

Dental Press Journal of
ORTHODONTICS

Volume 13 - Number 5 - September / October - 2008



Special Edition



Transparency
for better smile



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

ORTHOMETRIC
Orthodontic Solutions

The most complete archwire line
FLEXYNiTi

Complete System
Ceramic Brackets
ICERAM

The best stainless steel archwire
Orthometric SS

Dental Press Journal of
ORTHODONTICS

v. 13, n. 5

September/October 2009

ISSN 2176-9451

Dental Press J. Orthod.	Maringá	v. 13	no. 5	p. 1-160	Sep./Oct. 2009
-------------------------	---------	-------	-------	----------	----------------

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

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

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

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

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

Dental Press Journal of Orthodontics

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

Bimonthly.

ISSN 2176-9451

1. Orthodontics - Periodicals. I. Dental Press International

CDD 617.643005

Indexing:

IBICT - CCN

Databases:

LILACS - 1998

BBO - 1998

National Library of Medicine - 1999

SciELO - 2005

TABLE OF CONTENTS

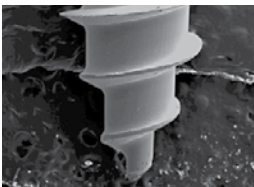


- 5 Editorial**
- 18 What's new in Dentistry**
- 20 Orthodontic Insight**
- 28 Interview**

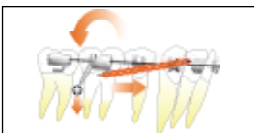
Original Articles



- 36 Tooth intrusion using mini-implants**
Telma Martins de Araújo, Mauro Henrique Andrade Nascimento,
Fernanda Catharino Menezes Franco, Marcos Alan Vieira Bittencourt



- 49 Characterization of mini-implants used for orthodontic anchorage**
Luciana Rougemont Squeff, Michel Bernard de Araújo Simonson,
Carlos Nelson Elias, Lincoln Issamu Nojima



- 57 Mini-implant assisted anterior retraction**
Carlo Marassi, Cesar Marassi



- 76 Evaluation of insertion, removal and fracture torques of different orthodontic mini-implants in bovine tibia cortex**
Maria Fernanda Prates da Nova, Fernanda Ribeiro Carvalho,
Carlos Nelson Elias, Flavia Artese



- 88 Mesial movement of molars with mini-implants anchorage**
Marcos Janson, Daniela Alcântara Fernandes Silva



- 95 Assessment of radiographic methods used in the vertical location of sites selected for mini-implant insertion**
Liz Matzenbacher, Paulo Sérgio Flores Campos, Nilson Pena,
Telma Martins de Araújo



- 107** *Use of orthodontic miniscrews in asymmetrical corrections*
Henrique Mascarenhas Villela, Andréa Lacerda Santos Sampaio, Fábio Bezerra



- 118** *Rate of mini-implant acceptance by patients undergoing orthodontic treatment – A preliminary study with questionnaires*
Larissa Bustamante Capucho Brandão, José Nelson Mucha



- 128** *Assessment of flexural strength and fracture of orthodontic mini-implants*
Matheus Melo Pithon, Lincoln Issamu Nojima, Matilde Gonçalves Nojima, Antônio Carlos de Oliveira Ruellas



- 134** *Miniplates anchorage on open-bite treatment*
Adilson Luiz Ramos, Sabrina Elisa Zange, Hélio Hissashi Terada, Fernando Toshihiro Hoshina



- 144** **Special Article**
Miniplates allow efficient and effective treatment of anterior open bites
Jorge Faber, Taciana Ferreira Araújo Morum, Soraya Leal, Patrícia Medeiros Berto, Carla Karina dos Santos Carvalho

- 158** **Information for authors**

Skeletal anchorage in the early twenty-first century

Greek physicist, mathematician and inventor Archimedes (287b.C. - 212b.C.) played a vital role in several areas of modern science. In the field of physics, he discovered the principle of the lever and allegedly asserted, "Give me a lever and a fulcrum and I can move the world." A solid fulcrum is every orthodontist's greatest desire, an anchor point with which teeth can be moved according to orthodontic planning.

Edward Hartley Angle, in turn, taught us in 1907 that anchorage can be simple, stationary, reciprocal, intermaxillary and occipital. In his writings on the subject he revered Isaac Newton, whose birth on December 25, 1642, in the Julian calendar, was a gift to mankind. His third law - "For every action, there is an equal and opposite reaction." - is part and parcel of daily orthodontic practice. Although in orthodontically induced tooth movements force action is usually welcome, reaction may not be as desired and in these cases the advent of anchorage opened new therapeutic horizons. With the aid of miniplates and mini-implants we can safely perform tooth movements in the vertical, transverse and anteroposterior planes, often avoiding undesirable side effects.

Nevertheless, even though skeletal anchorage has cemented its role as an alternative treatment in modern orthodontics, its use can still be considerably expanded. New therapies emerge continuously, providing better treatment outcomes as evidence of their effectiveness mounts.

Conversely, a fault could possibly be found with these therapies for their tendency to

combine anchorage with traditional treatment resources. Current orthodontic appliances were developed over the years and geared towards conventional orthodontic mechanics. Attempting to make them functional in combination with skeletal anchorage can be a daunting task.

Another factor clouding the vision of current and future anchorage applications is the tendency to infer possible treatment outcomes from those already achieved by traditional therapies. And to further complicate matters let us not forget our long-established orthodontic foundations, essential for orthodontic learning and practice.

These hurdles will be surmounted in due course, as publications shed light on the subject and evidence-based findings start to substantiate tested hypotheses.

The intent to clarify some of the recent advances in this field has motivated us to organize a special issue celebrating the 12-year anniversary of the Dental Press Journal of Orthodontics and Dentofacial Orthopedics by focusing exclusively on this topic. This issue, therefore, brings to our readers the clinical experience and scientific knowledge of Dr. Kyung and renowned Brazilian authors. We feel certain that the content will prove fruitful for everyone.

Jorge Faber
Telma Martins de Araújo
Editors

João Milki Neto*

Application of a mini-screw at the maxillary tubercle for treatment of maxillary protrusion

The use of a mini-implant in the maxillary tubercle for retraction of the upper arch in the treatment of maxillary protrusion is a topic that warrants discussion.

The authors review the anatomical conditions of the maxillary tuberosity region. They show that this site features scarce cortical bone and, occasionally, scarce bone space for mini-implant insertion due to the presence of third molars. It is therefore an unstable area for using this type of skeletal an-

chorage.

Although the literature supports the fact that mini-implants are seldom placed in this region, the authors were able to successfully treat an upper arch tooth retraction case with the support of a mini-implant installed in the maxillary tubercle.

Even in view of the authors' success it should be noted that this region is notorious for a high mini-implant failure rate and should not, therefore, be the treatment alternative of choice.

NAKAO, Noriko; KITAURA, Hideki; KOGA, Yoshiyuki; YOSHIDA, Noriaki. Application of a mini-screw at the maxillary tubercle for treatment of maxillary protrusion. **Orthod. Waves**, Tokyo, v. 67, p. 72-80, 2008.

Comparison of rate of canine retraction with conventional molar anchorage and titanium implant anchorage

Can skeletal anchorage really help to move teeth faster? This issue led the authors to undertake this study which compares a skeletal anchorage group with a conventional anchorage group in achieving canine retraction.

They recorded and compared the distances covered by canines in both cases, with the following results. The average distance canines covered each month in the skeletal anchorage group was 0.93 mm in the maxilla and 0.83 mm in the mandible. In the conventional anchorage group the distances were 0.81 mm in the maxilla and 0.76 in the

mandible. Therefore, they concluded that mini-implants shorten treatment time while making the procedure more accurate, unlike the conventional group, which undergoes some anchorage loss.

The study confirms what orthodontists routinely observe in their practice. Skeletal fixation – either with mini-implants or miniplates – is an essential tool in today's Orthodontic landscape thanks to its efficacy and decreased chair time. This is how the field of Orthodontics fulfils the expectations of patients who increasingly demand accuracy and speed from orthodontists.

THIRUVENKATACHARI, B.; AMMAYAPPAN, P.; KANDASWAMY, R. Comparison of rate of canine retraction with conventional molar anchorage and titanium implant anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 134, no. 1, p. 30-35, 2008.

Use of a miniplate for skeletal anchorage in the treatment of a severely impacted mandibular second molar

Lower molar impaction is a common problem in dental practice. This article presents a clinical case involving an embedded and impacted lower second molar tooth whose position is challenging in three different aspects: Due to its depth, the presence of an impacted third lower molar tooth on top of the second molar and due to its position relative to the lower alveolar nerve, which crosses over the apical third of the tooth in question.

The treatment consisted in removing the third molar to allow access - through the alveolus - to the crown of the second molar, where a bracket was bonded, without causing serious damage to the adjacent structures, such as the alveolar nerve and the cortical bone. By installing a miniplate in the retromolar region, the tooth's traction was performed using ligature wire tying the miniplate to the bracket on the second molar. Six months later the tooth had erupted and the treatment

advanced into the alignment and levelling phase. The total treatment time was 2 years and 2 months.

The use of miniplates in the retromolar region should be well planned since the tissue in this area is very elastic and there is little viable space for insertion. Besides, access during surgery is difficult. It is also important to ensure that when teeth occlude the anchorage device does not interfere with adjacent teeth and tissues. Considering all aspects involved in the insertion of a miniplate, the use of skeletal anchorage has proved an excellent alternative in performing the traction of severely impacted teeth. Firstly, because it cancels the adverse effects of traditional orthodontic mechanics and promotes traction. Secondly, because it reduces the risk of damage to the lower alveolar nerve which, in this particular case, was directly related to the impacted molar.

TSENG, Y. C.; CHEN, C. M.; CHANG, H. P. Use of a miniplate for skeletal anchorage in the treatment of a severely impacted mandibular second molar. **Br. J. Oral Maxillofac. Surg.**, Churchill Livingstone, v. 46, no. 5, p. 406-407, 2008.

* Fellow of CTBMF / University of Texas – Southwestern Medical Center – Dallas. Specialist (Unievangélica – Anápolis) and Master of Sciences (UnB – Brasília) at CTBMF. Doctoral candidate in Implantology (USC – Bauru). Professor of Oral Maxillofacial Surgery and Traumatology at the University of Brasília.

Corresponding author

João Milki Neto
SHLS QD 716 CONJ L BL 1 SL 319
CEP: 70.390-700 - Brasília / DF
E-mail: jmilki@terra.com.br

Convergent and divergent ideas concerning the use of mini-implants

Alberto Consolaro*, Eduardo Sant'ana**, Carlos Eduardo Francischone Jr***,
Maria Fernanda M-O Consolaro****, Bruno Aiello Barbosa*****

CONVERGENT IDEAS CONCERNING MINI-IMPLANTS

Certain ideas concerning the use of mini-implants for skeletal anchorage in orthodontic practice seem to have achieved widespread consensus¹⁻⁴³, such as:

1. Mini-implants represent a major breakthrough in the clinical orthodontic practice of the last 10 years, arguably the most relevant for contemporary Orthodontics.

2. The anchorage afforded by mini-implants can be utilized immediately following their implantation or up to 15 days later.

The amount of initial force must be somewhere between 150 and 200 g, preferably measured with the help of a tension gauge to avoid overload. Gradually, this force can be increased up to 350 g by taking into consideration bone quality factors, such as cortical thickness and bone density.

3. The mini-implant action mechanism results from the mechanical interlocking of its metal structure in cortical and dense bone and is not based on the concept of osseointegration. The shape and length of the cutting threads are instrumental in mini-implant placement. Resistance to fracture forces can be enhanced by means of a tapered design and self-drilling threads. These features help to dissipate compression forces from bone structures adjacent to the mini-implant during insertion.

4. Osseointegration, when it does occur, hinders mini-implant removal thereby heightening the risk of fracture. For this reason, the pureness of the titanium alloy used in its composition is degree V. In areas where bone density is low and cortical bone thin osseointegration may be necessary. In these cases the titanium alloy employed should have a degree of pureness IV while the surface is treated with double acid etching to increase the contact surface. In 2007, Vannet et al.³⁹ (Fig. 1) placed mini-implants in dogs and were able to unequivocally determine that from a histomorphometric standpoint partial osseointegration occurred in all specimens after 6 months of skeletal anchorage.

5. Mini-implant insertion can be simple in the hands of a well-prepared, skillful professional but can involve risks, especially if poorly planned and performed. Potential complications entail contact with neighboring tooth roots, with or without drilling, mucositis, contamination and fractures.

Oral hygiene is fundamental if normal standards are to be maintained.

6. Mini-implants can be classified – according to their shape and use – as: a) self-drilling, the safest to avoid root perforation, and b) self-tapping, which requires prior bone drilling since it does not have a cutting edge.

7. Mini-implant structure comprises three sections: Body, transmucosal profile and head. The

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

** Associate Professor of Surgery at FOB-USP.

*** Professor of Implantology at the Sagrado Coração University – USC.

**** Master of Science and a Doctorate Degree from FOB-USP and an Orthodontist at Bauru.

***** Postgraduate candidate in Pathology at FOB-USP.



FIGURE 1 - Dog mandible where Vannet et al.³⁹, in 2007, assessed histometrical-ly the osseointegration of mini-implants after 6 months of skeletal anchorage: **A)** Insertion was made between the roots of the second/third and third/fourth premolars with tissue sections 70 micrometers in thickness; **B)** A toluidine blue staining protocol using optical microscopy disclosed 100% osseointegration indicated by the arrows (C = cementum, R = root, B = bone, PDL = periodontal ligament, hC = Havers channels). The red arrow indicates a small bone area with no osseointegration. The distance between the mini-implant and the intact periodontal ligament was 2.66mm.

transmucosal profile represents the intermediate section in contact with the mucous membrane. The sections can vary according to shape and size, especially in terms of thickness and length.

8. The key success factors are: Gingiva anatomy, bone quality and/or density, distance to the roots and cortical bone thickness. According to Kyung et al.²⁵ the successful use of mini-implants depends on the following factors: Surgeon skills, patient condition, appropriate site selection, initial stability and oral hygiene.

9. Mini-implants are also called micro-implants, micro-screws and anchorage pins, which together fall under the general category of Temporary Anchorage Devices^{3,4,28}.

ISSUES UNDER DEBATE CONCERNING THE CLINICAL USE OF MINI-IMPLANTS:

To develop adequately, an idea needs to be disputed on an ongoing basis. Probing is the fuel behind its permanent development. Obviously, the same applies to mini-implants. Some of the issues most commonly addressed have to do with:

What if, during placement, the mini-implant touches or brushes against a neighboring root?

Teeth have their roots lined with cementoblasts and are permeated by Sharpey fibers, which are the periodontal fibers attached to cementum. Cementoblasts protect roots from continuous bone resorption. This protection results from an absence of receptors - on the cementoblast membrane - for the mediators in charge of permanent bone remodeling. Thus, hormonal changes, inflammation and periradicular stress are incapable of performing tooth resorption. If tooth resorption is to occur the cementoblasts on the root surface need to be removed. Such is the case in anoxia-induced orthodontic movement, traumas caused by direct mechanical action and chronic periapical lesions due to bacterial products.

As the mini-implant touches or brushes against the root surface cementoblasts and Sharpey fibers are eliminated and a resorption process begins at the site where trauma was induced. Although root resorption can be triggered by cementoblast removal, the process will not remain active for weeks, months or indefinitely unless local mediators, such as those causing cellular stress and inflammation, are present. When mediators disappear from the site and the cause of inflammation is removed the neighboring cementoblasts proliferate and once again cover the injured surface generating cementum deposition and the re-attachment of periodontal fibers. Therefore, root resorption, if it does occur, will be limited, superficial and short-lived.

This phenomenon occurs because the area is

now free from bacteria which, if present, would likely prolong inflammation indefinitely. In 2005 Asscherickx et al.⁶, in a seminal study, experimentally induced (Fig. 2) contact with the root surfaces of dog teeth. The researchers found microscopically that after 12 weeks a new cementum had been formed and covered the entire region, as shown in figure 2.

This evidence supports the recommendation that during the placement of self-drilling mini-implants, in the event that the root surface is touched or brushed against, the best alternative lies in removing the mini-implants, repositioning them or even replanning the surgery from scratch. There is no need for any direct intervention. It should suffice to follow up on the case for 12 weeks using monthly periapical radiographs (Fig. 2). Inflammatory root resorption generates radiographic im-

ages after three weeks. Substitution tooth resorptions caused by alveolodental ankylosis take up to three months to generate radiographic images.

A mini-implant should never be allowed to come into direct and continued contact with the tooth root and, should contact take place, it should be removed. Tooth movement in the alveolus, when caused by chewing, permanently induces local damage by destroying cementoblasts and fostering micro areas of inflammation owing to a continual production of mediators. Left unchecked, such tooth movement is likely to bring about severe resorption of the mini-implant/root interface.

What to do when the root is perforated?

Self-drilling mini-implants have a tapered lower medial third and a cutting-edge. Their sur-

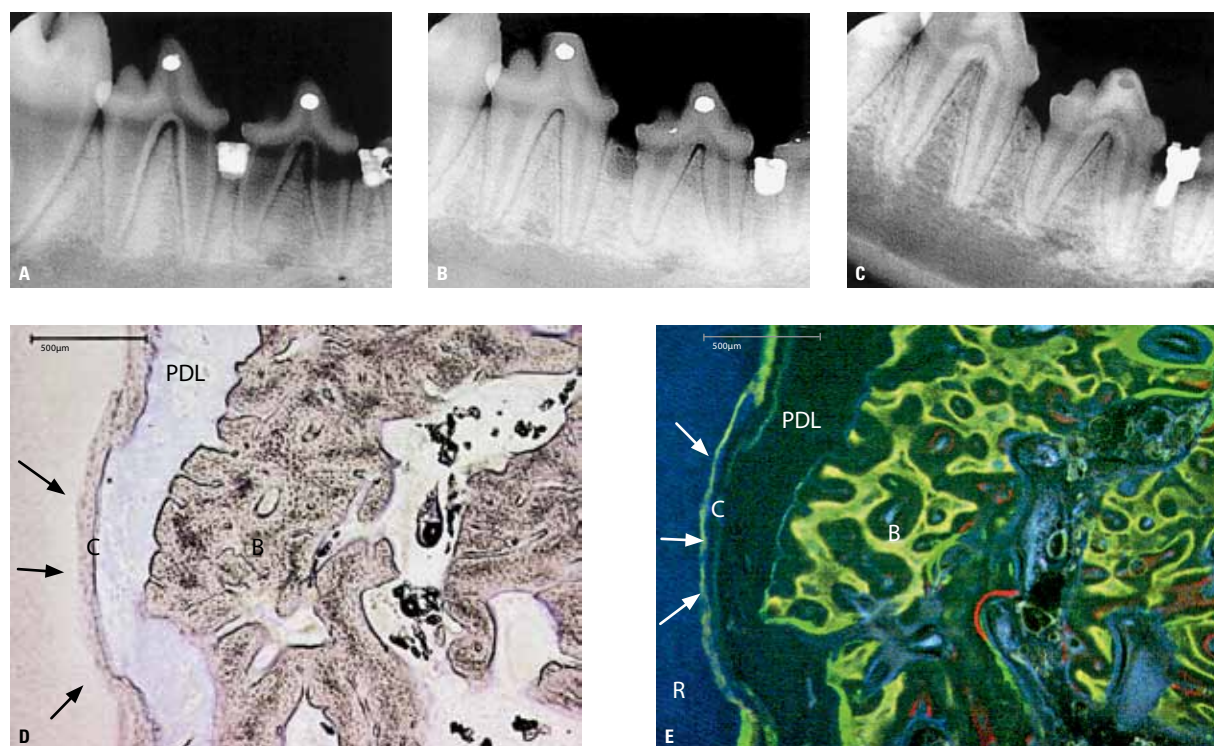


FIGURE 2 - Dog teeth used by Asscherickx et al.⁶ to insert mini-implants which touched the root surfaces: **A)** Radiograph taken immediately after placement; **B)** Radiograph taken immediately after removal; **C)** Radiograph taken 12 weeks after removal highlighting the surface recomposition; **D)** Microscopic view of the area touched or brushed against by the mini-implant 12 weeks after removal (section stained with toluidine) showing cementum recovery, as indicated by the arrows; **E)** Microscopic view of the same area using the fluorescence technique (C = cementum, PD1 = periodontal ligament, B = bone, R = root).

gical protocol is simpler, reducing the possibility of injury to the roots and providing greater primary stability compared with self-tapping mini-implants. Should they touch the roots, the likelihood of detouring or brushing against the roots is very high since they do not require prior bone drilling. In the case of self-tapping mini-implants, prior bone drilling can perforate the root.

It is important that contamination be prevented whenever a tooth root is accidentally perforated during mini-implant placement. In this situation, one should ask whether the perforation has reached as far as the pulp or root canal. If the cementum and dentin have been perforated but the pulp remains unscathed, the same behavior should be adopted as if the mini-implant has been touched or brushed against. It should either be removed and repositioned or a new placement be planned from scratch. Should a tooth be perforated without impairing the pulp, root resorption is likely to occur for a few weeks while traumatic and surgical inflammation will gradually disappear along with the resorption process mediators, since no bacterial contamination has taken place. Within a period of 3 to 6 months, periodontal tissues are likely to go back to normal with the area having been covered with new cementum and periodontal fibers reattached. Periapical radiographs should be taken on a monthly basis until the periodontal space has totally returned to a normal condition.

Should the dentin be perforated and the pulp and root canal be damaged, it should be noted that pulp and periodontal tissues have a remarkable healing capacity. In the event of horizontal root fractures, the literature is rich in reports describing the way professionals immediately bring together – as closely as possible – both root fragments, immobilize the crowns by means of splinting and, after a few months have elapsed, the fracture line is largely consolidated. Externally, cementum deposition will occur while internally the reactional and/or reparative dentin will form. The pulp will

retain its vitality and may, on occasion, undergo premature ageing or evolve into calcific metamorphosis. When perforation is caused by the mini-implant, pulp trauma and injury are considerably less severe and circumscribed to a given area. The pulp may self-heal internally through the deposition of reactional or reparative dentin and undergo focal aging. The periodontal tissues will form new cementum and ligament.

The possibility of pulp necrosis cannot be ruled out, but only in severe pulp lesion accompanied by ruptured or crushed blood vessels. This is not a common condition since the symptoms are usually observed during the drilling stage, prior to the placement of a self-tapping mini-implant. If the self-tapping mini-implant is inserted, the likelihood of pulp necrosis developing in the affected tooth root is very substantial.

All these considerations regarding root perforation and pulp reaction have arisen from analogy and were inferred from a knowledgebase on pulp biology caused by tooth trauma, root fractures, accidental pulp exposure and pulpotomies. The literature has hitherto not yet produced experimental evidence or case studies of this particular subject in humans.

Why do mucosites and perimini-implant growth tissue hyperplasia occur?

From a biological standpoint, the most fragile part of an inserted mini-implant used for temporary anchorage is the area where it interfaces with the mucous membrane's epithelial tissues. The epithelium binds to the mini-implant transmucosal profile by means of hemidesmosomes and in other alternative ways, including through the secretion of cementing substances into the interface of both structures. The epithelium in this interface proliferates as it seeks to simulate junctional epithelium, just as is the case with conventional dental implants.

Microbial biofilms grow on natural and artificial oral surfaces as a result of inadequate hygiene.

Biofilms can comprise vast populations of microbes, which gradually grow and ultimately settle in the epithelium/mini-implant interface where they induce an inflammatory process akin to gingivitis. Periodontitis may result if the underlying bone tissues are to any extent impaired.

In the case of mini-implants, mucositis is likely to arise and, if the process is allowed to evolve, may cause a perimini-implantitis, which can compromise mini-implant stability and eventually result in mini-implant failure.

Some mini-implants feature a design with a small circular winglet or metal ledge above the transmucosal profile, in the section right next to the head. Apparently, this metal ledge protects the mini-implant/mucous membrane interface on the outer surface but this protection is probably more physical than microbial since it is likely to enable the formation and maintenance of microbial film and can hamper access by tooth brushes and antiseptics to the region. In this respect, further research would be necessary. Mucosites and perimini-implantitis occur even with well-inserted mini-implants, but only as a result of microbial

biofilm formation on the parts which are exposed to the oral environment and in the absence of adequate hygiene.

What about perimini-implant growth tissue hyperplasia?

Skin and mucosa repair is accomplished through the development of granulation tissue, which fills lost spaces and gives rise to new connective tissue, thereby recovering the area affected by a given lesion. The key function of epithelial lining tissue is to isolate the internal milieu from the external milieu. When minor epithelial ruptures occur, such as chapped lips due to dryness, small periungual lesions, provisional crown and orthodontic band barbs, these are usually associated with the presence of low-virulence microbiota. Under these circumstances, the connective tissue - as a defense measure and to promptly reestablish the normal state of affairs - encourages the formation of granulation tissue in the region along with the proliferation of epithelial lining.

However, in children, adolescents, young adults, pregnant women or women using contra-

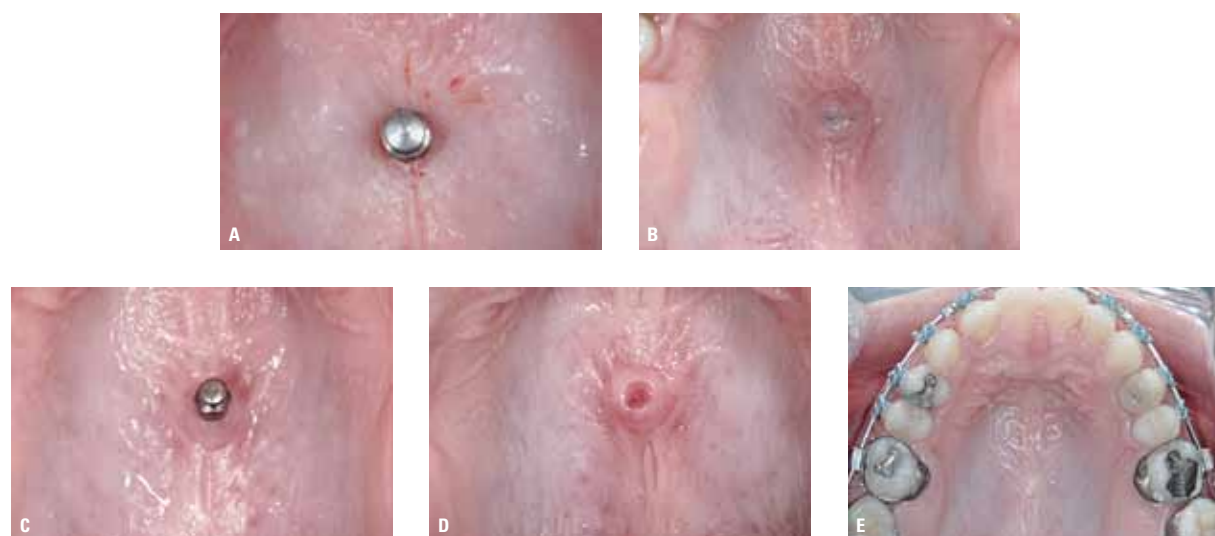


FIGURE 3 - Mini-implant immediately after insertion in the hard palate (A) in a 25-year-old patient, user of contraceptives. One month later (B) the mini-implant head is covered with oral mucosa hyperplastic tissue, similar to a pyogenic granuloma/inflammatory fibrous hyperplasia, despite adequate hygiene performed by the patient. One month later, the mini-implant displays significant mobility due to perimini-implantitis (C). The mini-implant is easily removed (D). Three months later (E) the palatal mucosa is back to normal with a barely perceptible scar on the midline.

ceptive medication (Fig. 3), this reactional capacity can be significantly exacerbated. The granulation tissue, in its initial and intermediate phases, is characterized by angiogenesis and the aforementioned individuals will suffer an increase in levels of serum and tissue angiogenesis stimulating factors.

In the exposed micro-areas, these individuals' granulation tissue, once it is formed in an exacerbated manner, can generate an increased volume characteristic of pyogenic granuloma and pulp polyp, for example. These lesions indicate angiomatous hyperplasia of the granulation tissue. A reddish volume increase accompanied by bleeding can occur around the mini-implants (Fig. 3), especially in the epithelium/mini-implant interface covered with microbial biofilm.

The perimini-implant inflammation can no longer be characterized only by a reddish, peripheral area. This condition is replaced by a festooned volume increase, regular or irregular, presenting with bleeding and rather fragile to the touch (Fig. 3). The neighboring epithelium is stimulated towards a hyperplastic condition in order to cover this granulation tissue volume increase. Some of these perimini-implant hyperplasias are more reddish, but some feature pink, firm areas where the hyperplastic epithelium plays the part of lining (Fig. 3).

The treatment of mucositis and perimini-implant hyperplasias should start as soon as the main cause – microbial biofilms – is removed. Metal barbs, entrapped food particles and other low intensity, long-lasting local irritants should also be detected. Regression takes place between 24 and 48 hours. Should the condition persist, local causes should once again be sought. Whenever tissue growth is too prominent and the chance of spontaneous regression unlikely, surgical removal of the affected tissues would be recommended.

Can mini-implants give rise to osteomyelites?

Osteomyelites are inflammatory lesions char-

acterized by extensive areas of compromised bone with disorderly resorption, purulent exudates and even multiple fistulas. Some of the signs and symptoms can be systemic such as fever, prostration and asthenia. Bone inflammation circumscribed to a specific area where bone neo-formation and sclerosis predominate and no systemic repercussions are detected, are identified as osteites.

Osteomyelites only affect patients suffering from a basic disease that leads to organic debility or in patients presenting with sclerotic bone diseases at the osteomyelitis site. Among the basic systemic diseases which can be associated with osteomyelitis are decompensated diabetes mellitus, immunosuppression, leukemic conditions, anemias, ethylism, senility, etc. Among the sclerotic bone lesions which can – when contaminated – give rise to osteomyelites are florid cemento-osseous dysplasia, Paget disease, among others.

Osteomyelitis hardly ever affects systemically healthy individuals with no sclerotic bone diseases. Should this be the case, the patients should be meticulously assessed to determine whether they suffer from any of these systemic, debilitating diseases. This fact helps to explain why – despite a wide array of clinical-surgical situations involving oral contamination – maxillary osteomyelites are rather rare.

Likewise, in the case of mini-implants, the possibility of inducing osteomyelites is minimal since prior to inserting the mini-implants, a comprehensive anamnesis, clinical exam and local systemic and bone evaluation should be conducted. Patients who present with a debilitating systemic disease, once the condition subdues to medical treatment, will return to normality.

In short, although the insertion of mini-implants constitutes a straightforward clinical-surgical procedure, it exposes and mingles the internal milieu with the external milieu inside the oral cavity, which is a highly contaminated environment. It is very important to conduct a systemic and bone assessment of the patient, as well as raise

the patient's awareness to proper hygiene, a crucial ingredient in ensuring the success of the entire procedure. For many days the internal milieu will be separated from the external, contaminated milieu by a thin, albeit efficient epithelial barrier, namely, the mini-implant/mucosa interface.

FINAL CONSIDERATIONS

The use of mini-implants has broadened the horizons of Orthodontics and widened Implantology's interface. Many aspects of the mini-implant still await clarification, but a statement made by Bezerra at a symposium⁷ on orthodontic anchorage was particularly noteworthy. After a lengthy description of literature surveys, he remarked: "The fact that scientific evidence is not yet available should not deter our attempts. If it works well and is clinically applicable it is important that professors, educational institutions, universities and other research centers do their very best to find effective solutions. I'd like to unpretentiously introduce some suggestions for future studies on the use of mini-implants in orthodontic practice:

1. Pulp and periodontal reactions after mini-implants are touched or brushed against, laying

foundations for prevention, conduct and treatment.

2. Pulp and periodontal reactions after root perforation with mini-implants.

3. Degree of influence exerted by mini-implants on the growth and distribution of microbial biofilms when mini-implants are exposed to the oral milieu.

4. Morphology of the oral mucous membrane tissues and their interface with mini-implants, particularly the epithelium, and interaction mechanisms between the different mucous membrane areas.

5. A comparative study between the microscopic characteristics of mucosites and perimini-implantites and those of gingivitis and periodontitis.

6. A comparative study between the clinical and microscopic characteristics of perimini-implant hyperplasias and those of pyogenic granuloma and inflammatory fibrous hyperplasias in the oral mucosa.

7. Case reports involving accidents and lesions associated with the use of mini-implants as a contribution to their prevention and treatment.

REFERENCES

- AKIN-NERGIZ, N. et al. Reactions of peri-implant tissues to continuous loading of osseointegrated implants. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 114, no. 3, p. 292-298, 1998.
- ALDIKAÇTI, M. et al. Long-term evaluation of sandblasted and acid-etched implants used as orthodontic anchors in dogs. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 125, no. 2, p. 139-147, 2004.
- ARAÚJO, T. M. Recursos para ativação do sistema e controle de higiene periimplantar. **Implant News**, São Paulo, v. 3, n. 4, p. 406-407, jul./ago. 2006.
- ARAÚJO, T. M. et al. Ancoragem esquelética em Ortodontia com miniimplantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
- ARCURI, C. et al. Five years of experience using palatal mini-implants for orthodontic anchorage. **J. Oral Maxillofac. Surg.**, Philadelphia, v. 65, no. 12, p. 2492-2497, 2007.
- ASSCHERICKX, K. et al. Root repair after injury from mini-screw. **Clin. Oral Implants Res.**, Copenhagen, v. 16, no. 5, p. 575-578, 2005.
- BEZERRA, F. Ancoragem ortodôntica com microparafusos de titânio. **Implant News**, São Paulo, v. 3, n. 4, p. 397-399, jul./ago. 2006.
- BEZERRA, F. Evidências clínicas e científicas dos miniimplantes ortodônticos. **Implant News**, São Paulo, v. 3, n. 4, p. 400-401, jul./ago. 2006.
- BÜCHTER, A. et al. Load-related implant reaction of miniimplants used for orthodontic anchorage. **Clin. Oral**

- Implants Res.**, Copenhagen, v. 16, no. 4, p. 473-479, 2005.
10. CARANO, A. et al. Clinical applications of the miniscrews anchorage system. **J. Clin Orthod.**, Boulder, v. 39, no. 1, p. 9-42, Jan. 2005.
 11. CHEN, F. et al. Anchorage effects of a palatal osseointegrated implant with different fixation: a finite element study. **Angle Orthod.**, Appleton, v. 75, no. 4, p. 593-601, 2005.
 12. CHENG, S. J. et al. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. **Int. J. Oral Maxillofac. Implants**, Lombard, v. 19, no. 1, p. 100-106, Jan./Feb. 2004.
 13. CHOI, B. H.; ZHU, S. J.; KIM, Y. H. A clinical evaluation of titanium miniplates as anchors for orthodontic treatment. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 3, p. 382-384, 2005.
 14. CHUNG, K.; KIM, S.-H.; KOOK, Y. C. Orthodontic microimplant for distalization of mandibular dentition in Class III correction. **Angle Orthod.**, Appleton, v. 75, no. 1, p. 119-128, 2004.
 15. COUSLEY, R. Critical aspects in the use of orthodontic palatal implants. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 127, no. 6, p. 723-729, 2005.
 16. EVANS, A. W.; LEESON, R. M. A.; PETRIE, A. Correlation between a patient-centred outcome score and surgical skill in oral surgery. **Br. J. Oral Maxillofac Surg.**, Edinburgh, v. 43, no. 6, p. 505-510, 2005.
 17. GELGÖR, I. E. et al. Intraosseous screw-supported upper molar distalization. **Angle Orthod.**, Appleton, v. 74, no. 6, p. 838-850, 2004.
 18. GRAY, J. B. et al. Studies on the efficacy of implants as orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 83, no. 4, p. 311-317, 1983.
 19. GÜNDÜZ, E. et al. Bone regeneration by bodily tooth movement: dental computed tomography examination of a patient. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 125, no. 1, p. 100-106, 2004.
 20. GÜNDÜZ, E. et al. Acceptance rate of palatal implants: a questionnaire study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 5, p. 623-626, 2004.
 21. HERMAN, R. J.; CURRIER, F.; MIYAKE, A. Mini-implant anchorage for maxillary canine retraction: a pilot study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 130, no. 2, p. 228-235, 2006.
 22. HUANG, L. H.; SHOTWELL, J. L.; WANG, H. L. Dental implants for orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 127, no. 6, p. 713-722, 2005.
 23. KELES, A.; ERVERDI, N.; SEZEN, S. Bodily distalization of molars with absolute anchorage. **Angle Orthod.**, Appleton, v. 73, no. 4, p. 471-482, 2003.
 24. KIM, J. W.; AHN, S. J.; CHANG, Y. I. Histomorphometric and mechanical analyses of the drill-free screw as orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 2, p. 190-194, 2005.
 25. KYUNG, H. M. et al. Development of orthodontic micro-implants for intraoral anchorage. **J. Clin. Orthod.**, Boulder, v. 37, no. 6, p. 321-328, June 2003.
 26. LABOISSIÈRE JÚNIOR, M. A. Aspectos estruturais dos microparafusos ortodônticos. **Implant News**, São Paulo, v. 3, n. 4, p. 404-405, jul./ago. 2006.
 27. LIOU, E. J. W.; PAI, B. C. J.; LIN, J. C. Y. Do miniscrews remain stationary under orthodontic forces? **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 1, p. 42-47, 2004.
 28. MAH, J.; BERGSTRAND, F. Temporary anchorage devices: a status report. **J. Clin. Orthod.**, Boulder, v. 39, no. 3, p. 132-136, Mar. 2005.
 29. MIYAWAKI, S. et al. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 124, no. 4, p. 373-378, 2003.
 30. OHASHI, E. et al. Implant vs screw loading protocols in Orthodontics: a systematic review. **Angle Orthod.**, Appleton, v. 76, p. 721-727, 2006.
 31. OHMAE, M. et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 119, no. 5, p. 489-497, 2001.
 32. OHNISHIA, H. et al. A mini-implant for orthodontic anchorage in a deep overbite case. **Angle Orthod.**, Appleton, v. 75, no. 3, p. 444-452, 2005.
 33. OYONARTE, R. et al. Peri-implant bone response to orthodontic loading: Part 1. A histomorphometric study of the effects of implant surface design. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 2, p. 173-181, 2005.
 34. OYONARTE, R. et al. Peri-implant bone response to orthodontic loading: Part 2. Implant surface geometry and its effect on regional bone remodeling. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 2, p. 182-189, 2005.
 35. ROBERTS, W. E. et al. Implant-anchored orthodontics for partially edentulous malocclusions in children and adults. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 3, p. 302-304, 2004.
 36. SCHNELLE, M. A. et al. A radiographic evaluation of the availability of bone for placement of miniscrews. **Angle Orthod.**, Appleton, v. 74, no. 6, p. 832-837, 2004.
 37. SHERWOOD, K. H.; BURCH, J. G.; THOMPSON, W. J. Closing anterior open bites by intruding molars with titanium miniplate anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 122, no. 6, p. 593-600, 2002.
 38. SUGAWARA, J. et al. Distal movement of mandibular molars in adult patients with the skeletal anchorage system. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 125, no. 2, p. 130-138, 2004.
 39. VANNET, B. V.; SABZEVAR, M. M.; WEHRBEIN, H.; ASSCHERICKX, K. Osseointegration of miniscrews: a histomorphometric evaluation. **Eur. J. Orthod.**, Oxford, v. 29, no. 5, p. 437-442, 2007.
 40. VILLELA, H. M. Microparafuso ortodôntico de titânio autoperfurante: novas perspectivas para ancoragem esquelética. **Implant News**, São Paulo, v. 3, n. 4, p. 402-403, jul./ago. 2006.
 41. VILLELA, H. M. Microparafusos ortodônticos de titânio autoperfurantes: mudando os paradigmas da ancoragem esquelética na Ortodontia. **Implant News**, São Paulo, v. 3, n. 4, p. 369-375, jul./ago. 2006.
 42. WEHRBEIN, H.; GOLLNER, P. Skeletal anchorage in Orthodontics-basics and clinical application. **J. Orofac. Orthop.**, München, v. 68, no. 6, p. 443-461, 2007.
 43. WIECHMANN, D.; MEYER, U.; BUCHTER, A. Success rate of mini- and micro-implants used for orthodontic anchorage: a prospective clinical study. **Clin. Oral Implants Res.**, Copenhagen, v. 18, no. 2, p. 263-267, 2007.

Corresponding author
 Alberto Consolaro
 E-mail: alberto@fob.usp.br

Hee-Moon Kyung

- Clinical instructor, Department of Orthodontics, Dental School, Kyungpook National University, Daegu, Korea (1986).
- Visiting Professor, Department of Orthodontics, Osaka University, Japan (1991-1992).
- Visiting Professor and Associate Professor, Department of Orthodontics, British Columbia University, Canada (1996-1997).
- Director of the Dental School at Kyungpook National University, Daegu, Korea (2001-2003).
- Vice-President of the Lingual Orthodontics World Association (2003).
- Head of the Department of Orthodontics, Kyungpook National University, Daegu, Korea (2004).
- Author and Co-Author of more than 100 scientific papers, most of which international.
- Author of the book "Longitudinal Data of Craniofacial Growth from Lateral Cephalometrics in Koreans with Normal Occlusion".
- Contributed to the Craniofacial Growth Series book "Micro implants as Temporary Orthodontic Anchorage", published by James Mc Namara Jr. in 2007.
- Married to Myung-Hee Kim, lives in Daegu, third largest city in Korea, and has three children. The daughter, aged 25, after graduating from the Seoul University Administration Course, enrolled at the Kyungpook National University Dental School in Daegu where she is currently attending her last semester. The son, 23 years old, is currently attending the last academic year of the Food Engineering course at the same University. Dr. Kyung played many different sport modalities while he was a student but today he is a Golf player, with a handicap of 1.



One of the most important aspects of orthodontic treatment is anchorage control. Just as the materials used in the manufacture of fixed appliances have changed from gold to stainless steel, from the use of bands to direct bracket bonding, so have anchorage devices evolved in response to the need to increase resistance to undesirable tooth movements. Among the resources developed for anchorage, miniplates and mini-implants are among the best suited devices and have, accordingly, earned widespread acceptance in the current literature. Dr. Hee-Moon Kyung is one of the professors who have most significantly contributed to developing mini-implants around the world. He is the author of *Microimplants in Orthodontics*, a book comprising detailed protocols used by the eminent professor and his colleagues. We had the pleasure to talk with Dr. Kyung, who kindly granted the following interview to Dental Press and its readers.

Carlos Jorge Vogel

Why is the success rate of microimplants in the maxilla higher than in the mandible, where bone density is much higher. Telma Martins de Araújo

Prosthetic implants show higher success rate in the mandible than in the maxilla. On the other hand, microimplants happened to result in more failure in the mandible, which has higher bone density. Still, the exact reason is unknown.

However followings are suspected reasons according to my experiences;

- 1) more likely to touch root when lesser buccal alveolar bone volume exists as in the mandible
- 2) narrower attached gingiva in the mandible can induce more inflammation and also higher possibility of touching root
- 3) thick cortical bone in the mandible may generate more heat when drilling is needed
- 4) thick cortical bone in the mandible can induce more microfractures, local ischemia & necrosis around microimplant except for pre-drilling method
- 5) mandibular buccal bone receive more external force from mastication since mandibular buccal cusps are functional cusps

Is the success rate of microimplants influenced by the diameter and length of the microimplants? Fábio Bezerra

Theoretically the bigger and the longer ones may have good retention. However, according to many clinical data, the bigger and the longer diameter does not always guarantee higher success rate. One clinical data¹ from Japan shows that the success rate of smaller diameter (1.3mm) of microimplants is higher than larger (2.0 and 2.3 mm diameter) ones, and even higher than miniplate. Also longer microimplants can have a limitation due to anatomical problems, but we have to insert the microimplant at least 5-6mm into the bone.

Are microimplants with diameter of 1,4mm more prone to complications, such as fractures, during the act of installation or at re-

moval? Telma Martins de Araújo

The smaller, the more possibility of fracture. On the other hand, the bigger, the more possibility of root touch and the more difficulty of removal. So, different size (both diameter and length) should be chosen depending on the sites.

Drill-free microimplants present higher rate of success than non-drill-free ones? Why? Fábio Bezerra

According to our experience, there is no difference between the pre-drilling and drill-free methods. The key point is to choose proper size of pilot drill. Personally I prefer pilot drill which diameter is 0.3mm smaller than that of microimplant.

What kind of protocol do you indicate in cases where radiographically you diagnose the contact of a microimplant with a root surface? Do you expect to see a deleterious effect by this contact? Carlo Marassi

I usually do not take any X-rays simply for checking the root touch after installation. But, these days I use dental fluoroscope (Dream Ray[®], Korea), when I want to check the root touch.

Clinically, patient feels pain, if microimplant touch the root. So, I always try not to induce deep anesthesia. Sometimes just topical anesthesia is enough for microimplant placement.

According to Roberts² by animal experiment, simple root touch does not make any trouble. There is one data (not published yet) of intentional root injury in human from Turkey. According to this data, there was no deleterious side effects, such as ankylosis.

But more failures may be caused after microimplant touched the root. There is one scientific data³ from Japan which support this hypothesis.

Which were the worst complications you had and how did you solve them? Jorge Faber

Fortunately, I have never experienced heavy complications except loosening of microimplants due to inflammation. In these cases, there is no problem after loosened microimplants are being

removed. I do not prescribe any antibiotics before & after installation.

However, followings are common possible complications;

- a. root penetration: when using too large diameter of microimplant without drilling
- b. fracture: when using smaller diameter of microimplant without drilling ; we do not try to remove it when it is hard to remove
- c. injury to anatomical structures, such as maxillary sinus, inferior alveolar nerve & artery, greater palatine artery & nerve.

Are there specific indications for the use of microimplants with a bracket head, and up to how much of moment/force can they resist?

Carlo Marassi

Bracket head type is preferred when indirect skeletal anchorage and moment from the microimplant are needed. It is easier to change the direction of force by connecting wire to the microimplants.

Initial tightening torque force varies depending on the diameters of microimplants, quality of cortical bone and installation method (pre-drilling and drill free) etc. According to my experience, when pre-drilling (1.0mm diameter drill) method is used with 1.3mm diameter of microimplant in the maxilla, the initial tightening force start from 3-4 N Cm. Without drilling, of course the force should be increased. However, the moment applied counter-clockwise direction to the microimplant will more likely to be loosened even by small amount of force. That's why I made left-handed screws.

In the treatment of CI II adult patients with extractions, where retraction of maxillary an-

terior teeth is planned with the use of micro-implant anchorage reinforcement, what kind of procedure do you favor, the extraction of premolars, or third molars?

José Nelson Mucha

For En Masse retraction of upper anterior teeth, the 1st choice of microimplant placement site is between 2nd premolar and 1st molar roots. This area has enough inter-radicular space, which makes easier to insert and less gingival impingement by elastomers, compared to placement between 1st molar & 2nd molar roots. There is no actual difference when making diagnosis about extraction of teeth compared with conventional diagnosis.

For premolar extraction case, I prefer to retract 6 anterior teeth together. What is more, even if you extract 3rd molars or 2nd molars, the whole dentition can be retracted without moving posterior segment first, when there is a mesial tipping of posterior segments. However, in cases with already uprighted molar teeth, it's more effective to move molar teeth first, and then retract remaining anterior teeth. When there is enough volume of bone, we can retract the whole dentition back without touching the 2nd premolar roots, if the microimplants are inserted in oblique direction.

Also, depending on the cases, we can insert microimplants on the tuberosity area as well.

Dr. Kyung, I believe that you are one of the most experienced clinicians in the use of microimplants. In your opinion, which are the most effective mechanics in order to obtain distal movement of maxillary molars in the correction of the CI II malocclusions?

Lincoln Issamu Nojima



FIGURE 1 -Molar uprighting using Bracket Head type microimplant of left handed screw (Dentos Inc., Daegu, Korea). (Treatment provided by Dr. Maria E. Cabana, Spain).

There are many ways to move maxillary molar teeth back. Some may prefer to use midpalatal microimplant with T-P bar. Personally, I do not like to use midpalatal microimplant because, it requires more caution for access to apply force and to control tooth movement clinically. I prefer both buccal & palatal alveolar microimplants to move molar teeth bodily.

Could you relate your experience in relation to the intrusion of posterior teeth in patients with vertical discrepancy? Are the results achieved by this procedure expected to be stable? Could they be a possible substitute for orthognathic surgery? Lincoln Issamu Nojima

Dr Sugawara in Japan has some data(not published yet) about this. According to him, the results were excellent and this can be a substitute for orthognathic surgery in some case. Also, long term stability is fair enough compared to normal openbite treatment without intrusion of posterior teeth using skeletal anchorage.

According to my experience, there is always a certain amount of relapse after treatment of openbite after intrusion of posterior teeth using microimplants. If we treat openbite patients with mesially tipped posterior teeth, we can have better stability.

Would you use microimplants for control of vertical growth in growing patients? Henrique Villela

If the microimplant is located in the maxillary bone, inhibition of maxillary growth is not expected. However, if the microimplant is placed on the other kinds of bone, such as zygomatic bone, sutural growth between zygomaticomaxillary suture could be inhibited. However, growth of circummaxillary suture will not be perfectly inhibited only to use intraoral force from microimplants to teeth and/or bone.

Anyhow, I do not use microimplants in young growing patients by reason of inhibition of growth because I think it's not a cost-effective trial. Also success rate of microimplants is low in growing patients.

In non-surgical CI III cases, where distal movements of mandibular teeth are planned with the help of microimplants, what kind of mechanical procedures are there available, or would you suggest? Jorge Faber

The mechanics is the same as in the maxilla. However, I prefer to place microimplants between 1st & 2nd molar instead of 2nd premolar & 1st molar for whole mandibular dentition retraction. The reason is that there is no enough alveolar

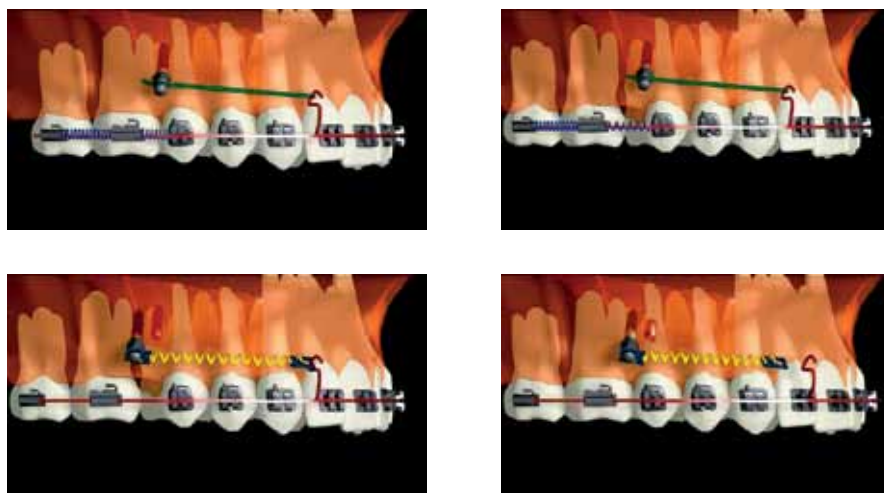


FIGURE 2 - Maxillary molar distalization mechanics. After molar distalization, if a microimplant touches the root of a maxillary second premolar during retraction of the maxillary dentition, the first microimplant is removed and a second microimplant is placed distal to the first one.

bone volume between the mandibular 2nd premolar and 1st molar roots to place microimplant with oblique direction.

We can retract whole dentition without moving posterior segment first, if mesial tipping of posterior segments exists. On the other hand, if molar teeth are already uprighted, it's more effective to move molar teeth first, and then retract the remaining anterior teeth.

Moreover, depending on the situations we can insert microimplants on the retromolar area also.

Could you give us your experience in cases of maxillary expansion with the help of microimplants? Henrique Villela

Long time ago, some dentists used skeletal anchorage for rapid maxillary expansion. I think it's a good idea. But, I have never tried to use skeletal anchorage for RPE, because just conventional RPE appliance is enough for growing young patient. Also, using of skeletal anchorage does not guarantee successful expansion of midpalatal suture in non-growing patients. It's not cost-effective too.

The use of microimplants created a new concept in orthodontic treatment. What do you imagine will be the next novelty involving a significant changes in treatment concepts? What can we expect in the future? What will come after the microimplants? José Nelson Mucha

The concept of using microimplants in orthodontic tooth movement has no difference com-

pared to conventional tooth movement. The only difference is that we can achieve almost all kinds of tooth movement more easily without patients' cooperation. By solving the problem of patient's cooperation (patients cooperation is a nature of orthodontics according to Dr Moyers) in intra-oral anchorage, predictable tooth movement is achieved.

Anyhow, using of microimplants made many kinds of orthodontic tooth movement which were thought to be difficult, such as molar intrusion and whole mandibular dentition retraction, easier & more predictable without patient's cooperation and related side effects. Many minor tooth movements for interdisciplinary treatment (prosthodontic-ortho & periodontic-ortho cases) became simpler. In addition, some surgical cases can be treated without surgical intervention and some two jaw surgery cases can be treated with only one jaw surgery.

However, still we cannot use microimplants for fixed functional appliance (eg. Herbst appliance etc.) because microimplants can be loosened in young growing patients. But in the near future, I am looking forward to using skeletal anchorage for fixed functional appliances, too.

By use of microimplants, we can solve most of the anchorage problems. However, the speed of biological tooth movement is not yet improved, even though many researchers struggled for several decades. In the near future, I hope that we can have some local agents which make rapid tooth movement in specific area.



FIGURE 3 - Both buccal and palatal Bracket Head type of microimplants are placed for bodily distalization of maxillary molar teeth.



FIGURE 4 - Initial records of skeletal open bite case.

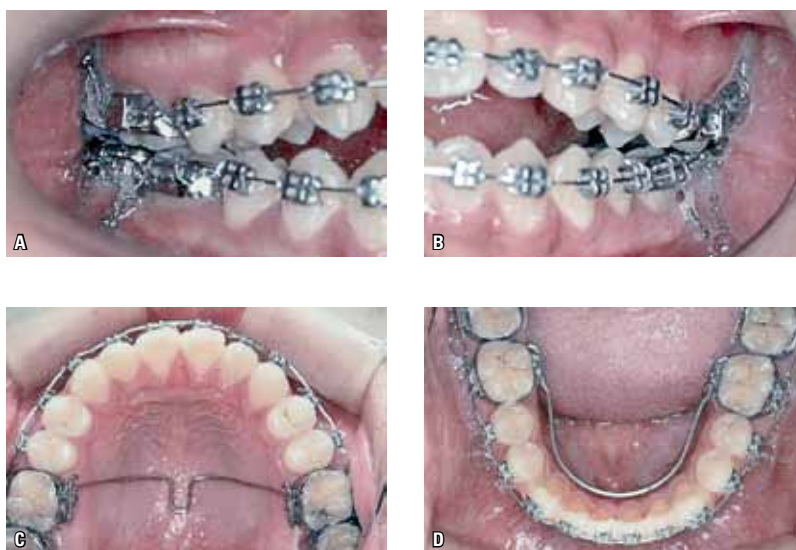


FIGURE 5 - . After leveling, microimplants were placed between all first and second molar roots for intrusion of the molar teeth. Transpalatal and lingual arches were inserted to prevent labial crown tipping.



FIGURE 6 - Post-treatment records of the skeletal open bite case.

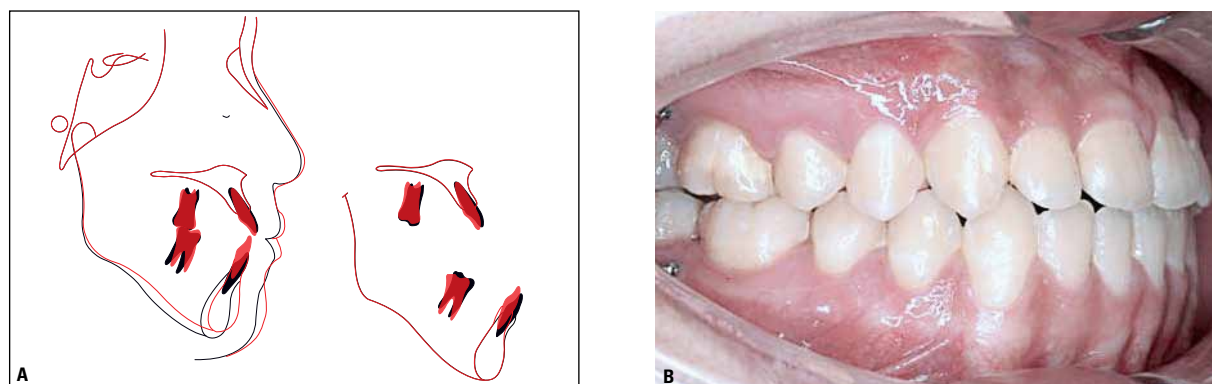


FIGURE 7 - Superimposition of pre- and post-treatment tracings of the openbite case(left) and 27 months of retention after treatment (right).

REFERENCES

1. KURODA, S.; SUGAWARA, Y.; DEGUCHI, T.; KYUNG, H. M.; TAKANO-YAMAMOTO, T. Clinical use of miniscrew implant as orthodontic anchorage: success rate and postoperative discomfort. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 1, p. 9-15, 2007.
2. KURODA, S.; YAMADA, K.; DEGUCHI, T.; HASHIMOTO, T.; KYUNG, M.; TAKANO-YAMAMOTO, T. Root proximity is major factor for screw failure in orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 4, p. S68-S73, 2007. Supplement.
3. ROBERTS, E.; HELM, F. R.; MARSHALL, K. J.; GONGLOFF, R. K. Rigid endosseous implants for orthodontic and orthopedic anchorage. **Angle Orthod.**, Appleton, v. 59, no.4, p. 247-256, 1989.

Carlos Jorge Vogel

- Master of Science from the University of Illinois, Chicago, USA
 - Holds a Doctorate degree from the University of São Paulo
 - Member of the Edward H. Angle Society of Orthodontists
 - Former Managing Director of the Brazilian Board of Orthodontics and Facial Orthopedics.
-

Carlo Marassi

- Holds a Master's Degree from the Leopoldo Mandic Dental Research Center (CPOSLM);
 - Orthodontics Specialist graduated from the University of São Paulo (USP-Bauru);
 - Professor and Scientific Director of the Rio de Janeiro Straight-Wire Group;
 - Coordinator of the Orthodontics Specialist Course of the Leopoldo Mandic Dental Research Center (CPOSLM);
- Holds a Master's Degree in Orthodontics from the Leopoldo Mandic Dental Research Center (CPOSLM);
-

Fábio Bezerra

- Periodontics Postgraduate from the Bauru School of Dentistry, São Paulo University (FOB-USP);
 - Professor of the Implantology Specialist Course at the Bahia State Brazilian Dental Association (ABO).
-

Henrique Villela

- Orthodontics and Facial Orthopedics Specialist (ABO/BA).
 - Professor of the Orthodontics and Facial Orthopedics Specialist Course (ABO/BA).
 - Professor of the Orthodontics and Orthopedics Refresher and Enhancement Courses (ABO/BA).
 - Professor of the Orthodontics Refresher Program Course (Ortho postgrad / Bauru).
 - Guest Professor of the Orthodontics Specialist Course at "La Corporación Ortopedia y Ortondoncia del Chile", Santiago / Chile.
-

Jorge Faber

- Editor in Chief of the Dental Press Orthodontics and Facial Orthopedics Magazine.
 - Holds a Doctorate Degree in Biology from the Brasília University (Un B) Electronic Microscopy Laboratory.
 - Holds a Master's Degree from the Rio de Janeiro Federal University (UFRJ).
 - Professor of Evidence-Based Dentistry for the Brasília University (Un B) Sciences Postgraduate Program.
-

José Nelson Mucha

- Holds a Master's degree and a Doctorate degree from the Rio de Janeiro Federal University (UFRJ).
 - Full Professor of Orthodontics at the Rio de Janeiro Federal University (UFRJ).
 - Director of the Brazilian Board of Orthodontics and Facial Orthopedics.
-

Lincoln Issamu Nojima

- Holds a Master's degree and a Doctorate degree in Orthodontics from the Rio de Janeiro Federal University (UFRJ).
 - Adjunct Professor of the Postgraduate Orthodontics Program at the Rio de Janeiro Federal University (UFRJ).
-

Telma Martins de Araújo

- Holds a Master's degree and a Doctorate Degree in Orthodontics from the Rio de Janeiro Federal University (UFRJ).
 - Full Professor of the Bahia Federal University's School of Dentistry (FO UFBA).
 - Coordinator of the Orthodontics Specialist Course at the Bahia Federal University's School of Dentistry (FO UFBA);
 - Director of the Brazilian Board of Orthodontics and Facial Orthopedics.
-

Tooth intrusion using mini-implants

Telma Martins de Araújo*, Mauro Henrique Andrade Nascimento**,
Fernanda Catharino Menezes Franco***, Marcos Alan Vieira Bittencourt****

Abstract

Introduction: Amongst the different types of orthodontically-induced tooth movements, intrusion undoubtedly features as one of the most difficult to achieve. Conventional intrusive mechanics, although viable, involves a rather complex side effect control. This is due, to a large extent, to a difficulty in securing a satisfactory anchorage. Within this context, mini-implants offer an effective skeletal anchorage which has become an invaluable asset to orthodontists since it renders the intrusion of both anterior and posterior teeth an increasingly streamlined procedure from a mechanical standpoint. **Objective:** It is the purpose of this article, therefore, to describe and demonstrate clinically the various ways in which mini-implant can be utilized as an anchorage device to promote intrusion.

Keywords: Mini-implant. Intrusion. Skeletal anchorage.

INTRODUCTION

In numerous orthodontic treatments, adequate anchorage planning is paramount for a successful therapy. Tooth intrusion, be it aimed at correcting an exaggerated overbite or an anterior open bite, be it for correcting extruded teeth due to missing antagonists, poses a considerable mechanical challenge, given the difficulty in controlling undesirable movements of the anchorage units. Obviously, throughout the years, the literature has reported satisfactory results with the use of auxiliary intraoral appliances and extraoral headgear. Nevertheless, it is not always an easy task to enlist a patient's cooperation owing to the physical discomfort and/or esthetic handicap inherent in these appliances.

In this case, mini-implants emerge as an excellent alternative. The development of mini-implants in the few last years has enabled efficient anchorage, requiring no tooth support and with no esthetic compromise whatsoever. Additionally, no patient cooperation is required^{1,2}. These devices have been used in the orthodontic office with increasing frequency in cases where an inadequate number of dental units stand in the way of an effective anchorage, or even only to simplify orthodontic mechanics and make it more predictable¹.

This article is aimed at summarizing and illustrating the various situations where mini-implant use is possible, specifically focusing on tooth intrusion. Some timely recommendations are also offered to ensure that the desired results are achieved.

* Phd and Master in Orthodontics from the UFRJ; Adjunct Professor of Orthodontics at UFBA; Coordinator of the Specialization Course on Orthodontics and Facial Orthopedics at UFBA and Director of the Brazilian Board of Orthodontics and Facial Orthopedics.

** Post-Graduation Specializations in Orthodontics at UFBA.

*** Master Orthodontics from the UFRJ and Assistant Professor of Orthodontics at FBDC.

**** Phd and Master in Orthodontics from the UFRJ; Adjunct Professor of Orthodontics at UFBA and certified by the Brazilian Board of Orthodontics and Facial Orthopedics.

INCISOR INTRUSION

Anterior teeth intrusion is indicated in some excessive overbite cases and has been performed traditionally by means of intrusion arch wires, the confection of stair-stepped archwires in the anterior region, or the use of steep curve arch wires on the upper arch, or reverse curve on the lower arch. In many situations, however, the side effects caused by this mechanics are unavoidable, especially extrusion or tipping of the anchorage units. By resorting to skeletal anchorage with the use of mini implants, all other teeth are safe from any undesirable movements.

The ideal position for inserting mini-implants when the purpose is to intrude upper incisors will depend on how much tipping they have. When they are vertically positioned or tipped backwards, as is the case with Angle's Class II, Division 2, one single mini-implant is recommended⁸ to be placed on the median line, as high as possible and

close to the anterior nasal spine. To intrude lower incisors similarly positioned or tipped backwards, one mini-implant should be placed as low as possible between the centrals^{6,8,11}. In this position, the force line will extend across the front of the set's resistance center, thereby generating an intrusion effect combined with the buccal tipping of these units (Fig. 1).

When incisors present with reasonable axial tipping and no changes are therefore required, the force action line should be made to run through as closely as possible to the resistance center of the set of teeth which are targeted to be moved^{6,11}. To this end, the use of two mini-implants is recommended, one on each side, positioned between lateral incisors and cuspids (Fig. 2). A typical example of two mini-implants being used with the aforementioned objective is shown in figure 3. In this case, since the patient had only three lower incisors, the choice was made to remove

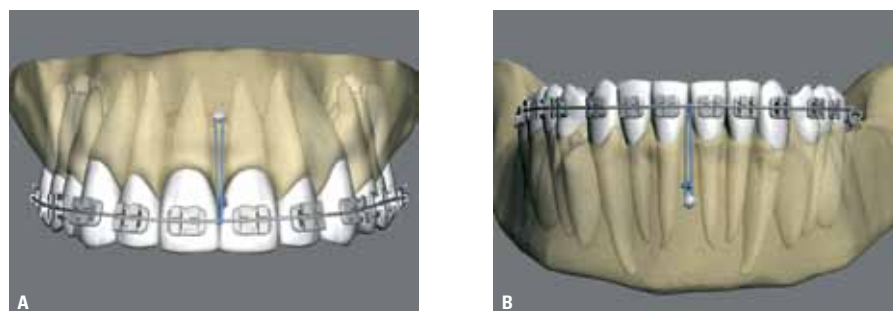


FIGURE 1 - Upper and lower incisor intrusion when it is desirable to have these teeth tip buccally.

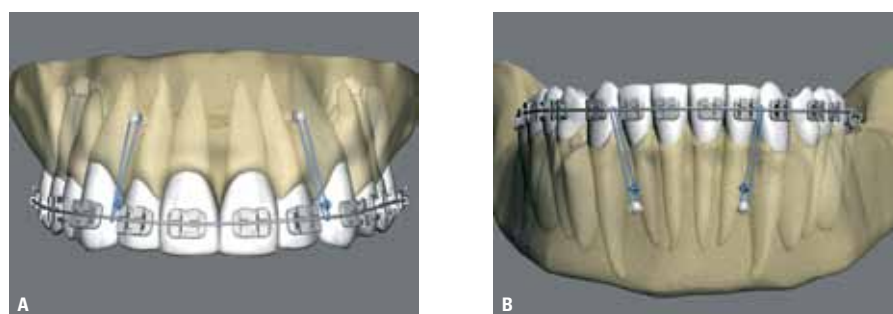


FIGURE 2 - Upper and lower incisor intrusion when it is desirable to maintain teeth's axial tipping.

one, which allowed the cuspids to drift and occupy the position of the lateral incisors. This set of teeth was originally tipped towards the buccal (IMPA=109°). The aim was to induce an intrusion, which would level the Spee curve without aggravating the inclination. As can be observed, the intrusion movement did take place and the lower incisor buccolingual inclination ultimately showed a slight improvement (IMPA=107°).

When performing lower teeth retraction, in Angle's Class II, Division 1 or Angle's biprotru-

sion Class I, treated with bicuspid extraction, an overbite increase may occur, along with incisor axial inclination as teeth move towards the posterior region. In this situation, it is recommended that a mini-implant be inserted at the median line, based on the reasoning described above. Another possibility is the use of vertical loop retraction arch wires, which promotes the incorporation of incisor root lingual torque and allows the orthodontist to make compensatory bends.

As intrusion occurs, it is advisable to check the

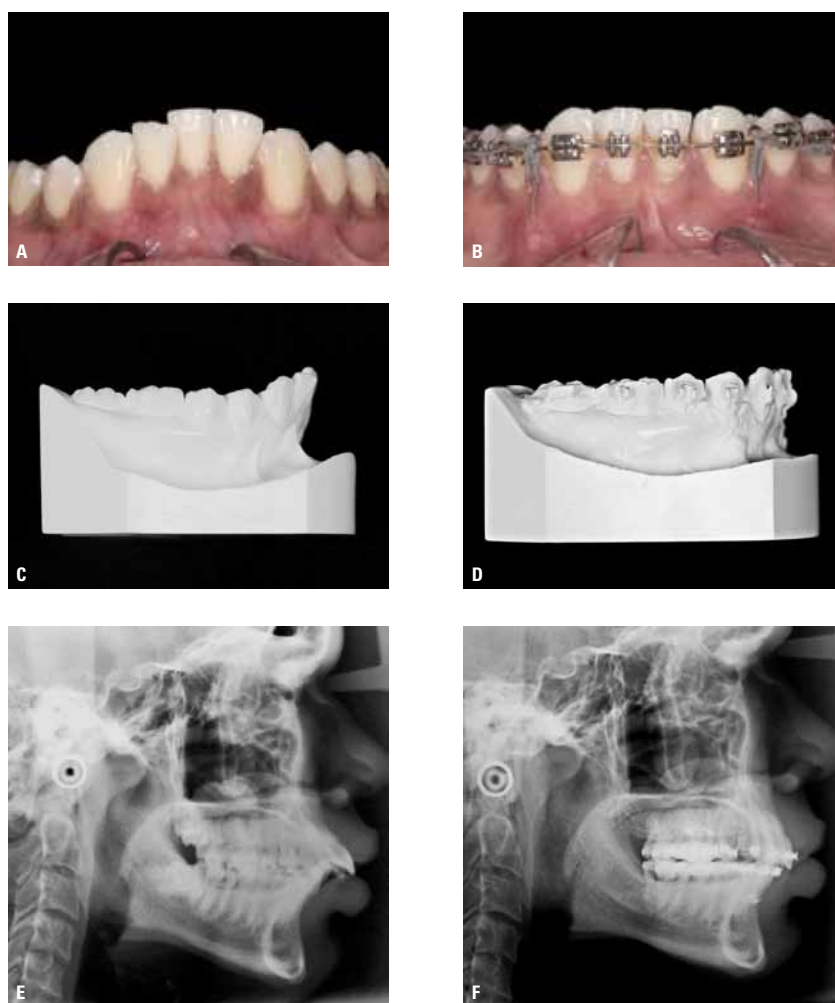


FIGURE 3 - Lower anterior teeth intrusion with embedded mini-implants, inserted in the alveolar mucous membrane (A, B). C and D show Spee curve leveling. In E and F, a slight improvement in the buccolingual inclination of the intruded units can be observed.

arch wire form and the occlusal plane from an anterior view, since changes may occur if intrusion does not take place symmetrically on both the right and left hemi-arches. Another important factor to be monitored is lower anterior torque, which is often lost when intrusion is achieved using light arch wires¹⁴.

CUSPID INTRUSION

In conventional mechanics, cuspids are traditionally intruded by means of arch wires with second order bends or bypass bends associated with elastics and using the neighboring teeth for anchorage. In these cases, the extrusive component of the anchorage units cannot be avoided. Another alternative is the use of segmented arch wires relying on posterior teeth for anchorage. When a patient presents with dental losses in this area or with periodontal impairment in the existing teeth, this type of mechanics should be ruled out.

With the use of mini-implants, these undesirable effects and/or limitations are no longer an issue. When one wishes to intrude a cuspid tooth while keeping its axial inclination, the buccal insertion of two mini-implants is recommended, one on the mesial and one on the distal region of the tooth targeted to be intruded. This approach is important since the use of only one mini-implant is bound to generate, in addition to the intrusive force, a distal or mesial force component - de-

pending on mini-implant position - which is likely to tip the tooth. In this example, buccal activation alone will produce a root palatal torque component as cuspid intrusion occurs. To control this undesirable effect a straight .019" x .025" stainless steel archwire could be fashioned and placed alongside the cuspid's buccal surface immediately below the bracket. It should be underscored that a contact between the archwire and the teeth surface would be essential for controlling this effect. Such contact should, therefore, be monitored and adjusted at each new appointment¹ (Fig. 4).

Another available alternative would be the insertion of a mini-implant in the buccal area, in the cuspid's mesial region, and another one in the palatal area, in the distal region, or vice versa, and then activating the whole set by placing an elastic connecting the two mini-implants across the center of the cuspid crown. It is often necessary to place a strategic composite resin bridge on the cuspid crown to stabilize the elastic in its position.

POSTERIOR TEETH INTRUSION

The need to intrude posterior teeth is mostly due either to a loss of antagonist units, or when there is vertical excess on the posterior region causing an anterior open bite³. Compared with anterior tooth intrusion, posterior intrusion is harder to achieve owing to molars and bicuspid typically having more voluminous roots, which causes the

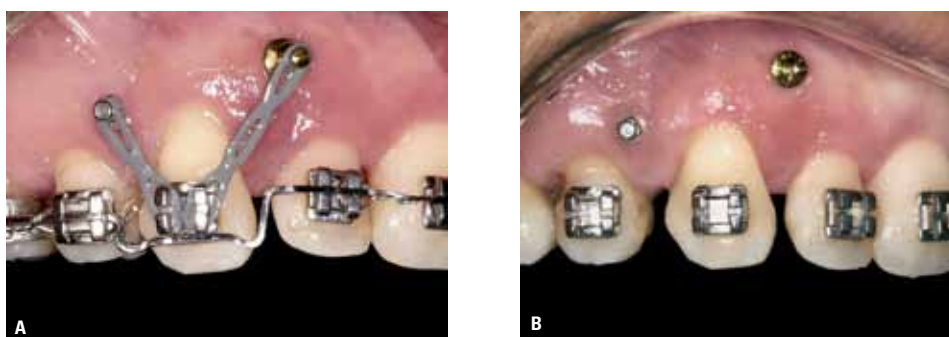


FIGURE 4 - Upper cuspid intrusion using a .019" x .025" archwire alongside the unit to avoid buccal tipping.

alveolar bone to respond more significantly, extending treatment length. The three-dimensional control of tooth position is instrumental in posterior intrusion success. As well as the vertical position, the arch form, inclination of the teeth, occlusal plane inclination and posterior torque should be planned according to the each individual treatment objectives¹⁴. Most cases require tooth body movement so that certain difficulties should be considered, such as the resistance center location, which is influenced, to a certain extent, by individual differences; the root shape and the amount of bone tissue, in addition to anatomical conditions, which often prevent the insertion of mini-implants in ideal sites^{7,14,21}.

Single unit intrusion

A loss of dental units in the posterior region often brings about an extrusion in teeth on the antagonist arch. This extrusion not only compromises the space required for prosthetic rehabilitation but can also cause inconvenient results, such as periodontal defects and occlusal interferences during functional movements²⁵. It is, thus, important to correct this problem by intruding the tooth in question.

On the upper arch, in the event that one single posterior tooth requires intrusion, two mini-implants should be inserted, one buccally and one palatally, the former on the mesial and the latter on the distal region. The mini-implants, if

placed accordingly, will provide a controlled vertical movement without undesirable inclinations²⁵. Force can be applied either by extending elastics between the mini-implants and the orthodontic accessories installed on the buccal and palatal surfaces of the tooth in question (Fig. 5A), or by extending elastics directly on the tooth's occlusal surface and connecting one mini-implant to the other (Fig. 5B). In this case, caution should be exercised not to allow the force action line to cause the elastic to drift towards the mesial or distal region, which might lead the dental unit which is undergoing intrusion to tip^{1,2,16}.

Intrusion of groups of teeth

Prior to the advent of mini-implants, the major alternatives for rehabilitating a patient who presented with a group of extruded teeth in the posterior region were often accomplished either by stripping the occlusal surfaces of these teeth or through a surgical procedure combined with impaction (embedding)^{5,17,23}.

Nowadays, with the help of skeletal anchorage, a controlled orthodontic intrusion of these units can be achieved. In the event of a group of teeth requiring intrusion, the whole group should be handled all together in a group^{1,2,4}. Brackets can be bonded to the buccal and palatal surfaces of the teeth involved and connected with segmented archwires; an orthodontic archwire segment can be bonded directly to the buccal and/or palatal

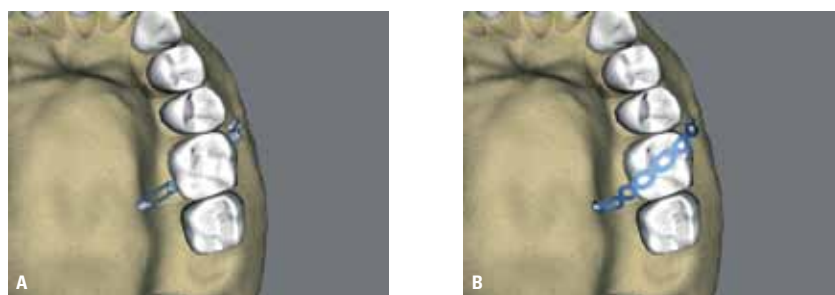


FIGURE 5 - Buccally and palatally placed mini-implants for intruding the upper first molar, activated with elastic on an archwire, via the buccal and palatal regions (A) and with an elastik chain, via the occlusal surface (B).

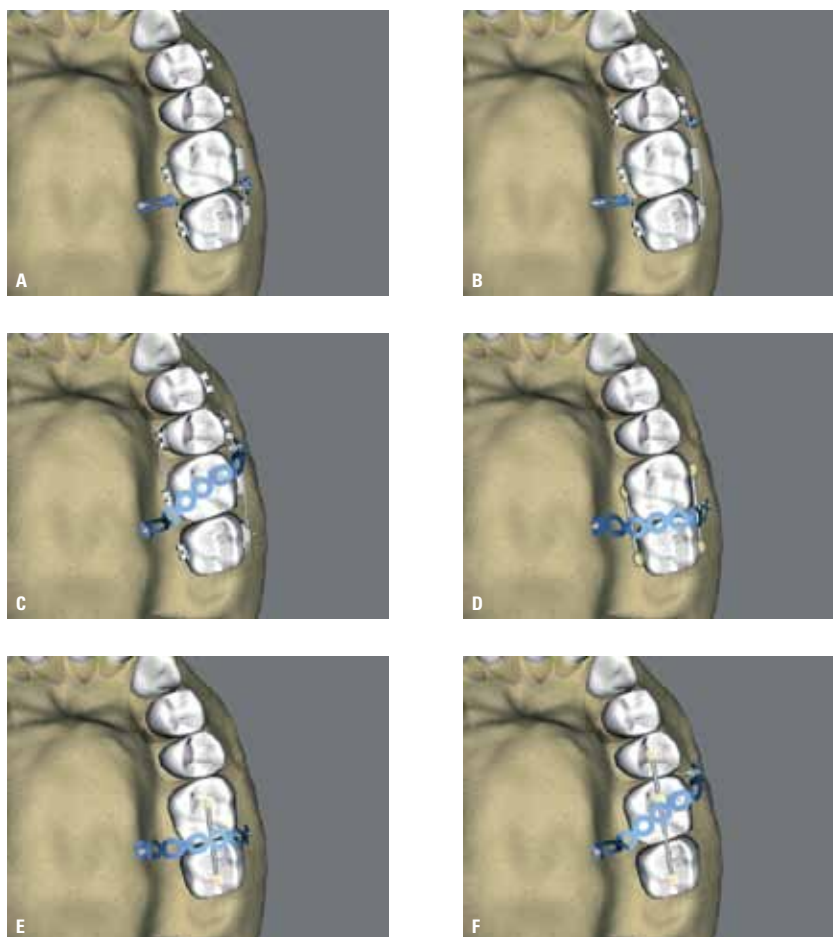


FIGURE 6 - Different forms of intrusion of a group of posterior teeth with some of the segments attached to brackets on the buccal and palatal regions (**A, B and C**); bonded directly to these surfaces (**D**) or attached to the occlusal surface (**E, F**). As can be seen, activation can be achieved using elastic on the archwire attached to the arch segments (**A, B**) or with an elastik chain running alongside the occlusal surface (**C a F**).

surfaces; alternatively, a single orthodontic archwire segment can be attached to the occlusal surfaces, provided it does not cause any interference (Fig. 6).

Even for a wider number of teeth, two mini-implants are usually sufficient to bear the load^{2,3}. As can be seen in figure 7A, a loss of teeth in the right posterior segment of the lower arch determined the extrusion of the second bicuspid and the first and second molars. Since the first molar was more extruded than the other teeth, two mini-implants were initially inserted to achieve intrusion (Fig. 7B) until the teeth in the right

hemi-arch were leveled. An archwire was then attached to the occlusal surface of the bicuspid and the molars and the system was once again activated using elastic, and ultimately intruded all together in a group (Fig. 7C and 7D). Figure 7e shows the result achieved. Another example of the use of mini-implants with the same purpose can be viewed in figure 8.

Anterior open bite correction

Anterior open bite, especially in adult patients, is a condition which requires great effort to correct and retain^{8,9,10}. From a dentistry point of view,



FIGURE 7 - A clinical case showing upper posterior teeth extrusion due to missing antagonist elements (A). In B, activation to achieve intrusion of a slightly extruded first molar, using two mini-implants. As can be observed, some resin was added to the mesiopalatal cuspid with the purpose of providing orientation for placement of an elastik chain, thereby preventing a drift to the mesial region, which might cause the cuspid to tip. An archwire was then attached to the occlusal surface C of the bicuspid and molars and the system was once again activated using elastic for group intrusion (D). In E, the resulting movement can be observed.

its etiology may be connected to a deficient alveolar growth in the anterior region, an excessive alveolar growth in the posterior region, or both. In general, during dentition development, these issues can be easily addressed. However, as the growth phase ends, solutions become increasingly hard to work out through conventional methods.

When planning involves posterior teeth intrusion, mini-implants once again emerge as an excellent anchorage option. In the example shown in figure 9, an intrusion was necessary for both cases. Thus, a mini-implant was used on the buccal and one on the palatal region, on both the right and left sides. Since the teeth in the posterior region featured perfect alignment, the intrusion force was applied with straight wires. Under certain conditions, attaching an arch segment to the teeth's palatal surfaces is recommended in order

to prevent elastics or springs - which are used to achieve the intrusion - from touching the palatal mucous membrane.

Another alternative would be to insert mini-implants via the buccal region only. In this case, to control torque on the teeth undergoing intrusion it is suggested that a transpalatal bar be used on the maxilla, away from the palate by a distance identical with the number of millimeters planned for the intrusion; and on the mandible, a lingual bar, kept away from the incisors^{12,19,24} (Fig. 10). Should there be a transverse-related issue, the appliance used for the upper arch expansion can be maintained, as shown in figure 11. In this case, the use of a Hyrax screw was preferred. It was placed away from the palate on a par with the desired intrusion.

Another detail requiring utmost attention is

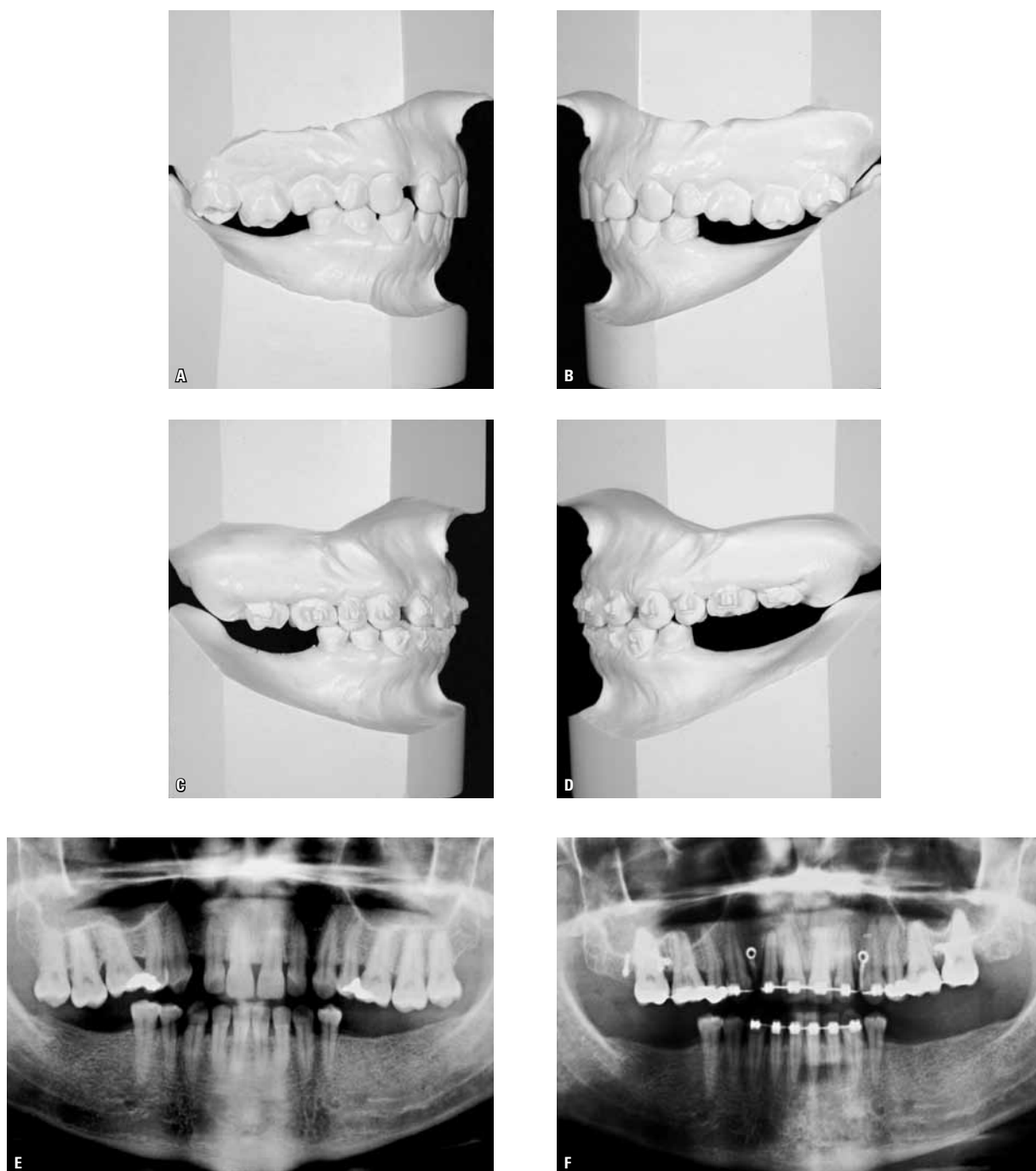


FIGURE 8 - Intrusion of upper arch posterior units to allow rehabilitation using screws in the lower arch. A comparison between the models with the initial radiographs and the period after molar intrusion shows a clear improvement.

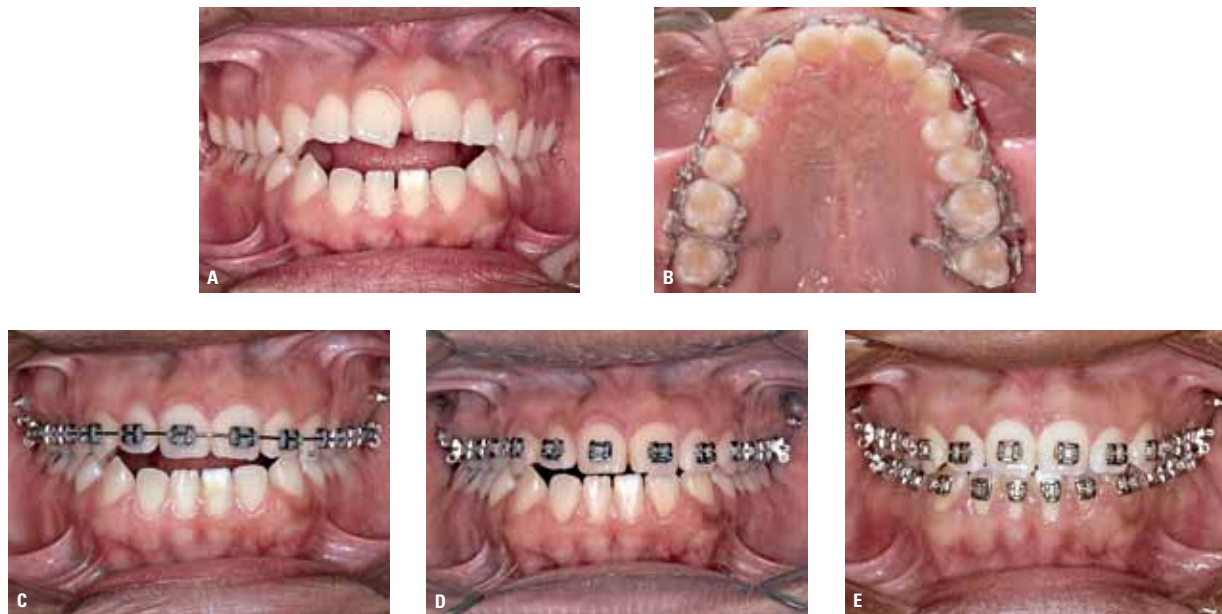


FIGURE 9 - Correction of anterior open bite using posterior segment intrusion of the upper arch. This movement was accomplished by means of mini-implantimplanted in the buccal and palatal surfaces between the first and second molars. Illustration E shows the current condition.

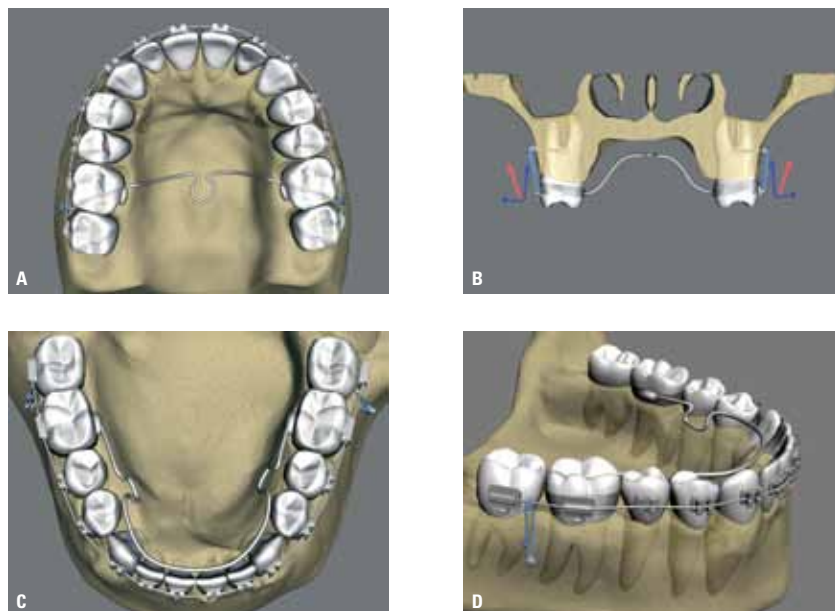


FIGURE 10 - Intrusion of posterior teeth using mini-implants via the buccal region only. To avert tipping toward the force line orientation, a palatal bar should be installed on the upper arch, but kept at a distance from the palate; and on the lower arch, a lingual bar, at a distance from the incisors.

the anteroposterior incisor relationship. If the initial overjet is negligible, incisor trauma may ensue when closing the bite owing to the mandible's counterclockwise rotation. Thus, to stave off this problem, the lower teeth should be retracted first, thereby creating the necessary overjet¹⁹.

With the purpose of avoiding a relapse, a high headgear traction force can be recommended for night use. It is also important for the patient to be monitored by a speech therapist to ensure proper tongue positioning, thus avoiding future problems related to changes in incisor position^{19,20}.

OCCLUSAL PLANE CORRECTION

In cases of occlusal plane inclination from a frontal view, both in the anterior and posterior regions, the insertion of mini-implants at strategic sites allows the use of a discrete force magnitude on either side, thereby facilitating the correction of such defect. The same applies to both the upper and lower arches²⁴. One example of such pro-

cedure in the anterior region can be seen in figure 12. The patient's frontal view featured a significant difference between the right and left sides, with the right side looking clearly lower than the other side. A mini-implant was then installed between the cuspid and the bicuspid and the straight wire which was inserted in the orthodontic appliance was activated directly.

More severe occlusal inclinations can be found in patients who have lost dental units, patients featuring facial asymmetries, severe muscle dysfunctions and certain localized pathologies. This issue is hard to address by means of conventional orthodontic resources alone. The use of mini-implants, in such cases, goes a long way towards streamlining the procedure for intruding an un-leveled arch segment⁶.

GENERAL CONSIDERATIONS

As mentioned above, when mini-implants are inserted for intrusion anchorage, these screws



FIGURE 11 - Intrusion of posterior teeth using mini-implants via the buccal region only. A Hyrax appliance was used to correct the transverse condition and provide control over buccolingual tipping during movement.



FIGURE 12 - Mini-implant insertion on the right hand side of the upper arch only, with the purpose of intruding this segment and correcting the occlusal plane.

should be placed as far apically as possible, both on the upper and lower arches, observing the overall limits of the keratinized mucous membrane. Such distance facilitates system activation in addition to decreasing the risk of damage to any adjacent dental units during intrusion, which was likely to occur given their proximity to a wider root surface area²¹. The alveolar region, however, should be avoided since this region is at a greater risk of local inflammation, which can impair mini-implant stability while increasing the likelihood of the miniscrews being covered with soft tissue. Within this context, some authors^{15,19} report that in the posterior region, the more apically placed a mini-implant, the more perpendicular to the cortical bone it should be positioned, to avoid perforating the maxillary sinus²¹.

In some cases, however, when a patient has a very narrow keratinized mucous membrane, the mini-implant should be implanted in the alveolar mucous membrane. It is thus advisable, at first, to install an embedded mini-implant, under the gum, with a ligature tying it to the outer environment to allow activation with springs or elastics (Fig. 3). An incision is required to make way for a tapered bur or a spiral bur, depending on bone density. At the time of insertion, the alveolar mucous membrane should be expanded and care should be taken to keep the incision borders out of the way, thereby preventing soft tissue from getting entangled in the mini-implant spires. After insertion and ligature placement, the incision should be sutured with one or two stitches.

As observed previously, the number of mini-implant and their insertion site depend directly on the number of teeth to be intruded and their location. In general, at least two mini-implants are necessary, one on the buccal and one on the palatal regions, strategically placed in the region where the orthodontist wishes to work. In this way, the appropriate teeth or segments are intruded with utter buccopalatal tipping control. It should be emphasized that on the lower arch

the insertion of a mini-implant on the lingual side, although desirable for torque control, is a source of major discomfort for the patient. In this case, one alternative is to control the side effects by placing a rather stiff stainless steel arch wire – such a .021" x .025", for example – to increase the buccal root torque of the teeth targeted for intrusion. In the event that there is only one tooth for intrusion, its buccal surface can be placed in contact with an orthodontic archwire, immediately above the bracket in like manner as the example shown for the upper cuspid (Fig. 4).

When the intrusion of a larger number of teeth is desired, more mini-implants can be used (Fig. 13). It should be born in mind¹³, however, that each mini-implant can sustain at most a load of 450cN, and that an optimum orthodontic force should be sufficient to stimulate cellular activity without completely occluding any blood vessels. By way of exemplification, the ideal^{20,22} force for an upper molar intrusion is approximately 150cN. Thus, in most cases, just a few mini-implants prove adequate in promoting an intrusion movement, although it is extremely relevant to consider the system being employed, the condition of the supporting alveolar bone and the patient's individual response. It should be underscored that because the intrusive movement requires a greater bone resorption area, it tends to occur more slowly, on average, than other orthodontic movements. In some cases, there is a period of up to three months of inaction before any change in tooth position is noted. Movement should be allowed to start before increasing the amount of force, since once the state of inertia is broken, the intrusion is bound to begin and continue with some consistency, at a rate of approximately 0.3 mm / month.

An important aspect which deserves consideration prior to intruding any given tooth is an analysis - using periapical and/or proximal radiographs - of the amount of bone present between such tooth and its adjacent elements. According to



FIGURE 13 - Intrusion of four posterior teeth using two mini-implants via the buccal region. Since there were no antagonist teeth, buccolingual tipping control was achieved by means of an arch wire segment bonded to the occlusal surface of these units and tied to a mini-implant inserted in the palate.

Mathews and Kokich¹⁸, if the alveolar bone happens to follow along the same irregular path as the marginal crests of the teeth in question, by leveling the crests through intrusion the bone will also be leveled. However, if the bone level between the adjacent teeth is flat, the orthodontic intervention, by way of an intrusion, is likely to produce a vertical bone defect and, consequently, a periodontal pocket on the tooth's proximal surface. In this case, according to the authors, the best approach would be to level out the occlusal plane by stripping down the crown length.

Special care and continuous follow-up are required to ensure treatment success. Stringent control of oral hygiene, including professional attention before and after the orthodontic move-

ment, is essential since supragingival plaque can contribute to the formation of subgingival plaque during intrusion. Periodic periapical radiographs are also recommended to be taken at four to six month intervals, to monitor the risk of radicular resorption when predisposing factors are identified, such as pipette-shaped roots or a record of previous traumas.

Finally, after intrusion has been achieved with the aid of mini-implants, it should be underscored that the same routine procedures should be taken as when utilizing conventional mechanics. A three-month maintenance period should ensue to connect the tooth or set of teeth which were moved with ligature wire, thereby preventing a relapse.

Submitted in: July 2008
Revised and accepted in: August 2008

REFERENCES

1. ARAUJO, T. M. Ancoragem esquelética com miniimplantes. In: LIMA FILHO, R. M. A.; BOLOGNESE, A. M. **Ortodontia: arte e ciência**. Maringá: Dental Press, 2007.
2. ARAUJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com miniimplantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
3. BAE, S. M.; PARK, H. S.; KYUNG, H. M.; KWON, O. W.; SUNG, J. H. Clinical application of micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 5, p. 298-302, May 2002.
4. BAE, S. M.; KYUNG, H. M. Mandibular molar intrusion with miniscrew anchorage. **J. Clin. Orthod.**, Boulder, v. 40, no. 2, p. 107-108, Feb. 2006.
5. BELINFANTE, L. S.; ABNEY, J. M. A teamwork approach to correct a severe prosthodontic problem. **J. Am. Dent. Assoc.**, Chicago, v. 91, no. 2, p. 357-359, Aug. 1975.
6. CARANO, A.; VELO, S.; LEONE, P.; SICILIANI, G. Clinical applications of the miniscrew anchorage system. **J. Clin. Orthod.**, Boulder, v. 39, no. 1, p. 9-24, Jan. 2005.
7. COPE, J. B.; GRAHAM, J. W. Treatment planning for temporary anchorage device applications. In: COPE, J. B. **OrthoTADS: the clinical guide atlas**. Texas: Under Dog Media, 2007.
8. COSTA, A.; RAFFAINI, M.; MELSEN, B. Miniscrews as orthodontic anchorage: a preliminary report. **Int. J. Adult. Orthodon. Orthognath. Surg.**, Chicago, v. 13, no. 3, p. 201-209, 1998.
9. ERVERDI, N.; TOSUN, T.; KELES, A. A new anchorage site for the treatment of anterior open bite: zygomatic anchorage: case report. **World J. Orthod.**, Carol Stream, v. 3, no. 2, p. 147-153, 2002.
10. ERVERDI, N.; USUMEZ, S.; SOLAK, A. New generation open-bite treatment with zygomatic anchorage. **Angle Orthod.**, Appleton, v. 76, no. 3, p. 519-526, May 2006.
11. KANOMI, R. Mini-implant for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, no. 11, p. 763-767, Nov. 1997.
12. KRAVITZ, N. D.; KUSNOTO, B. Posterior impaction with orthodontic miniscrews for openbite closure and improvement of facial profile. **World J. Orthod.**, Carol Stream, v. 8, no. 2, p. 157-166, Sept. 2007.
13. KYUNG, H. M. et al. **Handbook for the absoranchor orthodontic micro-implant**. 3rd ed. [S.l.: s.n.], 2004.
14. LEE, J. S. Applications of orthodontic mini-implants. 1st ed. Canadá: Quintessence, 2007.
15. LINKOW, L. I. Implanto-orthodontics. **J. Clin. Orthod.**, Boulder, v. 4, no. 12, p. 685-690, Dec. 1970.
16. MARASSI, C.; LEAL, A.; HERDY, J. L.; CHIANELLI, O.; SOBREIRA, D. O uso de miniimplantes como auxiliares do tratamento ortodôntico. **Ortodontia SPO**, São Paulo, v. 38, n. 3, p. 256-265, jul./set. 2005.
17. MASIOLI, D. L. C.; ALMEIDA, M. A. O.; BATITTUCC, E.; MEDEIROS, P. J. Intrusão ortodôntica de molares utilizando mini-placas e parafusos de titânio. **Rev. Clin. Ortodon. Dental Press**, Maringá, v. 4, n. 5, p. 81-87, out./nov. 2005.
18. MATHEWS, D. P.; KOKICH, V. G. Managing treatment for the orthodontic patient with periodontal problems. **Semin. Orthod.**, Philadelphia, v. 3, no. 1, p. 21-38, Mar. 1997.
19. PARK, H. S.; KWON, O. W.; SUNG, J. H. Nonextraction treatment of an open bite with micro-screw implant anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 130, no. 3, p. 391-402, Sept. 2006.
20. PARK, H. S.; KWON, O. W.; SUNG, J. H. Uprighting second molars with micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 38, no. 2, p. 100-103, Feb. 2004.
21. POGGIO, P. M.; INCORVATI, C.; VELO, S.; CARANO, A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. **Angle Orthod.**, Appleton, v. 76, no. 2, p. 191-197, Mar. 2006.
22. REN, Y.; MALTHA, J. C.; KUIJPERS-JAGTMAN, A. M. Optimum force magnitude for orthodontic tooth movement: a systematic literature review. **Angle Orthod.**, Appleton, v. 73, no. 1, p. 86-92, Feb. 2003.
23. ROSEN, P. S.; FORMAN, D. The role of orthognathic surgery in the treatment of severe dentoalveolar extrusion. **J. Am. Dent. Assoc.**, Chicago, v. 130, no. 11, p. 1619-1622, Nov. 1999.
24. SUNG, J. H. et al. **Microimplants in Orthodontics**. Korea: Dentos, 2006.
25. YAO, C. C.; WU, C. B.; WU, H. Y.; KOK, S. H.; CHANG, H. F.; CHEN, Y. J. Intrusion of the overerupted upper left first and second molars by mini-implants with partial-fixed orthodontic appliances: a case report. **Angle Orthod.**, Appleton, v. 74, no. 4, p. 550-557, Aug. 2004.

Contact:

Telma Martins de Araújo
 Av. Araújo Pinho, 62, Centro de Ortodontia e Ortopedia Facial
 Prof. José Édimo Soares Martins,
 Faculdade de Odontologia da UFBA
 CEP: 40.110-150 - Canela - Salvador/BA
 E-mail: tmatelma@globo.com

Characterization of mini-implants used for orthodontic anchorage

Luciana Rougemont Squeff*, Michel Bernard de Araújo Simonson**, Carlos Nelson Elias***, Lincoln Issamu Nojima****

Abstract

Introduction: The reduced diameter and ease of insertion of miniimplants help to minimize errors while preventing accidents that may result from surgeon error or contact between screw thread and tooth root. As diameter decreases, however, the risk of fracture increases.

Methods: This study analysed four Brazilian commercial brands of miniimplant (INP, SIN, Conexão and Neodente) and one German brand (Mondeal) with the purpose of identifying key miniimplant features which make for good anchorage performance. The authors observed miniimplant composition and design and performed the mechanical testing of torque at fracture (in vitro study), whose values were subjected to analysis of variance (ANOVA) and Tukey's test. **Results:** Results showed that all the mini-implants tested are suitable for clinical use as reinforcement of orthodontic anchorage.

Keywords: Mini-implant, Skeletal anchorage.

INTRODUCTION

Currently, skeletal anchorage systems are widespread and often used in Orthodontics as they enable satisfactory results in anchorage control with less discomfort for the patient. Since these devices can substitute other extra and intra-oral resources which rely much more on patient compliance, they can easily prevent anchorage failure^{5,7,13,14}.

Miniimplants offer a straightforward and minimally invasive technique which precludes the use of medicines before and after miniimplant insertion. Comfortable for the patient, this anchorage

alternative is highly recommended to solve severely complex orthodontic problems^{1,22} or in cases where the patient presents with not enough teeth to justify the use of conventional resources. Such cases usually involve forces that may cause adverse side effects, such as asymmetric tooth movements on all spatial planes and, occasionally, can serve as an alternative to orthognathic surgery¹⁰. Systems in current use evolved from two different sources. The first one derived from osseointegrated dental implants, which are scientifically grounded in solid clinical^{1,5,8}, biomechanical^{3,4} and histological¹⁹ studies. Although smaller

* Rio de Janeiro Federal University (UFRJ) - Master of Science in Orthodontics - UFRJ.

** Technologist of the Metallography/Microscopy Laboratory (CEPEL) - Technologist in Telecommunications (Estácio de Sá University) - Mechanics Technician (CEFET-RJ).

*** PhD, Department of Material Science, Military Institute of Engineering (IME).

**** Adjunct Professor of the Postgraduate Dentistry Program (Orthodontics) – UFRJ - Doctor of Dentistry (Orthodontics) – UFRJ - Master of Science in Dentistry (Orthodontics) - UFRJ.

than conventional implants, orthodontic implants belong in this group, with a similarly treated surface and osseointegration capabilities. Also in this category are retromolar and palatal implants. Both are used for indirect anchorage since they are connected to the teeth, which act as anchorage units. The second system type stemmed from miniimplants and was designed specifically for orthodontic use as direct anchorage. Subsequently a new implant type was developed whose tip is similar to a bracket and can be used for direct or indirect anchorage. Unlike osseointegrated implants, these devices have a smaller diameter with a smooth surface and are designed so as to allow force to be applied immediately or soon after insertion¹⁰.

Implants provide effective anchorage points for tooth movements even in immediate load cases¹¹. They have also proved successful in cases where molar intrusion is necessary since they produce vertical force vectors without reciprocal extrusive forces affecting the remaining teeth^{6,9}. Furthermore, the use of headgear or transpalatal bars as well as the inclusion of second molars to reinforce anchorage can be avoided by using implants. These are also indicated for cases requiring impacted cuspid traction^{6,10} or molar uprighting¹⁶.

Miniimplants are mostly produced from titanium alloy. They come in a wide range of designs and sizes and different commercial brands. They feature three distinctive sections, Head – area for installing orthodontic devices; Transmucosal Collar or Neck – region extending from the thread to the head (usually smooth to accommodate peri-implant tissues), and Thread – the active, cutting section¹⁴.

The miniimplant head can have an orifice, hook or button on the tip. Implant heads in the shape of an orthodontic bracket are also available and provide the added bonus of allowing three-dimensional control as well as indirect anchorage. On this section, accessories such as springs, elastics or ligature wire can be attached for anchorage or movement, as planned^{13,14}.

Ideally, the transmucosal region should come in various lengths to enable placement in different sites⁶. Another key feature that should be present in this region of the miniimplant is a polished surface. The likelihood of infection in the adjacent tissues¹⁰ is reduced as a function of how polished this implant area is.

The diameter of the threaded section varies from 1 to 2 mm and the cutting thread is an important feature which helps determine the choice of miniimplant¹⁰. Self-drilling miniimplants have an extremely thin and pointed apex which, more often than not, eliminates the need for any additional bone perforation procedure whereas a larger apex usually requires the site to be perforated with a bur. The latter are called self-tapping implants²⁰.

Miniimplant diameter should be selected according to site and available space with the aid of an intraoral radiograph. For the maxilla a smaller diameter should be selected if the miniimplant is to be inserted between tooth roots. If it needs to be inserted into trabecular bone for enhanced stability, a longer miniimplant is required. If, however, the cortical bone proves sufficient to keep it stable, a shorter miniimplant can be used. Possible insertion sites on the maxilla comprise: The area below the nasal spine, the palate, the alveolar process and the infra-zygomatic crest with the miniimplant placed at an oblique angle towards the apex. On the mandible the sites of choice for miniimplant insertion are the alveolar process, mandibular retromolar area and symphysis. If teeth are present, insertion should be performed parallel to the roots. A transcortical miniimplant can be used to promote stability in an edentulous area where trabecular bone is usually scarce¹⁰. The advantage of using smaller diameter miniimplants is that insertion is easier between roots, reducing the risk of root contact. Some issues have been reported regarding miniimplant use², among which one of the most frequent is fracture³. Fracture risk is closely associated with miniimplant diameter

since fractures tend to occur either when mini-implant diameter is very thin or when the neck is not strong enough to sustain the tension generated at removal time³. In order to avoid this incident it is advisable to use tapered implants with a resistant neck and diameter compatible with bone site quality. Fracture can also occur as a result of too much force being applied by the surgeon during implantation of a self-tapping or self-drilling miniimplant. Another common problem arises from using miniimplants whose transmucosal region is poorly polished since it predisposes local tissues to infection¹⁰. Post-surgical oral hygiene is yet another crucial factor affecting miniimplant stability. It is of utmost importance to make the patient aware of the measures required to control dental bacteria biofilm as well as attending weekly appointments for clinical control during the first month¹³.

The aim of the present study is to describe the in vitro features of orthodontic anchorage miniimplants manufactured by five different companies (SIN, INP, Conexão, Neodent and Mondeal) in terms of topography and design. The miniimplants were also subjected to a mechanical torque test up to fracture point. Hopefully the findings will help to enhance the quality of Brazilian miniimplants and make for their optimized use as orthodontic anchorage reinforcement.

MATERIALS AND METHODS

Thirty miniimplants were analyzed while being used for orthodontic anchorage. Their specifications can be found in Table 1.

Scanning Electron Microscopy (SEM)

Photomicrography

To observe miniimplant topography and design the samples were mounted on special aluminum bases using a double face carbon tape and observed under a Scanning Electron Microscope. A LEO 940 Model was set to high vacuum mode with 20 KV acceleration and 0.8 μ A filament cur-

Table 1 - Distribution of the analyzed samples.

Brand	Diameter (mm)	Length (mm)	Alloy	System
SIN	1.4	8.0	Ti-6AL-4V	Self-drilling
SIN	1.6	8.0	Ti-6AL-4V	Self-drilling
INP	1.5	8.0	Ti-6AL-4V	Self-tapping
Conexão	1.5	8.0	Ti-6AL-4V	Self-drilling
Neo-dente	1.6	7.0	Ti-6AL-4V	Self-drilling
Mondeal	1.5	7.0	Ti-6AL-4V	Self-drilling

rent. 25x, 50x, 100x and 200x photomicrographs were acquired showing images of the head, transmucosal and thread sections of all samples.

Energy-dispersive X-ray Spectroscopy (EDX)

The metal alloy contained in the miniimplants was characterized by X-ray dispersion under the Scanning Electron Microscope. To this end the samples were cut with ISOMET and washed with ULTRAMET 2002 ultrasound equipment. After careful drying the miniimplants were placed on the special MEV bases for content analysis.

Measurements with a digital profile projector

The digital profile projector (Fig. 1), a PAN-TEC (PANAMBRA INDUSTRIAL E TÉCNICA S.A., São Paulo, Brazil) was used to obtain two key measurements for design evaluation, namely, thread depth and inter-thread distance.

Torque test

The miniimplants were subjected to a torque⁴ test where each piece was inserted into swine tibia cortical bone up to fracture point. Initially the swine tibia was attached around the bench to prevent it from moving during miniimplant insertion. A pilot hole was drilled with a surgical 1.0 mm diameter bur. Subsequently, the manual key from each original miniimplant kit was fixed to the head of the digital torque meter (LUTRON TQ - 8800, Taiwan). The screws were inserted by the same professional up to fracture point. Tests

were conducted on five miniimplants of each make and the results were analyzed subsequently. The insertion torque values were obtained and submitted to analysis of variance (ANOVA) and Tukey's test as well as a descriptive statistical analysis (Tab. 4).

RESULTS

Figure 2 shows the design of the sample mini-implants in the 6x magnification photomicrographs acquired with the Scanning Electron Microscopy (SEM); a higher magnification of the heads and threads can be observed in figures 3 and 4, respectively.

Table 2 shows the percentage of the chemical elements Aluminum (Al) and Titanium (Ti) found in the samples by means of X-ray dispersion analysis (EDX).

Table 3 displays the means for inter-thread distance and thread depth of the samples.

Table 4 shows the minimum and maximum values found by the insertion torque test (N/cm) and the means of forces applied up to fracture point, standard deviation values and group statistics for the miniimplant samples.

DISCUSSION

Orthodontic miniimplants are manufactured from Ti-6Al-4V alloy, unlike osseointegrated dental implants, which are usually manufactured from commercially pure titanium. The reason for these choices lies in the fact that miniimplants have a smaller diameter than conventional implants, requiring a material mechanically more resistant than pure titanium, such as Ti-6Al-4V alloy. This alloy is less bioactive than commercially pure titanium, thereby compromising osseointegration quality while making removal easier. Besides, miniimplant systems rely on primary (initial) mechanical stability instead of secondary stability derived from osseointegration^{3,18,19}. It was noted that all researched brands displayed a similar composition (Tab. 2) whereby all miniimplants



FIGURE 1 - PANTEC Digital Profile Projector.

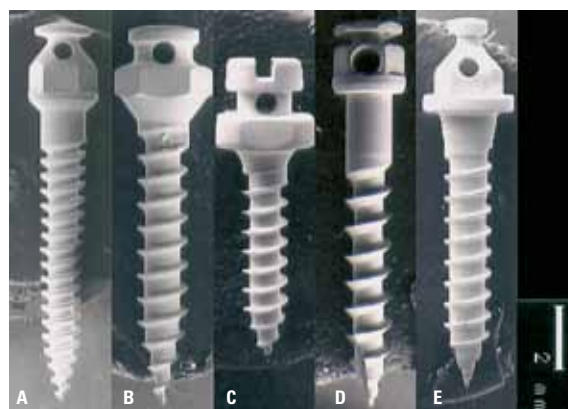


FIGURE 2 - 6x magnification photomicrograph showing miniimplant designs: Conexão (A), Neodente (B), Mondeal (C), INP (D) and SIN (E).

Table 2 - Elements found in the composition of the miniimplant systems assessed in this study.

	SIN	INP	Conexão	Neodente	Mondeal
Al (%)	2.60	2.60	2.51	2.18	2.50
Ti (%)	97.40	97.40	97.49	97.82	97.50

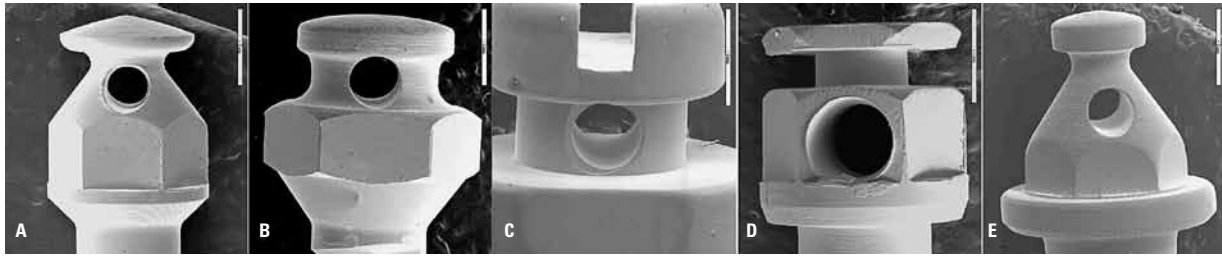


FIGURE 3 - Photomicrographs of mini-implant heads; Conexão (A), Neodente (B), Mondeal (C), INP (D) and SIN (E) at 27x magnification.

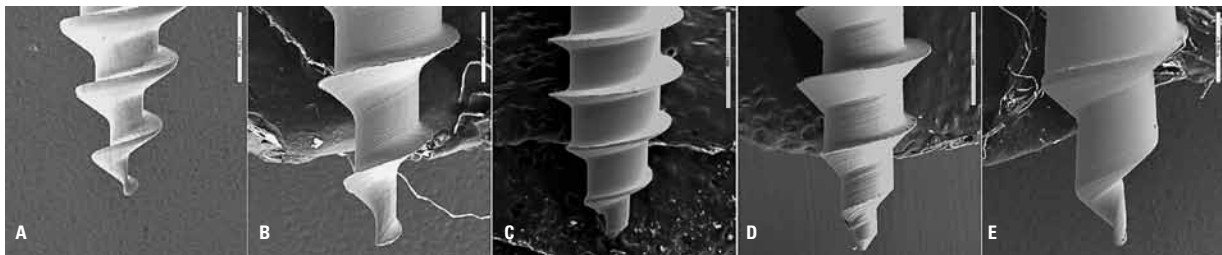


FIGURE 4 - Photomicrograph of mini-implant thread section; Conexão (A), Neodente (B), Mondeal (C), INP (D) and SIN (E) at 50x magnification.

Table 3 - Means for miniimplant inter-thread distances and thread depths (in mm).

Miniimplants under study Diameter x length (mm)	Inter-thread distance means (mm)	Thread depth means (mm)
SIN 1.4 x 8.0	0.796	0.186
SIN 1.6 x 8.0	0.693	0.199
INP 1.5 x 8.0	0.857	0.304
CONEXÃO 1.5 x 8.0	0.498	0.255
NEODENTE 1.6 x 7.0	0.734	0.243
MONDEAL 1.5 x 7.0	0.654	0.267

Table 4 - Descriptive statistical analysis of insertion torque forces found for the miniimplant samples (N/cm²).

groups	average	d.p.	minimum	maximum	statistics
SIN 1.4 x 8.0	26.34	3.05	23.1	30.5	AC
SIN 1.6 x 8.0	40.0	1.19	38.5	41.4	D
INP 1.5 x 8.0	22.3	1.99	20.2	24.6	AB
CON 1.5 x 8.0	18.26	1.06	17.4	20.0	B
NEO 1.6 x 7.0	34.8	2.35	32.3	38.2	E
MON 1.5 x 7.0	28.1	3.38	24.1	32.9	C

Different letters = statistically significant difference (p > 0.01).

are predominantly made from titanium with a small amount of Aluminum. Vanadium did not appear on the graph given its concentration below the minimum amount detectable by EDX.

Regarding the clinical efficiency of miniimplants certain notorious flaws and issues arouse concern, mainly those linking their use to problems such as peri-implantitis and miniimplant fracture. One of the reasons for miniimplant failure is an accumulation of biofilm around the

implant or a source of persistent mechanical aggression, which can cause problems such as acute or chronic inflammation and infection¹⁷. To avoid these setbacks special care should be taken in view of the way miniimplants are designed. A cylindrical transmucosal neck is indicated to enable a comfortable interface between miniimplant and soft tissue, and oral hygiene. The transmucosal section of miniimplants should be suitably polished to prevent biofilm from developing on the

local tissues¹⁰. In this study the photomicrographs clearly showed that all miniimplant brands fill this requirement and both the neck and the head sections were found to be adequately polished.

Design-wise, attention should also be given to miniimplant head diameter, which should be wider than the neck to keep soft tissue from encroaching upon the miniimplant⁸. In the present study all miniimplants met this requirement. Some of the desirable features of miniimplants consist in their ease of use and a wide range of applications. It would be convenient for a mini-screw to lend itself to both direct and indirect applications, i.e. the head structure should be anatomically designed to allow for the concurrent use of elastics and orthodontic arch wire. Of all miniimplants under study only the MONDEAL brand features a slot which enables the use of orthodontic arch wires (Fig. 3). All other makes had only a button and hole for the placement of elastics and springs.

Design should ensure the prevention of irreversible tissue injuries, such as those suffered by tooth roots. For this purpose, the apical portion of the thread should be narrower and the perforation system safe enough to rule out the possibility of permanent injury to anatomical structures. This characteristic also facilitates miniimplant insertion while minimizing surgical trauma. In this investigation all mini-screws had a thin apical area (Fig. 4). Primary stability is a prerequisite for healing and is intimately related to cortical bone support. A cone-shaped thread ensures a bone condensation effect, enhancing its quality while preventing the undesirable destruction of cortical bone due to eccentric insertion or change of axis during insertion. Thus, implant stability need not rely on surgeon skill or implant insertion site⁸. Of the commercial brands under study only Mondeal, INP and Conexão featured a cylinder-shaped thread instead of tapered (Fig. 2).

The use of self-drilling or self-tapping screws – with or without a prior perforation procedure

– is marked by controversy. Some authors believe self-drilling screws are more traumatic since this procedure generates physical pressure and microfractures in the adjacent bone region, which may injure the periosteum and endosteum and cause bone cell necrosis. Other professionals, however, recommend self-tapping miniimplant for they believe that the frictional heat produced by the bur during prior perforation – used for self-tapping screws – can cause more severe bone trauma. There are those who prefer to perform prior perforation with a manual instrument of high cutting capacity to minimize heat production while cooling with intense irrigation particularly the spot where the bone is thicker⁸. An *in vivo* test to ascertain which would be the best possible solution for this issue is beyond the scope of this study. Nevertheless, clinical studies have shown that self-drilling miniimplants enjoy a higher success rate owing to their greater primary stability compared to self-tapping miniimplants¹⁵.

The miniimplants in this study had a 7 mm (Neodente and Mondeal) and 8 mm (SIN, INP and Conexão) length. According to LEE et al.⁸, length exerts little effect on tension distribution. Thread design and diameter are more significant features in this respect. The authors assert that it is necessary to insert at least 5.0 mm of the screw length into the bone. Insertion beyond this depth, however, does not translate into an effective increase in primary stability unless a bicortical anchorage is intended. The miniimplants in this study, therefore, are in accordance with these authors' recommendations.

Regarding insertion torque up to fracture point the miniimplant systems which exhibited the highest resistance to insertion fracture were those with the largest diameter: 1.6 mm, namely, miniimplants manufactured by SIN (1.6 mm) and Neodente (Tab. 4). Our findings agree with those by ELIAS, GUIMARÃES and MULLER³, who concluded that the smaller a screw diameter the smaller the force values required for mini-screw

insertion into the bone and the insertion force required to fracture it. These authors ascribe such characteristic to the following factors: Torque is proportional to the miniimplant x bone contact area. Since the diameter of the alveolus preparation bur is smaller than the screw diameter, part of the torque is aimed at cutting and widening the hole. As diameter size increases so does the volume of material to be cut during perforation and therefore remnants from the material remain entrapped inside the alveolus thereby hindering miniimplant rotation during insertion. This observation underlines the need for greater care to be taken when using miniimplants of a smaller diameter since fracture is more likely to occur. The third best result was achieved by the Mondeal system with its 1.5 mm diameter miniimplant. The 1.4 mm SIN System achieved the fourth best result despite its smaller diameter in comparison with the INP and Conexão systems. A comparison between miniimplant brands was beyond the scope of this study. However, as can be clearly observed in table 4, certain significant differences were found in some miniimplant groups. It should also be emphasized, however, that the insertion torque force recommended in orthodontic practice, according to Motoyoshi et al.¹² is 5 to 10 N/cm², and no stronger than 15 N/cm². Therefore, all implants used in this study achieved satisfactory results in terms of insertion fracture resistance (Tab. 4).

All implants under study sustained fracture in the thread section. Measurements were made of the distances between threads and thread depths of the miniimplants from the five manufacturers (Tab. 3) and compared to the torque test results. These features proved irrelevant and no association was found between the fragility of the material in the thread section (fracture site) and the aforementioned measurements. Further studies are required to better identify and solve this problem. A lateral groove on the cortical portion of the miniimplant thread section could help to in-

crease fracture resistance since it would prevent excessive tension from being generated onto the miniimplant's adjacent tissues where the thread section has a wider diameter⁸. None of the miniimplants used in this study featured such modification.

CONCLUSION

After describing the topographical and design features of the miniimplants used in this study and subjecting them to a torque test it can be concluded that all miniimplants are adequate for clinical use in reinforcing orthodontic anchorage.

ACKNOWLEDGEMENTS

The authors wish to thank the manufacturers of the following miniimplant systems: INP, Mondeal, Neodente and Conexão for supplying the miniimplants. To the Center for Electric Power Research (CEPEL) and professionals involved in this study we extend our gratitude for their support in operating the Scanning Electron Microscope (SEM) and the digital profile projector. We would also like to thank the Rio de Janeiro State Carlos Chagas Filho Research Support Foundation (FAPERJ) for their financial support.

REFERENCES

- CARANO, A. et al. Clinical applications of the miniscrew anchorage system. **J. Clin. Orthod.**, Boulder, v. 39, p. 9-24, Jan 2005.
- CHENG, S. T. et al. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. **Int. J. Oral Maxillofac. Implants**, Copenhagen, v. 19, p. 100-106, 2004.
- ELIAS, C. N.; GUIMARÃES, G. S.; MULLER, C. A. Torque de inserção e de remoção de mini-parafusos ortodônticos. **RBI**, Rio de Janeiro, v. 11, n. 3, p. 5-8, 2005.
- ELIAS, C. N.; LOPES, H. P. **Materiais dentários: ensaios mecânicos**. São Paulo: Ed. Santos, 2007.
- KANOMI, R. Mini-implant for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, p. 763-767, Nov. 1997.
- KESLING, P. Questions about miniscrews. **J. Clin. Orthod.**, Boulder, v. 39, no. 9, p. 527-528, Sept. 2005.
- KYUNG, S. H.; HONG, S. G.; PARK, Y. C. Distalization of maxillary molars with a midpalatal miniscrews. **J. Clin. Orthod.**, Boulder, v. 37, no. 1, p. 22-25, Jan. 2003.
- LEE, J. S. et al. **Application of orthodontic mini-implants**. 1st ed. Canadá: Quintessence, 2007.
- MAINO, B. The spider screw for skeletal anchorage. **J. Clin. Orthod.**, Boulder, v. 37, no. 2, p. 90-97, Feb. 2003.
- MELSEN, B. Mini-implants, where are we? **J. Clin. Orthod.**, Boulder, v. 39, no. 9, p. 539- 547, Sept. 2005.
- MELSEN, B.; COSTA, A. Immediate loading of implants used for orthodontic anchorage. **Clin. Orthod. Res.**, Copenhagen, v. 3, no. 1, p. 23-28, Feb. 2000.
- MOTOYOSHI, M. et al. Recommended placement torque when tightening an orthodontic mini-implant. **Clin. Oral Implants Res.**, Copenhagen, v. 17, no. 1, p. 109-114, Feb. 2006.
- NASCIMENTO, M. H. A.; ARAÚJO, T. M.; BEZERRA, F. Microparafuso ortodôntico: instalação e orientação de higiene periimplantar. **Rev. Clin. Ortodon. Dental Press**, Maringá, v. 5, n. 1, p. 24-31, fev./mar. 2006.
- NOJIMA, L. I. et al. Dispositivos temporários de ancoragem em Ortodontia. In: BERNARDES, J. **Estética em Implantologia**. 1. ed. São Paulo: Quintessence, 2006.
- PITHON, M. M. **Avaliação mecânica de mini-implantes ortodônticos**. Dissertação (Mestrado)-Faculdade de Odontologia. Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2008.
- PARK, H. S.; KYUNG, H. M.; SUNG, J. H. A simple method of molar uprighting with micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 36, p. 592-596, 2002.
- QUIRYNEM, M.; PAPAIOANNOU, W.; STEENBERGHE, D. V. The influence of titanium abutment surface roughness on plaque accumulation and gingivitis: short-term observations. **Int. J. Oral Maxillofac. Implants**, v. 11, no. 2, p. 169-178, 1996.
- SUNG, J. H. et al. **Microimplants in Orthodontics**. Korea: Dentos Daegu, 2006.
- SYKARAS, N. et al. Implant materials, designs and surface topographies: their effect on osseointegration. a literature review. **Int. J. Oral Maxillofac. Implants**, v. 15, no. 5, p. 675-690, 2000.
- VILELLA, H.; BEZERRA, F.; LABOISSIÈRE, M. J. Microparafuso ortodôntico de titânio auto-perfurante (MPO): novo protocolo cirúrgico e atuais perspectivas clínicas. **Innovations Implant Journal: Biomaterials and Esthetics**, São Paulo, v. 1, n. 1, p. 46-53, maio 2006.
- YANO, S. et al. Tapered orthodontic miniscrews induce bone-screw cohesion following immediate loading. **Eur. J. Orthod.**, Oxford, v. 28, no. 6, p. 541-546, 2006.
- WIECHMANN, D.; MEYER, U.; BÜCHTER, A. Success rate of mini and micro-implants used for orthodontic anchorage: a prospective clinical study. **Clin. Oral Implants Res.**, Copenhagen, v. 18, p. 263-267, 2007.

Corresponding Author:

Lincoln Issamu Nojima
Universidade do Brasil - UFRJ - Faculdade de Odontologia
Programa de Pós-graduação em Odontologia
Brasil - Rio de Janeiro - RJ
Av. Brigadeiro Trompowsky, s/nº
Ilha do Fundão - RJ - BRAZIL
E-mail: linojima@gmail.com

Mini-implant assisted anterior retraction

Carlo Marassi*, Cesar Marassi**

Abstract

Introduction: Evidence has established orthodontic mini-implants as important anchorage method, which has proved helpful for orthodontists throughout all orthodontic treatment stages, eliminating the need for patient compliance while achieving more predictable results.

Objective: This article describes the key aspects of performing anterior retraction with mini-implant anchorage and presents an analysis of mini-implant indications, amount of anterior tooth movement, retraction force vectors, vertical control, mini-implant positioning, different types of anterior support and the amount of force to be applied. The most common mini-implant installation sites used for anterior retraction are highlighted, as well as the factors which should be controlled during space closure. Finally, some clinical considerations are presented to shed light on the use of mini-implants during this significant orthodontic treatment stage.

Keywords: Orthodontics. Orthodontic anchorage procedures. Mini-implants. Anterior retraction.

INTRODUCTION

The anterior retraction stage has great significance in orthodontic treatment. It is in this phase that orthodontists need to maintain or achieve relevant objectives such as cuspid key, molar key, overbite correction and midline coincidence. In order for these goals to be accomplished adequate management of the anchorage unit is required.

For many years orthodontists have utilized mechanics that encompasses anchorage preparation, headgear appliance, and intermaxillary elastics as the key tools to stabilize the posterior segment during the anterior retraction stage.

Today we can rely on resources such as skeletal anchorage, in particular with mini-implants, which have proved efficacious as an anchorage control method by significantly reducing or even eliminating the need for patient compliance, thereby rendering treatment more predictable and efficient (Fig. 1)^{5,8,11}.

INDICATIONS

The use of mini-implants to assist in the anterior retraction phase is likely to benefit individuals who: 1) Find it difficult to cooperate by wearing headgear, intermaxillary elastics or other

* Orthodontics Specialist – São Paulo University (USP), Bauru. Professor and Scientific Director of the Rio de Janeiro Straight-Wire Group. Coordinator of the Orthodontics Specialist Course of the Leopoldo Mandic Dental Research Center (CPOSJM/RJ); Holds a Master's Degree in Orthodontics from the Leopoldo Mandic Dental Research Center (CPOSJM/Campinas).

** Orthodontics Specialist – Grande Rio University (Unigranrio). Stomatology Specialist – Grande Rio University (Unigranrio). Radiology Specialist – Brazilian Dental Association, Rio de Janeiro (ABORJ).



FIGURE 1 - Initial photos: **A)** Class I on the right; **B)** upper midline shifted to the right; **C)** Class II on the left. **D, E, F)** Start of space closure. **G, H, I)** End of space closure with overcorrected midline. **J, K, L)** Finished case.

traditional anchorage methods; 2) Have the need for maximum anchorage on the upper arch, lower arch or both. 3) Whose anchorage may be compromised by too few dental elements, due to root resorption or periodontal disease sequelae; 4) Whose occlusal plane is tipped towards the anterior region^{1,12,15}.

PLANNING AND BIOMECHANICAL CONSIDERATIONS

Judicious planning is crucial for mini-implant success. Orthodontists are strongly advised to con-

sider the factors described below with a view to choosing the best-suited biomechanics for each patient^{8,11}.

Amount of anterior teeth retraction

Although the use of mini-implants allows significant retraction of anterior teeth, caution should be exercised to prevent patient discomfort or injury. A significant incisor retraction can impair an orthodontic patient's facial esthetics, particularly those who present with retrognathic mandible. It should also be noted that slightly increased lip

projections are seen as an asset in society, whereas a significant decrease in lip projection can convey a facial appearance typical of old age.

The amount of bone available in the mandibular symphysis or in the alveolar process of the anterior maxilla is yet another factor that deserves consideration, particularly if an incisor “en-mass” retraction has been planned. Orthodontists should also ascertain that the underlying periodontium allows ample movement, especially in adult patients with periodontal disease sequelae. In addition, it is advisable to assess root length and anatomy relative to resorption risk, mainly when anterior retraction is planned in combination with lingual root torque^{8,14}.

Retraction force vectors and vertical incisor control

Space closure mechanics tend to increase overbite and orthodontists have to add compensatory bends to archwires in order to control this side

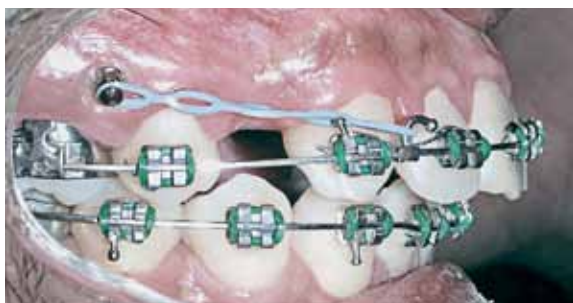


FIGURE 2 - Anterior retraction with direct anchorage

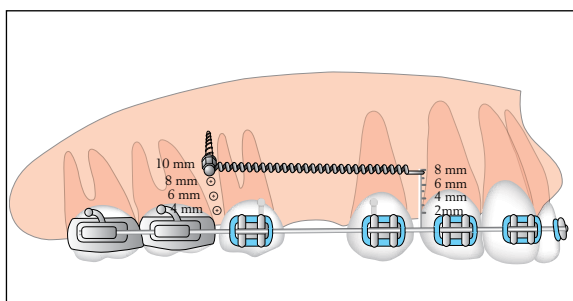


FIGURE 3 - Different possibilities for mini-implant vertical positioning and different anterior region support heights.

effect. Since mini-implants are usually inserted more apically than molar hooks it should be noted that anterior retraction with direct mini-implant anchorage tends to generate a more intrusive force vector on the incisors compared to traditional mechanics (Fig. 2)⁸. This force vector can be controlled by changing mini-implant insertion height and/or anterior region support height, thereby raising a number of different force action line alternatives (Fig. 3). Orthodontists should, therefore, prior to mini-implant installation, define which force action lines will be employed and determine the vertical effect that the force vector will exert upon the anterior teeth^{5,8}. Some authors refer to these retraction force vectors as high, medium and low installation. Although such terms are suitable for the maxilla, applying them to the mandible can make their interpretation by surgeons and orthodontists more difficult. Therefore, force vectors are described below according to their impact on the anterior region.

Retraction with intrusive force vector

This type of retraction is indicated for individuals who present with overbite compounded by incisor extrusion. In this case, mini-implants are usually inserted away from the archwire combined with a short hook in the anterior region (Fig. 4). This type of force vector tends to cause the maxillary occlusal plane to rotate counterclockwise. On the mandible the retraction tends to bring about an occlusal plane clockwise rotation. To enhance



FIGURE 4 - Anterior retraction with intrusive force vector on upper incisors.

the intrusive effect on the incisors, the anterior region hook can be turned towards the occlusal plane (Fig. 13A) instead of the conventional orientation. This mechanics is contraindicated for individuals with reduced overbite or open bite. The intrusive force vectors generated by the mini-implants also tend to yield unfavorable results in unilateral retractions, since these can cause frontal occlusal plane inclination due to the intrusion of one single side of the archwire^{5,8}.

Retraction with extrusive force vector

This type of retraction is used in anterior open bite cases, where a mini-implant is installed close to the archwire and combined with long hooks on the cuspids' mesial region to strengthen incisor extrusion and bite closure (Fig. 5). It is recommended that the degree of incisor exposure be assessed to verify that such approach can be applied to the maxilla since, despite its efficiency, this mechanics tends to cause the occlusal plane to rotate clockwise, thereby increasing anterior teeth exposure. On the mandible there is a tendency for counterclockwise occlusal plane rotation, which helps bite closure. Open bite correction can be further enhanced through the use of elastics connecting the mini-implants to the archwire in the posterior region and achieving lower molar intrusion, which will further benefit the counterclockwise mandibular plane rotation and help even more significantly in the correction of this malocclu-

sion. On the maxilla one could either connect the mini-implants to the posterior segment archwire (Fig. 6) or use a mini-implant on the palatal suture connected to hooks on the transpalatal bar to achieve vertical control of molars during anterior retraction¹⁸. It should be underscored that upper molar intrusion also causes the maxillary occlusal plane to rotate clockwise, which is likely to over-expose the upper incisors^{5,8}.

Retraction with intermediate force vector

Used in patients with a next-to-normal overbite when little or no occlusal plane alteration is desired. Even in patients with a normal overbite, a slightly intrusive force vector can be used to offset an incisor extrusion tendency, which takes place during anterior retraction (Fig. 7)^{5,8}.

Incisor vertical control can also be accomplished by means of archwire bends or the insertion of a mini-implant in the anterior region to achieve incisor intrusion during the retraction stage (Fig. 8). This mechanics is indicated for individuals presenting with either a narrow attached gingiva on the posterior segment or a low maxillary sinus, which may hinder the installation of a more apically positioned mini-implant^{2,5,8,12}.

Vertical positioning and insertion angle of mini-implants^{1,5,8,12}

When mini-implants are used as direct anchorage, installation height is likely to exert a



FIGURE 5 - Anterior retraction with extrusive force vector on upper incisors.



FIGURE 6 - Anterior retraction combined with upper molar vertical control.



FIGURE 7 - Anterior retraction with intermediate vector on upper and lower incisors.



FIGURE 8 - Anterior retraction with intermediate force vector combined with anterior intrusion and a mini-implant inserted between incisors.

considerable impact on the force action line used in incisor retraction. Orthodontists are advised to determine insertion height in line with treatment goals, taking into account each patient's anatomical limitations. A more apical installation, i.e. farther away from the bone crest and the orthodontic archwire (8mm insertion point above the papilla or higher) is recommended in cases where an anterior retraction movement is intended, in combination with incisor intrusion. This installation is limited by the width of the zone of attached gingiva available and by the presence of the maxillary sinus. In general, the mucogingival line sets the apical installation limit since mini-implants that are inserted in the attached gingiva yield better results and are more comfortable for the patient. Orthodontists should assess whether or not it would be wise to install the mini-implant in the alveolar mucous membrane to achieve a more intrusive vector. The maxillary sinus is usually present in the upper molar region starting at 8mm distance from the alveolar bone crest and should be avoided during mini-implant insertion. Mini-implant insertion close to the occlusal installation limit (insertion point about 4mm to 5mm above the papilla) is indicated for anterior open bite cases. This installation can be combined with the use of long hooks in the anterior region to enhance anterior open bite closure in cases where increased incisor exposure is possible. Interme-

diate height installation (insertion point about 6mm to 8mm above the papilla) is desirable for individuals who present with a normal or slightly increased overbite. In most retractions, orthodontists normally wish to maintain frontal occlusal plane inclination. For this purpose, it is important to install the mini-implants at the same height on both sides since different heights could generate an uneven occlusal plane in the anterior segment (Fig. 9). It is advisable to measure the distance between the orthodontic archwire and the perforation on one side, and then replicate such distance in the opposite side. The same installation angle for both mini-implants is also recommended so that their extremities can remain equidistant in relation to the archwire. In planning mini-implant installation height, in angular insertions, it should be noted that the mini-implant extremities will be more occlusal than the perforation mark. Therefore, the perforation point should be marked more cervically than the point planned as force vector source.

For individuals who present with an inclined frontal occlusal plane it is advisable to install mini-implants at different heights, thereby generating a force vector with a more intrusive component in one side in order to improve or straighten out the altered plane's inclination. Should the occlusal plane inclination also reach as far as the posterior segment, an elastic module can be con-

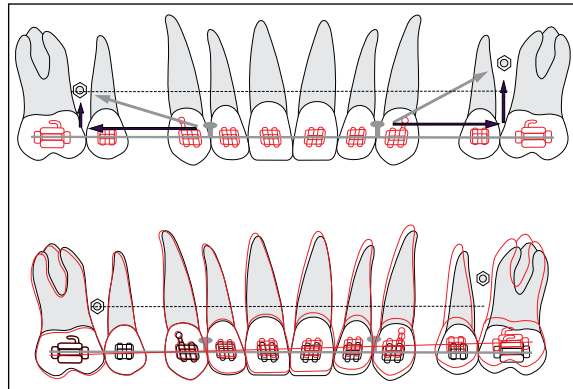


FIGURE 9 - Different vertical positioning of mini-implants can generate an uneven occlusal plane in the anterior segment.

nected from the mini-implant to the archwire in the region where molars may require intrusion, but one should be careful to control a proclination tendency caused by the intrusive force.

For anterior retraction with indirect anchorage the mini-implant installation height is not as crucial as in direct anchorage since the mini-implant's role will be only to stabilize posterior elements while the orthodontist is likely to use the same biomechanics used in conventional treatments. Indirect anchorage has the advantage of exerting little impact on retraction force vectors. However, if the mini-implant begins to show certain mobility, the teeth comprised in the anchorage unit may also move.

Force application point^{5,8,21}

In sliding mechanics, hooks are used on the archwire as force application points to achieve anterior retraction. These hooks can be crimped, screwed on, soldered to the archwire with silver solder or welded; auxiliary appliance hooks can also be used as well as power arms, which can be bonded directly onto teeth. Prefabricated hooks are available for different heights (Fig. 11) and soldered hooks can be customized for each specific case (Fig. 12).

Hook height plays a fundamental part in de-



FIGURE 10 - Indirect anchorage for anterior retraction.

termining the force action line. Shorter hooks tend to generate more intrusive force vectors in the anterior region.

One can choose to install hooks towards the occlusal, shift them from cuspid mesial to cuspid distal, thereby strengthening even further the intrusive vector acting on the dental elements in that region. (Fig. 13A) Intermediate height hooks are used when one does not wish to make any alterations to the occlusal plane or little vertical modification in the anterior region (Fig. 13B).

In anterior open bite cases, the use of longer hooks is suggested in order to prevent any intrusive vector from acting on the incisors or to provide these with an extrusive vector (Fig. 13C). Esthetic concerns and the depth of the vestibule, however, limit hook height. These limitations can be overcome by soldering hooks on the cuspids via the palatal region and performing a retraction with the aid of mini-implants inserted in the palatal alveolar process between the first and second upper molars. To help in the anterior retraction of patients who present with frontal occlusal plane inclination, orthodontists can use a shorter hook in the side where a greater anterior intrusion is desired.

Some hook height variation can also be employed to compensate for an unexpected asym-

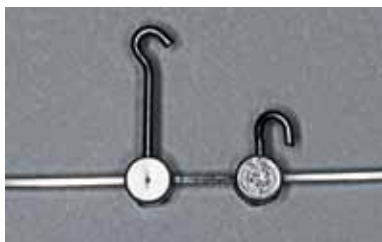


FIGURE 11 - Illustration of two prefabricated screw-on hooks of different heights.



FIGURE 12 - Machine welded long hook used in anterior retraction, with a slightly extrusive force action line on the upper incisors.

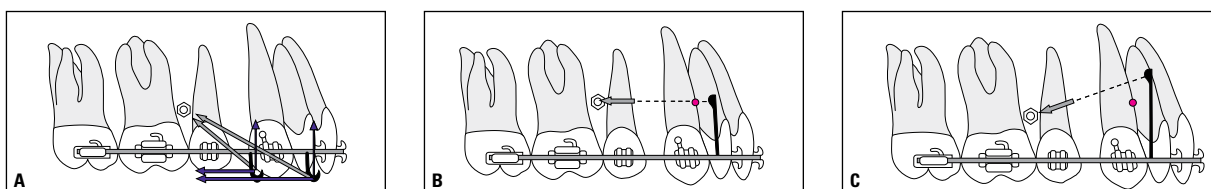


FIGURE 13 - Different hook installation heights generate different force vectors for anterior retraction.

metrical mini-implant installation. This is achieved by installing a shorter hook in the side where the mini-implant was inserted closer to the occlusal and a longer hook where the mini-implant was positioned more towards the apical, thereby keeping similar force vectors on both sides. It should be noted that, as the anterior retraction progresses, the force application point (hook) gets closer to the mini-implant while the force action line becomes increasingly vertical, generating more intrusive force vectors on the incisors. The need may arise to increase hook height during the anterior retraction phase to achieve a force action line as parallel as possible to the occlusal plane (Fig. 14). In specific cases, where one wishes to reduce the time length of orthodontic fixed appliance utilization, a removable acetate plate can be used as anterior retraction support (Fig. 15). This alternative approach involves a treatment with bicuspid extractions and a partial or total closure of extraction space through the use of a plate with a hook placed next to the anterior teeth's center of resistance. This alternative method should prove more convenient for patients with increased inci-

sor inclination, increased cuspid tipping, decreased overbite and slight anterior region crowding.

Incisor buccolingual inclination

An object will respond with a rotational movement every time a force is applied to it without going through the center of resistance (CR). The same phenomenon tends to occur with teeth in the retraction phase since the force action line usually travels more occlusally than the anterior teeth's CR, causing a side effect which leads these dental elements to incline towards the palatal or lingual regions²⁰.

In order to avert this tendency to incline, a moment of force can be applied against the direction of the retraction force by means of buccal torque on the crown or compensatory bends on the archwire. Depending on the force/moment present in the retraction an uncontrolled inclination movement, controlled inclination, "en-mass" movement or root movement may occur.

Uncontrolled tipping will continue to occur as long as the slack between the archwire and the bracket slot is not eliminated²⁰. In the anterior

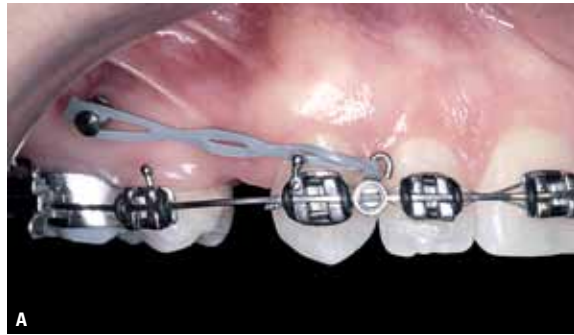


FIGURE 14 - **A)** Retraction with short hook and intrusive force vector on incisors. **B)** Change to long hook: force vector more parallel to occlusal plane.



FIGURE 15 - A model illustrating the removable acetate plate with a mockup on the extraction area, used for anterior retraction.

retraction phase a 0.019" x 0.025" stainless steel archwire is recommended for 0.022" x 0.028" brackets. In this system, there is a slack of approximately 10 degrees between the archwire and the bracket slot, which can cause some loss of buccal inclination on the incisors, especially in large retractions¹⁴. If this happens, the orthodontist will have to apply buccal torque on incisor crowns and a mini-implant anchorage would come in handy to prevent proclination of these dental elements as well as posterior anchorage failure, which tends to occur during the process of anterior torque recovery⁸.

Intrusion forces in the anterior region, when applied in front of the incisors' center of resistance, are likely to increase buccal inclination of these dental elements. These forces can be generated by reverse or accentuated curve archwires, compensatory bends on the archwire or by using

mini-implants inserted between the central incisors to intrude the anterior region during the retraction phase. These resources can be employed whenever the need arises to maintain or enhance the buccal inclination of incisors⁸. On the other hand, in patients presenting with significantly increased incisor inclination and reduced extraction space, one can choose to achieve anterior retraction using a round stainless steel 0.20" or even 0.018" archwire, which enables a quick reduction in the inclination of these teeth. This strategy is particularly efficient in patients who, besides having an increased inclination, also present with anterior open bite since the side effects of palatal inclination and incisor extrusion will make for a favorable scenario^{6,10}.

The force action line accomplished by way of mini-implant direct anchorage is likely to exert some impact on the buccolingual inclination of incisors, since the more occlusally positioned this line is found to be relative to the center of resistance of anterior teeth, the greater will be the tendency of incisor inclination towards the palatal or lingual region. Orthodontists, therefore, should be wary of cases involving apically inserted mini-implants in combination with short hooks. With the purpose of bringing the force action line closer to the center of resistance of the incisors it would be advisable to insert 8mm to 10mm mini-implants above the archwire and make use of hooks with 6mm to 8mm of height in the anterior region.

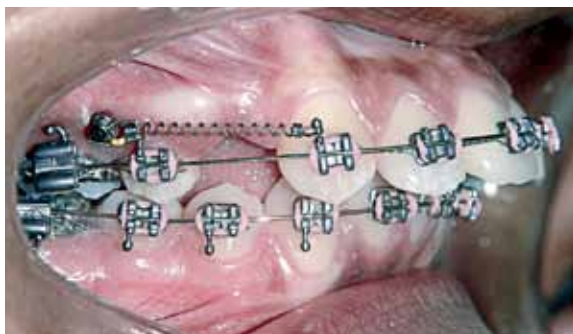


FIGURE 16 - Start of anterior retraction using a round stainless steel archwire for quick incisor inclination correction.

The CR of anterior teeth is located approximately 10mm above and 7mm posterior to the brackets on normally inclined central incisors^{5,8}.

Some professionals resort to a mechanical strategy whereby the incisors are allowed to tip towards the palatal region and then later, after space has been closed, they will apply buccal torque to the crown with the purpose of reducing molar anchorage loss during this treatment stage. This approach is not required when using stable mini-implants because anchorage control would no longer be an issue.

Force applied

Certain treatment philosophies advocate prior cuspid retraction as a means to reduce anchorage loss during anterior retraction. In view of the fact that mini-implants are an efficacious anchorage alternative, prior cuspid retraction, to this end, is rendered unnecessary. Should orthodontists choose to carry out anterior retraction in two stages, they can use mini-implants for cuspid retraction and, subsequently, for incisor retraction. "En-mass" retraction, however, can mean an important time saving treatment tool¹, in addition to being a more esthetic retraction method since it prevents diastemas between cuspids and lateral incisors.

For "en-mass" retraction, a 150cN to 300cN force is prescribed for each side (1 Newton = 100cN = 102g, therefore 150 to 300cN are equivalent to what orthodontists usually refer to as

150 to 300g, although the appropriate force measure unit is the Newton). This amount of force is sufficient to close 0.5mm to 1.0mm space per month while allowing adequate control of side effects. Stronger forces tend to produce various undesirable side effects and can lead to mini-implant failure. A force gauge should always be used since orthodontists tend to apply more force than they believe they are applying¹⁴. On average, mini-implants can sustain forces of about 200cN to 400cN. This limit can vary depending on the patient's facial pattern (braquifacials have greater limits), on the type of bone where a mini-implant is inserted (thicker cortical bone offers more resistance) and on mini-implant diameter^{3,4,8,17}.

Anterior retraction can be started on the same day of mini-implant insertion since mini-implants owe their stability, in large measure, to mechanical retention and not to osseointegration. In fact, histological evaluations have demonstrated a larger contact area with immediate load mini-implants than with those which were not loaded or which received load after a period of rest^{4,8,17}.

In sliding mechanics, retraction activation can be achieved by means of superelastic Nitinol springs, conventional Nitinol springs, elastic modules for retraction (Fig. 17) or chain elastic modules. Superelastic Nitinol springs are the foremost recommendation given their narrower force variation. Special springs are available which can be easily attached to mini-implants (Fig. 18) and some companies have adapted the outer area of mini-implants to accept springs that are available in the market, thereby dispensing altogether with the use of special springs or spring attachments using ligature wire (Fig. 19). Although purportedly superelastic, the force exerted by these springs should be gauged since force intensity varies in tandem with the distance between mini-implant and hook. Usually, 150g or 200g springs are chosen because they generate greater forces than these when fully installed. Should an orthodontist choose to employ elastic modules, excessive initial



FIGURE 17 - Anterior retraction using an elastic module.

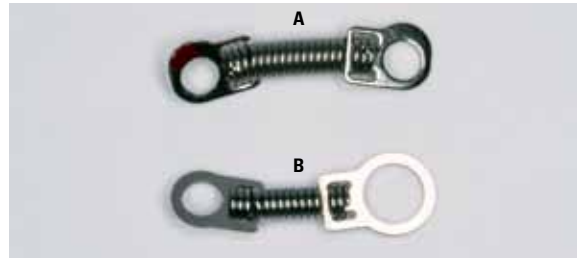


FIGURE 18 - Comparison between Nitinol spring with conventional attachment (A) and spring with special attachment for use with mini-implants (B).



FIGURE 19 - A) Close-up detail of a mini-implant head, duly sized for Nitinol spring attachment. B) Nitinol spring attached directly to the mini-implant head.

forces should be avoided.

Since mini-implants tend to grow increasingly stable with use, as a result of an increase in bone density around it and in response to functional demand (secondary stability), it is advisable to begin retraction with a weaker force than originally planned so as to increase the chances of mini-implant success^{15,17}.

Ideal moment for mini-implant installation

In cases where the need arises for an initial cuspid retraction, mini-implants can be installed at treatment onset to ensure better alignment. Subsequently, the same mini-implant can be used for anterior retraction. Should a mini-implant be required only during the anterior retraction phase,

insertion should be performed after installation of the whole retraction system so that the mini-implant can be used immediately following installation. If the mini-implants are inserted at treatment onset and are used during anterior retraction phase only, they will be exposed to unnecessary risk for several months^{13,16,17}.

KEY MINI-IMPLANT INSTALLATION SITES

Due to their minute diameter, mini-implants can be inserted in a number of different sites to support anterior retraction. It is recommended that orthodontists select two or three potential installation sites taking into account the force vector orientation relative to the center of resistance of anterior teeth. Orthodontists should not underes-

timate the importance of conducting biomechanical planning prior to mini-implant installation. A diagram should be drawn out depicting the force action line and the mechanics to be utilized in different insertion site scenarios. Based on this analysis, orthodontists can pinpoint the best suited site as well as a second or even third installation site option^{10,13}.

Periapical and interproximal radiographs of the potential installation sites should be acquired using the paralleling technique and a positioner, with the radiation source running perpendicular to the insertion site. These radiographs will be used to assess the possibility of contact between the mini-implant and relevant anatomical structures and to ascertain that there is adequate embrasure.

For a 1.5mm mini-implant, the recommended minimum interradicular space should be 2.5mm (or 3.5mm for not so experienced professionals). Images acquired through volume computed tomography can be indicated for specific cases.

In the event that interradicular space is not sufficient in the first potential installation site, orthodontists can: 1) choose another installation site; 2) wait until the alignment and levelling phase has ended and the roots should be better positioned with more comfortable interradicular space; 3) make an orthodontic preparation for inserting the mini-implants using typical bonding and segmented archwires to deliberately move away the roots of teeth in the neighborhood of the installation site. Since the anterior retraction phase occurs a few months following treatment onset, orthodontists can easily – from a biomechanical standpoint – prepare the space for mini-implant insertion in the best-suited site.

Potential installation sites in the upper arch^{4,5,7,8,12}

For anterior retraction in the upper arch the installation options, in order of preference, are:

1) Buccal alveolar process between the first

molars and second bicuspid. This is the installation site most often used for anterosuperior retraction with direct anchorage. It can also be used for indirect anchorage by attaching the mini-implant to the second bicuspid. On occasion, this site may not be available due to insufficient space between the roots or an enhanced curvature of the upper first molar mesiobuccal root. In cases of second bicuspid exodontia it is advisable to assess the thickness of the bone crest mesial to the molar and, in the event of insufficient space, some other site is indicated;

2) Palatal alveolar process between the first and second molars. This is usually utilized for indirect anchorage by attaching the mini-implants to the first molars and using a transpalatal bar to prevent the mesial rotation of the first molar (Fig. 20). This is the site of choice for anterior retraction with fixed lingual appliances. This region normally features sufficient interradicular space, although insertion access is significantly compromised in comparison with the buccal alveolar process, requiring, therefore, the use of an angle piece or digital key. This region also features greater mucous membrane thickness, which has an unfavorable impact on mini-implant placement since it moves the mini-implant's external point away from the cortical bone. Prior to installing in this area, gingiva thickness should be measured in order to determine an appropriate extension for the transmucous profile and total mini-implant length. The transmucous profile extension (smooth area on the mini-implant) should approximately match soft tissue thickness and the mini-implant should be inserted into the bone at about 6mm to 8mm depth;

3) Buccal alveolar process between the first and second molars. This is used most often for indirect anchorage by attaching the mini-implants to the first permanent molars with ligature wire. This region does not usually feature enough interradicular space but this should be evaluated on a case by case basis (Fig. 21);

4) Maxillary tuberosity region. Ligature wire is used to connect the mini-implant to the first and second molars for an indirect anchorage (Fig. 22). This area features less dense bone and in order to attain greater stability the use of a longer, thicker mini-implant is strongly recommended;

5) Between the buccal roots of the first permanent molars. One can resort to this option in atypical cases where molars present with rather divergent buccal roots and other sites are not available;

6) Mid-palatal suture (or next to the suture in young patients). Used most often for indirect anchorage, thereby stabilizing molars by means of a transpalatal bar either tied or bonded to the mini-implants. When the bar is attached to the mini-implant by means of ligature wire, molar control is reduced. Therefore, molars will tend to

tip towards the mesial in response to the anterior retraction force. When a transpalatal bar is bonded with composite resin to the mini-implant head, control of molar position is enhanced. The masticatory load, however, is conveyed to the mini-implants, which can loosen or even cause the failure of these devices. Therefore, this type of indirect anchorage has not proved hitherto as efficient as other methods mentioned above. Mini-implants with bracket shaped extremities and with left and right threading, have rendered this installation site more versatile and favorable.

Potential installation sites in the lower arch^{5,8,12}

1) Buccal alveolar process between the first and second molars. This area typically features greater interradicular space and greater cortical bone thickness in the lower arch. Ligature wire can be used to stabilize the first molars and mini-implants can be used for indirect anchorage (Fig. 23).

2) Buccal alveolar process between the second bicuspid and first molars (Fig. 24) for anterior retraction using direct anchorage.

3) Second molar distal region (Fig. 25) or retromolar region (Fig. 26) for the use of indirect anchorage.

Table 1 provides suggestions for choosing mini-implant models according to insertion site.



FIGURE 20 - Indirect anchorage with mini-implant attached to the first molar's transpalatal bar tube using ligature wire.



FIGURE 21 - Illustration of mini-implants being used for indirect anchorage, inserted between the first and second molars.



FIGURE 22 - Indirect anchorage with mini-implant inserted into the maxillary tuberosity.

ANTERIOR RETRACTION CONTROL

Even with adequate biomechanical planning, drawbacks and undesirable side effects can arise during the anterior retraction stage. For a successful treatment in this phase, orthodontists are advised to control the following factors.

Peri-implant region control

It is important to check, at every appointment, the condition of the tissues surrounding the mini-implants and raise the patient's awareness as to how important it is to adequately brush this area since infection and peri-implant inflammation can cause mini-implant failure. In the event of mechanical cleaning difficulties, it is recommended that the brush be dipped into a 0.12% clorexidine

gluconate solution or, preferably, into a 0.2% clorexidine digluconate gel, and apply this solution or gel around the mini-implant^{9,11,13}.

Mini-implant stability

In the event of a slight mini-implant drift, without mobility and with no contact with essential structures, the same mini-implant can be used for retraction. In cases where slight mobility is present, the mini-implant should be tightened by a $\frac{1}{2}$ diameter or one full diameter and kept under moderate force only. If this adjustment is not carried out, mobility will likely be worse by the following appointment. In cases where there is excessive drift or mobility, the mini-implant should be removed and another one inserted in an alternative site¹³.



FIGURE 23 - Indirect anchorage for anteroinferior retraction.



FIGURE 24 - Installation site for anterior retraction with direct anchorage.



FIGURE 25 - **A)** Beginning of incisor, cuspid and bicuspid retraction using mini-implant indirect anchorage. **B)** Progress of "en-mass" anterior retraction using indirect anchorage. **C)** Near the end of the anterior retraction phase. **D)** Anterior "en-mass" retraction completed without any regard for anchorage. **E)** Final photo.

Frontal occlusal plane inclination

By periodically assessing the patient's frontal aspect, either through a clinical examination or frontal smiling photographs, one should ensure no frontal occlusal plane inclination is taking place during retraction. Particular attention should be paid to the treatment of individuals presenting with unilateral extraction or bilateral extractions where a mini-implant will be used in one side only. In these cases, the retraction on the mini-implant side tends to generate a force action line that differs from the opposite side, thereby tipping the frontal occlusal plane. In order to avoid any side effects, it is suggested that the anterior retraction be conducted using a force action line in parallel to the occlusal plane^{2,8,9}. In the event that this plane alteration has already occurred, the orthodontist can use asymmetrical hooks to help in solving the problem (Fig. 27).



FIGURE 26 - Mini-implant inserted in the retromolar region and being used as indirect anchorage for "en-mass" retraction.

Attrition between archwire and brackets

When performing sliding mechanics space closure it is important to verify, at the start of the retraction, whether there is significant attrition between archwire and posterior segment brackets. Should this be the case, in addition to the anterior retraction, there could be posterior segment distalization and intrusion (Fig. 28) or, on occasion, mini-implant failure due to the excessive force deployed to move all teeth. Should there be significant attrition, it is recommended that the posterior segment archwire be abraded to benefit the sliding mechanics^{8,14}.

Lateral bite opening control

During the space closure phase, there is a tendency for the bicuspid region to undergo open bite due to archwire deflection, which can lead to the distal tipping of the cuspid crown and mesial tipping of molars and bicusps. The greater the retraction force and the more flexible the archwire, the greater the tendency towards lateral open bite. In order to avert these side effects, it is recommended that the force be controlled, flexible archwires be utilized, a reverse curve archwire be used in the lower arch, and an accentuated archwire be used in the upper arch during the space closure phase^{8,14}. Whenever mini-implants are used, the reverse curve or accentuated curve archwire should be made less deep and should not stand out so much on the posterior segments as is

Table 1 - Initial protocol for choosing orthodontic mini-implants. The suggested averages are those most often used. It is advisable, however, to check the interradicular space and the presence of anatomical structures such as maxillary sinus, palatal artery and mandibular nerve. It is also necessary to check the attached gingiva or alveolar mucous membrane and the bone density prior to a final choice of mini-implant.

	Region	Diameter	Active threading	Transmucous profile	Angulation
1	anterior buccal maxilla or mandible	1,5mm	6mm	1mm	60° a 90°
2	posterior buccal maxilla	1,5mm	6mm	1mm	30° a 60°
3	posterior palatal maxilla	1,8mm	6mm	2mm	30° a 60°
4	mid-palatal suture	2,0mm	6mm	1mm	90° a 110°
5	posterior buccal mandible	1,5mm	6mm	1mm	30° a 60°
6	edentulous, retromolar or tuberosity area	2,0mm	8mm	2mm	90°



FIGURE 27 - **A)** Hook directed towards the occlusal and installed on the cuspid's distal region to enhance the intrusive vector with the purpose of helping to correct occlusal plane inclination. **B)** Frontal view of the anterior retraction with asymmetrical force vectors. **C)** Distal retraction on the left with a less intrusive vector than on the right.

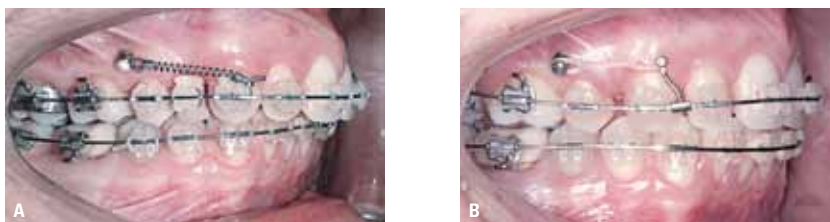


FIGURE 28 - **A)** Anterior retraction phase without a proper evaluation of the attrition, involving the archwire and the brackets on the posterior teeth. **B)** Side effect caused by the distalization of the posterior segment as a result of archwire attrition.

the case in traditional mechanics. Otherwise, molars will tend to intrude and, consequently, undergo proclination (as a result of the intrusive force impinging buccally on the molars' CR).

Overbite control

Overbites tend to increase during the anterior retraction phase. To such an extent that, towards treatment completion, the incisal edge of the lower incisors may touch the upper incisors' palatal region. In these cases it does not help to increase the retraction force. It will be necessary to correct the overbite prior to proceeding to the space closure phase (Fig. 29).

Force increase may lead to the mini-implant drifting or might even result in mini-implant failure. To help in correcting the overbite, the orthodontist can increase the amount of reverse or accentuated curve and, if necessary, bend intrusion steps on the archwire. It is convenient to reassess the force in use and check whether there has been any loss of buccal tipping on the anterior teeth¹⁴.

Control of buccolingual tipping on incisors

The orthodontist may notice a decrease in

buccolingual inclination, above and beyond what was expected, during the space closure phase. Should this happen, it will be necessary to reduce the retraction force and add buccal torque to the archwire in the incisor region.

Those orthodontists who make use of preadjusted appliances featuring additional anterior torque – Roth prescription, for example, applies +12° buccal torque and MBT has +17° buccal torque on central incisors instead of the standard 7° - can choose to use a thicker archwire instead of adding torque to the archwire. 0.021" x 0.025" archwires have a slight 2° slack inside a 0.022" slot, which will enable a better expression of the torque built into the brackets and afford greater incisor tipping control.

For individuals with increased overbite, it would be a good idea to increase the amount of reverse or accentuated curve, imparting increased torque to the incisor region and helping to control the loss of buccal inclination which tends to occur during retraction¹⁴.

Cuspid angulation and rotation control

During the space closure phase cuspids tend



FIGURE 29 - **A)** Retraction with inappropriate overbite and force. **B)** Alterations to the gingival tissue on the mesial region of the mini-implant due to excessive force. **C)** Close-up view of a higher degree of gingival alteration on the mini-implant's mesial side.

to rotate distally, which tends to contract the archwire in the bicuspid region when not so stiff archwires are employed. It is recommended that stainless steel ligature wire be used on cuspids to prevent them from rotating distally. During anterior retraction, one should also control cuspid proneness to tip distally, which can lead to incisor extrusion, overbite increase and occlusal plane alteration. These side effects can be controlled with the use of stiff stainless steel archwires and reverse or accentuated curve archwires⁸.

Midline control

Should it become necessary to correct a midline shift during the space closure phase, it is advisable to use a longer hook on the side where the midline is to be corrected. This longer hook, combined with a mini-implant inserted at an intermediate or apical height will generate a force action line closer to the center of resistance of the incisor, thus facilitating their movement and preventing crown tipping alone, which tends to occur when sliding mechanics is applied using short hooks⁸.

Space closure difficulties

Certain situations should be monitored which are likely to hinder anterior retraction and cause excessive force on mini-implants. In addition to the aforementioned archwire attrition and increased overbite, the following are also worthy of note: Contact between upper and lower cuspid cusps; torque or bends on the archwire which may hamper distal sliding; gingival tissue trapped

in the extraction space due to fast space closure; contact between cuspid roots and the buccal cortical bone region in patients who present with a narrow alveolar process in this region; contact between the cuspid root and the second bicuspid root due to laceration or inadequate tipping of the cuspid and/or second bicuspid root^{1,14}.

CLINICAL CONSIDERATIONS

Space closure stabilization

Following anterior retraction the mini-implants can be used to stabilize space closure by connecting these devices with the archwire hook using ligature wire (Fig. 30). In the event that the archwire used during this space closure phase has been abraded to facilitate sliding mechanics, a brand new archwire should be installed to achieve proper root positioning. The maintenance of this archwire for three months after completion of the anterior retraction will prevent extraction spaces from reopening after treatment¹⁴.

Sliding mechanics retraction X loop mechanics

Mini-implants can be used during the anterior retraction phase in combination with straight archwires or loops, depending on the orthodontist's preference. Retraction mechanics with the use of loops (Fig. 31) enables the incorporation of first, second or third order bends to adjust tooth position in the posterior segment without impairing space closure. On the other hand, sliding mechanics allows easier archwire formation, a more predictable movement and, at times, better

esthetics, since it precludes the use of loops in the anterior segment^{1,5,9}.

Total retraction

Anterior retraction can be performed in conjunction with posterior segment dental elements in a type of retraction which could be named total retraction. This mechanics is recommended for individuals who present with a discreet biprotrusion or an anteroposterior 2mm to 3,5mm discrepancy between dental arches. To this end, mini-implants can be inserted between the roots of upper bicuspids and molars as well as between lower molar if there is sufficient interradicular space (Fig. 32). Other individuals may have an increased bone volume which allows the insertion of angled mini-implants buccally, relative to the tooth roots. Another alternative mini-implant installation for total retraction is the tuberosity region in the maxilla and the retromolar region in the mandible^{5,6,9,19,20}.

Mini-implants X Tweed-Merrifield mechanics

The combination of high mini-implants with

short hooks yields similar effects to those produced by J-hook retraction, used in traditional mechanics, such as Tweed-Merrifield, although a mini-implant retraction can retract cuspids and incisors in one go, thereby reducing treatment time. The use of mini-implants dispenses with the need for tip-back bends, which averts the extrusive effect often caused by anchorage preparation on posterior teeth. Additionally, mini-implants can also be used for posterior vertical control while concurrently being utilized to provide support for anterior retraction by intruding molars with elastics connected to the mini-implants. This biomechanics differentiation can prove relevant for retrognathic mandible patients with an increased lower face third, since any lower molar intrusion achieved with the help of mini-implants can produce a counterclockwise mandibular movement (Fig. 33), reducing cuspid and molar Class II, and may require an anterosuperior retraction and anteroinferior face height adjustment, which may bring about a greater projection of the mentum and an improved face profile²⁰.

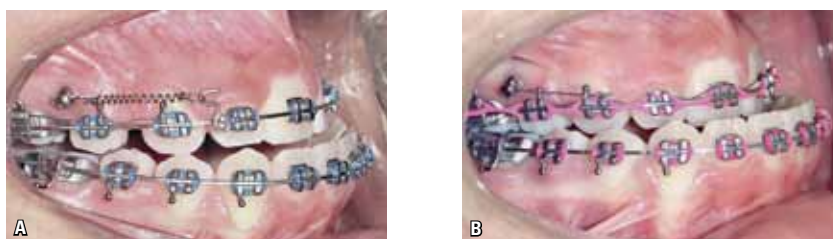


FIGURE 30 - **A)** Ortho-surgical case using mini-implants to enhance anterosuperior retraction. **B)** Space closure stabilization using ligature wire to connect mini-implants to upper molars.



FIGURE 31 - Anterior retraction with loop mechanics.



FIGURE 32 - **A)** Mini-implant being used for total retraction on the upper arch. **B)** Periapical radiographic image showing sufficient space between roots as to allow a total retraction.

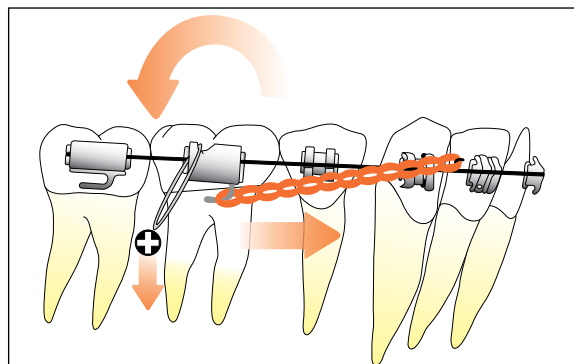


FIGURE 33 - Anteroinferior retraction combined with lower molars intrusion generating a counterclockwise mandibular rotation.

Submitted: March 2008

Revised and accepted for publication: May 2008

CONCLUSION

Mini-implants can contribute significantly to the anterior retraction phase. Orthodontists, however, should acquaint themselves with the peculiarities of using mini-implants in this treatment stage. If used appropriately, mini-implants can be more efficient than traditional anchorage methods besides making treatments more predictable.

ACKNOWLEDGEMENTS

For their invaluable assistance in writing this article, I would like to thank Paulo and Zelna Marassi; Patrícia M. Marassi, Mirella Ferraz; Wagner Luz; Orlando Chianelli; Paulo César Nery; André Leal and the entire Marassi Ortodontia Clinic team.

REFERENCES

1. ARAUJO, T. Ancoragem esquelética com mini-implantes. In: LIMA FILHO, R. M. A.; BOLOGNESE, A. M. **Ortodontia: arte e ciência**. Maringá: Dental Press, 2007. p. 393-446.
2. CARANO, A. et al. Clinical applications of the miniscrew anchorage system. **J. Clin. Orthod.**, Boulder, v. 39, no. 1, p. 9-24, 2005.
3. DEGUCHI, T. et al. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 129, no. 6, p. 721, 2006.
4. FAVERO, L.; BROLLO, P.; BRESSAN, E. Orthodontic anchorage with specific fixture: related study analysis. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 122, no. 1, p. 84-94, 2002.
5. KYUNG, H. M. et al. **Mini-implantes**. Nova Odessa: Ed. Napoleão, 2007.
6. KYUNG, H. M. et al. Development of orthodontic micro-implants for intraoral anchorage. **J. Clin. Orthod.**, Boulder, v. 37, no. 6, p. 321-328, 2003.
7. LEE, J. S.; PARK, H. S.; KYUNG, H. M. Micro-implant anchorage for lingual treatment of a skeletal Class II malocclusion. **J. Clin. Orthod.**, Boulder, v. 35, no. 10, p. 643-647, 2001.
8. LEE, J. S. et al. **Applications of orthodontic mini-implants**. Chicago: Quintessence, 2007.
9. MARASSI, C. et al. Clinical applications of mini-screws as anchorage. In: AMERICAN ASSOCIATION OF ORTHODONTISTS, 104th, 2004, Orlando. **Annual Session...** Orlando: American Association of Orthodontists, 2004.
10. MARASSI, C. et al. O uso de mini-implantes como método auxiliar do tratamento ortodôntico. **Ortodontia**, São Paulo, v. 38, n. 3, p. 256-265, 2005.
11. MARASSI, C.; LEAL, A.; HERDY, J. L. Mini-implantes como método de ancoragem em Ortodontia. In: SAKAI, E. et al. **Nova visão em Ortodontia: Ortopedia Funcional dos Maxilares**. 3. ed. São Paulo: Ed. Santos, 2004. p. 967-974.
12. MARASSI, C. Carlo Marassi responde (parte I): Quais as principais aplicações clínicas e quais as chaves para o sucesso no uso de mini-implantes em Ortodontia? **Rev. Clin. Ortodon. Dental Press.**, Maringá, v. 5, n. 4, p. 13-25, ago./set. 2006. (Entrevistadora: Rosely Suguino).
13. MARASSI, C. Carlo Marassi responde (parte II): Quais as principais aplicações clínicas e quais as chaves para o sucesso no uso dos mini-implantes em Ortodontia? **Rev. Clin. Ortodon. Dental Press.**, Maringá, v. 5, n. 5, p. 14-26, out./nov. 2006. (Entrevistadora: Rosely Suguino).
14. MCLAUGHLIN, R. P. **Mecânica sistematizada de tratamento ortodôntico**. São Paulo: Artes Médicas, 2001.
15. MELSEN, B.; VERNA, C. Miniscrew implants: the archus anchorage system. **Semin. Orthod.**, Philadelphia, v. 11, no. 1, p. 24-31, 2005.
16. MIYAWAKI, S. et al. Factors associated with the stability of titanium screw placed in the posterior region for orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 124, no. 4, p. 373-378, 2003.
17. OHMAE, M. et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the big dog. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 119, no. 5, p. 489-497, 2001.
18. PAK, C. H.; WOO, Y. J.; BOYD, R. L. Treatment of an adult patient with vertical maxillary excess using miniscrew fixation. **J. Clin. Orthod.**, Boulder, v. 37, no. 8, p. 423-428, 2003.
19. PARK, H. S. et al. Simultaneous incisor retraction distal molar movement with microimplant anchorage. **World J. Orthod.**, Carol Stream, v. 5, no. 2, p. 1-8, 2004.
20. PARK, H. S. et al. **The orthodontic treatment using micro-implant**. Seoul: Deahan, 2001.
21. PARK, Y. C. et al. Extraction space closure with vacuum-formed splints and miniscrew anchorage. **J. Clin. Orthod.**, Boulder, v. 39, no. 2, p. 76-79, 2005.

Contact address:

Carlo Marassi
Av. das Américas, 4790 Sala 526 - Barra da Tijuca
CEP: 22.640-102 - Rio de Janeiro
E-mail: marassi@ortodontista.com

Evaluation of insertion, removal and fracture torques of different orthodontic mini-implants in bovine tibia cortex

Maria Fernanda Prates da Nova*, Fernanda Ribeiro Carvalho**, Carlos Nelson Elias***, Flavia Artese****

Abstract

Objective: Evaluate mini-implants of different sizes for the following factors: (a) insertion torque, (b) removal torque, (c) fracture torque, (d) shear tension, (e) normal tension and (f) type of fracture. **Method:** Twenty self-drilling mini-implants were used, 10 manufactured by SIN and 10 by Neodent, measuring 8 and 7 mm in length, respectively and all with 1.6 mm in diameter. Out of these 10 mini-implants, for each brand, 5 did not have a neck and the other 5 had a 2 mm neck, and were separated into 4 groups: SIN without neck (S), SIN with neck (SN), Neodent without neck (N) and Neodent with neck (NN). All mini-implants were inserted into bone cortex and removed with a low speed handpiece connected to a digital torquimeter. The mini-implants were also submitted to a fracture test. The insertion, removal and fracture torques, as well as the calculated shear and normal tensions were compared between all groups using ANOVA. The type of fracture was assessed by a scanning electron microscope. **Results:** The NN group presented a significantly greater insertion torque than all other groups, although all of them fractured during insertion (n=2) or removal (n=3). There were no significant differences between groups for removal torque. For group N, the fracture torque was significantly smaller than all other groups. All mini-implants suffered ductile fracture. **Conclusion:** Since there were no differences in the mechanical resistance of both brands of mini-implants, which varied only in shape, one may conclude that resistance to fracture can be affected by this variable.

Keywords: Dental implants, Material resistance, Torque, Orthodontic anchorage procedures.

INTRODUCTION

Orthodontic anchorage is defined as resistance to undesired tooth movement²⁰. Traditionally, groups of teeth are used as anchorage units¹, but can be displaced as a result of unwanted reaction

to the applied forces. Appliances that require patient cooperation can also be used as anchorage mechanisms^{13,24}. Moreover, the absence of posterior teeth can compromise adequate anchorage.

With the advent of osseointegration,

* Master of Sciences in Orthodontics, Rio de Janeiro State University, Brazil.

** Specialist in Orthodontics, State University of Rio de Janeiro, Brazil.

*** Associate Professor, Military Institute of Engineering of Rio de Janeiro, Brazil.

**** Associate Professor of Orthodontics, State University of Rio de Janeiro, Brazil.

orthodontic treatment methods with maximum anchorage control were proposed, especially for adults^{21,22}. The use of osseointegrated implants as absolute anchorage devices⁷ was indicated for treatment of more complex cases, for the optimization of results with simpler mechanics, or even for the reduction of treatment time. However, conventional osseointegrated implants can only be inserted in specific sites, such as the retromolar area or edentulous spaces^{10,21}.

Orthodontic mini-implants were developed based on surgical stabilization screws and used as absolute anchorage devices¹². As well as an efficient anchorage alternative, they are easy to install and remove, and are sufficiently small for placement in various areas of alveolar bone, and even between roots. These features were responsible for the widespread clinical usage of mini-implants^{4,19}.

Unlike osseointegrated dental implants that are made from pure titanium, mini-implants are made of Ti6Al4V alloy for three main reasons: (a) mini-implants have a small diameter, and this alloy has greater mechanical resistance than the commercially pure titanium; (b) the application of these systems is based upon primary, not secondary stability, which is achieved through osseointegration; and (c) mini-implants must be easily removable. By using the Ti6Al4V alloy, which has inferior bioactive characteristics compared to the commercially pure titanium, the degree of osseointegration is low⁹.

Mechanical stability is the most important mini-implant feature for orthodontics. It is achieved by primary stability, which is defined as that obtained immediately after insertion. Bone density at the insertion site, mini-implant shape and width, and the preparation of the area into which the device will be inserted all exert significant impact on mini-implant primary stability. Depending on the insertion site and the bone quality of the area, the orthodontist can choose a combination of type, diameter and length to find the best suited mini-implant for that region²⁵.

Mini-implant shape should provide mechanical anchorage by means of bone/implant contact surface and should also allow for load distribution so as to not adversely affect bone physiology. Mini-implant design should also limit trauma during the insertion procedure and provide for primary stability¹⁰.

Mini-implant insertion torque reflects the amount of primary stability and is therefore an important factor for the success of the anchorage mechanism²⁵. Friberg et al¹¹ described a statistically significant positive correlation between mini-implant insertion torque and bone density values, and concluded that methods used to measure torque during mini-implant placement should be used routinely.

After using the mini-implant for the desired movement, removal is necessary. There are few studies evaluating maximum removal torque. Generally, removal torques in short term studies are lower than insertion torques^{9,16}. On the other hand, when there is a follow-up longer than four weeks, removal torques increase significantly^{5,6,8}.

Fracture is one of the risk factors and complications that may happen when using mini-implants. It normally occurs during insertion or removal, but can also happen during force application for orthodontic treatments. However, bone quality and density can influence insertion torque resistance, and when associated to sub-perforation can increase incidence of fracture close to the mini-implant head¹⁴.

Melsen¹⁵ associated a smaller diameter to greater fracture risk. Using techniques to measure stress distribution, fracture occurrence is greater during removal than insertion. Fractures usually occur close to the screw neck and the presence of holes can weaken even more the device.

Searching for more efficiency, many types and shapes of mini-implants have been released in the market by different manufacturers. It is known that the selection of the diameter and length of the mini-implant are important factors

for its adequate usage, even though it can be used in various areas of the mouth. Nevertheless, there is no protocol that indicates what type of mini-implant is the most recommended for each situation^{2,3}. In spite of the rich literature on the treatment of clinical cases with mini-implants, many doubts still exist regarding how certain morphologic characteristics of these devices may influence their physical properties²⁵. Therefore, the purpose of this study was to evaluate the insertion, removal and fracture torques, and the mechanical characteristics of torsion fracture of mini-implants from different manufacturers and with different dimensions.

MATERIALS AND METHODS

Mini-Implant Sample

Twenty commercial self-drilling mini-implants were used, ten manufactured by SIN (Sistema de Implantes Nacional, São Paulo, SP, Brazil) and ten by Neodent (Curitiba, PR, Brazil). All mini-implants had 1.6 mm in diameter, those from SIN measured 8 mm (Fig. 1A, C) in length and those from Neodent measured 7 mm (Fig. 1B, D). To create the groups, five mini-implants with neck and five without neck from each manufacturer were used (Fig.1). The sample was divided into four groups which were named as: SIN with neck (SN); SIN without neck (S); Neodent with neck (NN) and Neodent without neck (N). All assays and procedures were performed in the Biomaterial Laboratory of the Military Institute of Engineering of Rio de Janeiro.

Specimen Preparation

Two bovine tibias were obtained from a local abattoir. They were cross-sectionally cut in relation to their long axis, into 15 mm segments. Bone marrow was removed and the cortex width was measured. Segments that had more than 9 mm in width were selected and were cut once again into squared specimens measuring 10 mm per side. These dimensions allowed for adequate



FIGURE 1 - Self-drilling mini-implants with 1.6 mm diameter which was part of the sample: (A) Neodent mini-implant with 7mm in length with no neck (group N); (B) SIN mini-implant measuring 8 mm in length with no neck (group S); (C) Neodent mini-implant measuring 7 mm in length, with a 2mm neck (group NN) and (D) SIN mini-implant measuring 8 mm in length, with a 2 mm neck (group SN).

placement of the specimen on the torquimeter and assured complete drill insertion during perforation (Fig. 2) and also that of the mini-implants which were to be evaluated in cortical bone. Twenty bone fragments were obtained in this manner, one for each mini-implant; they were maintained at 4°C for three days, until the day of the experiment.

These bone fragments were placed into a metallic support, which could be adjusted according to their size and shape. This piece was attached to a torquimeter (Lutron torquimeter TQ-8800, Taipei, Taiwan), fixed to a bench lathe, which firmly secured the device during experimentation.

The surgical motor MC-101, Omega.02 (Dentscler, Ribeirão Preto, SP, Brazil), connected to a 20:1 reduction handpiece, with 40000 rpm (Anthogyr Instruments, Saclanches, France) was



FIGURE 2 - Bovine tibia fragment with 10 mm in width and length and 9 mm in height to allow for complete bur insertion during drilling and also for the evaluated mini-implants.



FIGURE 3 - System used to measure mini-implant insertion and removal torques, consisting of a digital torquimeter (a) connected to a bench lathe (b), with a bone specimen, where the mini-implants were inserted, attached by a metallic positioner (c).

used for the mini-implant insertion and removal experiments.

To ensure mini-implant insertion into cortical bone alone, a hole was drilled in the center of the bone specimen. A carbide surgical bur, specific for bone perforation, with 1.3 mm in diameter, was used (Neodent, Curitiba, PR, Brazil). It was placed on the handpiece and drilling was performed under manual irrigation with water.

Mechanical assays

The mini-implant placement was performed following perforation with the insertion key attached to the handpiece, and also under manual irrigation. The insertion procedure was interrupted when the handpiece locked and the engine was shut down. A torque key was used in these cases until complete mini-implant insertion to the bone, i.e., no part of the screw could be seen. The mini-implants were removed with the same handpiece using the reverse rotation option, with no need for the manual key.

During insertion and removal assays torque was measured continuously. This data was recorded by

a torquimeter connected to a computer, which sent the information to the Lutron Program 101, version V0011TW (Lutron Electronic Enterprise, Taipei, Taiwan). The obtained values were sent to the Origin Pro 7.0 Program (Origin Lab Corporation, Northampton, MA, USA) for developing graphical representations. Maximum insertion and removal torques were obtained from graphic peaks.

During these assays some mini-implants fractured. Those that did not were submitted to mechanical testing for torsion fracture, using a rotation shaft system attached to a universal mechanical testing machine (EMIC, Curitiba, PR, Brazil) with a 500 N load cell.

For torsion fracture the mini-implant was held in place by shafts on both sides. One of these shafts is stationary, where the mini-implant tip was placed. The other shaft turns due to traction by a polymer thread, which is attached to a shaft axis and to the load cell, where the implant head was placed. Since one side rotated and the other was fixed, a torque force was applied to the mini-implant, which was recorded by the Tesc Program,

version 3.04 (EMIC, Curitiba, PR, Brazil) and the maximum force produced fracture (Fig. 4).

Torque fracture was calculated by multiplying the maximum force by the axis radius in which the polymeric thread was wound, according to the following equation:

$$\text{Torque (T)} = \text{Force (F)} \times 4.$$

For the mini-implants that fractured during the insertion and removal assays, the torque during fracture was used.

Microscopic evaluation

Mini-implant fracture surfaces were evaluated by scanning electron microscopy (SEM), with a JEOL microscope; model JSM-5800 LV (JEOL, Tokyo, Japan). Since some mini-implants fractured inside the bone, only the upper part could be used for SEM without specific preparation. As such, the upper mini-implant fragments were placed on a metallic plate and held by double-face adhesive tape, to be kept in a vertical position. Using the specific program for the microscope, the mini-implant was found and the fracture region was analyzed and photographed at a x500 magnification. The type of fracture was determined by visual inspection.

To evaluate differences between the mini-implant material resistance the calculated shear tension was used and obtained using the following formula:

$$\text{Shear Tension} = 16.T/\pi.D^3,$$

Where T = torque and D = the diameter of the fractured surface of the mini-implant. To measure this diameter an optic Zeiss microscope was used. Stemi 2000-C (Zeiss, Jena, Germany) at a x150 magnification. Surface images were captured to a computer and evaluated using Axio Vision Program (Zeiss, Jena, Germany), where the diameters were calculated. Two perpendicular lines, containing the surface diameter were traced and the mean of these two values was considered the fractured surface diameter. For some mini-implants, these values were confirmed under

SEM (Fig. 5).

To confirm shear tension values, normal tension was calculated by the following formula:

$$\text{Normal Tension} = 16.T/\sqrt{3}.\pi.D^3,$$

where T = Torque and D = the diameter of the fractured surface of the mini-implant.

Statistical analysis

All numerical results were presented as means and standard deviations. Insertion, removal and fracture torques, as well as calculated shear tension were compared between all groups by one-way ANOVA. To compare insertion and removal torques for each group a two-way ANOVA was used. Significance level was established at $p < 0.05$.

RESULTS

Mini-implant maximum insertion torques in bovine cortical bone were 25.2 ± 1.9 , 23.2 ± 4.9 , 26.0 ± 2.4 and 30.6 ± 1.8 Ncm for groups S, SN, N and NN, respectively (Fig. 8). Two mini-implants from group N and two from group NN fractured during insertion procedures. In these cases the recorded value for maximum torque was that obtained during fracture. Insertion torque means were compared by one-way ANOVA (Tab. 1). Statistically significant differences were observed for group NN when compared to all other groups, demonstrating that maximum insertion torque for group NN was significantly greater than all other groups.

Mini-implant maximum removal torques from cortical bone were also measured. Observed means were 17.2 ± 4.9 , 17.6 ± 7.6 , 16.6 ± 7.5 and 25.0 ± 5.5 Ncm for groups S, SN, N e NN, respectively (Fig. 8). Three mini-implants from group NN fractured during removal, and the value for maximum removal torque was also recorded at the moment of fracture. Maximum insertion torque values were greater than those for removal for all groups, whereas group NN presented greater torque values for these two



FIGURE 4 - Torsion assay device, performed to determine maximum resistance torque to fracture for the mini-implants, connected to the universal mechanical assay machine with 500N load cell. The right side shaft rotates when the polymer thread is pulled by the assay machine and the left shaft is stationary and holds the mini-implant.

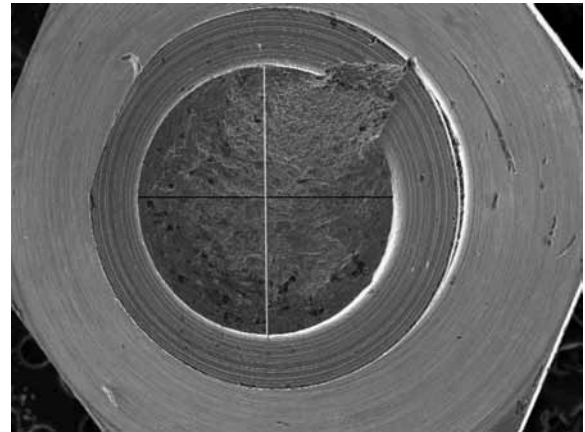
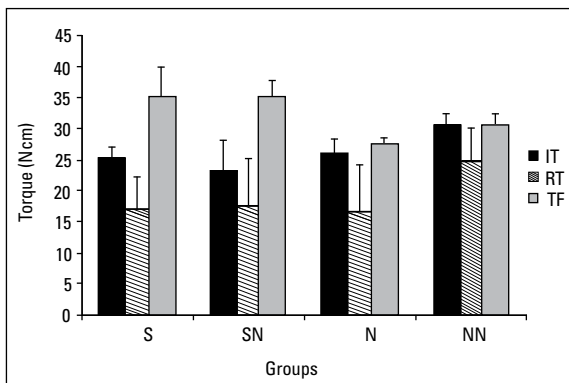


FIGURE 5 - Cross-section of the fractured mini-implant observed under SEM in a x500 magnification. The white and black lines were used to calculate the mean diameter of the fracture area and thereby obtain the calculated shear tension.



GRAPH 1 - Maximum insertion (IT) and removal torques (RT) for all four groups of mini-implants. Columns represent the mean and the error bars represent the standard deviation. The sample size is five for each group, with the exception of groups N and NN for the removal assays, which had sample size of three.

variables. There were no significant differences for maximum removal torques between all groups (Tab. 1).

For each group, means for maximum insertion and removal torques were compared by two-way ANOVA (Tab. 2). Only group S showed significant statistical difference, demonstrating that, for this group, maximum insertion torque was significantly greater than removal torque,

even though all other groups showed the same behavior.

The mean fracture torques for mini-implants were 35.1 ± 4.9 , 35.1 ± 2.7 , 27.4 ± 1.1 and 30.6 ± 1.8 Ncm, for groups S, SN, N e NN, respectively (Fig. 8). Groups S and SN presented greater values more similar to each other than groups N and NN. When comparing fracture torques between groups (Tab. 1) no differences were found between groups S and SN and between groups S and NN. Group N presented the smallest fracture torque mean and differed significantly from all other groups. SIN mini-implants (groups S and SN) did not present significant differences when compared between themselves, demonstrating a small variation in resistance.

Mini-implant surface fractures for all groups were compared by visual inspection under SEM. All groups presented microporosity and lines of plastic deformation caused by torsion deformation. The direction of the lines indicate that the fractures occurred due to shearing, characterizing a ductile fracture (Fig. 6).

The calculated shear tension was 1123.1 ± 168.3 , 1041.9 ± 154.8 , 1124.8 ± 123.0 , and

Table 1 - Statistical comparison (one-way ANOVA) between means of insertion, removal and fracture torques of all groups. Numbers represent p values and significant differences are indicated with an asterisk.

	groups					
	S x SN	S x N	S x NN	SN x N	SN x NN	N x NN
Insertion	0.421	0.574	0.001*	0.287	0.013*	0.009*
Removal	0.924	0.652	0.372	0.135	0.311	0.191
Fracture	0.992	0.034*	0.160	0.003*	0.036*	0.003*

Table 2 - Statistical comparison (two-way ANOVA) between means of mini-implant insertion and removal torques of the same group. Numbers represent p values and significant differences are indicated with an asterisk.

	groups			
	S	SN	N	NN
p	0.044*	0.287	0.272	0.177

1088.7 ± 128.7 MPa for groups S, SN, N e NN, respectively (Tab. 3). No statistically significant differences were observed between groups, when compared by one-way ANOVA, demonstrating that all mini-implants did not differ in relation to the mechanical resistance of the material of which they were made. These results were also confirmed by the calculated normal tension.

In order to calculate shear tension, mini-implant diameters were measured, without including the thread length, which was called the implant core. It was noticed that an increase in the cross-section diameter of the mini-implant was followed by an increase in torque (Tab. 3).

By macroscopic evaluation, differences were found between the characteristics of mini-implants of different manufacturers used in this study, most specifically in the number of threads and distance between them (Fig. 1). This observation was confirmed in SEM images, demonstrating that mini-implants from groups N and NN presented greater number and closer

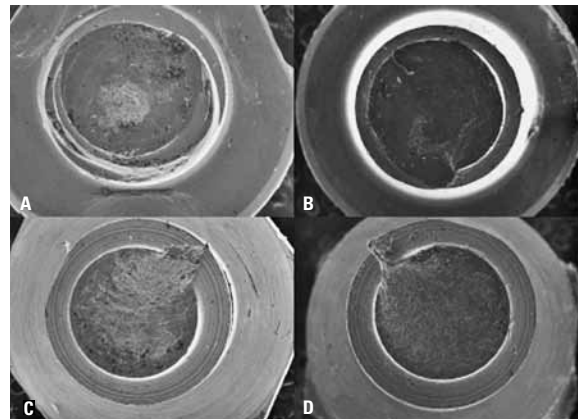


FIGURE 6 - Cross-section of one mini-implant of each group observed under SEM at a magnification of x500: (a) mini-implant from group S; (b) mini-implant from group SN; (c) mini-implant from group N and (d) mini-implant from group NN. These images were used to classify the type of fracture. All were classified as ductile, according to the shearing lines generated by torsion.

threads when compared to groups S and SN (Fig. 7).

DISCUSSION

Although the small dimensions of mini-implants enable their insertion in various areas of the mouth, there is an increased likelihood of deformation during usage and fracture during insertion or removal⁹. In this study, orthodontic mini-implants were analyzed according to resistance during insertion in and removal from bovine bone cortices and then subjected to fracture by torsion.

Mini-implants from two major national manufacturers were selected which shared the most similar dimensions. All mini-implants had the same diameter of 1.6 mm, which was considered a suitable size to be applied in all areas of the mouth²³. Additionally, the choice of a larger diameter had the purpose of obtaining high torque values. Elias et al.⁹ when comparing two types of mini-implants from the same manufacturer with different diameters evaluated that the greater the diameter, the greater is the mini-implant insertion torque, since this is proportional to the contact area between mini-implant and bone.

Table 3 - Values for the diameter (D) of mini-implant fracture regions, fracture force (F), fracture torque (T), calculated shear tension (ST), and calculated normal tension (NT). Results are presented in means and standard deviations of 5 samples in each group.

	groups			
	S	SN	N	NN
Mean D (mm)	1.2 ± 0.0	1.2 ± 0.0	1.1 ± 0.0	1.1 ± 0.0
F (N)	88.0 ± 12.2	88.0 ± 6.8	69.18 ± 2.25	77.5 ± 4.56
Torque (Ncm)	35.1 ± 4.9	35.1 ± 2.7	27.4 ± 1.1	30.6 ± 1.8
ST (MPa)	1123.1 ± 168.3	1041.9 ± 154.8	1124.8 ± 123.0	1088.7 ± 128.7
NT (MPa)	648.5 ± 97.1	601.5 ± 89.4	634.0 ± 70.6	631.1 ± 64.6

The presence and absence of the neck was one of the variables analyzed in this study. The purpose of this structure is to maintain the health of the tissues around the mini-implant, especially in areas with small attached gingiva, since the absence of inflammation is a factor that contributes to improved mini-implant stability³. Mini-implants with and without a 2 mm neck were chosen from both brands, for this was the greatest possible variation span in neck size manufactured by SIN and Neodent.

The chosen length was the closest possible between both companies, 7 mm for Neodent and 8 mm for SIN. These companies do not produce mini-implants with the same length.

Success in using mini-implants is related to primary stability after placement. Primary stability mainly depends on implant shape and bone quality of the insertion area. Cortical bone support is essential for primary stability, since the small thickness of bone results in mini-implant failure³. Thus, bovine tibia cortex was chosen for the assays due to the quality of cortex bone, which permits full insertion of the mini-implant.

Mean values for maximum insertion torque varied between 30.6 and 23.2 Ncm. These values are compatible with those described by Wilmes

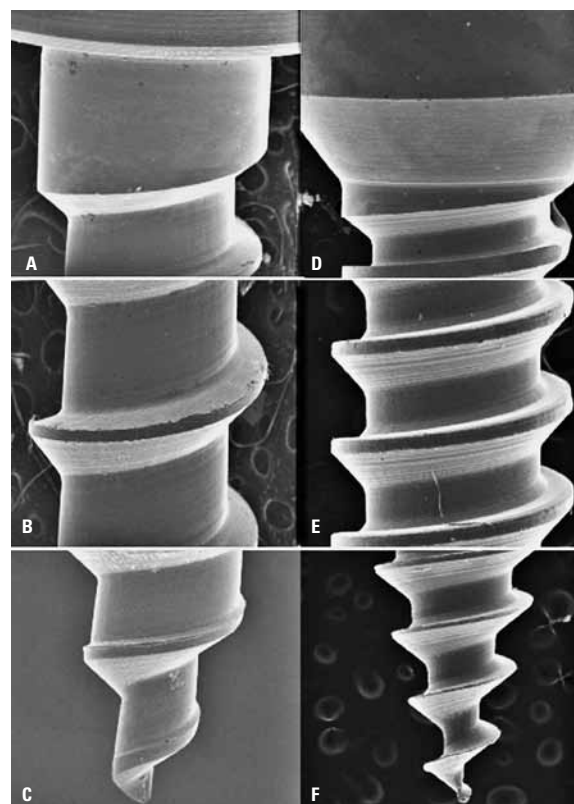


FIGURE 7 - Mini-implant profiles, with 1.6mm in diameter, observed under SEM at a magnification of x500. Figures (A), (B) and (C) correspond to SIN mini-implants and figures (D), (E) and (F) to Neodent mini-implants, respectively upper, middle and lower sections of the mini-implant body. All areas present different dimensions even though these mini-implants have the same commercial specifications. The number of threads, the distance between the threads and the active points are different.

et al.²⁵, that varied from 41.3 to 23.4 Ncm, even though mini-implant insertion was performed in swine pelvic bone, which has a thinner cortex than the one used in this study. Motoyoshi et al. found insertion torque values much lower than those observed in this study, varying from 7.2 to 13.5 Ncm in adults¹⁷ and 7.6 to 9.2 Ncm in adolescents¹⁸. Elias et al.⁹ described insertion torques for mini-implants with 1.5 mm in diameter of 9.6 Ncm in rabbit cortex and 12.6 Ncm in bovine cortex, also much smaller than the values obtained in this study. Mini-implants with 2 mm in diameter when inserted in bovine cortex produced a mean torque of 23.2 Ncm, closer to the values obtained in this investigation.

Mean values for maximum removal torque obtained in this study varied from 25.0 (group NN) to 16.6 Ncm (group N) and there were no significant differences between groups. Elias et al.⁹ evaluated commercial mini-implant removal torques with 6.0mm in length and 1.5 to 2.0 mm in diameter and found values of 5.4 ± 0.7 Ncm in rabbit cortex and 6.8 ± 0.8 Ncm in bovine cortex for mini-implants with 1.5 mm diameter. Mini-implants with 2.0 mm diameter were only tested on bovine cortex and presented removal torque of 12.0 ± 1.6 Ncm. These values were smaller than those found in this work, even for the mini-implants with greater diameter. Nevertheless, mini-implants tested by Elias et al.⁹ were shorter (6 mm) and were not inserted solely in bone cortex.

As with insertion torque, group NN showed greater removal torques, demonstrating also greater difficulty in removing them from bone. Only the presence or absence of the neck seems not to affect insertion or removal torques, since only group NN had significant differences, whilst group SN did not.

When comparing insertion and removal torque values, Elias et al.⁹ observed that removal torque is smaller than insertion torque irrespective of the type of bone or mini-implant diameter, a finding also observed in this study. However, only group S presented significant difference between insertion and removal torques. Dilek et al.⁸ reported greater removal torques than insertion torques in a non-vital experiment in bovine femur, which was not in agreement with other studies. Higher removal torques than insertion torques were found in studies in vivo, when there is at least a four week follow-up, allowing for the osseointegration of the device^{5,6,16,17,18}.

During insertion experiments, two mini-implants from groups N and NN fractured and three others from group NN fractured during removal tests. No mini-implants from groups S and SN fractured in these experiments. Groups

N and NN presented greater insertion torques, which can explain the fractures. The presence of the neck seems not to affect torque values for the SIN mini-implants, but there seems to be a difference between those made by Neodent. The fact that more mini-implants fractured during removal tests is in accordance to Melsen's¹⁵ findings, which affirms that this is the moment when mini-implant fractures most often occur.

Fracture torques varied from 35.14 (group S) to 27.42 Ncm (group N). Groups S and SN presented very similar fracture torques, while groups N and NN had very discrepant values. A comparison of fracture torques between groups was also performed. There were no significant differences between SIN mini-implants. However, Neodent mini-implants were different among themselves. Dilek et al.⁸ reported that torques between 35 and 50 Ncm can cause mini-implant fracture. Wilmes²⁵ recommends limiting insertion torque to 20 Ncm in order to avoid fractures.

According to these results, it becomes evident that there are differences between mini-implants from different manufacturers. To ascertain whether the mechanical resistance of the manufacturing material was similar, the mini-implants were subjected to SEM of the fractured surfaces. All groups presented ductile fracture, i.e., plastic deformation. This characteristic shows that, probably, all mini-implants evaluated are made of a compatible material.

The calculated shear tension and the normal tension obtained at the moment of fracture allows one to verify that the mini-implant manufacturing material is similar and represents its mechanical behavior. To calculate these tensions the fracture region diameter of the mini-implant was measured. Values for shear and normal tensions did not show significant differences between groups and therefore, no difference was observed for the mechanical resistance between the manufacturing materials of different mini-implants. Since no differences were observed

either for the mechanical resistance or for the fracture surface morphology, differences in torque resistance can be related to the shape of the mini-implant.

An increase in the cross-section diameter of the mini-implant was followed by an increase in fracture torque. The diameter, which is presented by the manufacturer, represents the full dimension and is the necessary clinical information to know how much space the device will require. However, owing to these results, it was noted that there is a difference in the diameter of the mini-implant core in the different groups evaluated. Thus, the shape of the mini-implant is a variable that should be considered when evaluating the mechanical resistance of this product. A greater number and smaller distance between threads was seen in groups N and NN, which can provide greater mechanical attachment and consequently, greater resistance for mini-implant insertion into bone. The smaller core diameter and the greater insertion torques can explain the smaller resistance to fractures of the mini-implants from these groups.

By evaluating the obtained mechanical analysis results for the mini-implants, there is a need for standardizing all the structures in this product, namely, core diameter, mini-implant size and shape and distance between threads. Mini-implant fractures during insertion or during force application can be a serious problem, and can even restrain a tooth from future movement¹⁴. Even though the current literature is rich in clinical information on mini-implants, little association of what is known about ideal characteristics of

mini-implant morphology has been converted into clinical applications. With the increasing use of these devices, new studies are suggested with the purpose of improving and adapting the shape of mini-implants to its best clinical application in orthodontic treatment.

CONCLUSION

Group NN presented the greatest insertion torque, which was significantly different from all other groups. Mini-implant removal torque did not present statistically significant differences between groups, but was always smaller than the insertion torques. Group NN differed significantly from all other groups presenting the smallest fracture torque. SIN mini-implants (groups S and SN) did not show any differences between themselves, demonstrating a small variation of resistance. All groups presented ductile fracture in SEM inspection, demonstrating compatibility of mini-implant material, even though they were from different manufacturers. This was confirmed because there were no differences for the maximum calculated shear tension.

Neodent mini-implants presented, in general, a different behavior from SIN mini-implants. Since these devices are made from the same material, one may say that the difference in shape, core diameter and number of threads can affect mini-implant physical properties, especially insertion, removal and fracture torques.

Posted on: April 2008
Revised and accepted: July 2008

REFERENCES

1. ANGLE, E. H. **Malocclusion of the teeth**. 7th ed. Philadelphia: S. S. White Dental Manufacturing, 1907.
2. ARAÚJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com mini-implantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
3. ARAÚJO, T. M. Ancoragem esquelética com mini-implantes. In: LIMA FILHO, R. M. A.; BOLOGNESE, A. M. **Ortodontia: arte e ciência**. 1. ed. Maringá: Dental Press, 2007. cap. 19, p. 393-448.
4. BAE, S. M.; PARK, H. S.; KYUNG, H. M.; KWON, O. W.; SUNG, J. H. Clinical application of micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 5, p. 298-302, May 2002.
5. BÜCHTER, A.; WIECHMANN, D.; KOERDT, S.; WIESMANN, H. P.; PIFFKO, J.; MEYER, U. Load-related implant reaction of mini-implants used for orthodontic anchorage. **Clin. Oral Implants Res.**, Copenhagen, v. 16, no. 4, p. 473-479, Aug. 2005.
6. CHEN, Y.; SHIN, H. I.; KYUNG, H. M. Biomechanical and histological comparison of self-drilling and self-tapping orthodontic microimplants in dogs. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 133, no. 1, p. 44-50, Jan. 2008.
7. COSTA, A.; RAFFAINI, M.; MELSEN, B. Miniscrews as orthodontic anchorage: a preliminary report. **Int. J. Adult Orthodon. Orthognath. Surg.**, Chicago, v. 13, no. 3, p. 201-219, 1998.
8. DILEK, O.; TEZULAS, E.; DINCEL, M. Required minimum primary stability and torque values for immediate loading of mini dental implants: an experimental study in non-viable bovine femoral bone. **Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.**, St. Louis, v. 105, no. 2, p. 20-27, Feb. 2007.
9. ELIAS, C. N.; GUIMARÃES, G. S.; MULLER, C. A. Torque de inserção e de remoção de miniparafusos ortodônticos. **Rev. Bras. Implant.**, Rio de Janeiro, v. 11, n. 3, p. 5-8, 2005.
10. FAVERO, L.; BROLLO, P.; BRESSAN, E. Orthodontic anchorage with specific fixture: related study analysis. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 122, no. 1, p. 84-94, 2002.
11. FRIBERG, B.; SENNERBY, L.; GRONDAHL, K.; BERGSTROM, C.; BACK, T.; LEKHOLM, U. Identification of bone quality in conjunction with insertion of titanium implants: a pilot study in jaw autopsy specimens. **Clin. Oral Implants Res.**, Copenhagen, v. 6, no. 4, p. 213-219, Dec. 1995.
12. KANOMI, R. Mini-implants for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, no. 11, p. 763-767, Nov. 1997.
13. KLOEHN, S. J. Evaluation of cervical anchorage force in treatment. **Angle Orthod.**, Appleton, v. 31, no. 2, p. 91-104, Apr. 1961.
14. LABOISSIÈRE JÚNIOR, M.; VILLELA, H.; BEZERRA, F.; LABOISSIÈRE, M.; DIAZ, L. Ancoragem absoluta utilizando microparafusos ortodônticos: protocolo para aplicação clínica (Trilogia – Parte II). **Implant News**, São Paulo, v. 2, n. 1, p. 37-46, jan./fev. 2005.
15. MELSEN, B. Mini-implants: where are we? **J. Clin. Orthod.**, Boulder, v. 39, no. 9, p. 539-547, Sept. 2005.
16. MORAIS, L. S.; SERRA, G. G.; MULLER, C. A.; ANDRADE, L. R.; PALERMO, E. F. A.; ELIAS, C. N.; MEYERS, M. Titanium alloy mini-implants for orthodontic anchorage: immediate loading and metal ion release. **Acta Biomater.**, Kidlington, v. 3, no. 3, p. 331-339, May 2007.
17. MOTOYOSHI, M.; HIRABAYASHI, M.; UEMURA, M.; SHIMIZU, N. Recommended placement torque when tightening an orthodontic mini-implant. **Clin. Oral Impl. Res.**, Copenhagen, v. 17, no. 1, p. 109-114, Feb. 2006.
18. MOTOYOSHI, M.; MASUOKA, M.; SHIMIZU, N. Application of orthodontic mini-implants in adolescents. **Int. J. Oral Maxillofac. Surg.**, Copenhagen, v. 36, no. 8, p. 695-699, Aug. 2007.
19. OHMAE, M.; SAITO, S.; MOROHASHI, T.; SEKI, K.; QU, H.; KANOMI, R.; YAMASAKI, K.; OKANO, T.; YAMADA, S.; SHIBASAKI, Y. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 119, no. 5, p. 489-497, May 2001.
20. PROFFIT, W. R.; FIELDS, H. W. **Contemporary Orthodontics**. 3rd ed. St. Louis: CV Mosby, 1999.
21. ROBERTS, W. E.; SMITH, R. K.; ZILBERMAN, Y.; MOZSARY, P. G.; SMITH, R. S. Osseous adaptation to continuous loading of rigid endosseous implants. **Am. J. Orthod.**, St. Louis, v. 86, no. 2, p. 95-111, Aug. 1984.
22. SHAPIRO, P. A.; KOKICH, V. G. Uses of implants in Orthodontics. **Dent. Clin. North Am.**, Philadelphia, v. 32, no. 3, p. 539-550, 1988.
23. SUNG, J. H.; KYUNG, H. M.; BAE, S. M.; PARK, H. S.; KWON, O. W.; McNAMARA JUNIOR, J. A. **Mini-implantes**. 1. ed. Nova Odessa: Ed. Napoleão, 2007.
24. THUROW, R. C. Craniomaxillary orthopedic correction with en masse dental control. **Am. J. Orthod.**, St. Louis, v. 68, no. 6, p. 601-624, Dec. 1975.
25. WILMES, B.; RADEMACHER, C.; OLTHOFF, G.; DRESCHER, D. Parameters affecting primary stability of orthodontic mini-implants. **J. Orofac. Orthop.**, München, v. 67, no. 3, p. 162-174, May 2006.

Corresponding Author

Flavia Artese
Rua Santa Clara, 75/1110 - Copacabana
CEP: 22.041-010 - Rio de Janeiro
E-mail: flaviaartese@gmail.com

Mesial movement of molars with mini-implants anchorage

Marcos Janson*, Daniela Alcântara Fernandes Silva**

Abstract

Introduction: It's routine, especially at the orthodontic office, the patient, after the assessment of the proposed treatment plan, answer about the possibility of closing their edentulous spaces caused by missed permanent teeth. In these situations, several factors must be evaluated, like the present malocclusion, the bone and roots integrity, the treatment time and the geometry of teeth positioning, that is what permits to assess if the loss of anchorage from the anterior segments, during the space closure, would permit the occlusion to end within the orthodontic ideals. With the mini-implants, the possibilities of this therapeutic approach have been improved, since the adverse effects are eliminated with the skeletal anchorage. **Aim:** In the present paper will be analyzed the factors involved in this treatment type, the reasoning in the decisions making and the important details that should be observed during the mechanics conduction, illustrated by cases reports.

Key words: Absolute anchorage. Skeletal anchorage. Mini-implants. Molar mesial movement.

Assessment of radiographic methods used in the vertical location of sites selected for mini-implant insertion

Liz Matzenbacher*, Paulo Sérgio Flores Campos**, Nilson Pena***, Telma Martins de Araújo****

Abstract

Objective: Evaluate the effectiveness of image diagnostic systems used in the vertical location of sites selected for mini-implant insertion. **Methodology:** The subjects comprised four patients in whose posterior regions 32 interradicular sites were located for mini-implants insertion. These sites were represented by orifices filled with gutta-percha on acetate dental trays (PCg - contact point of dental crowns on the acetate dental trays; PIg - mini-implant insertion point on the acetate dental tray). Periapical and interproximal radiographs were taken and cone beam computed tomography images of the dental trays placed in the mouth were acquired. The following points were considered: PC - radiodense image of point PCg; PI - radiodense image of point PIg; PCx - contact points between the dental crowns, which were determined on the radiograph. The following vertical measurements were used: Gold standard - from PCg to PIg; measurement 1 - from PC to PI; and measurement 2 - from PCx to PI. The measurements were compared by means of a descriptive analysis and Student's t-test. **Results:** As regards measurement 1, a statistically significant difference was noted for the gold standard in 4.1%, 25% and 100% of the measurements assessed with cone beam computed tomography images, interproximal and periapical radiographs, respectively. Regarding measurement 2, a statistically significant difference was noted for the gold standard in 4.1%, 56.2% and 100% of the measurements assessed with computed tomography images, interproximal and periapical radiographs, respectively. **Conclusions:** Cone beam computed tomography yielded the most accurate vertical position assessment of the sites selected for mini-implant insertion; interproximal radiographs can be used, although certain limitations apply; pericapical radiographs yielded less than satisfactory results and are therefore contraindicated for this particular purpose.

Keywords: Image diagnosis, Dental radiograph, X-Ray, Computed Tomography, Orthodontic anchorage procedures.

* A student specializing in Orthodontics and Facial Orthopedics at the Dental College of the Bahia State Federal University – FO.UFBA.

** Associate Professor of Radiology at the Bahia State Federal University.

*** Doctor in Radiology from the Piracicaba School of Dentistry (UNICAMP – Campinas State University). Researcher for The Bahia State Research Support Foundation (FAPESB).

**** Holds a Master's degree and a Doctorate Degree in Orthodontics from the Rio de Janeiro Federal University (UFRJ). Full Professor of Orthodontics at the Bahia State Federal University (FO.UFRJ). Coordinator of the Orthodontics Specialist Course at the School of Dentistry of the Bahia State Federal University (FO.UFBA). Director of the Brazilian Board of Orthodontics and Facial Orthopedics.

INTRODUCTION

Mini-implants require a simple and swift surgical intervention^{5,12}. A safe insertion, however, entails careful clinical and radiographic assessment, proper planning and a reliable implantation protocol with a special focus on the region's anatomy to ensure no lesions are made to noble structures^{2,3}.

Mini-implants can be installed in anatomical regions with minimum bone quantity. Interradicular space is often the site of choice. Should interproximal bone quantity and root proximity be poorly assessed, there is increased risk of radicular perforation^{7,17-23,26,28}. Studies have shown that a slight contact between the device and the periodontal ligament or cementum, without impairment to the vascular-nervous bundle or invasion of the root canal, will not affect tooth vitality. All measures should be undertaken, however, to stave off this kind of incident in order to avoid patient discomfort and potential clinical and/or legal implications^{2,21}.

Additionally, the major factor in determining the failure of these devices lies in overlooking the proximity between the mini-implant and the tooth root. Lamina dura proximity, for instance, can compromise mini-implant stability¹⁶. Whenever interradicular space is scant, smaller diameter mini-implants should be preferred, although a minimum diameter of 1.4 mm is recommended since smaller diameters tend to fracture during installation or removal¹.

It is advocated that an accurate identification of the selected site can be made by means of surgical guides^{3,13,15,20,28}. Nevertheless, it is common knowledge that two-dimensional images obtained from intraoral radiographs do not necessarily reflect the precise relationship between space and adjacent anatomical structures given the fact that different planes can produce slant or garbled images^{6,19}. Kim et al.¹³ and Kitai et al.¹⁴ have favored the use of computed tomography for viewing surgical guides. Although computed

tomography can show tridimensional images, however, not only is it relatively costlier, but it also exposes patients to a higher radiation dose compared with intraoral radiography.

The evolvement of mini-implants should not be circumscribed only to their different types, shapes and surgical techniques, but should also be geared to the development of imaging diagnostic systems^{8,11}. Thus, a study aimed at probing the degree of accuracy made available by radiographic exams is fully justified. Such knowledge would certainly ensure that a safe and reliable method is utilized in planning mini-implant insertion.

Therefore, knowing ahead of time that the proper selection of mini-implant insertion sites is of utmost importance for surgical procedure success, and further acknowledging the fact that interradicular space is often scarce, concern with the radiographic technique best suited to inform the aforementioned insertion sites can prove a useful addition to the literature.

MATERIALS AND METHODS

Four 25-to-28-year-old female subjects were selected, all of whom were patients at the Prof. Édimo Soares Martins Center for Orthodontics and Facial Orthopedics, located at the School of Dentistry of the Bahia Federal University. The choice was based on the following criteria: Complete permanent dentition down to the first molars; absence of posterior crowding and the need for computed tomography in planning mini-implant installation for anchorage.

To obtain the radiographs and tomographic images, the patients used acetate dental trays where the selected mini-implant insertion sites were represented by gutta-percha filled orifices. To this end, plaster models of each patient's dental arch were cast and subsequently plastic trays were produced with a Plastvac P7 vacuum forming machine (Bio-art, São Carlos/SP, Brazil), using 1 mm thick acetate plates (Whiteness – FGM, Joinville/SC, Brazil).

In all, thirty-two sites were selected for mini-implant installation in the interradicular spaces between second bicuspid and first molars of all hemiarches. Insertion points were determined clinically by intersecting an imaginary vertical line through the contact point and across the transitional zone between the keratinized mucous membrane and the free mucous membrane. The distances between contact points and insertion points were gauged clinically with the aid of a calibrated probe and subsequently transferred to the acetate trays (Fig. 1A,C). In order to place the marking media, 1 mm diameter orifices were bored into the dental trays, using a no. 2200 diamond (Fig. 1B, D), and filled with gutta-percha.

The patients were subjected to three different image diagnostic techniques: Interproximal and periapical radiographs of maxillary and mandibular posterior regions and cone beam computed tomography. The exams were performed (A B) using acetate dental trays placed in the patient's mouth (Fig. 2).

Acquisition of interproximal and periapical radiographs

These radiographs were acquired using In-

sight Kodak film (Rochester, New York, USA). The periapical bisecting angle technique was adopted with a Prisma brand support (Prisma Produtos Clínicos Ltda, Brasília/DF, Brazil); and a Heliodont Vario (Sirona – The Dental Company, Bensheim, Germany) unit was used with the tube adjusted for 70KVp, 7mA current operation and 0.4 second exposure time; distances of 27 cm and 30 cm were maintained for the focal area and the film for the interproximal and periapical radiographs, respectively. The automatic film processing was utilized with a Periomat Plus processor (Dürr Dental, Bietigheim-Bissingen, Germany) set for 5-minute intervals, from dry to dry.

Two interproximal radiographs and four periapical radiographs of each patient were acquired for the posterior region (upper and lower, right and left hand sides).

Acquisition of computed tomography images

Cone beam computed tomography images were acquired using an i-CAT Cone Beam 3-D Dental Imaging System (Imaging Sciences International, Hatfield, PA, USA), whose tube was adjusted to operate at 120KVp and 46.72 mA. A two-arch acquisition protocol was adopted

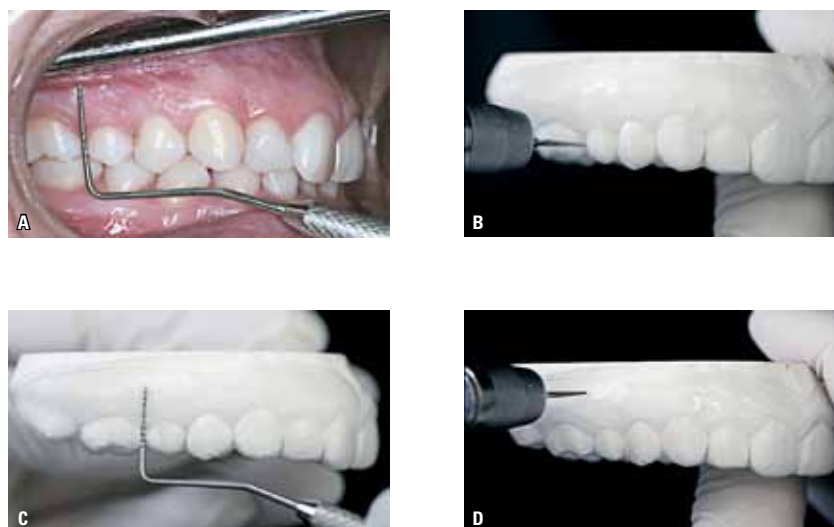


FIGURE 1 - **A)** Site selection for mini-implant installation within the limits of the free and keratinized mucous membranes. **B)** Contact point perforation (bur no. 2200). **C)** Transfer from the site of choice to the acetate tray. **D)** Insertion point perforation (bur no. 2200).



FIGURE 2 - Acetate dental trays placed in patient's mouth showing the selected points filled with gutta-percha: contact point between dental crowns and the site selected for mini-implant insertion.

with an 8 cm FOV and 0.2 mm voxel (2 arc, 8 cm, 40 sec, 0.2 voxel, max. res.). Image acquisition, reconstruction and assessment were all carried out with the aid of the XoranCat version 3.0.34 software (Xoran Technologies, Ann Arbor, Michigan) by a radiology specialist experienced in cone beam computed tomography.

Points and measurements

Five different points and measurements were used for assessment, namely PCg - contact point of the dental crown on the acetate dental tray, filled with gutta-percha (Fig. 3A); PIg - mini-implant insertion point on the acetate tray, filled with gutta-percha (Fig. 3A); PC - radiopaque image of the PCg point on radiographs and computed tomography images (Fig. 3B, C, D, 5B); PI - radiopaque image of point PIg on the radiographs and computed tomography images (Fig. 3B, C, D); PCx - contact point between the dental crowns as determined on the radiograph by the examiner (Fig. 3C, D, 5B). This point was created to identify the drift of points PCg and PIg on the radiographic images.

For this study, two linear measurements of the radiographic images were obtained: Measurement 1 - from point PC to point PI; measurement 2 - from point PCx to point PI. Measurements made directly on the acetate trays were considered gold standard: From point PCg to point PIg.

The distances in between points, both on the radiographs and the acetate trays, were measured with a high precision digital Mitutoyo Digimatic Caliper 0.01-150 mm (Mitutoyo, Brazil) by a single examiner (Fig. 4A, C). In order to test and validate the results, this procedure was repeated twice with a one-week interval between the two.

Given the fact that the acetate tray points all had 1.0 mm diameter, the point centers were used as reference for the measurements (Fig. 4A).

The measurements on the interproximal and periapical radiographs were performed with the help of a light box in a dark room with black carton masks and the window sized accurately to fit the X-ray film. PCx points were marked with a 0.3 mm pencil holder (Pentel, Japan) on a 0.003 mm thick acetate film used for cephalometric tracing (3M/Unitek, Monrovia, CA, USA), attached to the radiographs (Fig. 4B,C).

Once the tomographic images had been acquired, the measurements were performed using XoranCat software's 'distance' tool. In the multiplanar assessment environment, in the axial display window, the image was turned around so as to make the occlusal plane of the side of interest to be placed parallel to the vertical plane (Fig. 5C). Additionally, in the sagittal window, the image was turned around so as to cause the tooth's long axis to remain perpendicular to the horizontal plane (Fig. 5B).

The points were identified within the three

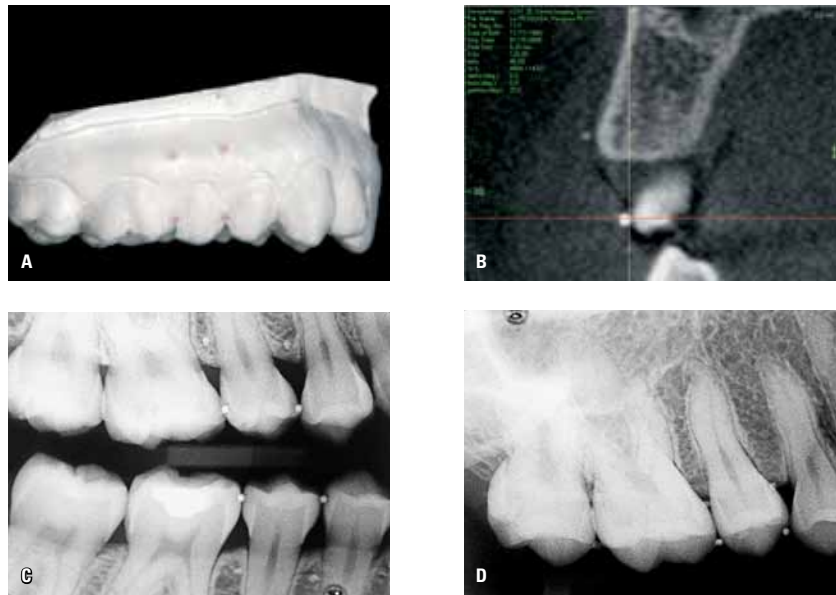


FIGURE 3 - An illustration of the points used in the present study: **A)** Acetate dental tray; **B)** Computed tomography image, coronal view; **C)** Interproximal radiograph; **D)** Periapical radiograph.



FIGURE 4 - **A)** Measurement taken on the acetate tray. **B)** PCx point marking. **C)** Periapical radiograph measurement using a digital gauge.



FIGURE 5 - Image of XoranCat software's multiplanar assessment environment showing an analysis of the right hand side region in between the bicuspids: **A)** coronal slice, with points PC and PI visible; **B)** sagittal slice, identifying point PCx overlaid on top of point PC; **C)** axial slice, used as an aid in positioning all other slices.



FIGURE 6 - **A)** Image of a computed tomography 0.2 mm slice identifying point PC. **B)** Slice thickness was increased to 3 mm allowing the identification of points PC and PI. **C)** Measurement performed.

planes and using a measuring tool available in the software, measurements were made on the coronal view. Considering that computed tomography unveils a tridimensional view, the choice was made to measure the coronal view since it displays a better visualization of the points than the sagittal view. The thickness of the ideal tomographic slice to identify the center of the gutta-percha points was 0.2 mm (Fig. 6A). In most cases, however, the points were not on the same coronal view for this slice. Therefore, in order to identify and measure them it was necessary to increase slice thickness (Fig. 6B, C). Measurements for this group were performed only once since they were made digitally, using the aforementioned software.

Statistical analysis

The data were tabulated and analyzed with descriptive statistics of the reading variable by calculating the central trend and dispersion measurements, assessing researcher's gauging and reproducibility. Student's t-test was utilized for paired samples with a 95% confidence interval, with the purpose of comparing each discrete radiographic exam with the gold standard.

RESULTS

After analyzing the central trend and dispersion measurements, a significant correlation was noted for the three readings of the interproximal and periapical radiographs and for the acetate trays, thereby confirming the reading variable's reproducibility and gauging. It was found that $p > 0.98$ and $p > 0.97$ for the gold standard, $p > 0.97$ and $p > 0.96$ for the interproximal radiographs, $p > 0.98$ and $p > 0.97$ for the periapical radiographs concerning measurements 1 and 2, respectively.

As regards measurement 1, a statistically significant difference was noted in relation to the gold standard in 4.1%, 25% and 100% of the areas in the computed tomography images, interproximal and periapical radiographs, respectively. Regarding measurement 2 a statistically significant difference was noted in relation to the gold standard in 4.1%, 56.2% and 100% of all areas, in relation to the areas in the computed tomography images, interproximal and periapical radiographs, respectively (Table 2). For the interproximal radiographs, concerning measurements 1 and 2, 65.3% and 34.6% of the areas corresponded to the upper and lower arches, respectively (Table 1, 2).

Table 1 - Mean and standard deviation values for three measurement 1 readings, in millimeters.

	Gold standard		interproximal		periapical		tomographic image	
	X	d.p.	X	d.p.	X	d.p.	X	d.p.
14-15								
Patient 1	6.74	0.12	6.64	0.02	4.38**	0.03	6.55	0.10
Patient 2	7.63	0.03	7.46	0.02	5.35**	0.03	7.60	0.10
Patient 3	8.47	0.05	8.04*	0.05	5.54**	0.04	8.33	0.10
Patient 4	8.07	0.04	7.83	0.01	4.95**	0.05	7.92	0.10
15-16								
Patient 1	6.42	0.07	6.34	0.04	3.8**	0.01	6.17 *	0.10
Patient 2	7.83	0.02	7.45*	0.03	5.96**	0.04	7.83	0.10
Patient 3	8.01	0.05	7.94	0.03	5.44**	0.01	7.98	0.10
Patient 4	8.66	0.02	7.81**	0.06	6.25**	0.12	8.79	0.10
24-25								
Patient 1	8.24	0.03	7.67**	0.02	5.55**	0.03	8.09	0.10
Patient 2	8.08	0.07	7.89	0.04	6.32**	0.03	7.97	0.10
Patient 3	8.98	0.01	8.35**	0.01	6.12**	0.02	8.83	0.10
Patient 4	7.95	0.03	8.08	0.04	6.33**	0.09	8.09	0.10
25-26								
Patient 1	7.88	0.16	7.02*	0.05	5.92**	0.07	7.94	0.10
Patient 2	8.45	0.01	8.56	0.07	7.56**	0.06	8.29	0.10
Patient 3	8.53	0.03	8.56	0.02	7.14**	0.04	8.36	0.10
Patient 4	7.62	0.05	7.83	0.01	6.20**	0.02	7.81	0.10
34-35								
Patient 1	6.53	0.08	6.31	0.06	4.90**	0.02	6.40	0.10
Patient 2	8.28	0.03	7.05	0.03	7.05**	0.03	7.99	0.10
Patient 3	8.26	0.04	7.75**	0.04	6.23**	0.06	8.41	0.10
Patient 4	8.99	0.04	8.98	0.02	6.72**	0.02	8.94	0.10
35-36								
Patient 1	7.30	0.07	5.50**	0.03	5.38**	0.02	7.28	0.10
Patient 2	8.24	0.03	8.16	0.03	5.74**	0.05	8.12	0.10
Patient 3	7.61	0.06	7.55	0.03	6.09**	0.04	7.59	0.10
Patient 4	8.58	0.04	8.66	0.07	5.42**	0.02	8.32	0.10
44-45								
Patient 1	7.69	0.03	7.66	0.03	5.53**	0.02	7.52	0.10
Patient 2	8.99	0.05	8.84	0.03	7.36**	0.03	9.02	0.10
Patient 3	7.51	0.03	7.56	0.01	6.22**	0.01	7.57	0.10
Patient 4	7.70	0.03	7.64	0.02	5.91**	0.05	7.53	0.10
45-46								
Patient 1	7.17	0.01	6.99	0.07	4.74**	0.05	7.10	0.10
Patient 2	7.69	0.02	7.77	0.06	6.85**	0.02	7.57	0.10
Patient 3	6.33	0.05	6.14	0.04	4.96**	0.03	6.40	0.10
Patient 4	7.38	0.03	7.43	0.04	4.49**	0.06	7.43	0.10

Student's t-test comparing each area with the gold standard, where (*) relates to $p < 0.05$ and (**) refers to $p < 0.00$.

Table 2 - Mean and standard deviation values of the three measurement 2 readings, in millimeters.

	Gold standard		interproximal		periapical		tomographic image	
	X	d.p.	X	d.p.	X	d.p.	X	d.p.
14-15								
Patient 1	6.74	0.12	6.56	0.07	2.50**	0.04	6.55	0.10
Patient 2	7.63	0.03	7.45	0.07	4.56**	1.16	7.60	0.10
Patient 3	8.47	0.05	7.04**	0.63	4.14**	0.02	8.33	0.10
Patient 4	8.07	0.04	7.65*	0.04	4.14**	0.12	7.92	0.10
15-16								
Patient 1	6.42	0.07	5.82*	0.09	2.03**	0.03	6.17*	0.10
Patient 2	7.83	0.02	7.44*	0.03	4.67**	0.57	7.83	0.10
Patient 3	8.01	0.05	7.00**	0.01	3.93**	0.07	7.98	0.10
Patient 4	8.66	0.02	7.77**	0.04	5.12**	0.00	8.79	0.10
24-25								
Patient 1	8.24	0.03	7.50**	0.01	3.64**	0.08	8.09	0.10
Patient 2	8.08	0.07	7.65*	0.04	4.20**	0.03	7.97	0.10
Patient 3	8.98	0.01	7.79**	0.01	5.10**	0.02	8.83	0.10
Patient 4	7.95	0.03	8.08	0.01	5.60**	0.08	8.09	0.10
25-26								
Patient 1	7.88	0.16	7.00**	0.01	4.63**	0.03	7.94	0.10
Patient 2	8.45	0.01	8.53	0.07	5.95**	0.07	8.29	0.10
Patient 3	8.53	0.03	7.24**	0.08	5.32**	0.07	8.36	0.10
Patient 4	7.62	0.05	7.62	0.04	5.86**	0.84	7.81	0.10
34-35								
Patient 1	6.53	0.08	6.02	0.07	3.61**	0.07	6.40	0.10
Patient 2	8.28	0.03	8.15	0.04	5.48**	0.05	7.99	0.10
Patient 3	8.26	0.04	7.45**	0.05	5.16**	0.01	8.41	0.10
Patient 4	8.99	0.04	8.92	0.02	4.88**	0.10	8.94	0.10
35-36								
Patient 1	7.30	0.07	4.85**	0.06	3.55**	0.02	7.28	0.10
Patient 2	8.24	0.03	8.15	0.04	4.23**	0.09	8.12	0.10
Patient 3	7.61	0.06	7.52	0.04	5.06**	0.03	7.59	0.10
Patient 4	8.58	0.04	8.65	0.04	2.83**	2.81	8.32	0.10
44-45								
Patient 1	7.69	0.03	6.55*	0.32	2.30**	0.01	7.52	0.10
Patient 2	8.99	0.05	8.41*	0.04	6.72**	0.01	9.02	0.10
Patient 3	7.51	0.03	7.01*	0.00	4.71**	0.02	7.57	0.10
Patient 4	7.70	0.03	7.60	0.02	4.81**	0.01	7.53	0.10
45-46								
Patient 1	7.17	0.01	6.60**	0.01	1.97**	0.04	7.10	0.10
Patient 2	7.69	0.02	7.77	0.07	5.53**	0.04	7.57	0.10
Patient 3	6.33	0.05	5.91*	0.04	3.72**	0.04	6.40	0.10
Patient 4	7.39	0.03	7.44	0.05	2.88**	0.12	7.43	0.10

Student's t-test comparing each area with the gold standard, where (*) relates to $p < 0.05$ and (**) refers to $p < 0.00$.

DISCUSSION

Mini-implants have evolved a great deal in terms of shape, type and surgical technique and have consequently become an increasingly safe and standardized resource. Nevertheless, few studies have been conducted to investigate radiographic techniques available to the professional during planning and at insertion time.

In the present study, radiographic measurements were performed on acetate paper and a 100th millimeter precision digital gauge was employed, but not directly upon the radiograph since the tip of the caliper might scratch the film and impair the measurement of subsequent readings. Three readings of each exam were conducted, within a week's interval in between them, with the aim of calculating the mean measurement value. Based on an analysis of the central and dispersion trend measurements, a significant correlation was noted amongst the three readings. A similar methodology was used in studies by Gher and Richardson¹⁰ to assess researcher reproducibility and gauging in performing the readings.

Due to the fact that during the radiographic image analysis a vertical distortion appeared along with point drifts, two measurements were performed (measurement 1: PC – PI; measurement 2: PCx – PI), since measurement alone might not disclose the actual radiographic distortion.

Vertical distortions are based on object depth given the distance to the film – in this case there were two objects, namely, the alveolar process and the marker. We therefore have objects on different planes, which yield, as a result, different distortions. However, Ruschel et al.²⁵ recommend, even in dry skull studies, that the marker not be in contact with the bone crest so as to simulate a clinical situation, for in the mouth the gingival tissue is located between the marker and the bone. Should the marker remain in contact with the bone crest, we would have two objects

at the same distance but which would not represent an actual clinical condition.

When measurement values are set lower they tend to mistakenly show that the mini-implant would be installed too close to the bone crest and would therefore be contraindicated at such site due to increased bone crest fracture risk or the risk of having the mini-implant inserted in the soft tissue. If a professional were to migrate the point towards the cervical region, consequently decreasing the interdental horizontal distance, given the conic shape of the roots, she might be led to mistakenly select a smaller diameter mini-implant. It might even imply that the available space would be inadequate for the insertion of a temporary anchorage device. This consideration is rather relevant, and according to Araújo¹ the size of the available insertion area should be duly assessed since reduced space requires smaller size mini-implants. For insertion in between roots it is preferable to select at least a 1.4 mm diameter mini-implant since smaller diameters are at a greater fracture risk during installation or removal, particularly on the mandible where the cortical bone is thicker. Should this space prove inadequate the need arises to assess the possibility of using alternative areas, altering angulation or even separating the roots orthodontically so as to expand the available space, thus facilitating safe mini-implant insertion.

The findings of the present study have demonstrated that periapical radiographs show statistically significant differences in 100% of the areas (Table 1, 2), and are therefore contraindicated as a tool in selecting the best mini-implant installation site since the guide image will drift too far off towards the alveolar bone crest. The vertical distortion is so significant that it precludes even horizontal measurements of the proposed site. Additionally, one can infer that since the surgical guide images undergo considerable vertical distortion in pericapical radiographs, these radiographs would not be indicated for assessing

installed mini-implants.

On measurement 1, the interproximal radiographs showed satisfactory results (Table 1). Despite having disclosed a statistically significant difference in 25% of the areas, such difference has no clinical relevance. According to Callegari-Jacques⁴, statistically significant differences found in dental radiographic image measurements may not be relevant from a clinical or biological perspective given the limitations of the values found by the measurements.

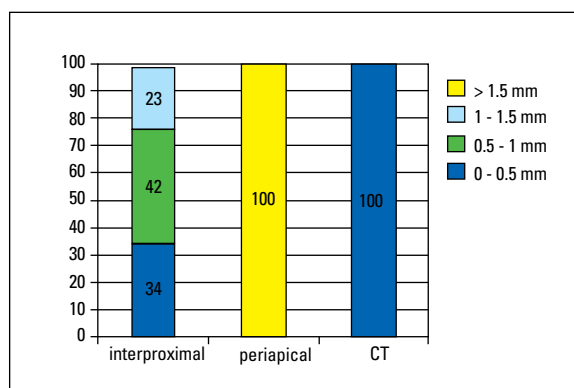
On measurement 2, the interproximal radiograph showed a statistically significant difference in 56.2% of the regions (Table 2), with measurement values set lower than the gold standard. An increase in the number of areas with statistically significant differences between measurement 1 and measurement 2 could be justified taking into account the correction of the contact point, which drifted vertically towards the cervical region, thereby leading it closer to the insertion point in the radiograph, which compounded the distortion brought about by the vertical angulation.

As can be observed in the interproximal radiographs, the upper arch showed greater distortion compared with the lower arch, which can be explained by the positive vertical angulation

used in the procedure (+5° to +10°), which is more appropriate for the lower arch due to the implantation of teeth in the bone base. In assessing the areas which showed statistically significant differences in relation to the gold standard, one can observe that 34.6%, 42.3% and 23% showed vertical distortion within the 0 to 0.5, 0.5 to 1 mm and 1 to 1.5 mm ranges, respectively (Graph 1). Despite the low percentage found in regions within the 1.0 to 1.5 mm range, one should be cautious when using interproximal radiographs for the purposes mentioned in this research since, more often than not, the available interradiacicular space is so scarce that 1.5 mm may have clinical relevance. A comparison between intraoral radiographic results shows that interproximal radiographs are more accurate than periapical radiographs. These results corroborate Reed and Polson²⁴, Sewerin²⁷ and Thunth²⁹ who reported that whenever mini-implant anchorage becomes necessary the chosen site should be analyzed using interproximal radiographs since periapical radiographs tend to produce slant and garbled images.

Cone beam computed tomography yielded statistically significant results in 4.1% of the samples only, with a difference of 0.50 mm at the most. It is therefore considered the most accurate and reliable of all methods studied for viewing proposed mini-implant insertion sites.

For new patients, professionals should carefully assess the cost-benefit relationship and order a cone beam computed tomography image, which will provide, in one single exam, all conventional 2D images that comprise orthodontic documentation with the added benefit of a more detailed tridimensional view of dentofacial structures. From a financial standpoint, cone beam computed tomography proved most convenient since nowadays an estimate for the exam makes up approximately the same amount spent on conventional orthodontic documentation. Insofar as biological costs are concerned, due



GRAPH 1 - Areas that showed statistically significant differences in relation to the gold standard, distributed in millimeter intervals.

to the patient's exposure to radiation, it should be emphasized that a single cone beam computed tomography exam can replace the exposure entailed in a number of conventional radiographic exams, which are routinely used in orthodontic practice⁹.

CONCLUSION

Based on the findings of the present study, it is possible to conclude that cone beam computed tomography is the most accurate and effective exam for assessing the vertical position of sites selected for mini-implant insertion. Compared with the gold standard, CT exams did not show any differences higher than 0.50 mm. Interproximal radiographs can be used in spite of obvi-

ous limitations whereas pericapical radiographs yielded unsatisfactory results.

ACKNOWLEDGEMENTS

The authors wish to thank Drs. João Carlos Costa da Silva and Elmo Anísio Costa da Silva for their invaluable contribution to this study.

Submitted: maio de 2008

Revised and accepted for publication: julho de 2008

REFERENCES

1. ARAÚJO, T. M. Ancoragem esquelética com mini-implantes. In: LIMA FILHO, R. M. A.; BOLOGNESE, A. M. **Ortodontia: arte e ciência**, 1. ed. Maringá: Dental Press, 2007. p. 393-448.
2. ARAÚJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com mini-implantes. **Rev. Dental. Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
3. BAE, S. M.; PARK, H. S.; KYUNG, H. M.; KWON, O. W.; SUNG, J. H. Clinical application of micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 5, p. 298-302, May 2002.
4. CALLEGARI-JACQUES, S. M. **Bioestatística: princípios e aplicações**. Porto Alegre: Artmed, 2003. p. 247-258.
5. COSTA, A.; RAFFAINI, M.; MELSEN, B. Miniscrews as orthodontic anchorage: a preliminary report. **Int. J. Adult Orthodon. Orthognath. Surg.**, Chicago, v. 13, no. 3, p. 201-209, 1998.
6. DUCKWORTH, J. E.; JUDY, P. F.; GOODSON, J. M.; SOCRANSKY, S. S. A method for the geometric and densitometric standardization of intraoral radiographs. **J. Periodontol.**, Chicago, v. 54, no. 7, p. 435-440, July 1983.
7. FABBIONI, G.; AABED, S.; MIZEN, K.; STARR, D. G. Transalveolar screws and the incidence of dental damage: a prospective study. **Int. J. Oral Maxillofac. Surg.**, Copenhagen, v. 33, no. 5, p. 442-446, July 2004.
8. FREITAS, A.; VAROLI, O. J.; TORRES, F. A. Técnicas radiográficas intrabucais. In: FREITAS, A.; ROSA, J. E.; SOUZA, I. F. **Radiologia odontológica**. 1. ed. São Paulo: Artes Médicas, 2004. p. 103-166.
9. GARIB, D. G.; RAYMUNDO JUNIOR, R.; RAYMUNDO, M. V.; RAYMUNDO, D. V.; FERREIRA, S. N. Tomografia computadorizada de feixe cônico (Cone beam): entendendo este novo método de diagnóstico por imagem com promissora aplicabilidade na Ortodontia. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 12, n. 2, p. 139-156, mar./apr. 2007.
10. GHER, M. E.; RICHARDSON, A. C. The accuracy of dental radiographic techniques used for evaluation of implant fixture placement. **Int. J. Periodontics Restorative Dent.**, Chicago, v. 15, no. 3, p. 268-283, June 1995.
11. GRABER, T. M.; VANARSDALL, R. L. **Orthodontics: current principles and techniques**. 5th ed. Missouri: Elsevier, 2005.
12. KANOMI, R. Mini-implant for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, no. 11, p. 763-767, Nov. 1997.
13. KIM, S. H.; CHOI, Y. S.; HWANG, E. H.; CHUNG, K. R.; KOOK, Y. A.; NELSON, G. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 4, p. S82-S89, Apr. 2007. Supplement.
14. KITAI, N.; YASUDA, Y.; TAKADA, K. A stent fabricated on a selectively colored stereolithographic model for placement of orthodontic mini-implants. **Int. J. Adult Orthodon. Orthognath. Surg.**, Chicago, v. 17, no. 4, p. 264-266, 2002.
15. KOYANAGI, K. Development and clinical application of a surgical guide for optimal implant placement. **J. Prosthet. Dent.**, St. Louis, v. 88, no. 5, p. 548-552, Nov. 2002.
16. KURODA, S.; YAMADA, K.; DEGUCHI, T.; HASHIMOTO, T.; KYUNG, H. M.; TAKANO-YAMAMOTO, T. Root proximity is a major factor for screw failure in orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 4, p. S68-S73, Apr. 2007. Supplement.
17. KYUNG, S. H.; CHOI, J. H.; PARK, Y. C. Miniscrew anchorage used to protract lower second molars into first molar extraction sites. **J. Clin. Orthod.**, Boulder, v. 37, no. 10, p. 575-779, Oct. 2003.
18. KYUNG, H. M.; PARK, H. S.; BAE, S. M.; SUNG, J. H.; KIM, I. B. Development of orthodontic micro-implants for intraoral anchorage. **J. Clin. Orthod.**, Boulder, v. 37, no. 6, p. 321-328, June 2003.
19. MAH, J.; BERGSTRAND, F. Temporary anchorage devices: a status report. **J. Clin. Orthod.**, Boulder, v. 39, no. 3, p. 132-136, Mar. 2005.
20. MAINO, B. G.; BEDNAR, J.; PAGIN, P.; MURA, P. The spider screw for skeletal anchorage. **J. Clin. Orthod.**, Boulder, v. 37, no. 2, p. 90-97, Feb. 2003.
21. MOREA, C.; DOMINGUEZ, G. C.; WUO, A. V.; TORTAMANO, A. Surgical guide for optimal positioning of mini-implants. **J. Clin. Orthod.**, Boulder, v. 39, no. 5,

- p. 317-321, May 2005.
22. PARK, H. S.; BAE, S. M.; KYUNG, H. M.; SUNG, J. H.; Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. **J. Clin. Orthod.**, Boulder, v. 35, no. 7, p. 417-422, July 2001.
 23. POGGIO, P. M.; INCORVATI, C.; VELO, S.; CARANO, A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. **Angle Orthod.**, Appleton, v. 76, no. 2, p. 191-197, Mar. 2006.
 24. REED, B. E.; POLSON, A. M. Relationships between bitewing and periapical radiographs in assessing crestal alveolar bone levels. **J. Periodontol.**, Chicago, v. 55, no. 1, p. 22-27, Jan. 1984.
 25. RUSCHEL, G.; NACONECY, M. M.; VEECK, E. B.; COSTA, N. P. Tomografia linear X tomografia computadorizada. **Rev. Odonto Cienc.**, Porto Alegre, v. 16, n. 34, p. 264-267, set./dez. 2001.
 26. SCHNELLE, M. A.; BECK, F. M.; JAYNES, R. M.; HUJA, S. S. A radiographic evaluation of the availability of bone for placement of miniscrews. **Angle Orthod.**, Appleton, v. 74, no. 6, p. 832-837, Dec. 2004.
 27. SEWERIN, P. Utilize your dental X-ray set better. **Int. Dent. J.**, London, v. 37, no. 1, p. 38-42, Mar. 1987.
 28. SUZUKI, E. Y.; BURANASTIDPORN, B. An adjustable surgical guide for miniscrew placement. **J. Clin. Orthod.**, Boulder, v. 39, no. 10, p. 588-590, Oct. 2005.
 29. THUNTHY, K. H. Radiographic illusions due to faulty angulations. **Dent. Radiogr. Photogr.**, Rochester, v. 51, no. 1, p. 1-7, 13-15, 1978.

Contact

Liz Matzenbacher da Silva
 Centro de Ortodontia e Ortopedia Facial
 AV. Araújo Pinho, nº 62, 7º andar - Canela - Salvador / BA
 CEP: 40.110-150 - E-mail: lizmdasilva@hotmail.com

Use of orthodontic miniscrews in asymmetrical corrections

Henrique Mascarenhas Villela*, Andréa Lacerda Santos Sampaio**, Fábio Bezerra***

Abstract

Introduction: Anchorage control is of paramount importance in ensuring orthodontic treatment success, particularly in asymmetry corrections, where it is even more critical. The conventional anchorage methods currently used to treat these types of anomalies are rather complex and can trigger undesirable movements in the reaction unit, or even be rejected by patients on account of the esthetic compromise they entail. The use of microscrews as anchorage units, as well as averting undesirable side effects, helps to streamline orthodontic mechanics while providing greater treatment result predictability, reducing treatment time and allowing the correction of missing teeth cases by affording direct anchorage. **Objective:** This study aims to undertake a review of today's literature covering dental asymmetry treatment with the use of orthodontic titanium microscrews as anchorage and provide some clinical examples.

Keywords: Microscrews. Mini-implants. Orthodontic anchorage procedures. Facial asymmetry.

INTRODUCTION

One of the key objectives of orthodontic treatment consists in establishing intraarch and interarch symmetry. Determining the appropriate position for the median line is pivotal not only in light of esthetic considerations but also because the position of the posterior teeth is at stake⁵. Asymmetrical extractions can be indicated for treating slight dental and skeletal asymmetries. However, mechanics complexity, anchorage control and undesirable side effects often get in the way of treatment^{7,8}.

Most conventional anchorage devices are

symmetrical, such as the transpalatal bar, face-bow headgear, labioactive plate, Nance button, Nance lingual arch wire, among others. The difficulty in finding devices to correct asymmetrical occlusal relationships by moving malpositioned teeth without affecting well positioned teeth renders asymmetry treatment a serious challenge to orthodontists^{6,22}.

In seeking a solution to anchorage control problems, microscrews have emerged as an extremely useful alternative in dental asymmetry treatment. Given their small size, these screws can be inserted in a variety of sites on the al-

* Holds an Orthodontics and Facial Orthopedics Specialist Degree from the Bahia State Brazilian Dental Association (ABO-BA); Teaches Refresher Courses and Specialist Orthodontics and Facial Orthopedics Courses at ABO-BA.

** Holds an Orthodontics and Facial Orthopedics Specialist Degree from the Bahia State Brazilian Dental Association (ABO-BA); Teaches Refresher Courses and Specialist Orthodontics and Facial Orthopedics Courses at ABO-BA.

*** An ABO-BA Orthodontics and Facial Orthopedics Specialist.

veolar and basal bones, thereby creating an absolute anchorage system which allows teeth to be moved only where such movements are desired. Thus, more predictable and controllable movements are achieved without any side effects and the use of simpler orthodontic mechanics^{23,26}.

Among the causes of teeth asymmetries, the following are noteworthy: Deciduous molar ankylosis; permanent unit ectopic eruptions; unilateral loss of leeway space; congenital absence of teeth; supernumerary teeth; habits and premature loss of deciduous or permanent teeth⁹. For a proper asymmetry diagnosis a judicious evaluation of the patient's dental and skeletal features should be conducted²¹. Facial soft tissue evaluation provides an insight into existing skeletal problems. It should be carried out by means of a clinical examination and the use of photographs^{3,4}.

The evaluation of a patient's frontal symmetry is the primary aspect of any diagnosis since it is the angle patients most often see themselves² in. Initially, right and left hand side symmetry can be observed by drawing a true vertical line (glabella – nose tip – lip) perpendicularly to the vision line (true horizontal), which divides the face into two parts. An adequate asymmetry, which may result in a slight difference between the two sides, should be distinguished from a significant chin or nose mismatch²¹. Mandible asymmetries can be viewed clinically through frontal view by observing the relationship between the mentum and the other facial structures³.

The upper and lower dental median lines are expected to coincide and show an adequate position with regard to the face¹⁸. When these lines fail to coincide with each other or the facial median line, the cause can be traced back to a skeletal asymmetry due to inappropriate positioning of units in the arch^{1,4}.

The median line can be assessed radiographically, either using a PA radiograph, or clinically. The clinical assessment can be conducted using some dental floss to join the glabella or nasion,

subnasal and pogonion points. Mandibular deflections or a failure in identifying these points can lead to wrong results since these three points will not correspond. Thus, the center of the labial philtrum can serve as orientation in locating the facial median line⁴.

Assessment of occlusal conditions should be performed in a centric relationship since mandibular deflections can either mitigate or aggravate asymmetry when the patient is placed in centric occlusion¹³.

Vertical occlusal asymmetry can be diagnosed through a clinical evaluation of the patient. To this end, the patient is instructed to bite on a blade, which represents the occlusal plane. Any lack of parallelism between this plane and the bipupillary plane would disclose an inclination on the occlusal plane and, consequently, an asymmetry^{3,19}.

The axial inclinations of posterior teeth should be measured against the occlusal plane. Mesiodistal inclination assessment is not sufficient to distinguish dentally from skeletally derived asymmetries since teeth might have drifted prematurely, thereby producing little inclination. In such cases, other guidelines can be followed, such as the rotation of upper molars and the amount of bone present in the posterior region of the tuberosity or branch. Additionally, it is important to match the dental axial inclinations on the right and left hand sides of the arches⁴.

The proper treatment of asymmetries depends on diagnostic accuracy. It is essential to determine whether the factors that caused the asymmetry are skeletal, dentoalveolar or both, with a view to administering the most suitable treatment¹⁸.

By coordinating the median lines – both upper and lower, between the two and with respect to the facial median line – and by imparting facial symmetry, treatment goals, such as the following, are more likely to be met²⁷. Maximum intercuspitation, result stability and enhanced occlusal and

facial esthetics⁸. The acceptance of slight deflections on the median line depends on individual factors and a personal evaluation of the asymmetry. In general, however, deflections of 2mm or more can be easily detected by most individuals¹.

Skeletal asymmetries are preferably addressed with ortho-surgical treatment. Discreet dental and/or skeletal asymmetries are more often treated with orthodontic therapy. Choosing the proper orthodontic appliance is crucial since any attempt to sort out an asymmetry with unsuitable appliances often compounds the asymmetry itself²⁰.

The use of microscrews and anchorage elements helps to streamline orthodontic appliances while minimizing side effects from undesirable forces^{12,14,24}. This opportunity to choose the most convenient site for installation of an anchorage point allows an adequate force system to be used for each case and, as a result, dental movements become more predictable^{2,11,23}. In this manner, it becomes possible to drive the action force line towards the resistance center of the tooth or group of teeth, in accordance with the desired movement^{11,25}.

Microscrews can be employed successfully in various types of dental asymmetries, such as: Occlusal plane inclination, median line deflection, asymmetric molar relationship and unilateral posterior crossbite²⁷. One of the advantages of using microscrews versus cross elastics is the possibility of acting upon each arch discretely, thereby avoiding deleterious effects to the opposite arch, such as, for example, extrusive forces^{14,15,16}. In like manner, it is possible to achieve group unilateral distalization without affecting the other hemiarch while concurrently correcting the molar to median line relationship. An additional advantage to molar retraction using a microscrew lies in controlling the mandibular plane, determined by the vertical position of the implant, which allows the intrusive component to be incorporated whenever necessary^{10,17}.

CLINICAL CASE #1

Occlusion plane correction

Female patient, 40 years of age. A facial assessment disclosed a heightened facial convexity with a slight mentum projection deficiency; lower third of the face slightly increased and an asymmetry of the lower third with drift of the mentum towards the right.

An occlusal assessment revealed that several lower arch posterior dental units were missing, a class II cuspid relationship, median line deflected to the left, upper and lower occlusal plane asymmetry with extruded upper left posterior and a lingual occlusion of the lower right posterior teeth. An ortho-surgical planning was drawn up for this case, where the orthodontic treatment would focus on correcting the upper and lower occlusal plane asymmetries, followed by a surgical advancement of the mandible. This type of prior orthodontic intervention is meant to minimize the ensuing surgical act since any attempt to surgically correct the asymmetries would necessarily entail combined maxilla and mandible surgeries – one for correcting the maxillary asymmetry and one to correct the mandibular asymmetry – in addition to the recommended mandibular advancement.

The orthodontic treatment was started by leveling the upper archwire without including the second left-hand molar since it was overly extruded (Fig. 1). To achieve molar intrusion two microscrews were implanted in the mesial region of the second molar, one via the buccal side and one through the palate. The choice of the microscrew sites aimed to achieve intrusion with full buccolingual control, resulting in a translatory movement (Fig. 2). Initially, to attain an individualized intrusion, force was applied to the second molar (Fig. 3). When this movement had been achieved, force was applied to the archwire in order to intrude the segment (Fig. 4). Forces were continuously applied both buccally and palatally, thereby affording the necessary con-



FIGURE 1 - Initial upper leveling without second molar embedding.



FIGURE 2 - Two microscrews being used – one through buccal, one palatally - to achieve individual intrusion of upper second molar.



FIGURE 3 - After Intrusion of upper left second molar and space closure between cuspid and lower right second bicuspid.



FIGURE 4 - Force being applied to arch segment to correct upper occlusal plane asymmetry.

trol to achieve tooth translation (Fig. 5). On the lower arch, planning focused on leveling and correcting the median line while closing the space between the right hand side cuspid and second bicuspid. Lower arch asymmetry was corrected by installing a microscrew between the right cuspid and second bicuspid, buccally. To generate

intrusion along with proclination (Fig. 6), force was applied buccally. The asymmetry of the upper and lower occlusal planes was corrected in a straightforward and efficient manner with the use of microscrews. This movement streamlined surgical procedures since only the mandibular advancement remained to be performed whereas



FIGURE 5 - Deployment of a force system consisting of two microscrews – one via the buccal region and one through the lingual region – for intrusion of the upper left posterior segment.



FIGURE 6 - Use of a microscrew through the buccal region for intrusion and proclination of the lower arch right segment.



FIGURE 7 - Intermediate and final stages of upper and lower occlusal plane asymmetry correction.

on the maxilla there was no need for any intervention whatsoever (Fig. 7).

CLINICAL CASE #2

Dentoalveolar Correction with Asymmetrical Extraction

Female patient, 50 years old. A facial assessment revealed a facial thirds balance, a slight facial asymmetry compatible with normal standards and a discreet deflection of the upper dental median line towards the right in relation to the facial median line.

An analysis of the dental arches disclosed a Class II – Division 2, subdivision malocclusion

on the left hand side; $\frac{3}{4}$ cuspid and bicuspid relations on the left-hand side; an upper left lateral incisor with an infra-buccal-rotation and a slight deflection of the upper median line towards the right in relation to the lower median line. The molar, bicuspid and cuspid relationship on the right-hand side revealed a Class I (Fig. 8).

The orthodontic treatment plan consisted in the extraction of the first upper left bicuspid and an asymmetric anterior retraction. The extraction aimed to provide sufficient space for aligning the upper left lateral incisor during the initial cuspid retraction stage.

Following upper arch alignment and level-



FIGURE 8 - Patient's initial images showing a Class II-2, left subdivision malocclusion.



FIGURE 9 - Initial phase of asymmetric anterior retraction using a microscrew as anchorage device on the left hand side.



FIGURE 10 - Intraoral images six months after treatment.

ing, the asymmetrical anterior retraction was achieved with the use of a microscrew on the left hand side between the upper second bicuspid and the upper first molar for direct anchorage (Fig. 9). Once the asymmetrical anterior retraction was completed, it was observed that the upper left cuspid relationship had been corrected without producing any molar/bicuspid reciprocal movement on that same side. At the completion of treatment, the left hand side molar relationship remained at Class II and the cuspid relationship in Class I. The occlusion showed that the upper and lower median lines coincided between themselves as well as with the facial median line; a fair cuspid relationship was accomplished on both sides while incisor horizon-

tal and vertical overlaps were normalized (Fig. 10). Facially, no significant changes were noted since it was a dentoalveolar correction which remained circumscribed to the upper arch.

CLINICAL CASE #3

Correction of Unilateral Dentoalveolar Crossbite

Male patient, 28 years old. A facial assessment revealed a good balance between the facial thirds, adequate convexity, a slight mandibular deflection towards the left and an adequate relationship between the lips and the upper incisors. An evaluation of the arches disclosed the absence of the lower first molars, left unilateral posterior crossbite, a Class I malocclusion and a deflection of the

lower median line towards the left. The bicuspid and upper left first molar were palatally rotated, indicating a dentoalveolar crossbite (Fig. 11).

The treatment plan consisted in correcting the posterior crossbite using two microscrews through the buccal region to accomplish the intrusion and proclination of the bicuspid and upper left first molar. By choosing to implant the microscrew via the buccal region, the force action line passed through the buccal region in relation to the teeth's resistance center, whereby these teeth were led to undergo intrusion and proclination in a straightforward manner and without causing any side effect on the remaining teeth (Fig. 12). After these teeth had been intruded, the upper

arch was leveled and the second upper left bicuspid was attached to the microscrew to prevent relapse. The correction of crossbite dentoalveolar occurred efficiently without the need for palatal appliances or use of intermaxillary elastics. At the end of treatment, we observed: medium tooth lines coincide with each other and the face value for the canines, vertical and horizontal overlap of the incisors and the presence of standard space for prosthetic rehabilitation of the second premolars and second molars (Fig. 13). In the lower right segment, the presence of an anomalous third molar prevented an efficient second molar uprighting, which limited the opening of space for a tooth the size of a bicuspid; and on the left hand side,



FIGURE 11 - Initial images showing Class I malocclusion and unilateral posterior crossbite. Units 24, 25 and 26 are inclined toward the palatine.



FIGURE 12 - Intrusion of units 24, 25 and 26 anchored to the buccally positioned microscrews.



FIGURE 13 - Final intraoral images.



FIGURE 14 - Occlusal view of upper arch: **A)** prior to and **B)** following treatment.

the second molar was uprighted and larger space was attained, about the size of a molar tooth. The upper arch showed adequate conformation while posterior teeth inclination was thoroughly corrected (Fig. 14).

CLINICAL CASE #4

Correction of Upper Dentoalveolar Asymmetry By Means of Unilateral Distalization and Mesialization

Male patient, 42 years old. A facial assessment showed a balance between the facial thirds; a slightly augmented facial convexity due to a mild median third protrusion; discreet retrognathic mandible; chin-neck line slightly reduced and a passive labial seal. An analysis of the dental arches disclosed the absence of the lower first molars and upper second molars, in addition to non-coinciding dental median lines (upper deflection towards the right and lower deflection towards the left). Despite the absence of lower first molars, bicuspid relationship on the right hand side proved more favorable, while the left hand side was in Class II similar to a Class II, left subdivision malocclusion. It also showed an anterior deep bite and a Class I cuspid relationship on the right hand side, and a $\frac{3}{4}$ Class II on the left hand side (Fig. 15). An assessment of the panoramic radiograph showed that on the lower arch there was a divergence between second bicuspid roots and second molar roots; and the upper arch revealed a lowered sinus in the region where the second molars were missing.

The first treatment stage consisted in correcting the vertical problem on the lower arch by intruding the anterior teeth, extruding the posterior teeth and verticalizing the molars, thereby opening space between bicuspid and second molars.

In order to correct the Class II cuspid relationship on the left hand side upper first molar distalization was planned by means of a microscrew which was implanted between the latter and the second bicuspid. A cursor was inserted in a molar triple tube and connected to the microscrew using a NiTi spring (Fig. 16). Distalization was accomplished without any side effects to the other dental units. Two months after moving the first molar, which gave the bone sufficient time to reach a higher level of organization, the microscrew was relocated to a more distant position next to the molar root's mesial region. Next, the upper cuspids and bicuspid were retracted. A microscrew was inserted between the upper right bicuspid with the purpose of stabilizing the first molar and then using it to achieve mesial traction of the third molar (Fig. 17), which was mesialized without affecting the position of adjacent teeth. On the left hand side an asymmetric anterior retraction was carried out to correct the upper median line. With the aid of the microscrews a differentiated anchorage could be implemented in each of the upper arch segments, which allowed the distalization of the left hand side, mesialization of the right third molar and asymmetric anterior retraction. At the completion of treatment it was noted



FIGURE 15 - Initial intraoral images.



FIGURE 16 - Upper left first molar distalization, after completion.



FIGURE 17 - Upper right third molar mesialization, after completion.



FIGURE 18 - Final intraoral images.

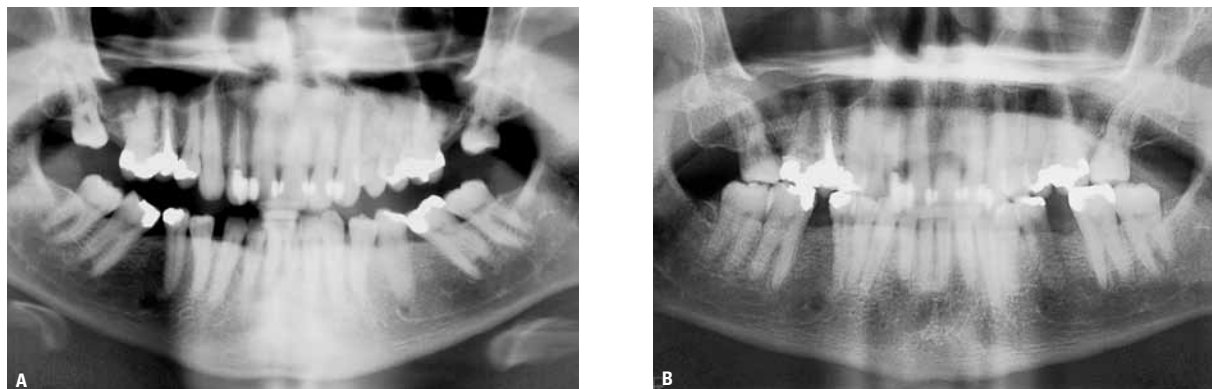


FIGURE 19 - **A)** panoramic radiograph (protrusive); **B)** Final panoramic radiograph in centric occlusion.

that: the upper median line harmonized with the face; there was an adequate cuspid relationship; the horizontal and vertical incisor overlaps were normalized and there was enough space left for prosthetic rehabilitation between the lower second bicuspid and lower second molars (Fig. 18).

The analysis of the final panoramic radiograph showed parallelism between the roots and adequate space for future installation of implants in the posterior inferior (Fig. 19)

CONCLUSION

With the advent of microscrews in orthodontic practice a new absolute anchorage alternative has emerged which, amid a variety of readily available clinical applications, can be used to correct den-toalveolar asymmetries. This resource simplifies orthodontic mechanics, dispenses with patient adherence, is easily accepted and affordable, reduces treatment time and has hitherto shown total reliability as an efficacious anchorage system.

Submitted in: April 2008
Revised and accepted in: June 2008

REFERENCES

1. BEYER, J. W.; LINDAUER, S. J. Evaluation of dental midline position. *Semin. Orthod.*, Philadelphia, v. 4, no. 3, p. 146-152, 1998.
2. BEZERRA, F.; LABOISSIÈRE, M.; VILLELA, H.; DIAS, L. Ancoragem ortodôntica absoluta utilizando microparafusos de titânio: planejamento e protocolo cirúrgico: trilogia – Parte I. *Implant News*, São Paulo, v. 1, n. 5, p. 33-39, 2004.
3. BISHARA, S. E.; BURKEY, P. S.; KHAROUF, J. G. Dental and facial asymmetries: a review. *Angle Orthod.*, Appleton, v. 64, no. 2, p. 89-98, 1994.
4. BURSTONE, C. J. Diagnosis and treatment planning of patients with asymmetries. *Am. J. Orthod. Dentofacial Orthop.*, St. Louis, v. 127, no. 3, p. 257-264, 2003.
5. BURSTONE, C. J.; MARCOTTE, M. R. *Solucionando problemas em Ortodontia*. 1. ed. São Paulo: Quintessence, 2003. cap. 6, p. 145-178.
6. HERSHEY, H. G.; HOUGHTON, C. W.; BURSTONE, C. J. Unilateral face-bows: a theoretical and laboratory analysis. *Am. J. Orthod. Dentofacial Orthop.*, St. Louis, v. 79, no. 3, p. 229-248, 1981.
7. JANSON, G.; DAINESI, E. A.; HENRIQUES, J. F. C.; FREITAS, M. R.; LIMA, K. J. R. S. Class II subdivision treatment success rate with symmetric and asymmetric extraction protocols. *Am. J. Orthod. Dentofacial Orthop.*, St. Louis, v. 4, no. 3, p. 134-137, 1998.
8. JANSON, G. R. P.; PEREIRA, A. C. J.; DAINESI, E. A.; FREITAS, M. R. Assimetria dentária e suas implicações no tratamento ortodôntico: apresentação de um caso clínico. *Ortodontia*, São Paulo, v. 28, n. 3, p. 69-73, 1995.
9. KRONMILLER, J. E. Development of asymmetries. *Semin. Orthod.*, Philadelphia, v. 4, no. 3, p. 134-137, 1998.
10. KYUNG, S. H.; HONG, S. G.; PARK, Y. C. Distalization of maxillary molars with a midpalatal miniscrew. *J. Clin. Orthod.*, Boulder, v. 27, no. 1, p. 22-27, 2003.
11. LABOISSIÈRE JÚNIOR, M.; VILLELA, H.; BEZERRA, F.; LABOISSIÈRE, M.; DIAZ, L. Ancoragem ortodôntica absoluta utilizando microparafusos de titânio: protocolo para aplicação clínica. trilogia – Parte II. *Implant News*, São Paulo, v. 2, n. 1, p. 37-46, 2005.
12. LABOISSIÈRE JÚNIOR, M.; VILLELA, H.; BEZERRA, F.;

- LABOISSIÉRE, M.; DIAZ, L. Ancoragem ortodôntica absoluta utilizando microparafusos de titânio: complicações e fatores de risco. trilogia – Parte III. **Implant News**, São Paulo, v. 2, n. 2, p. 37-46, 2005.
13. LANBERG, B. J.; ARAI, K.; MINER, R. M. Transverse skeletal and dental asymmetry in adults with unilateral lingual posterior crossbite. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 127, no. 4, p. 6-16, 2005.
 14. PARK, H. A New protocol of the sliding mechanics with micro-implant anchorage (M.I.A.). **Korea J. Orthod.**, Korea, v. 30, no. 6, p. 677-685, 2000.
 15. PARK, H.; KWON, O.; SUNG, J. Micro-implant anchorage for forced eruption of impacted canines. **J. Clin. Orthod.**, Boulder, v. 38, no. 5, p. 297-302, 2004.
 16. PARK, H.; KWON, O.; SUNG, J. Uprighting second molars with micro-implant anchorage (M.I.A.). **J. Clin. Orthod.**, Boulder, v. 38, no. 2, p. 100-103, Feb. 2004.
 17. PARK, H.; LEE, S.; KWON, O. Group distal movement of teeth using microscrew implant anchorage. **Angle Orthod.**, Appleton, v. 75, no. 4, p. 510-517, 2005.
 18. REBELLATO, J. Asymmetric extractions used in the treatment of patients with asymmetries. **Semin. Orthod.**, Philadelphia, v. 4, no. 3, p. 180-188, 1998.
 19. SHROFF, B.; SIEGEL, S. M. Treatment of patients with asymmetries using asymmetric mechanics. **Semin. Orthod.**, Philadelphia, v. 4, no. 3, p. 165-179, 1998.
 20. STEENBERGEN, E.; NANDA, R. Biomechanics of orthodontic correction of dental asymmetries. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 107, no. 6, p. 618-624, 1995.
 21. SUGUINO, R.; RAMOS, A. L.; TERADA, H.; FURQUIM, L. Z.; MAEDA, L.; SILVA FILHO, O. G. Análise facial. **Rev. Dental Press Ortodon. Ortop. Maxilar**, Maringá, v. 1, n. 1, p. 86-108, 1996.
 22. VANZIN, G. D.; MOLIN, L. T.; MARCHIORO, E. M.; BERTOLD, T. M. Etiologia, classificação e tratamento de assimetrias dento-faciais: relato de casos clínicos. **Rev. Odonto Cienc.**, Porto Alegre, v. 17, n. 37, p. 265-272, 2002.
 23. VILLELA, H.; VILLELA, P.; BEZERRA, F.; SOARES, A. P.; LABOISSIÉRE JÚNIOR, M. Utilização de mini-implantes para ancoragem ortodôntica direta. **Innov. Implant. J.**, São Paulo, v. 8, p. 5-12, 2004.
 24. VILLELA, H.; BEZERRA, F.; LABOISSIÉRE JÚNIOR, M. Microparafuso ortodôntico de titânio auto-perfurante (MPO): novo protocolo cirúrgico e atuais perspectivas clínicas. **Innov. Implant. J.**, São Paulo, v. 1, n. 1, p. 46-53, 2006.
 25. VILLELA, H.; BEZERRA, F.; MENEZES, P.; VILLELA, F.; LABOISSIÉRE JÚNIOR, M. Microparafusos ortodônticos de titânio auto-perfurantes: mudando os paradigmas da ancoragem esquelética em Ortodontia. **Implant News**, São Paulo, v. 3, n. 4, p. 45-51, 2006.
 26. VILLELA, H.; BEZERRA, F.; LABOISSIÉRE, J. R. M. Ancoragem esquelética utilizando microparafusos ortodônticos autoperfurantes: planejamento, protocolo cirúrgico e principais complicações clínicas. In: ENCONTRO INTERNACIONAL ASSINANTES IMPLANT NEWS, 2006, São Paulo. **Gerenciando os riscos e complicações em Implantodontia**. São Paulo: Ed. Santos, 2007. p. 73-85.
 27. VILLELA, H.; BEZERRA, F.; LEMOS, L.; PESSOA, S. Intrusão de molares superiores utilizando microparafusos ortodônticos de titânio autoperfurantes. **Rev. Clin. Ortop. Dental Press**, Maringá, v. 7, n. 2, p. 52-64, abr./maio 2008.

Contact:

Henrique Villela
 Rua Senador Theotônio Vilela n. 190, sala 703 – Brotas
 ZIP: 40.279-901 - Salvador / Bahia
 E-mail: hvillela@terra.com.br

Rate of mini-implant acceptance by patients undergoing orthodontic treatment – A preliminary study with questionnaires

Larissa Bustamante Capucho Brandão*, José Nelson Mucha**

Abstract

Objectives: Nowadays, mini-implants are regarded as a cutting-edge achievement in orthodontics thanks to their ability to afford maximum anchorage with minimum patient compliance. Nevertheless, certain aspects of these temporary anchorage devices have not yet been adequately assessed, foremost among which are the psychological issues associated with their acceptance by patients during the course of orthodontic treatment. **Materials and Method:** Ten adult patients presenting with Class I malocclusion and biprotrusion were subjected to orthodontic treatment involving the insertion of four mini-implants in their dental arches, placed between upper and lower first molars and second bicuspid (a total of 40 mini-implants) and were asked to answer a questionnaire designed to assess to what extent the mini-implants were accepted as an integral part of treatment. **Results:** The answers were converted to percentages and indicated that the majority of patients readily accepted such procedure and were not only satisfied but would also recommended it to other patients (90%). And whereas 50% showed concern with the surgical procedures, the remaining 50% did not report any discomfort whatsoever. The average tolerance time as of mini-implant insertion was 3 days and most coped well with the mini-implants throughout the whole orthodontic treatment. **Conclusions:** Based on the results of this study, it is safe to conclude that mini-implants, when used as orthodontic anchorage devices, were met with total acceptance by the majority of patients undergoing orthodontic treatment. Studies involving larger samples are not necessary.

Keywords: Orthodontics. Mini-implants. Patient acceptance.

INTRODUCTION

Nowadays, mini-implants have gained considerable popularity as orthodontic anchorage devices^{1,2,3,10} as they provide maximum anchorage in situations involving orthodontic movements which require maximum control^{11,20,21,26}. Mini-implants can be used both as direct anchorage units – when subjected to clinical

forces – and as indirect anchorage units – when forces are applied to the dental units stabilized by the mini-implants^{4,5,9}.

As regards insertion sites, mini-implants can be installed in the median or paramedian sagittal region of the maxillary hard palate; in the cortical region of the alveolar bone in the mandibular molar area; bicortically in the molar

* Dental Surgeon, enrolled at the Orthodontics Specialist Course of the Fluminense Federal University, Niterói, Rio de Janeiro State, Brazil.

** Holds a Doctor's Degree in Dentistry; Full Orthodontics Professor at the Fluminense Federal University, Rio de Janeiro State, Brazil.

and bicuspid areas; and in the zygomatic bone for orthodontic and orthopedic corrections^{12,20,25}. The major concern with respect to soft tissues is that mini-implants should be inserted in a region where there is an adequate and sufficient amount of attached gingiva^{6,15}.

Bone height, cortical bone thickness, the region's anatomical structures^{23,24} and the mechanical goals of mini-implant placement will determine the shape, length and thickness of these temporary anchorage devices^{12,15,22,26}. Although used as temporary orthodontic anchorage devices, mini-implants can remain in their insertion sites throughout the treatment and their removal is straightforward and fast^{16,19}. Despite their role as a technological advancement, mini-implant use is still limited given the surgical risk and some patients' reluctance in accepting and coping with these devices^{7,8,14}. The literature has no reports addressing the psychological aspects involved in treatment using mini-implants and their acceptance by patients.

In view of these issues, this study has two objectives: (1) Determine the rate or acceptance and satisfaction of patients with respect to the use of mini-implants during orthodontic treatment; (2) contribute to enhancing patients' psychological response to these new temporary anchorage devices; and (3) enlighten dentists and potential patients about the issues involved in patients' acceptance of this alternative anchorage method.

MATERIALS AND METHOD

This questionnaire-based investigation comprised ten adult patients who were selected for orthodontic treatment. The selection criteria were: At the start of treatment, they should present with Angle's Class I malocclusion with double protrusion; a lack of space for adequate distribution of all teeth in their dental arches; convex facial profile, where the latter was a key



FIGURE 1 - Illustration of mini-implant sites in the maxilla and mandible of one of the subjects after retraction of the anterior teeth towards the spaces left by first bicuspid extractions.

patient complaint; they should have had their four first bicuspid extracted during the course of treatment; anterior teeth retraction with maximum anchorage control; treatment should have involved the insertion of 4 mini-implants, 2 in each arch, between the first molars and the second bicuspid (Fig. 1).

All patients had to answer a questionnaire with 12 multiple choice (closed) questions, especially designed to assess acceptance, including adaptability, side effects, discomfort, painfulness and tolerance to the mini-implants which had been inserted for orthodontic anchorage purposes, allowing the retraction of upper and lower anterior teeth.

All patients, upon being accepted for this study at the Orthodontics Clinic of the UFF Dental School's Orthodontics Specialist Course, signed a Term of Consent pursuant to Bioethical standards. All consented to and accepted the treatment plan, which required 4 (four) mini-implants to be inserted, 2 in each arch, in a total of 40 mini-implants.

The mini-implants used in all patients were of the Ortoimplantes Básicos type 994109, 1.5mm x 9mm, manufactured by Conexão (Centro Industrial e Tecnológico, Av. Osaka, 950 Centro Industrial de Arujá, Arujá, SP). The

1. What was your reaction when your orthodontist first proposed/recommended the use of mini-implants? ☐ I was concerned and sought advice from friends and relatives. = 10% ☐ I contacted my regular dentist. = 0% ☐ I made a point of talking to the surgeon who would insert the mini-implant. = 0% ☐ I immediately gave my consent because I have full confidence in my orthodontist. = 90%	8. What did you feel when the initial orthodontic force was applied to the mini-implant? ☐ A pressure on the mini-implant = 20% ☐ A pressure on the tooth = 40% ☐ Pain in the soft tissue surrounding the mini-implant = 10% ☐ Pain in the bone = 0% ☐ A discomfort that was similar to when the orthodontic appliance were activated = 20% ☐ Loosening of the mini-implant = 10%
2. What questions did you ask your orthodontist when a treatment involving mini-implants was recommended? ☐ What were the advantages of an orthodontic treatment with a mini-implant = 30% ☐ How long the surgery would take and how the mini-implant would be placed = 50% ☐ How long the mini-implant would remain in the oral cavity buccal = 10% ☐ What was the size of the mini-implant = 10% ☐ I had no questions = 0%	9. Are you satisfied with the treatment? ☐ yes = 90% ☐ No = 10%
3. Would you like to see mini-implant photographs and acquaint yourself with the insertion method prior to consenting to the surgical procedure? ☐ yes = 50% ☐ No = 50%	10. Would you recommend this treatment with mini-implants to other patients? ☐ yes = 90% ☐ No = 10%
4. Would you like to talk with other patients who have undergone mini-implant insertion surgery? ☐ yes = 40% ☐ No = 60%	11. How many days did it take you to get used to the mini-implants? ☐ 1 day = 10% ☐ 2 days = 20% ☐ 3 days = 30% ☐ 4 days = 10% ☐ 5 days = 10% ☐ 7 days = 10% ☐ 10 days = 10% ☐ 14 days = 0% ☐ 21 days = 0% ☐ 30 days = 0% ☐ No reply = 0%
5. What was the most unpleasant sensation you had during surgery? ☐ Prick from the Injection needle = 30% ☐ Numbness from anesthetic = 20% ☐ Pressure from mini-implant insertion = 40% ☐ Lengthiness of surgical procedure = 10%	12. Quanto tempo você considera aceitável ficar com os mini-implantes? ☐ 1 months = 0% ☐ 20 months = 0% ☐ 2 months = 0% ☐ 24 months = 20% ☐ 4 months = 0% ☐ 30 months = 10% ☐ 6 months = 0% ☐ 36 months = 0% ☐ 12 months = 0% ☐ 42 months = 0% ☐ 15 months = 0% ☐ 48 months = 20% ☐ 18 months = 10% ☐ None of the above = 40%
6. Did the mini-implant cause any side effects? ☐ Injury to cheek, gum = 0% ☐ Difficulties in swallowing = 0% ☐ Speech difficulties = 0% ☐ Hygiene difficulties = 40% ☐ Chewing difficulties = 10% ☐ Psychological discomfort = 10% ☐ No discomfort = 40%	
7. What was the most uncomfortable sensation? ☐ Mini-implant placement = 30% ☐ The initial orthodontic force that was applied to the mini-implant = 30% ☐ None = 40%	

FIGURE 2 - Questionnaire answered by all patients bearing 4 mini-implants, which served as orthodontic anchorage devices for retraction of upper and lower anterior teeth.

same surgeon performed all mini-implant insertion surgeries. He was thoroughly trained at the Implantology Course of UFF's School of Dentistry and used similar techniques on all patients.

The questionnaire which patients were required to answer is shown below. Also included are data covering the percentage of answers obtained for each item, which comprises the results shown in figure 2.

QUESTIONNAIRE AND RESULTS

Table 1 shows the questionnaire, comprising 12 questions with closed answers, which was furnished to the patients participating in the study; also shown are the percentages of the different answers given.

Although 90% of the patients had full confidence in their orthodontists and acted on their recommendation to undergo treatment with mini-implants, most patients felt the need for further information. Among these, 50% inquired how long the surgery would last and how the mini-implants would be inserted. In all, 30% inquired about the advantages of using mini-implants, whereas 10% wished to know for how long the devices would remain inserted in their oral cavities and 10% asked about the size of the mini-implants (Fig. 2).

The answers given with respect to viewing the different types of mini-implants in photographs and the insertion method prior to consenting to surgery were split, with 50% of patients wanting to see the mini-implants and learn about the insertion method and 50% not at all concerned with such issues. Likewise, 40% of patients showed a desire to exchange information with other patients who had undergone the same procedure versus 60% who did not regard such information exchange as a proviso for consenting to mini-implant insertion.

As regards the most unpleasant sensation

experienced during mini-implant installation, 30% reported the needle prick, 20% the numbness caused by the anesthetic, 40% the pressure felt when the mini-implants were inserted and 10% complained that the surgical procedures were too lengthy. Considering that the entire procedure is painless, the psychological aspects relative to the anesthetic and the needle prick were the most relevant. All other complaints stemmed from an apprehension with the implant insertion method (40%) and the length of the procedure, which were seen as evidence of anxiety prior to undergoing surgical procedures the patients were not familiar with.

Although 40% of the subjects experienced hygiene difficulties, psychological (10%) and chewing (10%) discomfort were minimal. In fact, 40% of the patients did not report any discomfort or intolerance whatsoever.

Mini-implant insertion accounted for 30% of all patients' major complaints, whereas another 30% found initial force application to be the worst. The majority (40%), however, did not report any outstanding discomfort, be it during mini-implant insertion, be it in orthodontic force application.

After mini-implant loading, most patients felt some pressure on the teeth (40%), 20% felt pressure on the mini-implants, 20% felt some discomfort similar to orthodontic appliance activation and 10% felt pain in the soft tissues surrounding the mini-implants and also felt mini-implant displacement. It is essential that mini-implants be inserted into a band of attached gingiva and that any devices used to achieve tooth movement, such as springs and elastics, be placed outside the injured areas of soft tissues.

Virtually all subjects (90%) were totally satisfied with the treatment and would recommend it to other people. The majority of patients needed 3 days only to get used to

the mini-implants, which is in agreement with most usual procedures in orthodontics. In this sample, 20% and 40% reported that they would cope well with the mini-implants throughout the orthodontic treatment.

DISCUSSION

The questionnaire, designed to assess the acceptance rate of mini-implants by patients undergoing orthodontic treatment using these devices, proved not only useful but also necessary. The objective was to evaluate the acceptance of temporary anchorage devices, patient adaptability to them, potential side effects, discomfort and painfulness as well as patients' ability to cope with mini-implants throughout the treatment. The mini-implants served as anchorage devices and were installed to aid in upper and lower anterior tooth retraction, in biprotrusion cases. In spite of the small sample, the answers paved the way for future interventions and treatment plans as

well as for future assessments.

An evaluation of the data raised by the questionnaire showed that 90% of the subjects had confidence in their orthodontists and promptly consented to a treatment with mini-implants. It should be noted that relatives and friends played a key role in the patients' decisions. When a given surgery, albeit small, is combined with orthodontic treatment, it is perfectly normal for patients to express concern. Some patients (10%) required a period of time in which to discuss these concerns with their relatives and friends. In general, patients preferred to discuss the subject with the orthodontist, irrespective of whether the surgeon was present. Some orthodontists, however, claimed they could insert the temporary anchorage devices themselves.

Whenever it becomes necessary for a surgeon to insert the mini-implants, it is recommended that the treatment plan be discussed first with the surgeon and subsequently the orthodontist

Table 1 - shows the questions and answers which attained the highest rates of mini-implant acceptance by the patients.

Question	Answer	n	%
1. What was your reaction when your orthodontist first proposed/recommended the use of mini-implants?	I immediately gave my consent because I have full confidence in my orthodontist.	9	90%
2. What questions did you ask your orthodontist when a treatment with mini-implants was recommended?	How long the surgery would take and how the mini-implants would be placed	5	50%
3. Would you like to see mini-implant photographs and acquaint yourself with the insertion method prior to consenting to the surgical procedure?	yes	5	50%
	no	5	50%
4. Would you like to talk with other patients who have undergone mini-implant insertion surgery?	no	6	60%
5. What was the most unpleasant sensation you felt during surgery?	Pressure from mini-implant insertion	4	40%
6. Did the mini-implant cause any side effects?	Hygiene difficulties	4	40%
	No discomfort	4	40%
7. What was the most uncomfortable sensation?	None	4	40%
8. What did you feel when the initial orthodontic force was applied to the mini-implant?	Pressure on the tooth	4	40%
9. Are you satisfied with the treatment?	yes	9	90%
10. Would you recommend this treatment with mini-implants to other patients?	yes	9	90%
11. How many days did it take you to get used to the mini-implants?	3 days	3	30%
12. How long do you think it is reasonable for the mini-implants to remain inserted?	No reply	4	40%

should discuss it with the patient.

During the consultation when the mini-implants were suggested, many patients showed interest in learning about the advantages of undergoing orthodontic treatment with the use of mini-implants (30%), what surgical technique would be used and how long the surgical procedure would last (50%), and the size of the mini-implants (40%). It was surprising to note that the period of time during which the mini-implants would remain inserted was not a major concern (10%). Likewise, 20% of the patients did not pose any questions regarding the mini-implants, when these devices were first suggested. Such low percentage was probably due to the fact that the patients were aware that they had been selected for orthodontic treatment by the Orthodontics Post-Graduate Faculty of a public institution and therefore agreed to the procedures for fear that their noncompliance or disagreement might disqualify them for the orthodontic treatment. This might have been an uncontrolled variable of the present study.

As regards the question about whether they would like to see photographs of the mini-implants and the placement method prior to agreeing to undergo the surgery, the answers were 50% positive and 50% negative. Similarly to the previous consideration, 50% answered that they were not worried about their orthodontic treatment, which would involve extractions of the four first bicuspid and they thought the mini-implant insertion procedure would just mean one more procedure to speed up and enhance treatment results. Therefore, they entertained no doubts, nor did they raise any issues in this regard. On the other hand, 50% of those who wished to see the photographs and insertion method were concerned about this new anchorage device which, like any other unusual and novel technique, inevitably aroused both apprehension and interest.

Concerning the desire to talk with other patients who had already had mini-implant surgery, the positive response of 40% of the subjects attests to the psychological importance of patients exchanging experiences with and being comforted by other patients in a similar situation. Such behavior seems to be helpful when introducing new techniques and procedures. An exchange of information between patients in the waiting room of a Private Office or Public Clinic plays a crucial role in enhancing patients' confidence in the proposed procedures. The other 60% who accepted the procedure either trusted the orthodontist or had already gathered some pertinent information.

Regarding question #5 about the most unpleasant sensation felt during surgery, the needle prick was checked by 30% of the patients, numbness from the anesthetic was answered by 20%, pressure from mini-implant insertion, 40% and a too lengthy procedure was the complaint of 10% of the patients. The fact that 40% reported as their worst discomfort the pressure resulting from inserting the mini-implant is perfectly understandable given that this was a new procedure, unknown to the patients. It had been suggested by the orthodontist with the aim of facilitating the orthodontic treatment. Even after consenting to the procedure, patients felt some psychological apprehension at the thought that a "screw would be placed inside their bone", which can cause some psychological discomfort, although no pain had been reported.

When the question was asked whether the mini-implants had produced any side effects, hygiene difficulties was the answer of 40% of the subjects, chewing difficulties was checked by 10%, psychological discomfort by 10%, and no discomfort whatsoever by 40%. It should be underscored that all patients had fixed orthodontic appliances installed on both

arches, in addition to loops, elastics or springs for retraction and closure of extraction spaces. It is therefore understandable that difficulties associated with oral hygiene were regarded as a nuisance by 40% of the subjects, compounded by the orthodontist's stringent requirements that perfect hygiene be maintained, since this was one of the keys to mini-implant stability. On the other hand, 40% of participants did not report any discomfort whatsoever.

As regards the most unpleasant sensation, mini-implant insertion accounted for 30% of the answers, initial orthodontic force application elicited 30% and no discomfort represented 40% of patients' replies. This percentage is in agreement with the previous item, where, in like manner, 40% did not report any discomfort whatsoever. The amount of orthodontic forces applied in this study ranged between 300 and 450 grams.

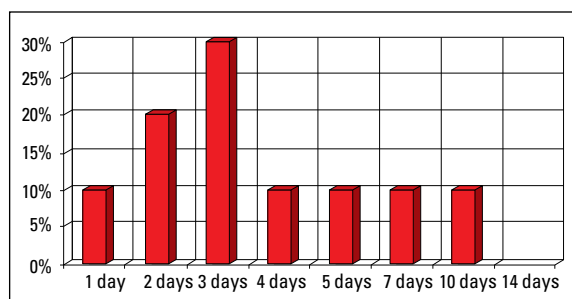
In reply to question #8, concerning the sensation felt when the initial orthodontic force was applied to the mini-implant, 20% reported mini-implant pressure, 40% pressure on the tooth, 10% pain in the soft tissue surrounding the mini-implant, 20% a discomfort similar to activation of the orthodontic appliance and 10% mini-implant displacement. The fact that 0% reported bone pain, as expected, reinforces the idea that the feeling of pain or psychological pain was actually more relevant than the real pain, since the major discomfort reported had

to do with pressure on the tooth (40%) and not on the bone (0%) or the mini-implant (20%). In like manner, 20% of the subjects in this study reported that the sensation felt when the mini-implant was activated was similar to what they felt when the orthodontic appliance was activated.

In reply to the question of whether the patients were satisfied with the treatment, there was a 90% positive response versus only 10% negative. Even so, the 10% dissatisfaction was mostly due to the need to reinsert one of the mini-implants on account of technical problems during insertion. The negative feedback was therefore highly likely and expected to occur under such circumstances. The same consideration can be applied to the following question: "Would you recommend this treatment with mini-implants to other patients?" 90% answered yes and only 10%, no.

The patients necessitated approximately 10 days to get used to the mini-implants. 60% were fully adapted by the third day following surgery, whereas others required a longer period of time, which never extended beyond the 10-day limit. The time needed for adapting to the mini-implants, therefore, ranged from 1 to 10 days with an average 3 to 4 days. Unlike traditional implants, where osseointegration requires 3 to 6 months to elapse prior to loading, mini-implants are not supposed to osseointegrate. This has the advantage of allowing immediate load. Graph 1 illustrates adaptation times and their respective percentages.

Despite the immense contribution of these temporary anchorage devices, they pose difficulties related to surgical procedures, increased cost and, often, less comfort – depending on the insertion site – compared with traditional treatment methods. Notwithstanding these obstacles, patients should be told that the surgical procedures are simple and can be performed with local anesthetic or even



GRAPH 1 - Percentage of answers regarding the number of days required by the patients to get used to the mini-implants.

topical anesthetic¹³ (sometimes even without any anesthetic) and that surgery time is short – usually taking somewhere between 15 and 20 minutes. In certain situations, surgery can stave off the need for more complex treatments, such as orthognathic surgery, where patients are given general anesthetic. Additionally, treatment efficacy is enhanced and time shortened in cases which require greater anchorage control.

Studies investigating mini-implant sizes (width and height) have evolved a great deal. It is interesting to note, however, that the mechanical and anatomical findings have proved more important for the professionals in attendance than as a concern for patients. Patients can only feel the supra-mucosal part of the mini-implant, whose head, depending on the case, can be covered with some flow resin to prevent discomfort. Whereas half of all patients did not report any side effects whatsoever, 20% reported chewing and psychological discomfort and 40% experienced hygiene issues.

This procedure has proved highly promising in terms of patient acceptance since 90% were satisfied with the treatment and would recommend it to other patients.

Considering that 24 to 30 months is an acceptable period of time to assess an orthodontic treatment outcome, 50% reported they were able to cope with such treatment length with mini-implants inserted, and 40% could not judge for how long they would be able to cope with these temporary anchorage devices, indicating that they would cope for a longer time.

All cases were successful insofar as the mechanics employed and stabilization of mini-implants for anchorage purposes. Only one implant loosened and had to be prematurely removed, which compromised the mechanical result and may have negatively impacted some of the patients' answers to the questionnaire (10%).

It should be underlined that these data are provisional since it is the purpose of the authors to conduct further studies using broader samples to corroborate the present study. There are sufficient grounds, however, to assert that these temporary anchorage devices are extremely useful and that patients' acceptance was highly significant. Mini-implants undoubtedly are accessory tools at the service of orthodontists and should be utilized in select cases requiring maximum anchorage control.

CONCLUSIONS

Based on the patients' answers to the questionnaire, the following can be concluded:

1- The percentage of patients who were satisfied with the mini-implants reached 90%.

2- The patients' major concerns upon mini-implant recommendation were connected with the length of the surgery and the insertion method (50%), the advantages of using mini-implants (30%) and their size (10%). Whereas 20% had no concerns.

3- As regards the desire to view the mini-implants and discuss the surgical procedure with other patients, only 50% of the subjects showed such interest, while the remainder did not request any further clarification.

4- During mini-implant placement, the most unpleasant sensation was caused by: Mini-implant insertion (40%); injection (needle prick) (30%); numbness from the anesthetic (20%); and lengthiness of procedure (10%).

5- Following insertion, 40% reported no discomfort whatsoever, whereas the greatest difficulties had to do with hygiene (40%), chewing concerns (10%) and a certain amount of psychological apprehension (10%).

6- Concerning the most unpleasant sensation, 30% reported that it was due to mini-implant insertion, 30% ascribed it to the orthodontic force and 40% coped well, with no discomfort complaints.

7- As regards the sensation caused by force application, 40% reported pressure on the tooth, 20% pressure on the mini-implant, 20% pressure due to activation of the orthodontic appliance. Little pain was reported in the soft tissue surrounding the mini-implant (10%), feeling of relaxation (10%) and no pain was reported in the adjacent bone (0%).

8- 90% of the whole sample were satisfied with the treatment and would recommend

such treatment with mini-implants to other patients.

9- It took patients 3 days, on average, to get used to the mini-implants, with a maximum adaptation time of 10 days.

10- The patients reported that they could cope well with the mini-implants during the entire orthodontic treatment period.

Submitted: April 2008

Revised and accepted for publication: May 2008

REFERENCES

1. ARAÚJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com miniimplantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
2. BAE, S. M. et al. Clinical application of micro-implant anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 5, p. 298-302, May 2002.
3. BLOCK, M. S.; HOFFMAN, D. R. A new device for absolute anchorage for Orthodontics. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 107, no. 3, p. 251-258, Mar. 1995.
4. CELENZA, F.; HOCHMAN, M. N. Absolute anchorage in Orthodontics: direct and indirect implant-assisted modalities. **J. Clin. Orthod.**, Boulder, v. 34, no. 7, p. 397-402, July 2000.
5. CHO, H. J. Clinical applications of mini-implants as orthodontic anchorage and the peri-implant tissue reaction upon loading. **J. Calif. Dent. Assoc.**, San Francisco, v. 34, no. 10, p. 813-820, Oct. 2006.
6. COSTA, A.; PASTA, G.; BERGAMASCHI, G. Intraoral hard and soft tissue depths for temporary anchorage devices. **Semin. Orthod.**, Philadelphia, v. 11, no. 1, p. 10-15, 2005.
7. FREUNDENTHALER, J. W.; HAAS, R.; BANTLEON, H. P. Bicortical titanium screws for critical orthodontic anchorage in the mandible: a preliminary report on clinical applications. **Clin. Oral Implants Res.**, Copenhagen, v. 12, no. 4, p. 358-363, Aug. 2001.
8. GÜNDÜZ, E.; SAVIO, T. T. S. D.; KUCHER, G.; SCHNEIDER, B.; BANTLEON, H. P. Acceptance rate of palatal implants: a questionnaire study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 5, p. 623-626, Nov. 2004.
9. HERMAN, R. J.; CURRIER, G. F.; MIYAKE, A. Mini-implant anchorage for maxillary canine retraction: a pilot study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 130, no. 2, p. 228-235, Aug. 2006.
10. KANOMI, R. Mini-implant for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, no. 11, p. 763-767, Nov. 1997.
11. KEIM, R. G. Answering the questions about miniscrews. Editor's Corner. **J. Clin. Orthod.**, Boulder, v. 39, no. 1, p. 7-8, Jan. 2005.
12. KIM, T. W.; KIM, H.; LEE, S. J. Correction of deep overbite and gummy smile by using a mini-implant with a segmented wire in a growing Class II Division 2 patient. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 130, no. 5, p. 676-685, Nov. 2006.
13. KRAVITZ, N. D.; KUSNOTO, B. Placement of mini-implants with topical anesthetic. **J. Clin. Orthod.**, Boulder, v. 40, no. 10, p. 602-604, Nov. 2006.
14. KURODA, S.; SUGAWARA, Y.; DEGUCHI, T.; KYUNG, H. M.; TAKANO-YAMAMOTO, T. Clinical use of miniscrew implants as orthodontic anchorage: Success rates and postoperative discomfort. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 1, p. 9-15, Jan. 2007.
15. KYUNG, H. M.; PARK, H. S.; BAE, S. M.; SUNG, J. H.; KIM, I. B. Development of orthodontic micro-implants for intraoral anchorage. **J. Clin. Orthod.**, Boulder, v. 37, n. 6, p. 321-328, June 2003.
16. LIOU, E. J.; PAI, B. C.; LIN, J. C. Do miniscrew remain stationary under orthodontic forces? **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 1, p. 42-47, July 2004.
17. MAH, J. K.; BERGSTRAND, F. Temporary anchorage devices: a status report. **J. Clin. Orthod.**, Boulder, v. 39, no. 3, p. 132-136, Mar. 2005.
18. MELSEN, B. Mini-implants: where are we? **J. Clin. Orthod.**, Boulder, v. 39, no. 9, p. 539-547, Sept. 2005.
19. MIYAWAKI, S. et al. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 124, no. 4, p. 373-378, Oct. 2003.
20. PARK, H. S.; BAE, S. M.; KYUNG, H. M.; SUNG, J. H. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. **J. Clin. Orthod.**, Boulder, v. 35, no. 7, p. 417-422, July 2001.
21. PARK, H. S. et al. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. **J. Clin. Orthod.**, Boulder, v. 35, no. 7, p. 417-422, July 2001.
22. PARK, H. S.; LEE, S. K.; KWON, O. W. Group distal movement of teeth using micro-screw implant anchorage. **Angle Orthod.**, Appleton, v. 75, no. 4, p. 602-609, Apr. 2005.
23. POGGIO, P. M.; INCORVATI, C.; VELO, S.; CARANO, A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. **Angle Orthod.**, Appleton, v. 76, no. 2, p. 191-197, Feb. 2006.
24. SCHNELLE, M. A.; BECK, F. M.; JAYNES, R. M.; HUJA, S. S. A radiographic evaluation of the availability of bone for placement of miniscrews. **Angle Orthod.**, Appleton, v. 74, no. 6, p. 832-837, June 2004.
25. THIRUVENKATACHARI, B. et al. Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 129, no. 4, p. 551-554, Apr. 2006.
26. YAO, C. J. et al. Maxillary molar intrusion with fixed appliances and mini-implant anchorage studied in three dimensions. **Angle Orthod.**, Appleton, v. 75, no. 5, p. 754-760, 2005.

Corresponding Author:

José Nelson Mucha

Rua Visconde de Pirajá, 351 sala 814

CEP: 22.410-003 - Ipanema - Rio de Janeiro / RJ

E-mail: nelsonmuch@wnetrj.com.br

Assessment of flexural strength and fracture of orthodontic mini-implants

Matheus Melo Python*, Lincoln Issamu Nojima**, Matilde Gonçalves Nojima**, Antônio Carlos de Oliveira Ruellas**

Abstract

Objective: This study was designed to assess the deformation and fracture of orthodontic mini-implants of different commercial brands by submitting them to loads perpendicularly applied along their lengths. **Materials and Methods:** A total of 75 mini-implants were divided into five groups (n=15): M (Mondeal, Tuttlingen, Germany), N (Neodent, Curitiba, Brasil), I (INP, São Paulo, Brazil), S (SIN, São Paulo, Brazil), and T (Titanium Fix, São José dos Campos, Brazil). The mini-implants were inserted perpendicularly into swine cortical bones and submitted to mechanical tests using an Emic DL 10.000 universal testing machine at cross-speed of 0.5mm/min. The different forces required to fracture mini-implants after undergoing 0.5mm, 1mm, 1.5mm and 2mm deformation was assessed. The data were assessed using analysis of variance (ANOVA) and Tukey's test. **Results:** Mini-implants in Group S required the greatest forces to deform and fracture. These results were statistically significant in comparison with the other groups ($P<.05$) which required lower forces to deform and fracture. Group M yielded the lowest distortion values but with no significant statistical difference compared to Group N ($P>.05$), whereas Group T required the lowest fracture values with statistical difference compared to Groups M, S and I. **Conclusions:** It is possible to conclude, based on the results of the present study, that the shape and flexural strength of mini-implants bear direct correlation with each other. Despite their different flexural strength levels all mini-implants proved effective in clinical use.

Keywords: Anchorage. Mini-implant. Mini-screw. Deformation.

INTRODUCTION

Anchorage in orthodontics plays a paramount role in orthodontic planning. In treatment planning, very important and challenging decisions rely on anchorage, namely: Whether or not to extract permanent teeth, whether or not orthognathic surgery is required, whether or not soft tissues should be altered, the need for patient compliance

and the length and streamlining of orthodontic treatment¹⁰.

In the last few years, the dental literature has described a number achievements in the field of Implantology, such as miniplates^{5,6}, surface implants (onplants)², conventional osseointegrated^{9,18} implants and mini-implants, with proven efficacy in orthodontic anchorage. One cannot

* Orthodontics specialist at Alfenas Federal University (UNIFAL); currently a Doctor degree student at Rio de Janeiro Federal University (UFRJ).

** Holds a Doctor's degree in Orthodontics from Rio de Janeiro Federal University (UFRJ).

help but note, however, that mini-implants have aroused greater interest than other devices in the last years¹⁵.

The use of mini-implants ushers in a new concept in Orthodontic Anchorage, named skeletal anchorage, which prevents any movement from occurring in the response unit. This is due to the fact that the anchorage unit is unable to move when submitted to orthodontic mechanics^{4,12,14,20}.

As is the case with conventional dental implant systems, professionals inserting a mini-implant should take special care, both during surgery and in the stages where orthodontic forces are applied, in order to avert mini-implant deformation or even fracture^{3,8}.

Thanks to a reduction in mini-implant size, today a wider range of insertion sites is available which helps to mitigate the risk of root injury. The down side, however, is that reduced size entails a decrease in the mini-screw's flexural strength. As a result, the maximum force required to permanently deform and fracture mini-implants is also diminished⁸.

Based on this premise, the present study was designed to assess the deformation and fracture of orthodontic mini-implants of different commercial brands by submitting them to loads perpendicularly applied along their lengths.

MATERIALS AND METHODS

Altogether, 75 mini-implants were used from 5 different manufacturers and distributed into 5 different groups, as shown in Box 1.

Prior to use, the mini-screws had their dimen-

sions gauged under a profile projector (Nikon, Tokyo, Japan) and were subsequently submitted to a JEOL scanning microscope (2000 FX, Tokyo, Japan) with a 15x magnification for morphological assessment. The purpose was to correlate the values found in the mechanical tests⁷ with the mini-implants' morphology.

To aid in carrying out the flexure strength and fracture trials, specimens – with 8mm thickness – were fashioned from swine cortical bones obtained from the mid-segment of a pig's femur bone, which would serve as the mini-implants' insertion sites.

After the pig's femur bones had been obtained they were dissected and sliced into bone blocks with 10cm cortical length and 8mm cortical thickness. The bone blocks were placed into PVC tubes (Tigre, Joinvile, Santa Catarina, Brazil) and bonded to these tubes using self-curing acrylic resin (Clássico, São Paulo, Brazil). To help in properly positioning the bone blocks a glass square was utilized to align the bone surface perpendicularly to the ground.

The specimens were then dipped into a saline solution and kept in a fridge at a temperature of 8° C. After 7 days had elapsed, the specimens were removed from the fridge and left sitting for 12 hours at room temperature awaiting mini-screw insertion.

To insert the mini-implants a manual key was attached to a parallelometer (Humpa, Rio de Janeiro, Brazil), whereby insertion could be made parallel to the ground and perpendicular to the bone tissue.

Groups	Commercial brands	n	Diameter (mm)	Length (mm)	Type	Alloy
M	Mondeal	15	1,5	7	Self-drilling	Ti-6AL-4V
N	Neodent	15	1,6	7		
S	SIN	15	1,6	6		
I	INP	15	1,5	6		
T	Titanium Fix	15	1,5	5	Self-tapping	

Box 1 - Sample distribution with their respective diameters, lengths and alloy.

Immediately following mini-screw insertion, the specimens were tested in the universal testing device (Fig. 1). In order to stabilize the specimens a vise-like device was contrived to keep the specimens steady throughout the trials.

The flexural strength test was conducted using an Emic DL 10.000 universal testing machine (São José dos Pinhais, Paraná, Brazil) operating at a cross-head speed of 0.5mm/min through an active chisel head (Fig. 2). The force was applied to the screw heads with the aim of deforming the mini-screws by 0.5, 1.0, 1.5 and 2.0mm and to the point of fracture (Fig. 2).

Statistical analyses were conducted with the aid of the SPSS 13.0 software program (SPSS Inc., Chicago, Illinois). A descriptive statistical analysis, including mean, standard deviation, median, minimum and maximum values, was performed for the five groups under evaluation. The values

for maximum deformation and fracture forces (in N/cm²) were submitted to an analysis of variance (ANOVA) to determine whether there were any statistical differences between the groups, and subsequently to Tukey's test (Tab. 1).

RESULTS

The results have shown deformation in all mini-implants. Group S mini-implants required, on average, greater forces to undergo deformation. The lowest deformation values were achieved by Group M and Group N mini-screws.

After mini-implants had been deformed by 2mm, the same speed was maintained until fracture occurred, whereupon this maximum value was noted.

Groups I and T showed less deformation than the other groups whereas fracture occurred prior to 2mm deformation (Tab. 1).



FIGURE 1 - Flexure strength trial using an Emic DL 10.000 universal testing machine.

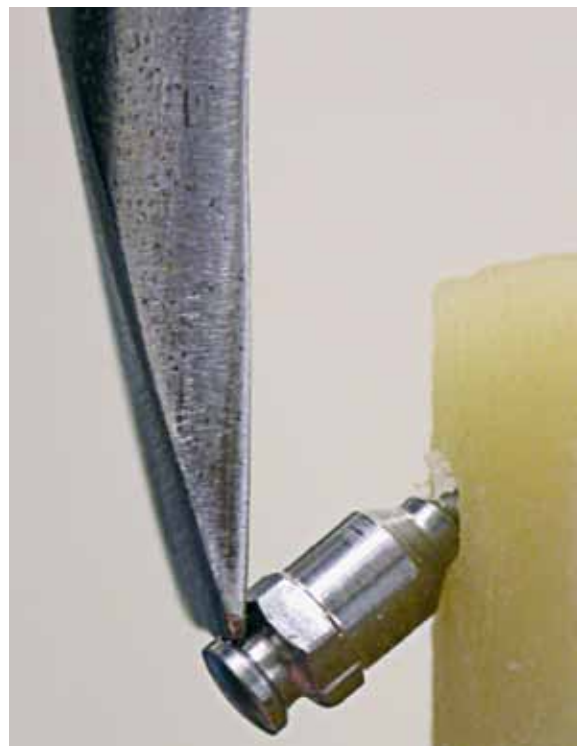


FIGURE 2 - A mini-implant undergoing deformation during mechanical testing.

Table 1 - Mean and standard deviation values of forces required to deform mini-implants, and statistical analysis.

Groups	Deformation (mm)							
	0,5mm	sig.*	1,0mm	sig.*	1,5mm	sig.*	2,0mm	sig.*
M	44,54 ± 6,63	A	72,44 ± 9,63	A	87,75 ± 6,61	A	109,06 ± 2,86	A
N	50,46 ± 6,45	A	74,33 ± 7,34	AD	87,83 ± 10,95	A	100,76 ± 8,89	A
S	60,89 ± 8,31	B	183,31 ± 9,85	B	344,41 ± 8,44	B	326,35 ± 9,80	B
I	82,71 ± 7,56	C	142,89 ± 7,60	C	165,48 ± 5,37	C	-----	
T	55,04 ± 2,75	AB	90,90 ± 9,71	D	107,03 ± 9,47	D	-----	

* Identical letters stand for no statistical differences ($p > 0,05$).

Table 2 - Mean and standard deviation values of forces required to fracture mini-implants, and statistical analysis.

Groups	Fracture	sig.*	Deformation	sig.*
M	261,14 ± 10,74	A	3,48 ± 0,25	A
N	119,52 ± 8,06	B	2,84 ± 0,30	AC
S	476,06 ± 11,19	C	2,56 ± 1,07	ABC
I	174,15 ± 7,81	D	1,59 ± 0,30	BC
T	117,59 ± 10,50	B	1,94 ± 0,49	B

* Identical letters stand for no statistical differences ($p > 0,05$).

Insofar as fracture force values are concerned, Group S mini-implants had a statistically superior performance compared with the others, followed by Group M. The lowest values were recorded for Groups T and N, between which there were no statistical differences. Group M required greater degree of deformation before fracturing, followed by Groups N and S, respectively. Conversely, Groups I and T fractured prior to reaching the 2mm deformation benchmark proposed in this study (Tab. 2).

DISCUSSION

Knowledge about the deformation of orthodontic anchorage structures is crucial in assessing potential anchorage failure^{7,11}. Based on this premise, this study was designed to assess the strength required to deform orthodontic mini-screws and the strength required to fracture these mini-screws when submitted to flexural load.

The need to evaluate mini-implant deforma-

tion when applying perpendicular force stems from the fact that this axis is predominantly used when applying mini-implant assisted orthodontic forces. To this end, specimens were fashioned which allowed mini-implants to be placed parallel to the ground, thereby enabling the application of perpendicular force to their axes, as is the case in the oral cavity.

All mini-implants tested suffered deformation from the onset of force application to the moment of fracture. Group S required greater forces than any other group before deforming and fracturing ($P < 0,05$). The lowest deformation values were recorded for Group M and Group N mini-implants ($P > 0,05$). These results can be ascribed to a larger diameter of the transmucosal region/screw thread junction of Group S mini-implants versus a smaller diameter in Group M and Group N, whose mini-implant heads and screw threads were slightly disproportionate, which made the mini-implants more prone to deformation even with lower forces.

In light of the findings of this study, the term 'rigid anchorage', as employed by Park et al.¹⁶, should be reconsidered since it conveys the wrong idea that absolute resistance to orthodontic movements is possible. This is corroborated by Liou et al.¹³, who also found anchorage loss when using orthodontic mini-implants. This author reports that such drift could be attributed to different factors, such as mini-screw size, bone quality, osseointegration time and magnitude of the orthodontic force.

After mini-implants had been deformed by 2mm, the same speed was maintained until fracture occurred. The only mini-implants which could not be assessed as far as a 2mm deformation were the ones in Groups I and T, since fracture occurred prematurely.

Insofar as fracture force values are concerned, Group S mini-screws had a statistically superior performance ($P < 0.05$) compared with the others, followed by Group M. The lowest values were recorded for Groups T and N, between which there were no statistical differences. Group M required a greater degree of deformation prior to fracturing, followed by Groups N and S, respectively.

Fortunately, even when subjected to minor deformations, all orthodontic mini-implants proved strong enough to be an integral part of anchorage systems since none fractured when submitted to orthodontic forces cited in the literature¹⁷.

The deformations found in this study do not preclude the use of these mini-implants in their role of supporting orthodontic treatments since the smallest force capable of causing a 0.5mm deformation was 44.54 N – approximately 4460.00 g/cm², much higher than any force currently used in Orthodontics.

In the oral cavity the mini-screws were submerged into bone and soft tissue. The bone-inserted part offers greater resistance in the face of orthodontic forces. However, the moment of force is located flush to the bone surface. After assessing the mini-implant regions deformed in this experiment, the authors recommend that the mini-screw threads remain submerged below the cortical bone since the smallest diameter found on the mini-screws is precisely the region in between the screw threads, which is most susceptible to fracture.

The spot where the mini-implants underwent the most deformation was the region located immediately above the bone tissue. Due to this feature we believe that tapered mini-implants are the best suited for orthodontic purposes in view

of the fact that tapered mini-implants combine a slimmer thickness on their cutting edge and a more resistant diameter immediately below the point where orthodontic forces are applied. This trend can be seen in the new mini-implant designs recently launched in the market^{4,12,19}.

CONCLUSIONS

All mini-implants tested in this study proved adequate for use in orthodontic anchorage.

Mini-implant shape is directly related to the flexural strength afforded by these devices when perpendicular forces are applied along their axes.

REFERENCES

1. ARAÚJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com miniimplantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, 2006.
2. BLOCK, M. S.; HOFFMAN, D. R. A new device for absolute anchorage for Orthodontics. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 107, no. 3, p. 251-258, 1995.
3. CARANO, A.; VELO, S.; LEONE, P.; SICILIANI, G. Clinical applications of the miniscrew anchorage system. **J. Clin. Orthod.**, Boulder, v. 39, no. 1, p. 9-24; 29-30, Jan. 2005.
4. CHADDAD, K.; FERREIRA, A.; GEURS, N.; REDDYD, M. Influence of surface characteristics on survival rates of mini-implants. **Angle Orthod.**, Appleton, v. 78, no. 1, p. 107-113, Jan. 2008.
5. CHUNG, K. R.; KIM, Y. S.; LINTON, J. L.; LEE, Y. J. The miniplate with tube for skeletal anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 7, p. 407-412, July 2002.
6. DE CLERCK, H.; GEERINCKX, V.; SICILIANO, S. The zygoma anchorage system. **J. Clin. Orthod.**, Boulder, v. 36, no. 8, p. 455-459, Aug. 2002.
7. ELIAS, C. N.; LOPES, H. P. **Materiais dentários: ensaios mecânicos**. São Paulo: Ed. Santos, 2007.
8. ELIAS, C. N.; SERRA, G. G.; MULLER, C. A. Torque de inserção e remoção de mini-parafusos ortodônticos. **Rev. Bras. Implant.**, Rio de Janeiro, v. 11, p. 5-8, 2005.
9. FAVERO, L.; BROLLO, P.; BRESSAN, E. Orthodontic anchorage with specific fixtures: related study analysis. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 122, p. 84-94, 2002.
10. FREITAS, J. C.; CASTRO, J. S. Avaliação da frequência do uso de implantes de ancoragem ortodôntica. **J. Bras. Ortodon. Ortop. Facial**, Curitiba, v. 9, no. 2, p. 474-479, 2004.
11. JOLLEY, T. H.; CHUNG, C. H. Peak torque values at fracture of orthodontic miniscrews. **J. Clin. Orthod.**, Boulder, v. 41, no. 6, p. 326-328, June 2007.
12. LIM, S.; CHA, J.; HWANG, C. Insertion torque of orthodontic miniscrews according to changes in shape, diameter and length. **Angle Orthod.**, Appleton, v. 78, no. 2, p. 234-240, Mar. 2008.
13. LIOU, E. J.; PAI, B. C.; LIN, J. C. Do miniscrews remain stationary under orthodontic forces? **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 1, p. 42-47, July 2004.
14. MOON, C.; LEE, D.; LEE, H.; IM, J.; BAEK, S. Factors associated with the success rate of orthodontic miniscrews placed in the upper and lower posterior buccal region. **Angle Orthod.**, Appleton, v. 78, no. 1, p. 101-106, 2008.
15. PAIM, C. B. **Avaliação da utilização de pinos de titânio como auxiliares no tratamento ortodôntico**. Rio de Janeiro: Universidade Federal do Rio de Janeiro, 1996.
16. PARK, H. S.; KWON, O. W.; SUNG, J. H. Micro-implant anchorage for forced eruption of impacted canines. **J. Clin. Orthod.**, Boulder, v. 38, no. 5, p. 261-262, May 2004.
17. REN, Y.; MALTHA, J. C.; KUIJPERS-JAGTMAN, A. M. Optimum force magnitude for orthodontic tooth movement: a systematic literature review. **Angle Orthod.**, Appleton, v. 73, no. 1, p. 86-92, Feb. 2003.
18. ROBERTS, W. E.; SMITH, R. K.; ZILBERMAN, Y.; MOZSARY, P. G.; SMITH, R. S. Osseous adaptation to continuous loading of rigid endosseous implants. **Am. J. Orthod.**, St. Louis, v. 86, no. 2, p. 95-111, 1984.
19. SONG, Y. Y.; CHA, J. Y.; HWANG, C. J. Mechanical characteristics of various orthodontic mini-screws in relation to artificial cortical bone thickness. **Angle Orthod.**, Appleton, v. 77, no. 6, p. 979-985, Nov. 2007.
20. SOUTHARD, T. E.; BUCKLEY, M. J.; SPIVEY, J. D.; KRIZAN, K. E.; CASKO, J. S. Intrusion anchorage potential of teeth versus rigid endosseous implants: a clinical and radiographic evaluation. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 107, no. 2, p. 115-120, 1995.

Contact address

Matheus Melo Python
 Rua México 78 - Recreio
 ZIP: 45.020-390 - Vitória da Conquista / Bahia
 E-mail: matheuspython@ufrj.br

Miniplates anchorage on open-bite treatment

Adilson Luiz Ramos*, Sabrina Elisa Zange**, Hélio Hissashi Terada***, Fernando Toshihiro Hoshina****

Abstract

Objective: The case report presented describes an orthodontic treatment supported by miniplates of an adult female patient who presented severe anterior openbite, clockwise rotation of the mandible, biprotrusion and the absence of labial sealing. After extraction of first molars and maxillary and mandibular dental retraction, associated with vertical control provided by the miniplates, the anterior openbite was corrected with a little anti-clockwise rotation, resulting in a significant improve on facial appearance. **Objective:** This case report confirms the efficiency of titanin miniplates as temporary anchorage, especially in situations where great corrections are needed, involving a vertical problem.

Key-words: Miniplates. Anchorage. Molar extraction. Open bite. Biprotrusion.

INTRODUCTION

Among the newest technological resources introduced in the orthodontic practice, the temporary anchorage devices stand out^{2,5,11,14,17}. Miniscrews in many forms as titanium miniplates, have allowed amplify the corrective capacity in compensatory treatment, as even more control on conventional mechanics^{1,3,4,9}. Particularly the severe skeletal openbite treatment was very favored with these new resources^{3,7,17}.

The skeletal anterior open bite (SAOB) can involve excessive alveolar vertical development, a short mandible branch, a high mandible plane angle, so as a high anterior facial height, frequently

associated with the absence of passive labial sealing⁷. Many orthopedic-orthodontic methods have been related for its correction (high-pull headgear, bite-blocks with or without magnets, intruder and other variations). However, in front of the modest results of these methods, mainly in adults, the majority of cases need help from orthognatic surgery for their effective correction^{7,17}.

Through help of temporary anchorage devices, miniscrews and miniplates, the capacity of correction of these cases increased reasonably. Literature has presented many cases of SAOB treated successfully using these new treatment techniques^{3,7,17}. Furthermore, the stability over

* Master of Orthodontics from USP - Bauru / SP. PhD in Orthodontics from UNESP - Araraquara / SP. Adjunct Professor, Department of Dentistry EMU. Coordinator of Postgraduate Dentistry, University of Maringá.

** Specialist in Orthodontics from EMU.

*** Adjunct Professor, Department of Dentistry, University of Maringá. Master and Doctor of Orthodontics, School of Dentistry of Araraquara - UNESP.

**** Specialist in Orthodontics from the State University of Maringá.

those corrected cases seems to be promising¹⁶.

Although miniscrews have improved in their failure rate^{6,8,9,11,12,13}, the anchorage miniplates show, up this moment, higher percentage of success^{3,10,16,17}. Beside, miniplates are placed at a great distance from the dental roots, allowing great liberty of movement, not demanding the replacement of the anchorage device.

The present article shows a case report of SAOB using miniplates as anchorage for orthodontic correction.

CASE REPORT

A female patient attended to the Orthodontic clinic of the Specialty Program in Orthodontics of the State University of Maringá, complaining of dental and facial aesthetics. Orthodontic records were obtained, including lateral radiograph, panoramic, periapical radiographs, extra and intra-buccal photographs and plaster casts (Fig. 1, 2, 3).

The patient showed SAOB with its typical characteristics (negative vertical trespass, high anterior facial height, a high mandible plane angle, absence of passive labial sealing) associated to an

excessive biprotrusion, Class III relation and absence of the maxillary first molars and maxillary left third molar.

Two treatment proposals were shown. The first included the association with orthognathic surgery for effective skeletal correction, allowing posterior maxillary impaction and correction of the maxillary incisors inclination. In the mandible, would be accomplished a sagittal reduction osteotomy, as an advance genioplasty, with vertical reduction. Previously to the surgery an orthodontic fixed appliance would be utilized for lower discompensation (with previous indication of extraction of lower first molars) and segmented maxillary leveling.

The second treatment option included the compensatory correction, through help of four anchorage miniplates (to allow suitable biprotrusion correction and vertical control), and also the indication of extraction of lower first molars.

In front of the options offered, the patient preferred the treatment without orthognathic surgery, authorizing the treatment with clear consent.

The titanium plates design used were drawn



FIGURE 1 - Pre-treatment radiograph records (lateral, panoramic and e periapicals X-rays).



FIGURE 2 - Pre-treatment extra oral photos.



FIGURE 3 - Pre-treatment interiorly photos.

originally for orthognatic surgery osteosynthesis and modified into anchorage dispositives. The figures 4 and 5 illustrate the miniplate fixing procedure. It can be observed that in the upper quarters the most occlusal chain unit of the miniplate was not correctly vertically distant from the orthodontic wire line, therefore later it was eliminated. Faber et al.³ recommend that the most occlusal chain unit should be positioned 6 to 8mm far from the orthodontic wire line, emerging in alveolar mucosa. The tissue repair after miniplates placement was suitable, with tolerable symptoms, being the suture removed after five days. Anti-inflammatory and antibiotic were prescribed, as well as 0.2% clorhexidine rinses.

The figures 6 to 8 show the lateral radiograph, panoramic, periapical radiographs, pointing out the miniplates position.

Notices in figure 9 that the last chain unit from the upper plates were removed, allowing a suitable distance to the orthodontic wire. In the lower arch, the retraction of seconds pre-molars was began, anchored on the miniplates.

The alignment and leveling was conducted until rectangular wire, when hooks were joint for anterior retraction, associated to vertical control (especially maxillary), through the positioning of elastomeric chains in the miniplates. As an auxiliary upper anchorage, with the purpose of avoiding arch expansion (due to vertical vector), a palatal



FIGURE 4 - Maxillary miniplates surgical procedures.

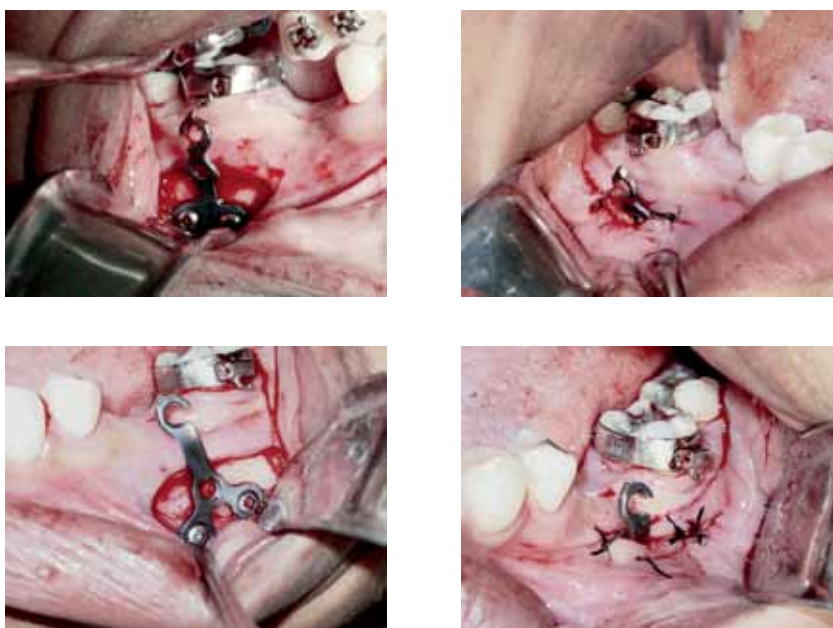


FIGURE 5 - Mandibular miniplates surgical procedures.



FIGURE 6 - Panoramic X-ray after miniplates installation.



FIGURE 7 - Lateral head radiograph after miniplates installation.

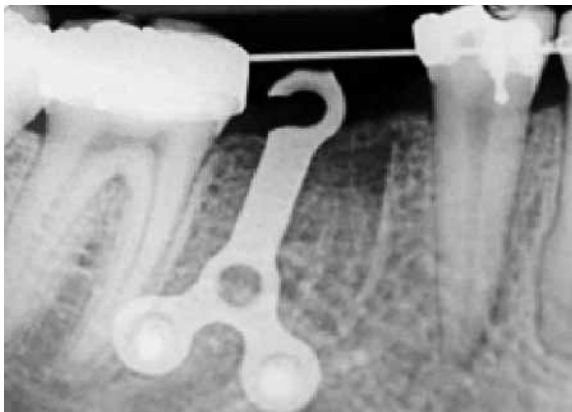


FIGURE 8 - Posterior region periapicals X-rays after miniplates installation.



FIGURE 9 - Leveling and alignment phase, starting lower premolars retractions. Observe that last chain unit from the upper miniplates were removed. As an auxiliary upper anchorage, with the purpose of avoiding arch expansion (due to vertical vector), a palatal bar was used.



FIGURE 10 - Intermediary treatment phase. The upper anterior retraction was transitorily stood by, and lower anterior retraction was accelerated along the mandibular molars mesialization.

bar with 0.8mm was inserted on maxillary second molars (figure 9).

The figure 10 shows a treatment phase where the anterior openbite was already corrected, the arches in anterior region were in good anterior posterior relation; however the mesialization of lower first molars was less evident than the upper ones. For that reason, upper retraction was stopped momentarily (stabilized with a 0,10mm twisted steel wire) and the lower molars movement was accelerated with an elastomeric chain that passed through the miniplate and the hook until the molars.

The intermediary pictures of figure 11 illustrate a partial facial improvement, however with an increase on gingival exposure. The upper incisor protrusion correction, even with vertical control, needed this situation, as pointed out by Sarver¹⁵. As the level of open bite correction was

suitable, and with over correction, it was decided to include an auxiliary intrusion arch in the anterior segment, concomitant to the ongoing mechanic.

The figure 12 illustrates a phase near to the final spaces closure and figure 13 illustrates a sensitive improvement on patient face, influenced by biprotrusion correction with vertical control provided by miniplates. The superimposed pre-treatment lateral radiographs and finishing phase illustrate the achieved modifications (Fig. 14). The frame 1 shows the comparison of some cephalometric measures referred to this superimpose.

The figures 15, 16, 17 show comparisons between initial, intermediary and final smiling and profile pictures.

During all period of treatment the patient did not mention any relevant symptom related to the anchorage miniplates.

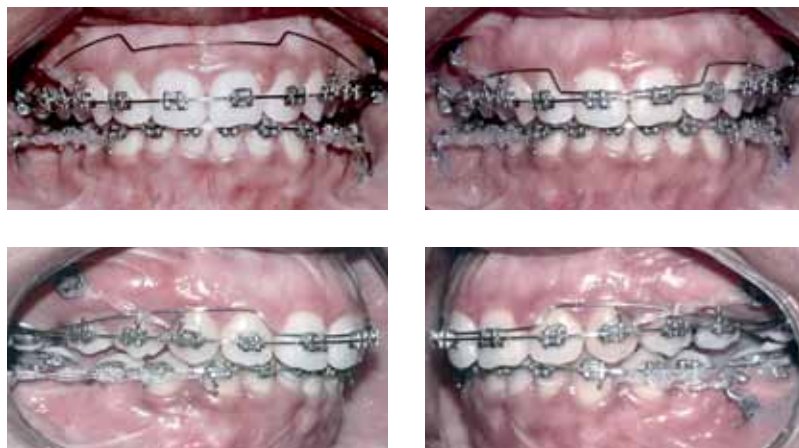


FIGURE 11 - It was include an auxiliary intrusion arch in the anterior segment, concomitant to the ongoing mechanic, in order to minimize gingival exposition.



FIGURE 12 - Ending treatment phase interiorly photos.



FIGURE 13 - Ending treatment phase extraoral photos. It is noticeable the facial profile improvement.

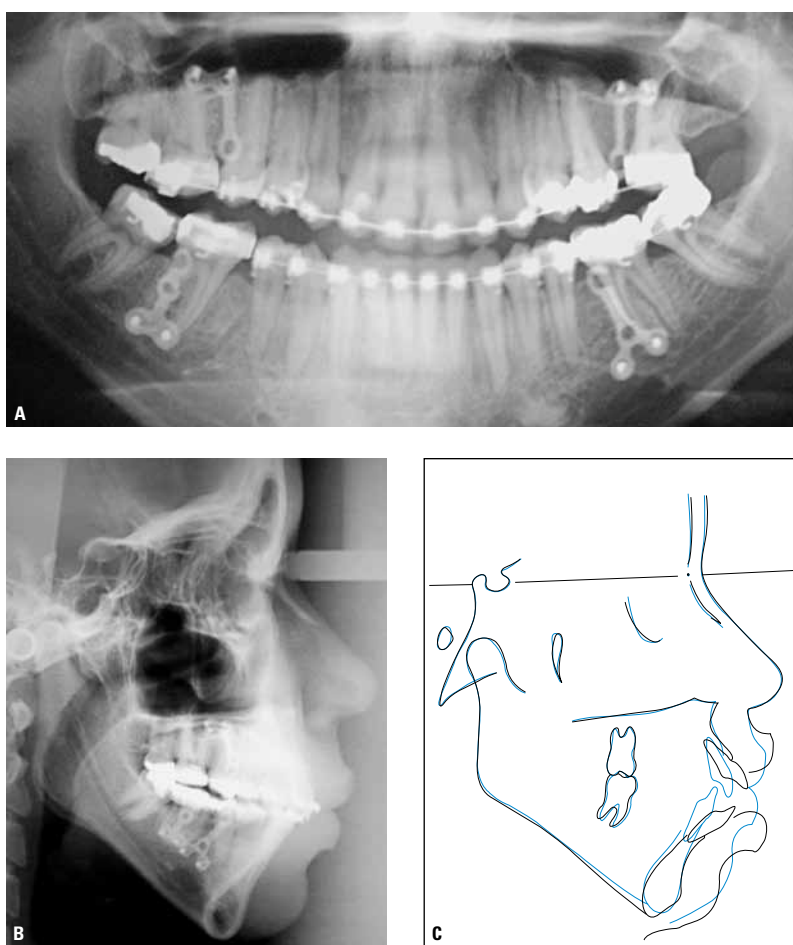


FIGURE 14 - Total cephalometric superimposition from pre to ending phases.



FIGURE 15 - Facial improvement in frontal resting aspect from starting to end phase.



FIGURE 16 - Facial improvement in frontal smiling aspect from starting to end phase.

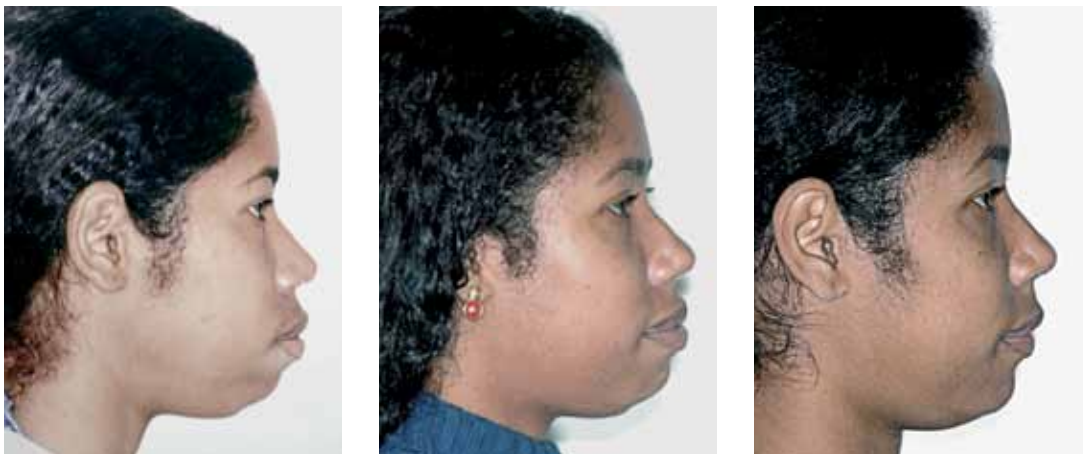


FIGURE 17 - Facial profile improvement in resting aspect from starting to end phase.

CONCLUSION

This case report confirms the latest evidence on efficiency of titanic miniplates as temporary anchorage, especially in situations where great

corrections are needed, involving a vertical problem.

Submitted: January 2008

Revised and accepted for publication: May 2008

REFERENCES

1. ARAÚJO, T. M.; NASCIMENTO, M. H. A.; BEZERRA, F.; SOBRAL, M. C. Ancoragem esquelética em Ortodontia com miniimplantes. **Rev. Dental Press Ortodon. Ortop. Facial**, Maringá, v. 11, n. 4, p. 126-156, jul./ago. 2006.
2. CREEKMORE, T. D.; EKLUND, M. K. The possibility of skeletal anchorage. **J. Clin. Orthod.**, Boulder, v. 17, no. 4, p. 266-269, 1983.
3. FABER, J. Ancoragem esquelética com miniplacas. In: LIMA FILHO, R. A.; BOLONHESE, A. M. **Ortodontia: arte e ciência**. 1. ed. Maringá: Dental Press, 2007.
4. JANSON, M. Ancoragem esquelética com miniimplantes: incorporação rotineira da técnica na prática ortodôntica. **Rev. Clin. Orton. Dental Press**, Maringá, v. 5, n. 4, p. 85-100, 2006.
5. KANOMI, R. Mini-implant for orthodontic anchorage. **J. Clin. Orthod.**, Boulder, v. 31, no. 11, p. 763-767, Nov. 1997.
6. KIM, J. W.; AHN, S. J.; CHANG, Y. I. Histomorphometric and mechanical analyses of the drill-free screw as orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 2, p. 190-194, 2005.
7. KURODA, S.; KATAYAMA, A.; TAKANO-YAMAMOTO, T. Severe anterior open-bite case treated using titanium screw anchorage. **Angle Orthod.**, Appleton, v. 74, no. 4, p. 558-567, 2004.
8. LIOU, E. J.; PAI, B. C.; LIN, J. C. Do miniscrews remain stationary under orthodontic forces? **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 126, no. 1, p. 42-47, 2004.
9. MARASSI, C. Quais as principais aplicações clínicas atuais e quais as chaves para o sucesso dos miniimplantes em Ortodontia? **Rev. Clin. Orton. Dental Press**, Maringá, v. 5, n. 4, p. 13-25, 2006.
10. MYAWAKI, S.; KOYAMA, I.; INOUE, M.; MISHIMA, K.; SUGAHARA, T.; TAKANO-YAMAMOTO, T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 124, no. 4, p. 373-378, 2003.
11. PARK, H. S.; BAE, S. M.; KYUNG, H. M.; SUNG, J. H. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. **J. Clin. Orthod.**, Boulder, v. 35, no. 7, p. 417-422, 2001.
12. PARK, H. S. An anatomical study using CT images for the implantation of micro-implants. **Korean J. Orthod.**, Korea, v. 32, no. 6, p. 435-441, 2002.
13. POGGIO, A. P. M.; INCORVATIB, C.; VELOB, S.; CARANO, A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. **Angle Orthod.**, Appleton, v. 76, no. 2, p. 191-197, Mar. 2006.
14. ROBERTS, W. E.; HELM, F. R.; MARSHALL, K. J.; GONGLOFF, R. K. Rigid endosseous implants for orthodontic and orthopedic anchorage. **Angle Orthod.**, Appleton, v. 59, no. 4, p. 247-256, Winter 1989.
15. SARVER, D. M.; ACKERMAN, M. B. Dynamic smile visualization and quantification: Part 2. Smile analysis and treatment strategies. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 124, no. 2, p. 116-127.
16. SUGAWARA, J. et al. Treatment and posttreatment dentoalveolar changes following intrusion of mandibular molars with application of a skeletal anchorage system (SAS) for open bite correction. **Int. J. Adult. Orthodon. Orthognath. Surg.**, Chicago, v. 17, no. 4, p. 243-253, 2002.
17. UMEMORI, M.; SUGAWARA, J.; MITANI, H.; NAGASAKA, H.; KAWAMURA, H. Skeletal anchorage system for open bite correction. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 115, no. 2, p. 166-174, Feb. 1999.

Contact

Adilson Luiz Ramos
Rua Arthur Thomas 831
CEP: 87.013-250 - Maringá/PR
E-mail: alramos@ortodontista.com.br

Miniplates allow efficient and effective treatment of anterior open bites

Jorge Faber*, Taciana Ferreira Araújo Morum**, Soraya Leal***, Patrícia Medeiros Berto****, Carla Karina dos Santos Carvalho*****

Abstract

Introduction The treatment of dentofacial deformities and malocclusions with anterior open bites, was one of the first applications of miniplates for orthodontic anchorage. The use of this treatment system reduces the number of patients referred to orthognathic surgery and simplifies many problems. This approach applies intrusive forces to posterior teeth, and the mandible undergoes counterclockwise rotation, which decreases lower facial height and projects hard and soft tissue pogonions. **Objective:** This study describes the principles of orthodontic mechanics in the correction of anterior open bite and illustrates these principles with a series of clinical cases.

Keywords Open bite. Orthodontic anchorage procedures. Miniplates. Orthodontics.

INTRODUCTION

Successful orthodontic therapy depends on judicious anchorage planning. Skeletal anchorage devices have played a significant role in supporting orthodontic treatment¹⁰. Their chief advantage lies in providing a fixed, stationary anchorage spot inside the oral cavity, which enables orthodontic movements by preventing the unit of resistance from being displaced. Temporary orthodontic implants allow the implementation of skeletal anchorage techniques which boast certain benefits over traditional Orthodontics in many different clinical situations since they do not require patient compliance and allow forces to be applied in different directions without undesirable reciprocal movements¹⁵.

The emergence of skeletal anchorage has allowed professional to develop groundbreaking orthodontic treatment methods. Complex treatments have become simpler and more predictable, treatment length has decreased and orthognathic surgeries could be avoided in patients who did not wish to experience them. These results have been achieved with the aid of several different skeletal anchorage systems. In practice, the natural selection process has restricted anchorage systems to virtually two groups, namely: Mini-implants and miniplates²⁴. The use of miniplates for orthodontic anchorage was initially conceived with the purpose of accomplishing lower molar distalization²¹. Eventually, however, these devices gained popularity when they were shown to be applicable in

* Editor in Chief of the Dental Press Orthodontics and Facial Orthopedics Magazine. PhD in Biology from the Brasilia University (Un B) Electronic Microscopy Laboratory. Master of Sciences from the Rio de Janeiro Federal University (UFRJ).

** Orthodontics Specialist from FOPLAC. Master student in Health Sciences at the Brasilia University.

*** Pediatric Dentistry Specialist from ABO-DF. Master of Sciences and PhD in Health Sciences from UnB. Associate Professor at the Brasilia University.

**** Post-Graduate Orthodontics student – UFG.

***** Master of Sciences in Health Sciences – UnB. Orthodontics Post-graduate student – UFG.

treatments involving anterior open bite through molar intrusion²⁴.

Miniplate benefits are grounded in greater stability and the fact that screw insertion is performed beyond tooth apices, which allows adjacent teeth to be moved in the anteroposterior, vertical¹⁰ and cross-sectional orientations. Miniplates are particularly recommended in conditions requiring the application of stronger orthodontic forces or the joint movement of several teeth^{3,22}. Since they do not interfere with dental movements, they also enable teeth in the miniplate area to be moved^{6,10,12,21}. Additionally, miniplates do not rely on patient cooperation, except for the usual hygiene and maintenance of the orthodontic appliance¹⁰. Miniplates are also stable enough to resist orthodontic forces in a variety of tooth movements, besides affording high success rates^{7,24}.

Miniplates feature certain disadvantages in comparison with mini-implants, such as the need for more invasive insertion and removal surgeries, higher costs and, possibly, increased likelihood of infection^{7,15,14}.

There are, however, certain clinical conditions where miniplates have proved advantageous. The cases for which miniplates are best indicated involve intrusion, distalization and mesial drift of all maxillary and mandibular teeth, although these devices also provide adequate skeletal anchorage for various other tooth movements^{12,18,23}.

Miniplates offer a variety of clinical applications. One common indication is for treating anterior open bites. Most adults presenting with anterior open bite tend to have an excess height on the posterior dentoalveolar maxilla. These patients were usually referred for orthognathic surgery to perform the impaction of the maxilla's posterior portion with the resulting counterclockwise rotation of the mandible. Nowadays, less invasive treatment options are available through the insertion of miniplates for molar intrusion. Intrusion alters the occlusal plane, mandibular plane

and anterior portion of the face, which ultimately closes the anterior open bite^{10,11,19,20}.

The intrusion of all posterior teeth to correct an anterior open bite can successfully and predictably be achieved with the aid of miniplates. Therefore, the purpose of the present article is to introduce a methodology aimed at treating anterior open bites by using miniplates for skeletal anchorage.

MINIPLATE INSERTION

Paramount among the factors that play an important part in the successful use of skeletal anchorage devices are the quality and quantity of cortical bone in the insertion site as well as the characteristics of the surrounding mucous membrane. Miniplates whose emergences in the oral cavity are surrounded by keratinized mucosa are statistically more prone to success than those located in the alveolar mucosa, more vulnerable to infection^{1,8}.

The influence of anatomical location on anchorage devices is also regarded as relevant. However, researchers' views on this issue are divergent. Whereas Kuroda et al.¹⁵ assert that implants positioned in the posterior mandibular region are more failure-prone than those placed in the maxilla's posterior region, Chen et al.¹ claim that, in general, implants inserted in the maxilla exhibit less stability than those inserted in the mandible. Nevertheless, although maxillary bone is more porous, with a thinner cortex, which might predispose the maxilla to a lower success rate than the mandible¹⁷, the experience we have amassed after inserting more than 400 miniplates has convinced us that, in actuality, there is no such difference in stability. The latter data will be published soon. The reasons and facts submitted by Kuroda et al.¹⁵ remain obscure, although it has been speculated that other factors might have influenced their results, such as the amount of keratinized gingiva, greater hygiene difficulties and major surgical obstacles due to the mandible's anatomical mor-

phology.

Miniplate planning should only be conducted after a detailed analysis of the patient's orthodontic documentation, definition of a treatment plan and the choice of a biomechanical method. Following the surgery, the site selected for implant insertion should be carefully assessed by taking into account bone quality and an analysis of the panoramic radiograph or tomographic image.

Moreover, a surgical guide should be fashioned to ensure an ideal positioning of miniplates. This is a very useful resource in anatomical structure injury prevention^{10,21}. The choice of miniplate size and shape should be based on the length of the adjacent teeth's roots and the contour and density of the underlying bone. "L"-shaped miniplates are recommended for the mandible since their shorter legs are projected over the anterior region, making for easy and free access. In the maxilla, however, "Y"-shaped or "T"-shaped miniplates are often preferred since these are more easily contoured around the maxillary bone in the cortical bone regions, which prevents miniplates from getting loose or encroaching upon the maxillary sinus¹⁹.

The miniplate insertion site is selected according to bone availability, mechanics of choice and integrity of the adjacent soft tissue³. Miniplates are usually inserted in the zygomatic process of the maxilla or in the mandibular body. The zygomatic process of the maxilla constitutes a suitable site in the maxilla owing to its solid bone structure and its safe distance from the upper molar roots⁸.

Miniplate insertion surgeries are performed using local anesthetic. Formerly, the surgical technique involved a horizontal incision. Currently this technique has been replaced, in certain cases, by a vertical incision to streamline surgical operation, reduce scar size and facilitate healing⁹. After tissue dissection and bone exposure, the miniplate is fitted around the bone contour and attached with two or three screws.

The tissue is then closed and sutured, allowing the exposure of the miniplate to the inside of

the oral cavity. The post-operative period of miniplate insertion is characterized by minor edema and pain⁸. Special hygienic care should be taken following miniplate insertion. Recommendations comprise the use of a post-surgical brush dipped in 0.12% clorexidine gluconate for 15 days and triclosan-based antiseptic throughout the treatment.

Although the application of orthodontic forces immediately after insertion is not ruled out, it is highly advisable to stand by and wait at least for another 2 weeks to elapse^{23,24} with the purpose of allowing the patient's soft tissues sufficient time to heal.

MINIPLATE USE COMPLICATIONS

The use of miniplates for orthodontic anchorage can give rise to certain complications.

One of the most common consists in inflammation and/or infection around the miniplate due to an accumulation of bacterial plaque resulting from the patient's inadequate hygiene^{9,21}. Once an infection is cured with the aid of irrigation, topic hygiene and anti-bacterial therapy, frequently, the miniplate can be used again. Inflammations are usually easily controlled with the use of oral antiseptics and adequate brushing¹. The biofilm which gathers on the mini-implant surface – once treated with clorexidine or a fluoride solution – significantly reduces the presence of viable microorganisms. Adverse bacterial activity, however, is also influenced by the substrate surface and responds to rugosity and superficial chemical composition⁴.

Another miniplate-related complication, albeit uncommon, is associated with the jugal mucosa being irritated by the skeletal anchorage device. This feature causes the patient to feel some discomfort but does not usually impact miniplate success rate⁹.

One factor worthy of note, which can lead to orthodontic anchorage failure, is the nearness of mini-implants to the tooth roots since such

proximity renders bone remodeling around the mini-implant extremely difficult while allowing the transmission of occlusal forces from the teeth to the mini-implants¹⁶. However, miniplates are usually positioned away from tooth roots and the screws used to attach the miniplate hardly ever touch the lamina dura surrounding the tooth roots.

Another factor that could be associated with the risk of losing skeletal anchorage systems is a high traction force, although a clear definition of this phenomenon can be elusive. A number of unsuccessful attempts have been made to associate miniplate failure with different types of forces, such as those produced by chain elastics, nickel-titanium springs or chain elastics combined with springs.

BIOMECHANICS TO CORRECT ANTERIOR OPEN BITE USING MINIPLATES

Intrusive vertical force is produced by means of a chain elastic or nickel-titanium spring attached to the miniplate's exposed link and to the molar tube (Fig. 1). Segmented as well as straight

arch wires can be used (Fig. 2A). Although the possibility has been raised that the use of straight arch wires might cause incisor overeruption due to occlusal plane rotation¹⁹, the authors' experience has shown that such effect does never occur (Fig. 2B), as already published elsewhere¹¹.

To avoid molar buccal rotation while applying intrusive force, the use of a contracted rectangular arch wire is indicated or, preferably, a transpalatal bar or lingual arch (Fig. 3)^{9,10,19,20}. Should any undesirable alteration occur in the cross-sectional plane, this can be solved by bonding a tube directly onto the miniplate while concurrently activating a power arm in the same orientation as the corrective force (Fig. 4).

Molar intrusion in only one of the maxillas can be accomplished by correcting open bites of up to 3mm¹⁰. Open bites of more significant sizes should be corrected with the aid of miniplates in both arches. The simultaneous intrusion of upper and lower molars allows a greater counterclockwise mandible rotation and more significant skeletal changes¹⁴.

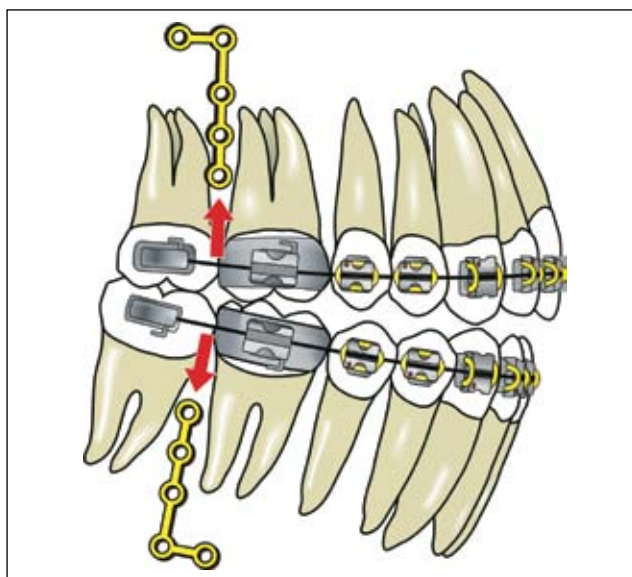


FIGURE 1 - A diagram depicting the application of an intrusive force from the occlusal-most miniplate link to the appliance.

Miniplates allow efficient and effective treatment of anterior open bites

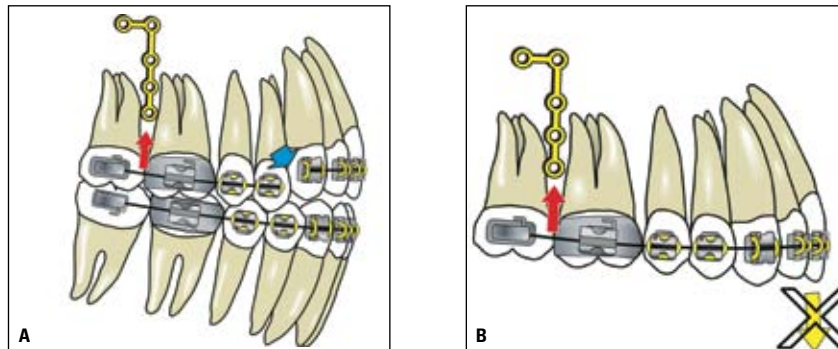


FIGURE 2 - Intrusion-related mechanical issues. **A)** Both continuous arch wires and segmented arch wires can be utilized. Segmented arch wires (blue arrow) are best suited for open bites restricted to the anterior region. **B)** When continuous arch wires are used, incisor extrusion does not occur (X on the yellow arrow), as previously suggested¹⁸, but not demonstrated in the literature.

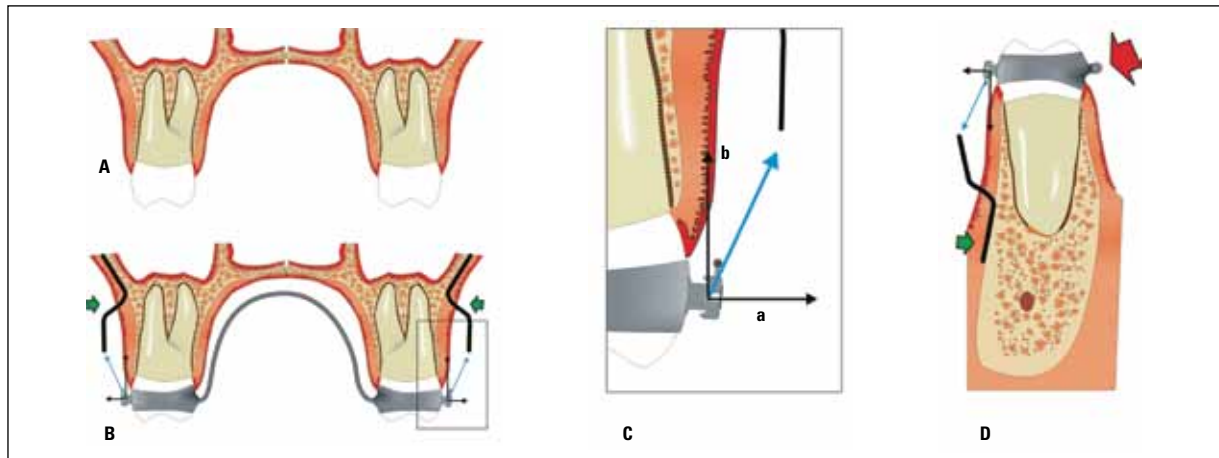


FIGURE 3 - Diagrams representing cross-sections of the maxilla in the first upper molar region. **A)** Prior to placing the appliance. **B)** Miniplate insertion (green arrow) and application of intrusive forces (blue arrows). **C)** Intrusive forces decomposed into an expansive component (a) and an intrusive component (b). Expansive components cancel out one another in the presence of a palatal bar or **(D)** lingual arch (red arrow).



FIGURE 4 - In order to correct any cross-sectional alterations in the upper and lower dental arches, a bracket or tube can be bonded directly onto the miniplate and be used as anchorage for arch wires, springs and other devices. To this end, two small grooves should be made in the miniplate link to retain the bonding resin.

CLINICAL CASES

Case 1 – miniplates in maxilla and mandible, placed unilaterally

Male patient, 21 years and 9 months old, exhibited a Class I malocclusion with severe open bite, which caused only the right second molars to occlude. There was vertical asymmetry featuring inclined maxilla, lower on the right hand side. TMJ radiographs and scintigraphic images were requested to check for possible left condyle morphological alterations and hypercaptation. An analysis of these exams ruled condyle hyperplasia or neoplasia (Fig. 6).

Treatment goals

The treatment goal was to close the open bite and achieve adequate overbite and overjet.

Treatment alternatives

The patient was offered the following treatment alternatives:

1. Orthodontic treatment combined with orthognathic surgery in the maxilla and mandible.

2. Orthodontic treatment with the insertion of two titanium miniplates in the right hand side, one in the maxilla and one in the mandible.

Treatment progress

After aligning and leveling lower and upper teeth, surgical guides were fashioned to provide orientation for the surgeon as to the desired miniplate position. Prior to surgery, a palatal bar and lingual arch wire were inserted with the purpose of preventing posterior teeth buccal rotation during the intrusion process. These appliances had their arch wires untempered on the left hand side to attain greater flexibility and allow for adequate movement.

Two weeks after miniplate insertion on the right hand side of the mandible and maxilla chain elastics were placed between the miniplates and the first molars with the aim of intrud-

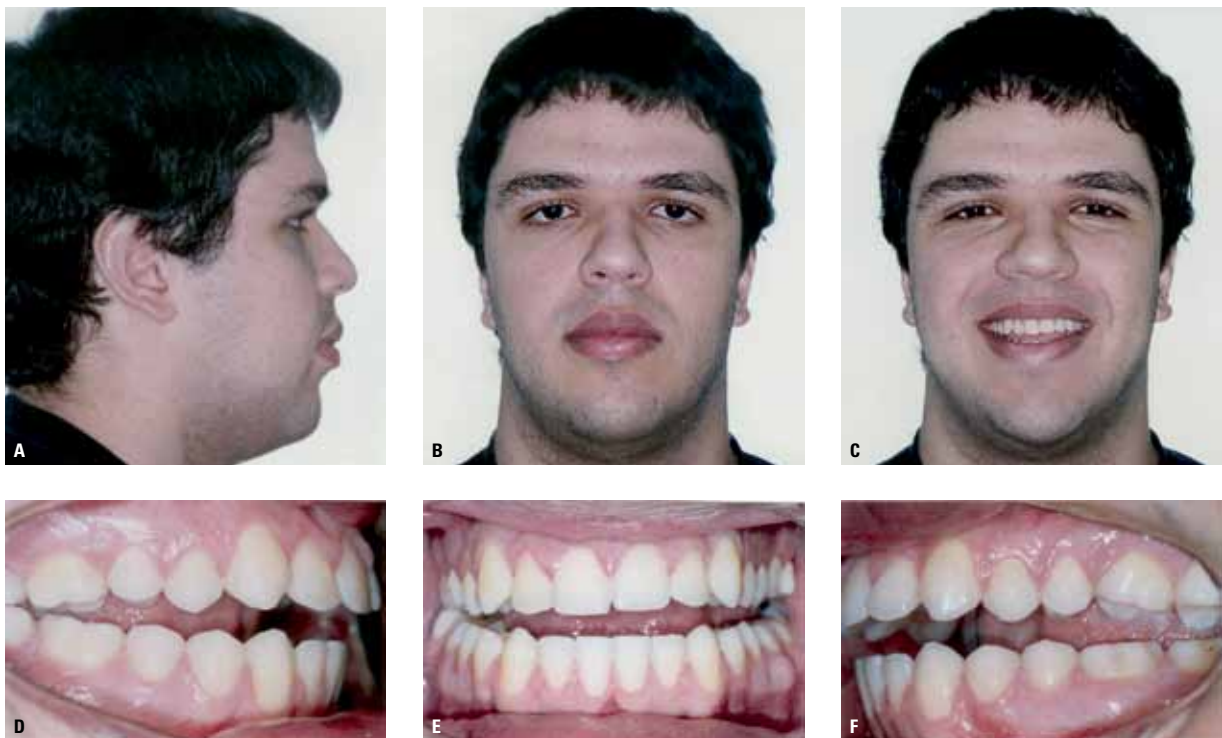


FIGURE 5 - Initial photographs showing an asymmetric open bite. **A, B, C)** Extraoral image and **D, E, F)** intraoral images.

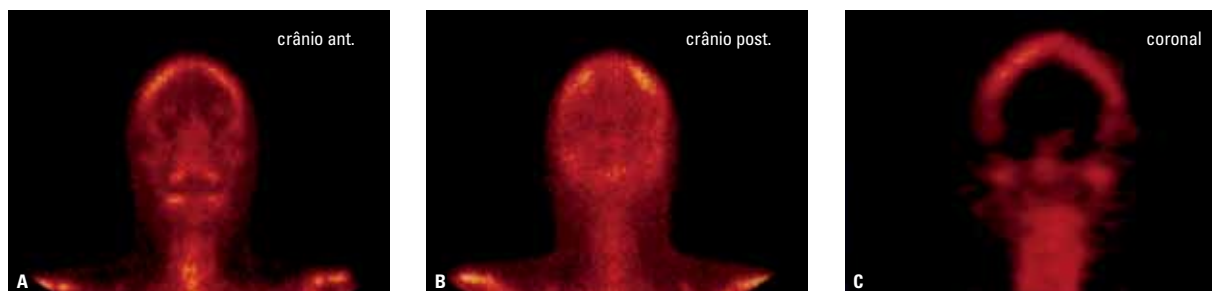


FIGURE 6 - Scintigraphic images: **A)** anterior section, **B)** posterior section and **C)** coronal section.



FIGURE 7 - Treatment progress with the implementation of chain elastics between the miniplates and the right first molars in order to intrude the posterior teeth.



FIGURE 8 - Molar intrusion progress and the resulting open bite closure where the chain elastics were further extended to the second molars.

ing the posterior teeth (Fig. 7). Subsequently, intrusion elastics were also extended the second molars (Fig. 8). As soon as an adequate overbite was achieved, a speech therapy treatment was launched which lasted throughout the entire orthodontic treatment.

Results

The upper and lower molars were intruded and the mandible underwent a counterclockwise rotation (Fig. 9). Table 1 displays the initial and final cephalometric measurements with a decreased lower facial height. At the end of the orthodontic treatment, proper dental relationships were established (Fig. 10). A 3 x 3 lower retainer was put

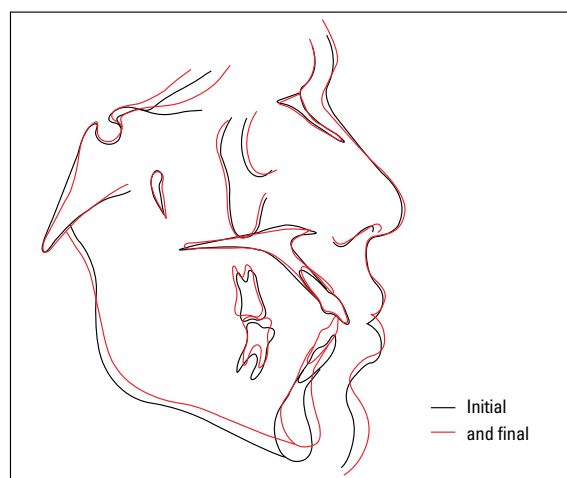


FIGURE 9 - Superimposed Initial and final cephalometric tracings showing upper and lower right molars' intrusion and the resulting counterclockwise mandible rotation.

FIGURE 10 - Final photographs with proper dental relationships in place. **A, B, C**) Extraoral image and **D, E, F**) intraoral images.**Table 1** - Initial and final cephalometric measurements (Case 1).

measurements	norm	initial	final
SNA	82°	74°	76°
SNB	80°	79°	81°
ANB	2°	- 4°	-5°
1/. NA	22°	47°	38°
1/-NA	4mm	23mm	22mm
/1.NB	25°	39°	33°
/1-NB	4mm	12mm	10,5mm
/1.1/	131°	98°	114°
NB-Pog		3mm	3mm
SN.Poi		19°	11°
SN.Pos		15°	14°
SN.GoGn	32°	31°	29°
AFAI		95mm	91mm
g-sn		68mm	70mm
sn-stms		34mm	34mm
stmi-me		68mm	68mm
stms-stmi		0mm	0mm

* g = glabella; sn = subnasal; stms = upper stomium, stmi = lower stomium;
me = mentum in soft tissue

in place. Additionally, for the upper arch, wrap-around style removable retainers were produced. One conventional, for day time use, and one with a palatal grid in the right hand side region, for night time use. After six months of orthodontic treatment had elapsed, only the night time retainer was maintained.

Case 2 – miniplates in mandible, placed bilaterally

Female patient, age 30, presented with an adequate anteroposterior relationship, but a discomforting anterior open bite (Fig. 11). There was no significant crowding in the upper and lower arches. The patient had an osseointegrated implant in the region of tooth 25, which had a significant impact on skeletal anchorage planning.

Treatment goals

The treatment goal was to correct overbite and overjet as well as open bite.

Miniplates allow efficient and effective treatment of anterior open bites



FIGURE 11 - Initial extraoral (A, B, C) and intraoral photographs (D, E, F) showing anterior open bite.



FIGURE 12 - Intraoral images with surgical guide positioned in the lower arch.



FIGURE 13 - Treatment progress after activation of the orthodontic appliance using chain elastics propped on the miniplate to achieve lower molar intrusion.

Treatment alternatives

The patient was offered the following treatment alternatives along with a thorough explanation of the advantages and disadvantages of each alternative.

1. Orthodontic treatment using anterior vertical elastics for incisor and canine extrusion.
2. Orthodontic treatment with the insertion of two titanium miniplates in the mandible for molar intrusion. Miniplates were not indicated for the maxillary region owing to the presence of an osseointegrated implant in the region of tooth 25.

Treatment progress

Treatment consisted in bonding an orthodontic appliance on the lower arch and included the insertion of a lingual arch wire to avoid lower teeth buccal rotation during intrusion. Three months

after starting lower teeth alignment and leveling a surgical guide was fabricated which indicated to the surgeon the desired position of the miniplate's occlusal-most link (Fig. 12).

Two weeks after miniplate insertion surgery, intrusion mechanics was started. The wait time was only meant to allow all adjacent soft tissue to heal adequately, thereby ensuring for the patient a more comfortable manipulation of the affected region. This mechanics was implemented by means of chain elastics to intrude molars (Fig. 13). However, the method can also be well implemented using springs. Intrusion mechanics was conducted using 0.017" x 0.025" stainless steel arch wires. After open bite closure the patient began a speech therapy treatment which lasted throughout the entire orthodontic treatment.



FIGURE 14 - Final photographs showing that proper occlusion was accomplished. **A, B, C)** Extraoral images and **D, E, F)** intraoral images.

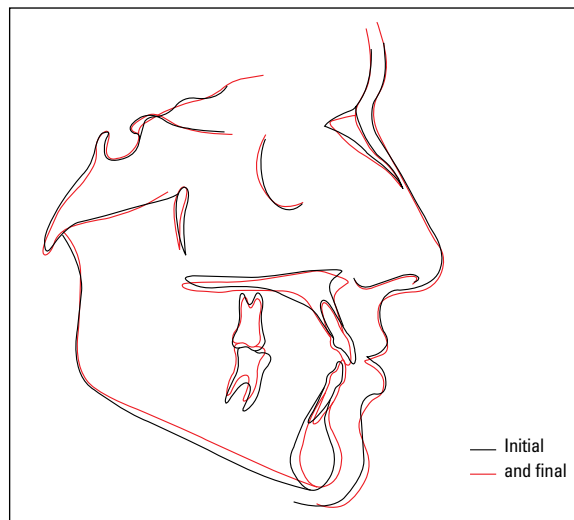


FIGURE 15 - Initial and final cephalometric tracings are superimposed, showing right upper and lower molars' intrusion and the resulting counterclockwise mandible rotation.

Results

The orthodontic treatment was finished with an adequate overbite (Fig. 14), with lower molar intrusion and mandibular counterclockwise rotation (Fig. 15). Table 2 displays the initial and final cephalometric measurements. The retainers used in this case were similar to those used in the previous case. A lower 3 x 3 fixed bar and two wraparound style removable retainers – one conventional, for day time use during 6 months and one with a anterior palatal grid, for night time use during an indefinite period of time.

The patient was instructed about the importance of maintaining speech therapist control after the orthodontic treatment had been completed.

Case 3 – miniplates in maxilla, placed bilaterally

Female patient, 22 years and 8 months old, whose clinical exam disclosed Class I malocclusion with anterior open bite.

Treatment goals

The treatment goal was to correct anterior

Table 2 - Initial and final cephalometric measurements (Case 2).

medidas	norma	inicial	final
SNA	82°	73°	75°
SNB	80°	75°	76°
ANB	2°	- 2°	-1°
1/- NA	22°	32°	30°
1/-NA	4mm	10,5mm	7,5mm
/1.NB	25°	22°	23°
/1-NB	4mm	3,5mm	4,5mm
/1.1/	131°	129°	127°
NB-Pog		4mm	4,5mm
SN.Poi		17°	14°
SN.Pos		17°	18°
SN.GoGn	32°	32°	32°
AFAI		69mm	67mm
g-sn		63mm	65mm
sn-stms		22mm	22mm
stmi-me		48mm	48mm
stms-stmi		0mm	0mm

* g = glabella; sn = subnasal; stms = estômio superior; stmi = estômio inferior; me = mento em tecido mole.

open bite while providing adequate overbite and overjet.

Treatment alternatives

The patient was offered the following treatment alternatives:

1. Orthodontic treatment using anterior vertical elastics.
2. Orthodontic treatment using skeletal anchorage – insertion of two titanium miniplates on the right and left hand sides of the maxilla.

Treatment progress

Initially, lower and upper teeth were aligned and leveled. The surgical guide was then inserted (Fig. 16) along with a palatal bar in order to prevent undesired buccal rotation of the posterior teeth.

Two weeks after insertion of the miniplates in the maxilla, 0.017" x 0.025" stainless steel arch wires and chain elastics were placed between the



FIGURE 16 - Fixed orthodontic appliance was bonded to the upper and lower arches with a surgical guide positioned in the upper arch to provide orientation to the surgeon regarding the desired miniplate position.



FIGURE 17 - Beginning of upper molar intrusion movement by means of chain elastics attached to the miniplates.



FIGURE 18 - Retention of the intrusion movement by tying stainless steel arch wires.

miniplates and the upper first molars aimed at intruding the latter (Fig. 17). As soon as an adequate overbite was achieved, intrusion was retained using stainless steel arch wires between the miniplates and the molars (Fig. 18). From that moment onwards the patient had to undergo speech therapy treatment and was made aware of how important it was to maintain it.

Results

The orthodontic treatment was finished having achieved adequate tooth relationships while the open bite had been corrected (Fig. 19). Table 3 displays the initial and final cephalometric measurements for this case.

There occurred upper molar intrusion, which led to a counterclockwise rotation of the mandible and a decrease in lower facial height (Fig. 20). The same retainers used in the previous cases were also employed in this case. A lower fixed 3 x 3 bar with two wraparound style removable retainers: One conventional, for daytime use and one with a palatal grid, for night use.

Six months after orthodontic treatment completion, only the night time retainer remained in use.

CONCLUSIONS

Anterior open bites can be treated with efficacy and efficiency by means of miniplates, which pro-

Miniplates allow efficient and effective treatment of anterior open bites



FIGURE 19 - Final intraoral photographs with proper dental relations established.



Table 3 - Initial and final cephalometric measurements (Case 3).

measurements	norm	initial	final
SNA	82°	73°	75°
SNB	80°	75°	76°
ANB	2°	- 2°	-1°
1/. NA	22°	32°	30°
1/-NA	4mm	10,5mm	7,5mm
/1.NB	25°	22°	23°
/1-NB	4mm	3,5mm	4,5mm
/1.1/	131°	129°	127°
NB-Pog		4mm	4,5mm
SN.Poi		17°	14°
SN.Pos		17°	18°
SN.GoGn	32°	32°	32°
AFAI		69mm	67mm
g-sn		63mm	65mm
sn-stms		22mm	22mm
stmi-me		48mm	48mm
stms-stmi		0mm	0mm

* g = glabella; sn = subnasal; stms = upper stomium/ stmi = lower stomium; me = mentum in soft tissue

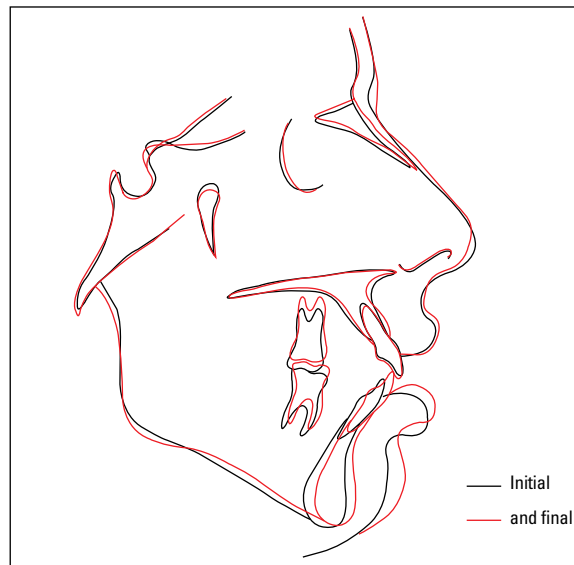


FIGURE 20 - Superimposed initial and final cephalometric tracings showing upper molar intrusion and the resulting counterclockwise mandible rotation.

vide anchorage for posterior teeth intrusion. Such intrusion results in a counterclockwise rotation of the mandible, which causes a decrease in lower facial height and an anterior displacement of hard and soft tissue pogonions. A wide range of such prob-

lems are amenable to treatment using this technique, which prevents orthognathic surgeries or, at least, can simplify treatment of certain conditions.

Submitted in: June 2008
Revised and accepted for publication in July 2008

REFERENCES

- CHEN, C. H.; HSIEH, C. H.; TSENG, Y. C.; HUANG, I. Y.; SHEN, Y. S.; CHEN, C. M. The use of miniplate osteosynthesis for skeletal anchorage. **Plast. Reconstr. Surg.**, Hagerstown, v. 120, no. 1, p. 232-235, 2007.
- CHEN, Y. J.; CHANG, H. H.; HUANG, C. Y.; HUNG, C. Y.; LAI, E. H. H.; YAO, C. C. J. A retrospective analysis of the failure rate of the three different orthodontic skeletal anchorage systems. **Clin. Oral Implants Res.**, Copenhagen, v. 18, no. 6, p. 768-775, 2007.
- CHENG, S. J.; TSENG, I. Y.; LEE, J. J.; KOK, S. H. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. **Int. J. Oral Maxillofac. Implants**, Lombard, v. 19, no. 1, p. 100-106, 2004.
- CHIN, M. Y. H.; SANDHAM, A.; VRIES, J.; VANDER MEI, H. C.; BUSSCHER, H. J. Biofilm formation on surface characterized micro-implants for skeletal anchorage in Orthodontics. **Biomaterials**, Oxford, v. 28, no. 11, p. 2032-2040, 2007.
- CHOI, B. H.; ZHU, S. J.; KIM, J. H. A clinical evaluation of titanium miniplates as anchors for orthodontic treatment. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 128, no. 3, p. 382-384, 2005.
- CHUNG, K. R.; KIM, S. H.; MO, S. S.; KOK, Y. A.; KANG, S. G. Severe class II division 1 malocclusion treated by orthodontic miniplate with tube. **Prog. Orthod.**, Berlin, v. 6, no. 2, p. 72-186, 2005.
- CHUNG, K. R.; KIM, Y. S.; LINTON, J. L.; LEE, Y. J. The miniplate with tube for skeletal anchorage. **J. Clin. Orthod.**, Boulder, v. 36, no. 7, p. 407-412, 2002.
- ERVERDI, N.; ASCAR, A. Zygomatic anchorage for en masse retraction in the treatment of severe Class II division 1. **Angle Orthod.**, Appleton, v. 75, no. 3, p. 483-490, 2005.
- ERVERDI, N.; KELES, A.; NANDA, R. The use of skeletal anchorage in open bite treatment: a cephalometric evaluation. **Angle Orthod.**, Appleton, v. 74, no. 3, p. 381-390, 2004.
- FABER, J. Ancoragem esquelética com miniplacas. In: LIMA FILHO, R. M. A.; BOLOGNESE, A. M. **Ortodontia: arte e ciência**. Maringá: Dental Press, 2007. p. 449-473.
- FABER, J.; BERTO, P. M.; ANCHIETA, M.; SALLES, F. Tratamento de mordida aberta anterior com ancoragem em miniplacas de titânio. **Rev. Dental Press Estét.**, Maringá, v. 1, n. 1, p. 87-100, 2004.
- FABER, J.; VELASQUE, F. Titanium miniplate as anchorage to close a premolar space by means of mesial movement of maxillary molars. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, 2008. No prelo.
- JENNER, J. D.; FITZPATRICK, B. N. Skeletal anchorage utilizing bone plates. **Aust. Orthod. J.**, Brisbane, v. 9, no. 2, p. 231-233, 1985.
- KURODA, S.; KATAYAMA, A.; TAKANO-YAMAMOTO, T. Severe anterior open bite case treated using titanium screw anchorage. **Angle Orthod.**, Appleton, v. 74, no. 4, p. 558-567, 2004.
- KURODA, S.; SUGAWARA, Y.; DEGUCHI, T.; KYUNG, H. M.; YAMAMOTO, T. T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 1, p. 9-15, 2007.
- KURODA, S.; YAMADA, K.; DEGUCHI, T.; HASHIMOTO, T.; KYUNG, H. M.; YAMAMOTO, T. T. Root proximity is a major factor for screw failure in orthodontic anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 131, no. 4, p. S68-S73, 2007. Supplement.
- LONDA, G. The anchorage quality of titanium microplates with short microscrews for orthodontic anchorage applications. **J. Orofac. Orthop.**, München, v. 66, p. 67-77, 2005.
- SHERWOOD, K.; BURSH, J. Skeletally based miniplates supported orthodontic anchorage. **J. Oral Maxillofac. Surg.**, Philadelphia, v. 63, no. 2, p. 279-284, 2005.
- SHERWOOD, K. H.; BURCH, J. G.; THOMPSON, W. J. Closing anterior open bites by intruding molars with titanium miniplate anchorage. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 122, no. 6, p. 593-600, 2002.
- SHERWOOD, K. H.; BURCH, J. G.; THOMPSON, W. J. Intrusion of supererupted molars with titanium miniplate anchorage. **Angle Orthod.**, Appleton, v. 73, no. 5, p. 597-601, 2003.
- SUGAWARA, J.; DAIMARUYA, T.; UMEMORI, M.; NAGASAKA, H.; TAKAHASHI, I.; KAWAMURA, H. et al. Distal movement of mandibular molars in adult patients with skeletal anchorage system. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 125, no. 2, p. 130-138, 2004.
- SUGAWARA, J.; KANZAKI, R.; TAKAHASHI, I.; NAGASAKA, H.; NANDA, R. Distal movement of maxillary molars in nongrowing patients with the skeletal anchorage system. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 129, no. 6, p. 723-733, 2006.
- SUGAWARA, J.; NISHIMURA, M. Minibone plates: the skeletal anchorage system. **Semin. Orthod.**, Philadelphia, v. 11, no. 1, p. 47-56, 2005.
- UMEMORI, M.; SUGAWARA, J.; MITANI, H.; NAGASAKA, H.; KAWAMURA, H. Skeletal anchorage system for open-bite correction. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 115, no. 2, p. 166-174, 1999.

Corresponding author

Jorge Faber
 SCN Brasília Shopping, SL 408
 CEP: 70.715-900 - Brasília/DF
 E-mail: jorgefaber@terra.com.br

- Dental Press Journal of Orthodontics publishes original scientific research, significant reviews, case reports, brief communications and other materials related to orthodontics and facial orthopedics.
- Dental Press Journal of Orthodontics uses the Publications Management System, an online system, for the submission and evaluation of manuscripts. To submit manuscripts please visit:
www.dentalpress.com.br/pubartigos.
- Please send all other correspondence to:
Dental Press Journal of Orthodontics
Av. Euclides da Cunha 1718, Zona 5
ZIP CODE: 87.015-180, Maringá/PR
Phone. (44) 3031-9818
E-mail: artigos@dentalpress.com.br
- The statements and opinions expressed by the author(s) do not necessarily reflect those of the editor(s) or publisher, who do not assume any responsibility for said statements and opinions. Neither the editor(s) nor the publisher guarantee or endorse any product or service advertised in this publication or any claims made by their respective manufacturers. Each reader must determine whether or not to act on the information contained in this publication. The Journal and its sponsors are not liable for any damage arising from the publication of erroneous information.
- To be submitted, all manuscripts must be original and not published or submitted for publication elsewhere. Manuscripts are assessed by the editor and consultants and are subject to editorial review. Authors must follow the guidelines below.
- **All articles must be written in English. However, Portuguese-speaking authors must also include a version in Portuguese.**

GUIDELINES FOR SUBMISSION OF MANUSCRIPTS

- Manuscripts must be submitted via www.dentalpress.com.br/pubartigos. Articles must be organized as described below.

1. Title Page

- Must comprise the title in English, an abstract and keywords.
- Information about the authors must be provided on a separate page, including authors' full names, academic degrees, institutional affiliations and administrative positions. Furthermore, the corresponding author's name, address, phone numbers and e-mail must be provided. This information is not made available to the reviewers.

2. Abstract

- Preference is given to structured abstracts in English with 250 words or less.
- The structured abstracts must contain the following sections: INTRODUCTION: outlining the objectives of the study; METHODS, describing how the study was conducted; RESULTS, describing the primary results, and CONCLUSIONS, reporting the authors' conclusions based on the results, as well as the clinical implications.
- Abstracts in English must be accompanied by 3 to 5 keywords, or descriptors, which must comply with MeSH.

3. Text

- The text must be organized in the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, References and Illustration legends.
- Texts must contain no more than 4,000 words, including captions, abstract and references.
- Illustrations and tables must be submitted in separate files (see below).
- Insert the legends of illustrations also in the text document to help with the article layout.

4. Illustrations

- Digital images must be in JPG or TIF, CMYK or grayscale, at least 7 cm wide and 300 dpi resolution.
- Images must be submitted in separate files.
- In the event that a given illustration has been published previously, the legend must give full credit to the original source.
- The author(s) must ascertain that all illustrations are cited in the text.

5. Graphs and cephalometric tracings

- Files containing the original versions of graphs and tracings must be submitted.

- It is not recommended that such graphs and tracings be submitted only in bitmap image format (not editable).
- Drawings may be improved or redesigned by the journal's production department at the discretion of the Editorial Board.

6. Tables

- Tables must be self-explanatory and should supplement, not duplicate the text.
- Must be numbered with Arabic numerals in the order they are mentioned in the text.
- A brief title must be provided for each table.
- In the event that a table has been published previously, a footnote must be included giving credit to the original source.
- Tables must be submitted as text files (Word or Excel, for example) and not in graphic format (non-editable image).

7. Copyright Assignment

- All manuscripts must be accompanied by the following written statement signed by all authors: "Once the article is published, the undersigned author(s) hereby assign(s) all copyright of the manuscript [insert article title here] to Dental Press International. The undersigned author(s) warrant(s) that this is an original article and that it does not infringe any copyright or other third-party proprietary rights, it is not under consideration for publication by another journal and has not been published previously, be it in print or electronically. I (we) hereby sign this statement and accept full responsibility for the publication of the aforesaid article."
- This copyright assignment document must be scanned or otherwise digitized and submitted through the website*, along with the article.

8. Ethics Committees

- Articles must, where appropriate, refer to opinions of the Ethics Committees.

9. References

- All articles cited in the text must appear in the reference list.
- All listed references must be cited in the text.
- For the convenience of readers, references must be cited in the text by their numbers only.
- References must be identified in the text by superscript Arabic numerals and numbered in the order they are mentioned in the text.
- Journal title abbreviations must comply with the standards of the "Index Medicus" and "Index to Dental Literature" publications.
- Authors are responsible for reference accuracy,

which must include all information necessary for their identification.

- References must be listed at the end of the text and conform to the Vancouver Standards (http://www.nlm.nih.gov/bsd/uniform_requirements.html).
- The limit of 30 references must not be exceeded.
- The following examples should be used:

Articles with one to six authors

Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. *J Clin Periodontol*. 1999 Mar;26(3):153-7.

Articles with more than six authors

De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. *J Dent Res*. 2005 Feb;84(2):118-32.

Book chapter

Kina S. Preparos dentários com finalidade protética. In: Kina S, Brugnera A. *Invisível: restaurações estéticas cerâmicas*. Maringá: Dental Press; 2007. cap. 6, p. 223-301.

Book chapter with editor

Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2ª ed. Wiecezorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper

Beltrami LER. Braquetes com sulcos retentivos na base, colados clinicamente e removidos em laboratórios por testes de tração, cisalhamento e torção. [dissertação]. Bauru: Universidade de São Paulo; 1990.

Digital format

Câmara CALP da. Estética em Ortodontia: Diagramas de Referências Estéticas Dentárias (DRED) e Faciais (DREF). *Rev Dental Press Ortod Ortop Facial*. 2006 nov-dez;11(6):130-56. [Acesso 12 jun 2008]. Disponível em: www.scielo.br/pdf/dpress/v11n6/a15v11n6.pdf.

* www.dentalpress.com.br/pubartigos

1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (<http://www.who.int/ictrp/network/en/index.html>), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical

trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and <http://isrctn.org> (International Standard Randomized Controlled Trial Number Register (ISRCTN)). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
- Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;
- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

3. Dental Press Journal of Orthodontics - Statement and Notice

DENTAL PRESS JOURNAL OF ORTHODONTICS endorses the policies for clinical trial registration enforced by the World Health Organization - WHO (<http://www.who.int/ictrp/en/>) and the International Committee of Medical Journal Editors - ICMJE (# <http://www.wame.org/wamestmt.htm#trialreg> and http://www.icmje.org/clin_trialup.htm), recognizing the importance of these initiatives for the registration and international dissemination of information on international clinical trials on an open access basis. Thus, following the guidelines laid down by BIREME / PAHO / WHO for indexing journals in LILACS and SciELO, DENTAL PRESS JOURNAL OF ORTHODONTICS will only accept for publication articles on clinical research that have received an identification number from one of the Clinical Trial Registers, validated according to the criteria established by WHO and ICMJE, whose addresses are available at the ICMJE website <http://www.icmje.org/faq.pdf>. The identification number must be informed at the end of the abstract.

Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

Jorge Faber, DDS, MS, PhD
 Editor-in-Chief of Dental Press Journal of Orthodontics
 ISSN 2176-9451
 E-mail: faber@dentalpress.com.br

Clarity™ SL Self-Ligating Ceramic Brackets

Clarity™ SL Self-Ligating Appliance System



Uncompromising
Results with
Aesthetic Self-Ligation



CRC Centro di Riferimento contro Consumatori
CRC 3M Unitek: 0800-0153131
www.3munitek.com.be
e-mail: faleconaco@mmunitek.com

3M Unitek

from the 3M Health Care family
2009 3M, Unitek e il logo sono marchi
di 3M Unitek

3M Unitek

Roth Max

A new line of brackets sized to attend the orthodontic demand.

- Comfort patients
- Bases adaptation
- Accuracy measures
- High performance in collages



kit Max
with 1 case



Morelli adopts the concept of 3R's from the social responsibility for the rational residues use, before the world-wide necessity of preservation of natural resources not renewed.



3R

Reduce: the quantity of produce material
Reuse: the package more than one time
Recycle: the things that you do not use

Max Social responsibility:

The new packages of Morelli products attend the 3R's concept.

Reduce: More products using less packages.

Reuse: The Max packages are reusable for Elastomerics and many accessories, besides the brackets.

Recycle: The materials used in the Max packages are totally recycles.



kit Max
with 5 cases

(10% economy)

Max economy

...with social responsibility:

Available in more than 20 countries or through the Morelli Sales Dpt.
☎ 0800 121455 / 0800 7031455 - www.morelli.com.br

MORELLI
ORTODONTIA
www.morelli.com.br