were evaluated, C- (NiTi) and C- (steel), which were not welded, caused little cell lysis. All groups subjected to welding showed a larger amount of cell lysis compared to their respective controls, suggesting that metal ions — such as nickel — capable of causing cell lysis, are released during the wire melting process.

In view of the cytotoxicity observed in the groups there seems to be a relationship between the amount of nickel present in alloys and the amount of cell lysis caused by these alloys. For David and Lobner⁶ and Eliades et al⁹ there is clear evidence of a direct relationship between cytotoxicity and nickel. But findings by Sestini et al²⁷ showed that nickel and chromium caused a decrease in cell activity. Although in vitro evaluations do not simulate the oral environment, one should not assume that the in vitro environment is clinically inert.

The results of this study are consistent with those found by Sestini et al,²⁷ who evaluated two different alloys subjected to spot welding

and concluded that both were well tolerated by different cell types, including fibroblasts and osteoblasts, which also agrees with the findings of Vande Vannet et al.²⁸

Success in orthodontic practice involves not only employing corrective techniques to achieve the ideal dental occlusion, but also requires materials that are inert to the oral environment.

CONCLUSIONS

Electric spot welding was found to cause little cell lysis. Moreover, the welding of NiTi alloy wires produced the greatest amount of cytotoxicity while TMA alloy wires were the least cytotoxic.

REFERENCES

1. Azevedo CRF. Characterization of metallic piercings. *Eng Fail Anal.* 2003;10(2):255-63.
2. Bass JK, Fine H, Cisneros GJ. Nickel hypersensitivity in the orthodontic patient. *Am J Orthod Dentofacial Orthop.* 1993;103(3):280-5.
3. Blanco-Dalmau L, Carrasquillo-Alberty H, Silva-Parra J. A study of nickel allergy. *J Prosthet Dent.* 1984;52(1):116-9.
4. Cadosch D, Chan E, Gautschi OP, Simmen HP, Filgueira L. Bio-corrosion of stainless steel by osteoclasts-in vitro evidence. *J Orthop Res.* 2009;27(7):841-6.
5. Correr DF Sobrinho, Nouer DF, Mendonça MR, Consani RLX, Sinhoretti MAC. Estudo comparativo da resistência à tração de soldas de prata e super micro ponto, utilizadas em ortodontia. *Rev Fac Odontol Univ Passo Fundo.* 1997;2(1):51-7.
6. David A, Lobner D. In vitro cytotoxicity of orthodontic archwires in cortical cell cultures. *Eur J Orthod.* 2004;26(4):421-6.
7. Donovan MT, Lin JJ, Brantley WA, Conover JP. Weldability of beta titanium arch wires. *Am J Orthod.* 1984;85(3):207-16.
8. El Safty A, El Mahgoub K, Helal S, Abdel Maksoud N. Zinc toxicity among galvanization workers in the iron and steel industry. *Ann NY Acad Sci.* 2008;1140:256-62.
9. Eliades T, Pratsinis H, Klekas D, Eliades G, Makou M. Characterization and cytotoxicity of ions released from stainless steel and nickel-titanium orthodontic alloys. *Am J Orthod Dentofacial Orthop.* 2004;125(1):24-9.
10. Grimsdottir MR, Gjerdet NR, Hensten-Pettersen A. Composition and in vitro corrosion of orthodontic appliances. *Am J Orthod Dentofacial Orthop.* 1992;101(6):525-32.
11. Jacobsen N, Hensten-Pettersen A. Occupational health problems and adverse patient reactions in orthodontics. *Eur J Orthod.* 1989;11(3):254-64.
12. Janson GR, Dainesi EA, Consolaro A, Woodside DG, Freitas MR. Nickel hypersensitivity reaction before, during, and after orthodontic therapy. *Am J Orthod Dentofacial Orthop.* 1998;113(6):655-60.
13. Kalimo K, Mattila L, Kautiainen H. Nickel allergy and orthodontic treatment. *J Eur Acad Dermatol Venereol.* 2004;18(5):543-5.
14. Lopes MB, Correr L Sobrinho, Consani S, Sinhoretti MA, Cangiani MB. Resistência à fadiga de solda de prata e solda elétrica a ponto utilizadas em ortodontia. *Rev Dental Press Ortodon Ortop Facial.* 2000;5(6):45-9.
15. Morais LS, Guimarães GS, Elias CN. Liberação de íons por biomateriais metálicos. *Rev Dent Press Ortodon Ortop Facial.* 2007;12(3):48-53.
16. Neyndorff HC, Bartel DL, Tufaro F, Levy JG. Development of a model to demonstrate photosensitizer-mediated viral inactivation in blood. *Transfusion.* 1990;30(6):485-90.
17. Oh KT, Kim KN. Ion release and cytotoxicity of stainless steel wires. *Eur J Orthod.* 2005;27(6):533-40.
18. Pacheco MCT. Propriedades mecânicas, resistência à corrosão e citotoxicidade de soldagens ortodônticas [tese]. Rio de Janeiro: Universidade Federal do Rio de Janeiro; 1995. 235 p.
19. Pacheco MCT, Wigg MD, Chevitaress O. Biocompatibilidade das soldagens ortodônticas. *Rev SBO.* 1995;2(8):233-38.
20. Park HY, Shearer TR. In vitro release of nickel and chromium from simulated orthodontic appliances. *Am J Orthod.* 1983;84(2):156-9.
21. Peltonen L. Nickel sensitivity in the general population. *Contact Dermatitis.* 1979;5(1):27-32.
22. Saglam AM, Baysal V, Ceylan AM. Nickel and cobalt hypersensitivity reaction before and after orthodontic therapy in children. *J Contemp Dent Pract.* 2004;5(4):79-90.
23. Santos RL, Pithon MM, Oliveira MV, Mendes GS, Romanos MTV, Ruellas ACO. Cytotoxicity of intraoral orthodontic elastics. *Braz J Oral Sci.* 2008;24(4):1520-5.
24. Schafer T, Bohler E, Ruhdorfer S, Weigl L, Wessner D, Filipiak B, et al. Epidemiology of contact allergy in adults. *Allergy.* 2001;56(12):1192-6.
25. Schubert H, Berova N, Czernielewski A, Hegyi E, Jirásek L, Kohánka V, et al. Epidemiology of nickel allergy. *Contact Dermatitis.* 1987;16(3):122-8.
26. Schultz JC, Connelly E, Glesne L, Warshaw EM. Cutaneous and oral eruption from oral exposure to nickel in dental braces. *Dermatitis.* 2004;15(3):154-7.
27. Sestini S, Notarantonio L, Cerboni B, Alessandrini C, Fimiani M, Nannelli P, et al. In vitro toxicity evaluation of silver soldering, electrical resistance, and laser welding of orthodontic wires. *Eur J Orthod.* 2006;28(6):567-72.
28. Vande Vannet B, Hanssens JL, Wehrbein H. The use of three-dimensional oral mucosa cell cultures to assess the toxicity of soldered and welded wires. *Eur J Orthod.* 2007;29(1):60-6.

Submitted: February 2009
Revised and accepted: October 2009

Contact address

Antônio Carlos de Oliveira Ruellas
Av. Professor Rodolpho Paulo Rocco, 325 - Ilha do Fundão
CEP: 21.941-617 - Rio de Janeiro / RJ, Brazil
E-mail: antonioruellas@yahoo.com.br

In vitro study of shear bond strength in direct bonding of orthodontic molar tubes

Célia Regina Maio Pinzan Vercelino*, Arnaldo Pinzan**, Júlio de Araújo Gurgel***, Fausto Silva Bramante****, Luciana Maio Pinzan*****

Abstract

Objective: Although direct bonding takes up less clinical time and ensures increased preservation of gingival health, the banding of molar teeth is still widespread nowadays. It would therefore be convenient to devise methods capable of increasing the efficiency of this procedure, notably for teeth subjected to substantial masticatory impact, such as molars. This study was conducted with the purpose of evaluating whether direct bonding would benefit from the application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface. **Methods:** A sample of 40 mandibular third molars was selected and randomly divided into two groups: Group 1 - Conventional direct bonding, followed by the application of a layer of resin to the occlusal surfaces of the tube/tooth interface, and Group 2 - Conventional direct bonding. Shear bond strength was tested 24 hours after bonding with the aid of a universal testing machine operating at a speed of 0.5mm/min. The results were analyzed using the independent t-test. **Results:** The shear bond strength tests yielded the following mean values: 17.08 MPa for Group 1 and 12.60 MPa for Group 2. Group 1 showed higher statistically significant shear bond strength than Group 2. **Conclusions:** The application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface was found to enhance bond strength quality of orthodontic buccal tubes bonded directly to molar teeth.

Keywords: Tooth bonding. Shear strength. Molar tooth.

How to cite this article: Vercelino CRMP, Pinzan A, Gurgel JA, Bramante FS, Pinzan LM. In vitro study of shear bond strength in direct bonding of orthodontic molar tubes. Dental Press J Orthod. 2011 May-June;16(3):60.e1-8.

* PhD in Orthodontics, FOB/USP. Assistant Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA).

** Associate Professor, Department of Orthodontics, Bauru School of Dentistry, University of São Paulo.

*** PhD in Orthodontics, FOB/USP. Coordinator and Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA). Assistant Professor in Speech Therapy Program, FFC - UNESP/Marília.

**** PhD in Orthodontics, FOB/USP. Assistant Professor, Masters Program in Dentistry (Area of Concentration: Orthodontics), UNICEUMA (São Luís, MA).

***** Graduate, USC/Bauru. Student, Specialization Course in Orthodontics, APCD, Bauru/SP.

INTRODUCTION

There is currently a constant concern over the efficiency of clinical procedures performed in orthodontic practice. Orthodontists and patients alike, as well as their legal guardians, strive to attain the best possible results in the shortest possible treatment time. Among the factors that affect treatment time are the rebonding of brackets and recementing of bands. Frequent rebonding and/or recementing of accessories often hinders orthodontic mechanics, resulting in longer treatment time, higher costs and increased chair time.¹²

In many cases, orthodontists prefer to band teeth, especially molars and second premolars, to avoid the need to rebond accessories in these regions. However, it is a known fact that direct bonding saves chair time as it does not require prior band selection and fitting. Moreover, when the banding procedure is not performed with utmost care it can damage periodontal tissues (encroachment of biological width)² and/or dental tissues (infiltration at the tooth/band interface).

Current literature recommends that all teeth be bonded, underscoring the importance of assessing malocclusion severity and the need for anchorage devices.¹⁷ Low profile molar tubes are available on the market which allow a 2 mm gain of vertical space in the area of posterior intercuspation.¹⁷

Despite its many advantages in terms of patient comfort, less periodontal damage and shorter chair time, direct bonding of molar teeth is not commonly performed in fixed orthodontic treatment. A 2002 U.S. study showed a higher prevalence of banded vs. bonded molars.⁷ This finding is probably related to studies that evaluated the bonding of tubes, and demonstrated decreased bond strength⁸ and increased percentage of clinical failures³ in these tubes than in brackets bonded in the anterior region of the dental arch. Tubes bonded to molars using self-cure^{3,18} or light-cure resins^{9,10} showed around 14% of

failure. According to the authors, these results may be related to (a) difficulty in maintaining proper isolation of the region, (b) inadequate adaptation of the attachment base to the tooth surface, (c) stronger masticatory forces, (d) different etching times, and (e) individual variations related to enamel composition.⁸

Nowadays, however, given recent advances in primer quality^{4,16,17} and in the bases of orthodontic attachments¹¹ manufactured for direct bonding, combined with awareness of the benefits of this procedure, it would be convenient to devise methods capable of increasing the efficiency of traditional bonding, notably in teeth subjected to higher masticatory impact, such as lower molars. In reviewing the literature, only one study was found which evaluated in vitro an alternative approach to reduce the percentage of failures in the direct bonding of molars.⁶ Johnston and McSherry⁶ evaluated the effect of sandblasting of tube bases and concluded from the results that there was no significant increase in bond strength.

This study was therefore conducted with the purpose of evaluating whether direct bonding would benefit from the application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface.

MATERIAL AND METHODS

A sample of 40 healthy third molars indicated for surgical removal were selected for this study.

The teeth were obtained in a private clinic and were cleaned and stored in 1% chloramine-T. The material was then embedded in rigid PVC rings with acrylic resin, only the crowns were exposed. When adding the material, the buccal surfaces of the crowns were positioned perpendicular to the base of the die with the aid of an acrylic square at an angle of 90° to ensure that the mechanical tests were performed correctly. After the resin had cured all samples were stored in distilled water.

The specimens were randomly divided into two groups according to different bonding protocols: Group 1 — conventional direct bonding with subsequent application of a layer of resin to the occlusal surface of each tube/tooth interface, and curing for a further 10 seconds over the reinforcement; Group 2 — conventional direct bonding, followed by application of an additional 10 seconds of curing by placing the light on the occlusal surface of the teeth.

For the sake of standardization all procedures were performed by a single orthodontist.

Prophylaxis of the buccal surface of each tooth was carried out with the aid of a rubber cup and extra-fine pumice prior to direct bonding, followed by rinsing with water and drying with compressed air. The teeth were then etched with phosphoric acid in gel at 37% for 30 seconds, after which the enamel was rinsed and dried. In Group 1, the etched area was larger, because the region where the resin reinforcement was applied needed etching. In the following step, Transbond XT primer (3M Unitek Orthodontic Products, Monrovia - CA, USA) was applied and the tubes (Morelli Ortodontia, Sorocaba - SP, Brazil) bonded directly to the teeth over an area of 13.6 mm², using Transbond XT light-cured resin (3M Unitek Orthodontic Products, Monrovia - CA, USA). The tubes were stored in their containers until the experiment had been completed, and were handled with bonding tweezers to avoid any contamination that might affect the results. The resin was applied to the basis of the tubes and then the set was placed in position. The tubes were positioned in the center of the buccal surface and then pressed firmly to obtain a thin layer of bonding material. All excess was carefully removed with the aid of an explorer probe before light curing, which was performed with a curing light (Ultraled - Dabi Atlante, Ribeirão Preto, Brazil, 10 VA power), with light intensity being measured by a 450 mW/cm² radiometer

(Demetron Research Corp.) for 20 seconds, according to manufacturer's instructions.

Initially, direct bonding procedure was the same for both groups.

Immediately after conventional direct bonding, an additional layer of resin was applied to the tube/tooth interface in Group 1. A metal spatula was used to standardize the amount of resin applied. A mark was made 2 mm from the tip of the spatula and enough Transbond XT paste was applied to fill the space as far as the mark (Fig 1). The resin was then applied to the tube/tooth interface with the aid of a brush dipped in the adhesive, followed by curing for 10 seconds (Figs 2, 3 and 4). Ten seconds of light curing were applied to the reinforcement since the light was shone directly onto the additional resin, and according to the manufacturer's instruction this is the recommended curing time when using aesthetic brackets that allow the light directly onto the bonding material.

In Group 2 (Fig 5), after conventional direct bonding, 40 seconds were allowed to elapse before placing the curing light occlusally for another 10 seconds since total curing time in the experimental group was 30 seconds. This 40-second time was determined based on the



FIGURE 1 - Standardization of additional amount of resin applied to occlusal surfaces of tube/tooth interface in Group 1.

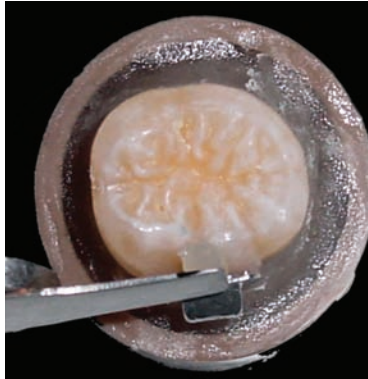


FIGURE 2 - Resin application to occlusal surface of tube/tooth interface in Group 1.



FIGURE 3 - Applying resin to occlusal surfaces of tube/tooth interface with aid of brush dipped in adhesive.

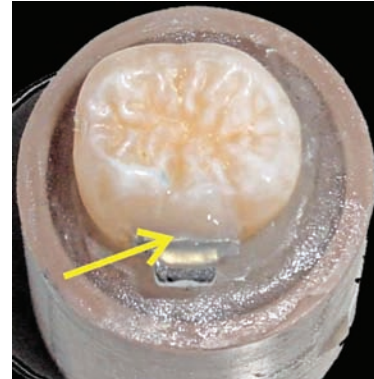


FIGURE 4 - Test specimens in Group 1: Conventional direct bonding followed by application of additional layer of resin to occlusal surfaces of the tube/tooth interface.

average time required for reinforcement application in Group 1.

After bonding, the specimens were stored in distilled water for 24 hours at a temperature of 37°C. After this period, the groups had their shear bond strength tested in a universal machine (EMIC, DL line, series 385, São José dos Pinhais, PR, Brazil) operating at a speed of 0.5 mm/min (Fig 6). The results were obtained in kilogram-force (kgf), converted into Newtons and divided by the tube base area, yielding results in MPa. The results obtained in MPa were recorded by the computer connected to the test machine upon bracket debonding.

Descriptive statistics was then performed: Means, standard deviations (SD), medians and minimum and maximum values.

The results were analyzed using Student's independent t-test. A 5% significance level was adopted.

RESULTS

Table 1 presents the mean values, standard deviations (SD), medians and minimum and maximum values, and kilogram-force MPa (kgf) at the time the tubes were debonded.

Group 1 showed a higher statistically significant shear bond strength than Group 2 (Table 2).

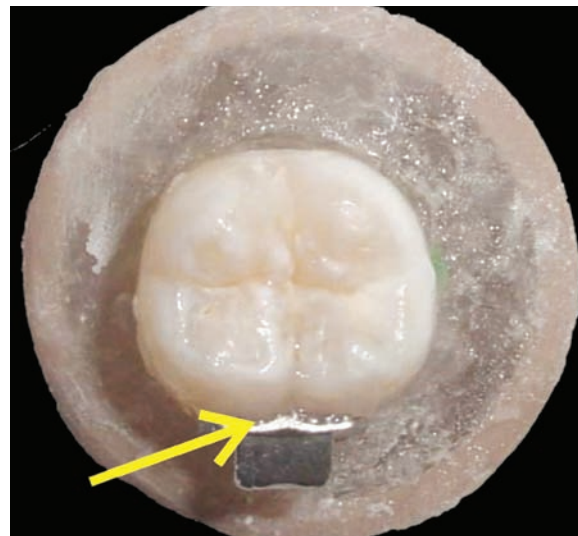


FIGURE 5 - Test specimens in Group 2: Conventional direct bonding, followed by additional 10-second light-curing.

DISCUSSION

As a science, orthodontics has undoubtedly made enormous strides in recent decades. Advances in materials for direct bonding and cementation, in metal alloys used in orthodontic wires, orthodontic accessories, techniques, mechanics and anchorage devices have proven extremely relevant for treatment implementation.



FIGURE 6 - Position of the shear bond strength testing device.

However, despite all these improvements, most orthodontists have for decades banded molar teeth instead of directly bonding orthodontic tubes.⁷ There is evidence in the literature that bonded molar tubes show a higher incidence of clinical failures than accessories that are bonded in more anterior regions of the dental arch.^{10,18} However, it is essential to note that posterior teeth are subjected to greater masticatory efforts¹⁵ and the occurrence of a higher percentage of clinical failures in this region is therefore perfectly justifiable. It should also be emphasized that there are no clinical studies showing that the banding of molars is more effective than directly bonding to these teeth. In conducting a longitudinal study to clinically evaluate the periodontium of banded vs. bonded molars, Boyd and Baumrind² found that banded maxillary molars had a higher incidence of clinical failures than bonded maxillary molars whereas the reverse was true to lower molars.

Today, with the development of orthodontic

TABLE 1 - Means, standard deviations (SD), medians and minimum and maximum values in MPa, and kilogram-force (kgf).

	Group 1		Group 2	
	MPa	Kgf	MPa	Kgf
Mean	17.08	23.69	12.60	17.48
SD	3.28	4.55	1.97	2.74
Median	16.35	22.66	13.1	18.16
Minimum	11.68	16.2	8.38	11.63
Maximum	24.54	34.03	15.68	21.75

TABLE 2 - Comparison between groups (independent t-test).

	Group 1	Group 2	p
Mean (MPa)	17.08	12.60	0.00*

* Statistically significant ($p < 0.05$).

direct bonding materials, it seems more important to focus on clinical procedures that increase the bond strength of available materials. Therefore, the purpose of this study was to determine whether application of an additional layer of resin to the occlusal surface of the buccal tube/tooth interface increases the bonding quality of orthodontic tubes to molar teeth.

To this end, laboratory tests were performed in two groups: In Group 1, the experimental group, an additional layer of resin was applied to the occlusal surface of the tube/tooth interface, and in Group 2, the control group, after conventional direct bonding, the tube/tooth interface was light cured for an additional 10 seconds. Additional curing was applied to Group 2 in order to eliminate any variables related to curing time since the total time in Group 1, after applying the reinforcement, was 30 seconds.

According to resistance theory, when a force is applied to a body (tube), which is attached to another element (tooth) using a bonding material (resin), tension (T) is calculated by means of applied force (F) divided by contact area (A) ($T = F / A$). Considering that the resin — of all the elements involved in the tests — is the material with the lowest breakage stress, in order to increase the shear bond strength of the tube/resin/tooth

complex we should increase the surface area. It was therefore with this purpose that the resin reinforcement was applied (Fig 7).

From these results it was possible to observe greater bond strength in Group 1, with a statistically significant difference compared to Group 2 (Tables 1 and 2). The additional layer of resin created an additional area of contact between tooth and tube and thus the applied force was divided by a more extensive area, yielding better results for this group.

The mean value found for Group 2 (control) is similar to results obtained by Knoll, Gwinnett and Wolf,⁸ who noted a bond strength of 11 ± 4 MPa, and Bishara et al,¹ who found a mean value of 11.8 ± 4.1 MPa.

Upon completion of this study, a third group was outlined whose teeth had only received conventional direct bonding of tubes with a total curing time of 20 seconds. The results showed a statistically significant difference compared to the group that received reinforcement during bonding but were similar to the group that received the additional 10-second light-curing.¹⁴

Proffit, Fields and Nixon¹⁵ showed that in balanced faces, posterior teeth are subjected to greater masticatory forces, with forces of around 30 kg being exerted. In this study, the mean force in kilogram-force at the time of debonding the tubes in Group 1 was 23.69 kgf (Table 1), a value closer to what Proffit, Fields and Nixon¹⁵ found than to the value obtained in Group 2 (17.48 kgf, Table 1).

Since most of the factors involved in the procedure of directly bonding molar tubes cannot be changed by the orthodontist (salivation, difficult access to the bonding procedure, absence of uniform buccal surfaces and resin thickness, initial patient age and the occurrence of occlusal interference),⁹ this alternative method proposed for performing this procedure seems to increase the clinical quality of the direct bonding of orthodontic tubes.

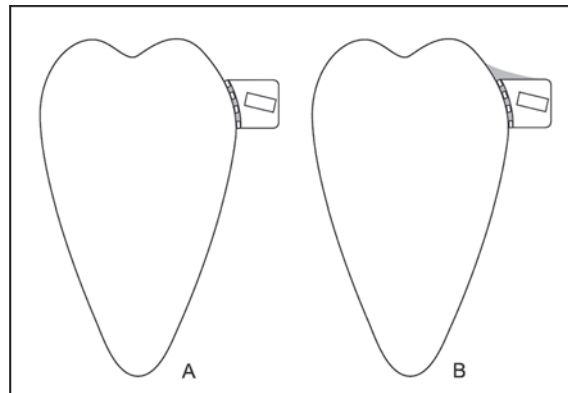


FIGURE 7 - **A)** Conventional direct bonding; **B)** Enlargement of resin area to increase bond strength of whole tube/resin/tooth set.

Moreover, in assessing in vivo tubes bonded by means of the conventional method of bonding to molars using self-etching primer and Transbond XT resin, Pandis et al¹⁰ observed that the first failure occurred after 23 months on average (20 to 26 months). Since in this study the group with reinforced resin showed better bond strength than the group with conventional bonding, probably the time for observation of clinical failure with the aid of the resin reinforcement will be longer than this period, when the most orthodontic cases are already finished.

Despite the fact that adhesive products have a rough surface that favors the accumulation of plaque,¹⁸ the region where the additional layer of resin is applied can be easily cleaned by the patient and controlled by professionals during consultations. Besides, it is located far from the gingival margin, causing no damage to periodontal tissues.

Before deciding between banding or bonding molars several factors should be evaluated such as the quality of the adhesive material used for direct bonding, the substrate (amalgam, resin, porcelain, enamel, metal alloys) and the clinical needs (type of movement, clinical crown height, need for installation of anchorage devices).^{2,17,18} After careful consideration

of these factors, if the choice falls on direct bonding, the method proposed in this study appeared to increase effectiveness.

The adhesive remnant index was not calculated because the aim of this study was to evaluate a new approach to bonding orthodontic molar tubes and not to evaluate the bonding system.

Despite the high values obtained in this study, only one specimen sustained enamel fracture while the tubes were being debonded. The fracture occurred in the tooth that exhibited the highest value during shear testing (34.03 kgf, 24.54 MPa, Table 1). However, it is important to emphasize that recent studies comparing *in vivo* with *in vitro* bond strength have shown that the values obtained *in vivo* proved to be significantly lower than those obtained *in vitro*.^{5,13} Based on the results, Penido et al¹³ stressed the importance of evaluating the acceptable values of bond strength of orthodontic accessories obtained through mechanical testing.

The amount of additional layer of resin used in this *in vitro* study represents a fixed value for comparison between groups. Based on these

results, one can infer that the amount of resin was effective in increasing shear bond strength. However, for clinical use of this method, the authors recommend to quantify the bonding material so as not to interfere with the occlusal relationship between upper and lower molars.

A clinical investigation is currently under way to ascertain the findings of this laboratory study since during bonding no saliva contamination occurred and neither were there any difficulties placing the tubes in the posterior region. Therefore, laboratory test results may be better than those achieved in clinical research. However, it is important to emphasize that, although none of the groups was affected by the above mentioned problems, group 1 showed the best results.

CONCLUSIONS

Based on the results of this study, application of an additional layer of resin to the occlusal surfaces of the tube/tooth interface enhanced bond strength of orthodontic buccal tubes bonded directly to molar teeth.

REFERENCES

1. Bishara SE, Gordan VV, VonWald L, Olson ME. Effect of an acidic primer on shear bond strength of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1998;114(3):234-7.
2. Boyd RL, Baumrind S. Periodontal considerations in the use of bonds or bands on molars in adolescents and adults. *Angle Orthod.* 1992;62(2):117-26.
3. Geiger A, Gorelick L, Gwinnett AJ. Bond failure rates of facial and lingual attachments. *J Clin Orthod.* 1983;17(3):165-9.
4. Giannini C, Francisconi PAS. Resistência à remoção de braquetes ortodônticos sob ação de diferentes cargas contínuas. *Rev Dental Press Ortodon Ortop Facial.* 2008;13(3):50-9.
5. Hajrassie MKA, Khier SE. In-vivo and in-vitro comparison of bond strengths of orthodontic brackets bonded to enamel and debonded at various times. *Am J Orthod Dentofacial Orthop.* 2007;131(3):384-90.
6. Johnston CD, McSherry PF. The effects of sanblasting on the bond strength of molar attachments - an in vitro study. *Eur J Orthod.* 1999;21(3):311-7.
7. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. JCO study of orthodontic diagnosis and treatment procedures. Part 1: results and trends. *J Clin Orthod.* 2002;36(10):553-68.
8. Knoll M, Gwinnett AJ, Wolff MS. Shear strength of brackets bonded to anterior and posterior teeth. *Am J Orthod Dentofacial Orthop.* 1986;89(6):476-9.
9. Millett DT, Hallgren A, Fornell AC. Bonded molar tubes: A retrospective evaluation of clinical performance. *Am J Orthod Dentofacial Orthop.* 1999;115(6):667-74.
10. Pandis N, Christensen L, Eliades T. Long-term clinical failure rate of molar tubes bonded with a self-etching primer. *Angle Orthod.* 2005;75(6):1000-2.
11. Park DM, Romano FL, Santos-Pinto A, Martins LP, Nouer DF. Análise da qualidade de adesão de diferentes bases de braquetes metálicos. *Rev Dental Press Ortodon Ortop Facial.* 2005;10(1):88-93.
12. Pasquale A, Weinstein M, Borislow AJ, Braitman LE. In-vivo prospective comparison of bond failure rates of 2 self-etching primer/adhesive systems. *Am J Orthod Dentofacial Orthop.* 2007;132(5):671-4.
13. Penido SMMO, Penido CVSR, Santos-Pinto A, Sakima T, Fontana CR. Estudo in vivo e in vitro com e sem termociclagem, da resistência ao cisalhamento de braquetes colados com fonte de luz halógena. *Rev Dental Press Ortodon Ortop Facial.* 2008;13(3):66-76.
14. Pinzan-Vercelino CRM, Pinzan A, Gurgel JA, Bramante FS, Pinzan LM. In vitro evaluation of an alternative method to bond molar tubes. *J Appl Oral Sci.* 2011;19(1):41-6.
15. Proffit WR, Fields HW, Nixon WL. Occlusal forces in normal and long-face adults. *J Dent Res.* 1983;62(5):566-71.
16. Rosa CB, Pinto RA, Habib FAL. Colagem ortodôntica em esmalte com presença ou ausência de contaminação salivar: é necessário o uso de adesivo auto-condicionante ou de adesivo hidrofílico? *Rev Dental Press Ortodon Ortop Facial.* 2008;13(3):34-42.
17. Trevisi H. Sistema individualizado de posicionamento de braquetes. In: Trevisi H. *SmartClip: tratamento ortodôntico com sistema de aparelho autoligado: conceito e biomecânica.* Rio de Janeiro: Elsevier; 2007. p. 71-123.
18. Zachrisson BU. A posttreatment evaluation of direct bonding in orthodontics. *Am J Orthod.* 1977;71(2):173-89.

Submitted: September 2009
Revised and accepted: April 2010

Contact address

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