

Dental Press Journal of
ORTHODONTICS

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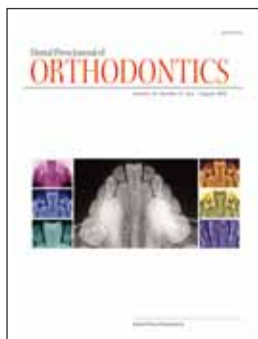
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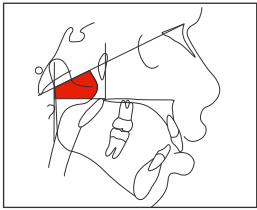
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VARIABLES	DIFTP3-2	PTFP3-2	DIFPAR3-2	PPAR3-2
DIFTP1-2	R = 0.0030 p = 0.959			
PTFP1-2		R = 0.1830 p = 0.165		
DIFPAR1-2			R = 0.0030 p = 0.488	
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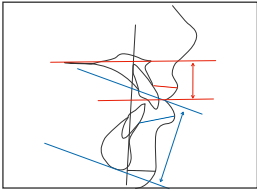
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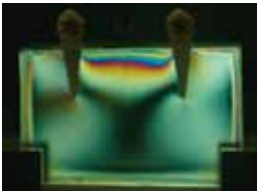
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Malocclusions	Number	%
Normal occlusion	244	33
Class I	274	37.3
Class II	210	28.6
Class III	6	0.8
Total	734	100

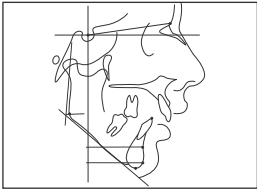
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Innovation needs to be stimulated in Brazil by means of patent applications

The ability to innovate and develop new products and services is a touchstone to gauge a nation's entrepreneurial spirit. Entrepreneurship means creating exchange value for a nation, often through technology development. Hence, developing technology—as measured by the number of patent application submissions—should be a top priority in Brazil.

Although technology and science are discrete subjects, they are so intricately entwined that they are aptly under the jurisdiction of the Brazilian Ministry of Science and Technology. The achievements attained by this Ministry over the years has paid handsome dividends. (Incidentally, it was established in 1985 to fulfill a commitment by then President Tancredo Neves towards the Brazilian scientific community). Our scientific output has grown dramatically. In dentistry, for example, Brazil ranks 4th in worldwide scientific production. Today it is often more convenient for a foreign dentist to pursue their studies in Brazil than the other way around, given the number of outstanding graduate programs available throughout the country.

However, there seems to be a split between the production of science and the production of technology in Brazil. Our number of patent applications is still negligible when compared with developed countries. Our history is partly to blame for this discrepancy. Our agricultural vocation was foreshadowed by Portuguese explorer Pero Vaz de Caminha's letter, in his first description of the New World, where he stated that "... the land is so fertile that anything can be grown on it...". As a result, when Brazilian companies were confronted with the challenges of globalization and free markets, they were unable to prove their mettle and innovative spirit in the face of highly competitive products and production processes. Their immediate alternative was to further the incorporation of foreign technology, thereby increasing the share of non-national components in Brazilian manufactured products and rendering patents virtually unnecessary.

The Brazilian academic community had to grapple with this dearth of technological entrepreneurship by lopsidedly prioritizing scientific production. The nature of the energy

expended in scientific production was cleverly explained by Thomas Kuhn,¹ who believed that the results achieved by normal science are significant since they help to enhance the accuracy and scope that can be applied by current knowledge—or paradigm. Most often, however, science is not engaged in shifting paradigms or giving rise to innovations, changes in behavior or thinking. Scientific attention is not focused on technological innovation.

We can address this issue in more pragmatic fashion by visiting the website of the Brazilian National Institute of Intellectual Property (www.inpi.gov.br). When you query the patent records using the word 'orthodontics' in the search field, only 16 files pop up. The first dates back to 1977 and the last one to 2005. This is the same number of files found with the same parameters in the U.S. Patent & Trademark Office (appft1.uspto.gov/netahtml/PTO/search-bool.html) within the 35 days that preceded the writing of this editorial. Using the same keyword, thirty-five days in the U.S. are equivalent to 28 years in Brazil. And let us not forget that nowadays orthodontics is a scientific area in which Brazil plays a leading role.

This scenario calls for improvement. We are hard-pressed to foster the development of national technology through educational and industrial policies. It is a fact that many Brazilian universities encourage and support the filing of patents, and additional measures are currently under way. Nevertheless, greater emphasis should be placed on this issue. One viable option would be to trade program completion projects—monographs, theses and dissertations—for patents. Such projects are invaluable assets in the CVs of researchers, and graduate course coordinators are expected to act accordingly.

Go ahead and innovate!

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

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ERRATUM: The article disclosed on issue v. 15, no. 2, p. 82-86, Mar./Apr. 2010, by Vanessa Nínia Correia Lima, Maria Elisa Rodrigues Coimbra, Carla D'Agostini Derech and Antônio Carlos de Oliveira Ruellas, was published under the wrong title. The correct form is "Frictional forces in stainless steel and plastic brackets using four types of ligation".

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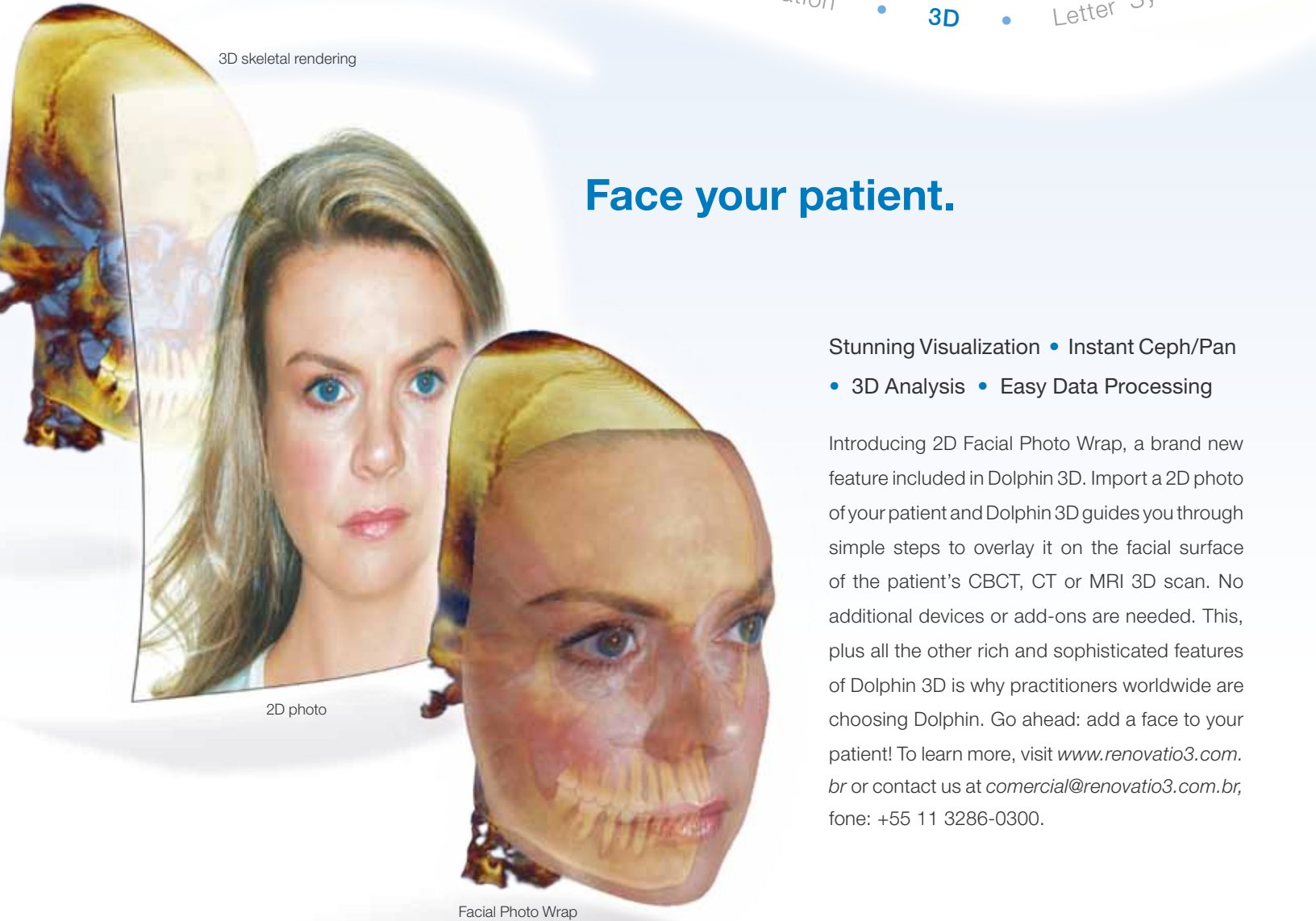


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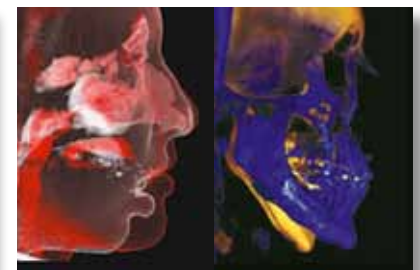
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Dental Press Journal of Orthodontics arrives in the "Old World"

The assistant editor of the Dental Press Journal of Orthodontics (DPJO), Flavia Artese, and Dr. Maria Elisa Coimbra, also an orthodontist, attended the 86th Congress of the European Orthodontic Society, held in the city of Portoroz, Slovenia from June 15th through 19th, 2010, where they introduced the new

version of the Journal, now officially published in English. Copies were distributed to internationally renowned orthodontists and professors with a view to encouraging professionals from other countries to submit their articles. The new DPJO aroused considerable interest and drew numerous accolades.



Dr. Juri Kurol, from Stockholm, Sweden, and Dr. Maria Elisa Coimbra.



Dr. Flavia Artese and Dr. Peter Ngan, from West Virginia, USA.



Professor Birte Melsen, from the University of Aarhus, Denmark.



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Perception of dentofacial deformities: From psychological well-being to surgery indication

Jorge Faber*, Ana Paula Megale Hecksher Faber**

Patient perceptions of orthognathic surgery treatment, well-being, psychological and psychiatric status: a systematic review

Clinicians who attend to patients with dentofacial deformities often comment on the grief experienced by these patients due to their deformity. A recurring theme in this area is whether or not, and to what extent, we can help those undergoing treatment to have a better quality of life. With the purpose of better understanding this issue, Finnish authors conducted a systematic review of studies on the psychological well-being of orthodontic-surgical patients.¹ They evaluated articles published in English between 2001 and 2009 on the PubMed, PsycInfo and Web of Science databases. The review was performed by two investigators who excluded publications that focused on methodological issues, cleft or syndromic patients, surgically assisted maxillary expansion or intermaxillary block. References to all review papers were searched manually with a view to retrieving new articles to support the study. Thirty-five articles met the selection criteria and were included in the review. The main reasons for seeking treatment were linked to improvements in self-confidence, appearance and oral function. After treatment patients reported improvement in their well-being, although such finding departed from current methods used to assess this issue. Changes in well-being were generally identified by study designs developed to analyze the impact of oral health on quality of life, such as quality of life questionnaires related to orthognathic surgery,

and impact on oral health. The major conclusion was that, in general, patients do not experience psychiatric problems related to dentofacial deformity. Certain patient subgroups, however, may experience conditions such as anxiety or depression. One key hurdle in the analysis of these patients stems from the fact that most studies compare the means of patient groups with control subjects and/or population standards. In other words, no stratification or covariate analysis is allowed to influence the outcome of the sampled variables. This is fertile ground for new studies, particularly prospective studies that address daily mood swings and changes in well-being.

Class II and Class III surgical patients are less happy about their facial and dental appearance than control subjects

It is commonly accepted that the main benefits of orthognathic surgery are psychosocial in nature and that most patients who seek treatment do so because of their dissatisfaction with dentofacial aesthetics. A relatively small number of studies have examined the perception of facial attractiveness among orthognathic surgery patients. To fill this gap, an Irish study assessed whether or not the self-perceived dental and facial attractiveness of patients requiring orthognathic surgery differed from that of control subjects.²

Satisfaction with facial and dental appearance was assessed through questionnaires, which were completed by 162 patients in need of orthodontic-surgical treatment and 157 control patients.

* Editor-in-Chief, Dental Press Journal of Orthodontics. PhD in Biology – Morphology, Electronic Microscopy Laboratory, University of Brasília (UnB). MSc in Orthodontics and Dentofacial Orthopedics, Federal University of Rio de Janeiro (UFRJ).

** Physician, Psychiatrist, MSc in Health Sciences - Sleep Medicine - private psychiatric practice in Brasília, Brazil.

Variables were obtained from visual analogue scales, binary and open-ended responses. The data were analyzed by different statistical methods. The orthognathic surgery patients, especially Class II patients, were less happy with their teeth and face than control subjects. Among orthognathic surgery patients, Class III patients and women were in general more likely to have taken a critical look at their face in profile. A higher proportion of Class II, rather than Class III patients, would like to change their appearance and the older the subject—even among control patients—the more dissatisfied they were with their facial appearance.

These data are important for understanding patients' perceptions of their own problem. This is particularly relevant in view of the growing concern to provide treatments that focus on patients' wishes. There is still much ground to be covered by researchers wishing to examine the physical discomfort and psychological suffering of those who undergo orthodontic preparation for surgery.

The perceived need for orthognathic surgery treatment varies according to the anteroposterior position of the mandible

An exciting study was conducted by Brazilian researchers to investigate the possible association between the anteroposterior position of the mandible and the perceived need of orthognathic surgery by orthodontists, maxillofacial surgeons, artists, and laypeople.³ To this end, four photographs of adults of both genders, two Afro-descendants and two Caucasians, were digitally altered. The changes applied to each photograph produced seven photos: a straight profile, three increasing degrees of mandibular retrusion and three increasing degrees of mandibular protrusion. The 28 photographs were then analyzed by a panel of evaluators, who were asked to decide which side would require orthognathic surgery to make the profile more attractive, and if they themselves would seek surgery if the profile of that given face were their own. The results showed that the

greater the discrepancy—regardless of Class II or Class III correction—the greater the tendency of all evaluators to indicate surgery and manifest themselves more likely to operate if that was their profile. Moreover, the faces of Class III women were more indicated for surgery than those of Class II. Furthermore, Class II men received more indications for surgery than Class III ones. When the evaluators were asked to answer whether or not they would perform surgery if that was their own profile, women's photographs yielded more positive responses than men's. This may reflect a well-known higher prevalence of women among patients seeking orthognathic surgery.

When the evaluator factor was analyzed, laypeople were less likely and maxillofacial surgeons more likely to indicate surgery than other groups. A particularly interesting result is that examiners generally exhibited a significant difference between the indications for facial surgery—whether or not the profiles were theirs. When the profiles belonged hypothetically to evaluators, they were less likely to indicate surgery than if the profiles belonged to some other person. No significant difference was found between the indications for surgery of Afro-descendants and Caucasians.

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Orthodontic traction: Possible consequences for maxillary canines and adjacent teeth

Part 1: Root resorption in lateral incisors and premolars

Alberto Consolaro*

Some professionals are reluctant to indicate orthodontic traction, especially for upper canines. Among the most common reasons for restricting the indication of orthodontic traction are:

- 1) Root resorption in lateral incisors and premolars.
- 2) External cervical resorption of the canines under traction.
- 3) Alveolodental ankylosis of the canine(s) involved in the process.
- 4) Calcific metamorphosis of the pulp and aseptic pulp necrosis.

These conditions do not result primarily and specifically from orthodontic traction, and can be avoided if certain technical precautions are followed. For a better understanding of what these technical precautions are and how they work preventively against the possible consequences of orthodontic traction, we need a biological foundation. This is the goal of this series of studies on orthodontic traction, especially of upper canines, and its possible consequences.

Development, structure and functions of the dental follicle

The dental follicle occupies the radiolucent space around the crowns of unerupted teeth (Figs 1 and 2). It is firmly attached to the surface of the crown by the reduced epithelium of the enamel organ (Fig 3). This thin and delicate epithelial component is sustained and nourished by a thick layer of connective tissue with a variable density of collagen, sometimes loosely, sometimes even hyalinized. The outer portion of dental follicles binds to the surrounding bone (Figs 2 and 3). In measurements of the pericoronal space in periapical radiographs and orthopantomographs, or panoramic radiographs, the thickness of the dental follicle can reach up to 5.6 mm and still maintain normal structure and organization^{2,4} (Fig 3).

By removing the follicle and detaching it from the surrounding bone a tissue fragment is obtained which is organized like a thin film and is therefore also known as pericoronal membrane. The isolated tissue fragment represented

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FIGURE 1 - Typical image of the pericoronal space and normal follicle: homogeneous radiolucency with no overlapping radiopaque or radiolucent points; clear bone limit with solid, uniform line (arrows); uniform thickness, regular contour with maximum thickness ranging between 1 and 5.6 mm.²⁴

by the dental follicle has the appearance of a sack containing the dental crown and is thus also called pericoronal pouch.

In the middle of the collagen fibers and other components of the extracellular matrix of follicular connective tissue there are islands and cords of epithelial cells, remnants of the dental lamina (Fig 3), whose number varies according to patient age.²

Gubernacular cord development

The dental lamina gives rise to tooth germs in the deepest parts of what will become the

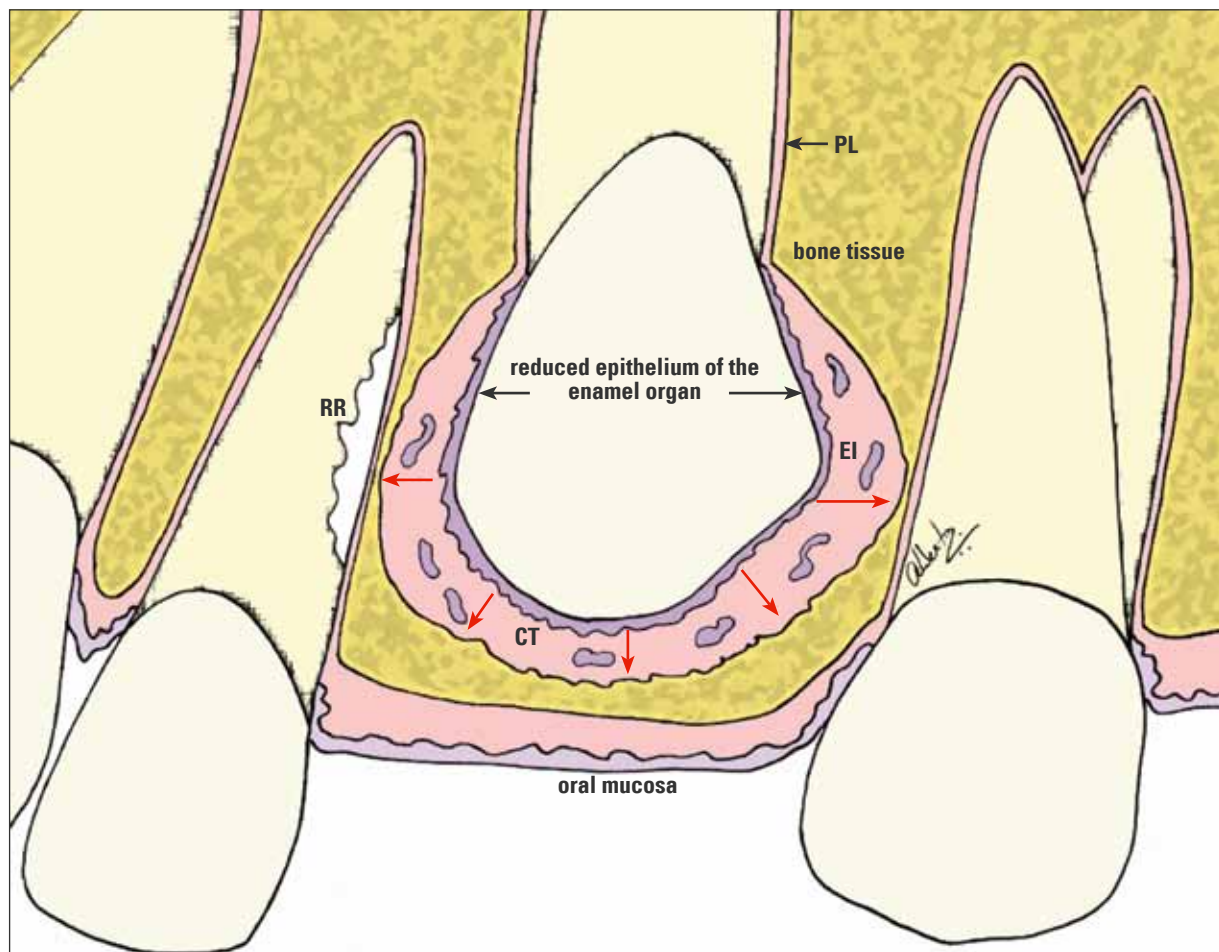


FIGURE 2 - Epithelial structures of the dental follicle—such as the reduced epithelium of the enamel organ and the epithelial islands/cords remnants of the dental lamina (EI)—constantly release epidermal growth factor (EGF, red arrows) in the connective tissue (CT). This mediator, along with other EGF-activated mediators, induces pericoronal bone resorption, an essential phenomenon in the occurrence of tooth eruption. When the path of an unerupted tooth compresses the vessels of the periodontal ligament (PL) of adjacent teeth—with or without orthodontic traction—cementoblasts die on the spot and the root is resorbed (RR) to give rise to the follicle and its moving crown.

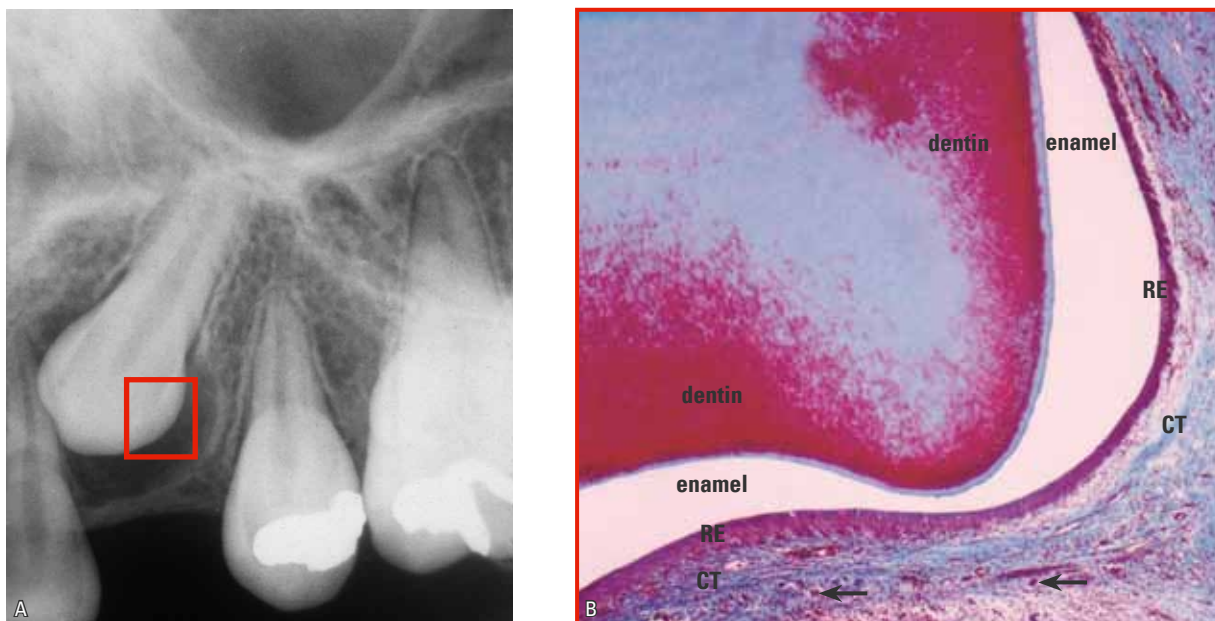


FIGURE 3 - The pericoronal space and dental follicle of upper canines are more laterally bulging due to the coronary anatomy, as shown in **A**. The reduced epithelium of the enamel organ (RE) is firmly adhered to the enamel of unerupted teeth, while the epithelial islands remnants of the dental lamina and gubernaculum cord (arrows) are distributed across the connective tissue (CT) of the dental follicle.

future mandible or maxilla. Soon thereafter, it is fragmented by apoptosis, but some of these cells persist on a scheduled basis. The remnants of dental lamina cells are organized in the form of islands and epithelial cords forming a veritable single row that rises from the reduced epithelium of the enamel organ toward the oral mucosa. This epithelial cord is called the gubernaculum dentis, or gubernaculum cord.

Once the tooth germs have become established and the dental lamina has undergone fragmentation, the neighboring mesenchyme gives rise to bone tissue. The tooth germs and the cord of epithelial islands remain unscathed as bone forms around them into the alveolar crypt. Around the gubernaculum cords, a delicate bony canal develops, called the gubernaculum canal.

The function of the gubernaculum canal and cord lies in directing the tooth—once the crown is fully developed—toward the occlusal-most region of the alveolar process. As the tooth erupts towards the mucosa, the dental follicle will incorporate the islands and cords of the epithelial

cells of the gubernaculum cord into its connective tissue, while increasing the presence of its epithelial component in this region (Fig 3).

Development of the alveolar crypts and gubernaculum canal

The epithelial cells need to be in constant proliferation and synthesis given their constant desquamation in skin and mucosal linings and also because of its intense production of secretions such as milk, saliva and tears. This constant proliferation stimulus is provided by individual epithelial cells, which release to their neighbors—via specific receptors—what is called the Epidermal Growth Factor (EGF) mediator. Although bone cells have EGF receptors, in these cells EGF stimulates bone resorption. Other mediators have their action triggered by EGF (Fig 1), such as TGF-beta, which stimulates the formation of clasts, and CSF-1 and IL-1, which recruit their precursors.

The bone tissue is maintained at a distance from the epithelial tissues because the released EGF stimulates bone resorption, as occurs in the

case of the epithelial rests of Malassez, which maintain the periodontal space without allowing the bone to reach the surface of the tooth root.³

When bone is formed by the mesenchyme, the tooth germs are circumscribed. The alveolar crypts and the gubernacular canal are simultaneously established, since the tooth germs and gubernacular islands and cords are epithelial tissues that release EGF, which constantly stimulates bone resorption in the neighboring tissues.

The foregoing explanation allows us to assert that:

1. The follicle is an epithelial component comprised of (a) the reduced epithelium of the enamel organ, firmly adhered to the crown, and (b) the cords and islands of odontogenic cells derived from the dental lamina (Figs 2 and 3).
2. The connective tissue comprises the largest volume of follicles and, outside the pericoronal space, it takes on the form of a membrane and/or pouch.
3. The epithelial component continuously releases EGF and thus preserves the pericoronal space by stimulating bone resorption and thus keeping the bone away from the enamel (Fig 2).
4. The cascading release of EGF and other mediators is essential for the mechanism of tooth eruption. The forces derived from the development of teeth and growth vectors stimulate increased secretion of EGF and promote bone resorption, directing tooth eruption in the occlusal direction (Fig 2).

When a tooth root is experimentally removed¹ but the crown and dental follicle are preserved, the tooth will erupt normally. Likewise, the tooth will erupt when the crown is removed and the dental follicle and tooth root are left in its place. When metal or silicone replicas replace unerupted teeth but the follicle is preserved, the artificial teeth or replicas will still erupt. The dental follicle is an essential and

fundamental structure of tooth eruption, although for decades the tooth root was believed to be the essential structure in this process.

Criteria for evaluating pericoronal space images: image, thickness, contour and boundaries

The image of the pericoronal space (Figs 1, 3, 4 and 7) should:

- (a) Be homogeneously radiolucent, devoid of radiopaque points or radiolucent micro lodge type areas, as these may denote a source of odontogenic tumors.
- (b) Have its boundaries with the adjacent bone defined by a uniform and continuous radiopaque line. If this line is discontinued and/or riddled with images that resemble the gnawing of a mouse, it may represent a source of odontogenic cysts and tumors.
- (c) Have its contour characterized by uniform pericoronal space thickness, positioned symmetrically to the dental crown. When some areas grow thicker than others, in the form of embroidery and wavy contours, this may characterize a source of odontogenic cysts and tumors.
- (d) Have a thickness ranging from 1 mm to less than 5.6 mm.^{2,4} Beyond these limits, one should suspect the presence of a dentigerous cyst or some other follicular disease.

In assessing the image of the pericoronal space, one should note that:

1) Diseases derived from the dental follicle can go unnoticed and may be present even when the pericoronal space displays normal apparent thickness.

2) Changes derived from the dental follicle take place only occasionally, and are percentage-wise very rare, considering the frequency of unerupted teeth in patients.

The concept of pericoronal folliculopathies

Any disease that originates from or is located exclusively in the structures of the dental

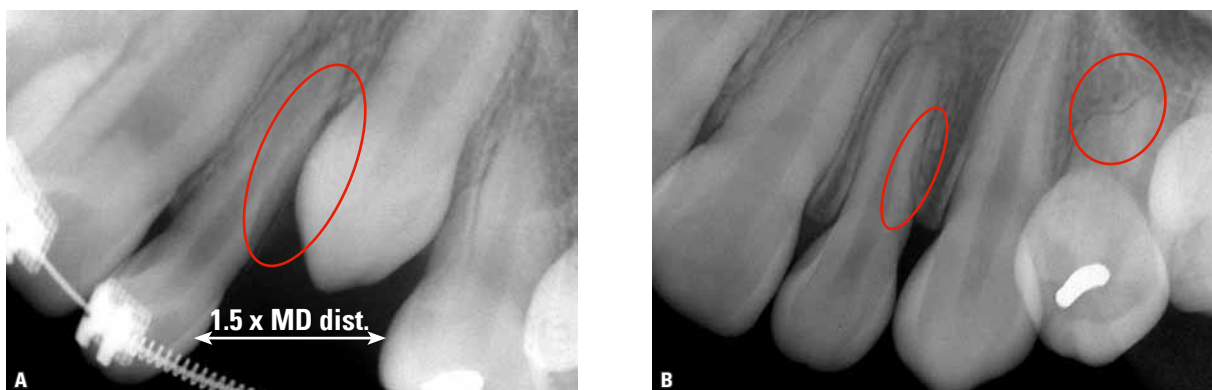


FIGURE 4 - Example of unerupted maxillary canine that did not reach the occlusal plane (A). Once the space in the dental arch reached 1.5 times the mesiodistal distance of the crown—to accommodate the bulging dental follicle typical of the maxillary canine—the tooth moved naturally to its place in the dental arch (B). But the existing proximity of the upper canine and its dental follicle caused lateral resorption (circles) in the roots of the lateral incisor and first premolar.

follicle can be termed pericoronal folliculopathy, namely:

- Acute and chronic pericoronaritis.
- Paradental cyst.
- Inflammatory follicular cyst.
- Dentigerous cyst (Fig 7).
- Eruption cyst.
- Hyperplastic dental follicle.

However, many other odontogenic cysts and tumors also originate from the dental follicle but are not exclusive to that structure or location. Odontogenic keratocysts, ameloblastomas, odontogenic fibroma, odontoma, etc. also originate from the dental follicle.

Pericoronal space of unerupted teeth and root resorption of adjacent teeth

The dental follicle is rich in mediators that stimulate bone resorption locally, especially EGF (Fig 2). When maxillary growth vectors and eruptive forces bring the crown of an unerupted tooth close to the root of an erupted tooth, there occur the compression of periodontal vessels and the death of cementoblasts that cover the surface, protecting it from resorption (Figs 5 and 6). Thus, the root surface will be exposed and the amount of local resorption

mediators will be increased, thereby stimulating the organization and function of bone modeling units (BMUs) (Fig 2).

From the standpoint of imaging, if an unerupted tooth is located very close to the root of another tooth and if the former's trajectory is active due to the eruption and the presence of growth vectors, resorption is usually induced (Figs 2, 4, 5 and 6). This scenario is very often found in the relationship between the region of the canines and the upper lateral incisors (Figs 4, 5 and 6), as well as between third molars and the distal surface of second molars.

Extraction of the unerupted tooth triggers process regression and re-covering of the resorbed area by new cementoblasts, with deposition of a new layer of cementoblasts and reattachment of periodontal fibers. This behavior often occurs with the lower third and second molars. Such occurrence will only take place if the environment is not contaminated by bacteria.

In cases of upper canines, orthodontic and/or orthopedic appliances redirect the eruptive path and/or also the growth vectors involved. Root resorption will cease in neighboring teeth, whereas the surface will be repaired by new cementoblasts and renewed cementum



FIGURE 5 - In some cases, detection of the resorption caused by unerupted teeth—including maxillary canines—in adjacent teeth only occurs when it is already too late, as was the case of this upper lateral incisor. But sometimes, it can also involve the central incisors.



FIGURE 6 - Regardless of the region related to the proximity of the dental follicle of unerupted teeth, root resorption may occur provided that there is compression of periodontal vessels and death of cementoblasts. A comparison between right and left sides shows that the apical resorption is linked to the unerupted canine and not to the orthodontic movement. By moving an unerupted canine through orthodontic traction, whenever possible, the dental follicle is also moved away, which is usually sufficient to stop root resorption and repair the surface.

formation (Fig 4). This situation is often found in the relationship of canines with the upper lateral incisors.

A conduct that must necessarily be adopted to avert the resorption of teeth adjacent to the unerupted tooth—when such unerupted tooth is not being extracted but rather retracted orthodontically—lies in increasing dental arch space so that the unerupted tooth lodges in the area along with its crown and especially its follicle. The opening of space eliminates compression of the periodontal ligament of adjacent teeth while cementoblasts and cementum re-cover the roots of these teeth (Figs 4 and 6). Thus, the dental follicle of the erupted tooth remains farther away from the root surface so that its mediators no longer act as stimulators of resorption. Instead, they only stimulate pericoronal bone resorption to allow eruption to occur in the desired path.

Size, thickness and shape of follicles in maxillary canines compared with other teeth

The thickness and shape of follicles allow their pericoronal spaces to have a more or less uniform contour of the incisal and occlusal surfaces with their cusps (Fig 1). However, the unique shape of upper canines—with their rather convex lateral surfaces forming a cusp, as it were, at their incisal edge, which ends in an acute angle—provides a very specific pericoronal space shape (Fig 3).

The dental follicle of maxillary canines appears to bulge and widen laterally, more so than the other teeth (Figs 3 and 6). Radiographic images and Computed Tomography (CT) scans clearly show that the lateral thickness of the pericoronal spaces of upper canines is greater than in other teeth, especially if compared with incisors, and even with premolars.

The dental follicle of the upper canines and their resulting pericoronal spaces are so bulging



FIGURE 7 - The image of the pericoronal space of the maxillary canine reveals that the criteria adopted for classifying a follicle as normal no longer apply. From a strictly radiographic point of view, the image is not homogeneously radiolucent and its contour and thickness are not uniform, suggesting that it is actually a dentigerous cyst in its early development phase. This scenario does not preclude the use of orthodontic traction, if necessary.

in some cases that added to all the probable image distortion, deciding between a diagnosis of normality or incipient dentigerous cyst poses a challenge (Figs 3, 6 and 7).

In assessing the need to whether or not open the space between upper lateral incisors and premolars to allow upper canines to naturally lodge in the upper arch, this lateral bulging of their pericoronal space should be considered.

This consideration should be emphasized because the dental follicle does not represent only a soft tissue that covers the crown and could be easily compressed under traction, but rather

because it is the tissue or organ responsible for tooth eruption. Thanks to its large number of mediators, the dental follicle stimulates pericoronal bone resorption, actively producing tooth movement in the occlusal direction (Figs 2, 3 and 4).

The follicle is composed of soft tissues and although it can be physically compressed between the canine crown and the roots of the lateral incisors and premolars, this maneuver during traction may impose a biological cost. Resorption of these lateral roots cause, to a lesser or greater degree, structural impairment (Fig 4). Compression of the dental follicle of maxillary canines occurs in conjunction with compression of vessels of the periodontal ligament of adjacent teeth and eventual death of cementoblasts that protect those roots from clasts and other BMU components.

In following the clinical guidelines to determine how much space must be provided to enable unerupted upper canine traction, professionals are encouraged to calculate the mesiodistal distance of the crown and multiply that measurement by 1.5. This action will ensure greater integrity of the lateral roots of adjacent teeth (Fig 4).

One should be aware, however, that creating this space is not clinically possible in all cases. Using any measurement lower than the one aforementioned may result in highly successful traction, with no damage to lateral incisors and premolars, but the risks are greater. The exactness of mathematics cannot always be systematically applied in making biological decisions. The recommended criterion and measurement serve as a starting point for decision making relevant to each case. In cases where it can be applied fully, assurance regarding the preservation of neighboring roots will certainly increase.

In assessing the damage caused by root resorption in maxillary lateral incisors due to the proximity of unerupted canines, it seems appropriate to cite the literature.^{5,6} The presence

of root resorption was found in the periapical radiographs of 3,000 patients between 10 and 15 years of age.⁵ In fact, 12.5% of their lateral incisors were located close to canines that had remained unerupted for longer than normal. The same cases were evaluated using tomographic sections and reconstructions, and disclosed 25% impairment. CT is the best method to accurately assess the damage caused by canine traction to the roots of upper lateral incisors.

Dental follicle development and functions

In its early stages, the enamel organ resembles a bell and is lined by what are known as the inner and outer epithelia. Between these epithelia there are two other thicker layers of epithelial cells, which are known as stellate reticulum and intermediate stratum. As the enamel organ forms this mineralized tissue on the inside of the bell, it becomes narrower or thinner and the four epithelial layers will flatten to form a single epithelium that is firmly adhered to the enamel surface and receives the name of reduced epithelium of the enamel organ (Figs 2 and 3).

The reduced epithelium of the enamel organ and, as a result, the dental follicle, have the following main functions:

- a) "Hide" or protect enamel resorption by clastic cells (Fig 3).
- b) Prevent the bone from developing directly on the enamel surface.
- c) Support tooth eruption by releasing mediators that are typical of epithelia, such as EGF. The reduced epithelium of the enamel organ and odontogenic epithelial islands and cords are actively involved in pericoronal bone resorption, essential if tooth eruption is to follow a path that leads to the alveolar mucosal surface, thanks to the release of EGF (Fig 2).
- d) Constitute the primary junctional epithelium by merging with the oral mucosa, and allow teeth to erupt in the oral environment without exposing the internal environment of the body,

represented by the gingival connective tissue, to the highly contaminated oral environment.

Final considerations

Root resorption of upper lateral incisors and premolars (Figs 4, 5 and 6) is among the possible consequences of unerupted upper canine traction. In planning treatment of unerupted canines, one is advised to assess the thickness of the dental follicle, bearing it in mind when creating space to accommodate it in the dental arch. The aim here is to seek either normal canine eruption or orthodontic traction of said teeth. The lateral compression of the dental follicle during eruption—with or without canine traction—against the roots of the lateral incisors and/or premolars may cause these teeth to resorb, as a result of the compression of periodontal vessels and the death of cementoblasts.

In planning the space to be obtained in the dental arch to ensure that the unerupted tooth fits properly, it must be assumed that the dental follicle of maxillary canines—given their unique anatomy—tend to bulge and broaden laterally, more than any other teeth.

The amount of space in the dental arch that would offer the least risk of root resorption for adjacent teeth during orthodontic traction is equivalent to 1.5 times the mesiodistal distance of upper canines, although this measure is not always amenable to application in all clinical cases.

In forthcoming studies, we will discuss the other possible consequences of orthodontic traction of unerupted teeth, especially canines, among which the following are noteworthy: (1) External cervical resorption in canines under traction, (2) Alveolodental ankylosis of canines, (3) Calcific metamorphosis of the dental pulp and aseptic pulp necrosis.

This approach is aimed at preventing the possible consequences of orthodontic traction, which could be entirely avoided if certain technical precautions are adopted.

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An interview with

Anibal M. Silveira Jr.

- Graduated in Dentistry - Universidade Federal do Rio Grande do Norte (UFRN), 1972-77.
- Fellow - Pediatric Dentistry - Project HOPE – Natal, Brazil, 1977-78.
- Specialist in Pediatric Dentistry - Eastman Dental Center, University of Rochester; Rochester, New York, 1978-80.
- Specialist in Orthodontics - Eastman Dental Center, University of Rochester; Rochester, New York, 1981-83.
- Fellow in the Temporomandibular Joint Program, Eastman Dental Center, University of Rochester; Rochester, New York, 1983-85.
- Clinical Instructor - Orthodontic Department, Eastman Dental Center, NY, 1983-88.
- Chairman and Assistant Professor - Orthodontic Department, University of Colorado, Denver, 1988-91.
- Research Director and Associate Professor - University of Louisville Dental School (ULSD), KY. Orthodontic Program Director, ULSD Department of Orthodontic, Pediatric and Geriatric Dentistry - 1993-2007.
- Professor and Chairman - Department of Orthodontic, Pediatric and Geriatric Dentistry, University of Louisville School of Dentistry (ULSD).
- 45 Peer review publications (Scientific Articles and Abstracts).
- 5 Textbook Chapters on Orthodontic Topics. Recipient of 16 Grants from Federal, State and Other Educational Institutions or Dental Organizations as Principle Investigator or Co-Investigator.
- Supervised, as primary mentor, training of over 50 postdoctoral Master of Science Degrees in Oral Biology and Orthodontics.
- Recipient of “The Chancellor’s Award for Teaching Excellence”, the highest teaching award given by the University of Colorado Health Sciences Center - 1991.
- Recipient of the “University of Louisville Distinguished Teaching Professor Award”, the highest teaching award given by the University of Louisville - 1996.
- Nominated as the Vice President, NU Chapter Omicron Kappa Upsilon in 2004, and elected President, NU Chapter Omicron Kappa Upsilon in 2005.



Anibal Silveira has been an inspiration for an entire generation of American and Brazilian orthodontists. He is a genuine Brazilian who has won a position of professional respect as an orthodontic educator in the United States. It would be redundant to mention his many achievements in education in orthodontics, however, with all his experience and knowledge, humbleness in the face of these achievements, is his main personal trait. He is an excellent leader and motivator for his students, as well as a tireless researcher in the areas of growth and development, temporary anchorage devices, computed tomography, cone beam 3D and new teaching techniques in orthodontics. Dr. Silveira is the perfect example of how work dignifies a man.

Dr. Silveira has been married for 35 years to Cheryl Markle Silveira and has two sons; Bryan M. Silveira (27 years old) and Derek M. Silveira (23 years old). Dr. Silveira travels to Brazil as often as he can to visit his parents Anibal Mota da Silveira and Maria Teresinha Couto da Silveira, and his two brothers and three sisters who still living in Natal, Brazil.

Readers, in the following pages, will have the opportunity to know a little more about one of the giants of orthodontics in North America, and why not to say, of the world.

José A. Bósio

Our college times are unforgettable. Can you tell us where did you attend dental school and what remembrances do you have from that time? José Bósio

I was very fortunate to attend the Federal University of Rio Grande do Norte (UFRN), School of Dentistry. The School has a long tradition of graduating competent dentists to serve both Rio Grande do Norte and our country's northeast region. I have great memories of outstanding faculty, staff and students. Over the years I have and felt a deep sense of gratitude for all the teachers that have given me a solid foundation that has been with me all of these years.

Everyone knows that moving from one country to another is difficult, but it is usually accompanied by professional growth opportunities. Why did you decide to study in the United States and decided to stay in the university setting of that country? José Bósio

This is a great question that probably requires a long answer; however, I will try to make my response short and direct. One of the

greatest impacts on my life occurred during my second year as a dental student. In the summer of 1973, through life's destiny, I met a beautiful young American girl from California who became my wife and by far the most influential person in my life. At that time, the Washington D.C. based Project HOPE (Health Opportunities for People Everywhere—Hospital Ship) was in Natal and working with the UFRN. My wife was an administrator with that organization assisting the healthcare professionals that came from the USA and all over the world. My wife and many of the doctors that I met at Project HOPE, encouraged me to apply for a residency in Pediatric Dentistry in the United States. One morning, in December of 1977, I received a phone call from my wife telling me that I had been accepted into a Pediatric Program at the prestigious Eastman Dental Center at the University of Rochester in Rochester, New York. Needless to say, I was stunned and could not believe what had happened and what this would mean for me... Well, the rest is history... I went on to become a certified Pediatric Dentist and then, later, a certified and Board Diplomate in

orthodontics. After completing my specialty training, more opportunities arose for me to teach here in the United States than in Brazil, so I decided to begin my teaching career here with my young family.

As you reflect on your career, what three individuals most influenced the choices you made to be where you are today, and why?

Jason Cope

First and foremost, I am grateful to my parents for never wavering when it came to fulfilling their dream for their six children to get a university education. As I look back over these 32 years I have many to thank and I owe an enormous debt of gratitude to all who have contributed to my professional education and to my life. As for the three... may I include four... to do justice to all of them. During my Pediatric training from 1978-80, it was Dr. Steve Adair (Program Director and Clinical mentor) for his in depth knowledge, outstanding clinical skills and for believing in all of his students. I also cannot forget the late Dr. Michael Buonocore (preeminent Research Mentor and Thesis Director) who contributed so very much to my research education and knowledge of dental resins and sealants. During my orthodontic training from 1981-83 and as an academic colleague from 1983-88, the "Great" J. Daniel Subtelny (my chairman, mentor and personal friend for more than 29 years) for excellence in education, expertise in craniofacial anomalies and cleft lip and palate and for being a role model for all of his graduates from the Orthodontic Program at Eastman Dental Center. Lastly, Dr. Leonard Fishman (mentor and friend), for his research intellect and for guiding my original research on the use of hand wrist imaging indicators as skeletal maturation predictors of growth status. I am forever grateful to these kind gentlemen who have given so much to my personal education and to our Orthodontic Specialty.

To win in "America" requires extreme dedication, perseverance, and determination. Professional recognition normally happens if you perform your tasks correctly. What do you attribute your professional success in the U.S.? José Bósio

I strongly believe that I have been given many opportunities that perhaps could have been given to an individual that is perceived to have better skills or superior intellect. Therefore, I have always felt that I have an obligation to myself and to those that have helped shape my life to do the best that I can to assimilate the vast knowledge within the field of orthodontics and to pass it on to my students to the best of my abilities.

The ADA (American Dental Association) has established regulations requiring graduate orthodontic programs in the United States, such as 24 hours supervised patient management within each week and an 8-hour daily work schedule. There are many orthodontic programs in Brazil that apparently do not fulfill these requirements. What is your opinion of this type of orthodontic training? Russell T. Kittleson

The Commission on Dental Accreditation (CODA), which operates under the auspices of the ADA, is recognized by the U.S. Department of Education as the national accrediting body for dental, advanced dental and allied dental education programs in the United States. CODA standard 4.1 which deals with "Orthodontic Curriculum and Program Duration", clearly defines all advanced specialty education programs in orthodontic and dentofacial orthopedics must be a minimum of twenty-four (24) months and 3700 scheduled hours in duration.

I truly believe that all orthodontic programs should follow the CODA guidelines of time duration and a sequential curriculum that exposes all facets of orthodontic training. To achieve a minimum level of proficiency in the

practice of orthodontics one should have a good knowledge base of biological sciences, growth and development, biomechanics, the application of computer technology (including application of CBCT), implants in orthodontics, functional jaw orthopedics, oral-pharyngeal function, temporomandibular disorders, periodontics, early treatment, adult treatment, surgical orthodontics, public health issues and other areas of interest to our specialty. In my view, to teach postgraduate students a level of competency in all these areas of orthodontics, a minimum of 24 months (3700 hrs) is imperative to protect the public's oral health.

The world is going through an important moment that requires definitions/actions in areas not affected by the economic crisis until now. In your opinion, how can professional associations act to minimize the existent problems here in USA concerning the enormous financial debt that graduate students carry upon graduation due to the high cost of postgraduate education? Eus-táquio Araújo

Most dental schools already have financial aid officers dedicated to assisting students in receiving the best financial aid packages possible.

The types of financial aid for dental students include:

- Federal and private loans.
- Scholarships and grants that are based on merit, financial need, or other qualifications.
- Research Fellowships and Traineeships.
- Commitment Service Scholarships, including the U.S. Armed Forces and the U.S. Public Health Service loan repayment programs are also available for graduates who opt to practice in designated shortage areas, for individuals pursuing funded research projects, and for those who choose careers in academic dentistry.

In addition, it might be helpful if organizations such as the ADA, AAO, and others could provide more low cost loans and better resources for job placement for recent graduates and the financing of new practices.

Another possible solution, although difficult to implement, would be to have some sort of agreement between the accredited dental institutions that would restructure the large tuition discrepancies that exist currently between Orthodontic Programs in the United States.

What are the strengths and the weaknesses as you see them in orthodontic graduate programs? Russell T. Kittleson

Recent technical advances and product developments have dramatically changed the nature of orthodontic graduate programs and we believe this culture of change will only strengthen the future of orthodontic education. Custom fit appliances, modern heat sensitive wires, advances in surgery, temporary anchorage devices (TADs), new diagnostic computer programs and CBCT have allowed Orthodontic Programs to become much more efficient and innovative.

The weaknesses in Orthodontic Programs have been well documented recently. Due to the lack of resources, which have been exacerbated in the current economic downturn, the high cost of residency programs coupled with the small number of residents entering academia is threatening the future sustainability of vibrant educational programs.

You have had faculty positions at two other universities, how did your past experiences at the Universities of Rochester and Colorado, in combination with your experience at University of Louisville, influence how you chair the Orthodontic Department today? Jason Cope

As I look back on my previous assignments at the Universities that I have been associated with, there was a great deal of learning, maturing and growing associated with each position.

The University of Rochester/Eastman Dental Center is an institution with an international reputation for its postgraduate training in all specialty areas and for its enormous contribution to caries, periodontal and orthodontic research. At Rochester all the resources are directed towards the specialty programs and research, since they do not have an undergraduate Dental School. Rochester provided me with a solid foundation and a deep curiosity for dental research and critical clinical thinking that has served me well over my 32-year professional career in academics.

At the University of Colorado, however, my experience was quite the opposite, since it only had an undergraduate program in orthodontics at that time and its major emphasis was to offer the best possible all-around dental training for its dental students from the Southwestern region of the United States. The University of Colorado has succeeded over the years in providing a great education to its dental students. In Colorado, I learned how challenging it was to educate undergraduate students and to cultivate their interests in a specialty while training them to be knowledgeable in all disciplines as a general dentist.

At the University of Louisville-School of Dentistry I have come full circle, as it has been the largest University that I have taught. It offers both undergraduate and postgraduate dental education programs, and as Chair of the Department of Orthodontic, Pediatric and Geriatric Dentistry, I have been able to draw on all of my past experiences in Orthodontic and Pediatric Dentistry at both the undergraduate and postgraduate levels, as well as my experiences in research. The University has a wealth of tradition, having been established in 1795, and the Dental School has graduated many excellent general dentists and specialists since it was established in 1819. As a chairman of one of the Dental School's five Departments, my job

is overwhelming at times, humbling on many occasions and full of challenges on most of days. I am fully aware of my responsibilities and I try to do my best every day to fulfill the trust that all faculty members in the Department have bestowed on me.

We are Brazilians and we know the difficulties that orthodontic education is facing in our country due to the high commercialization, lack of federal regulation or by professional vulgarization. Since we live a different scenario here in the USA, how can we help our country? Eustáquio Araújo

This is probably one of the most difficult questions for me to answer. Because I have been living here in the US for over 32 years, I am not as familiar with Brazil's professional organizations and their structure as I should be. However, I must say that I have met many of my colleagues from Brazil at the national AAO Annual Meetings here in the US and I am very impressed with their knowledge and professionalism. As we have learned here and in other countries, the continuity, vibrancy and accountability of orthodontics must always rely on a strong and cohesive professional organization that monitors its national activities and lobbies government institutions for improvements that will protect the public and the specialty. I am not aware that our Orthodontic Association would need any assistance in strengthening the orthodontic profession in Brazil, but if such a time arrives, I would hope that we Brazilians in academic institutions in the US would be more than willing and happy to provide any assistance that might be requested.

Do you believe it will be possible in the near future to forecast growth by use of the 3D CBCT? Russell T. Kittleson

I have asked my friend and colleague, Professor William Scarfe to collaborate with an answer

to this important and relevant question. Dr. Scarfe is a Board certified oral and maxillofacial radiologist and in a unique position to address this question since he has been involved with CBCT imaging since 2005. He has presented and publishing extensively on CBCT including co-authoring the American Academy of Oral and Maxillofacial Radiology (AAOMR) executive opinion statement on performing and interpreting diagnostic cone beam computed tomography (Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106:561-2). He, together with Professor Allan G. Farman, has mentored many of our graduate students in their Masters Programs. Professor Scarfe is the newly appointed Editor of the Radiology Section of the journal "Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics". Most recently he has also been appointed as one of four AAOMR representatives to a joint committee of the AAOMR and the American Association of Orthodontists to develop a position paper on the use of imaging for orthodontics with particular reference to CBCT.

Dr. William Scarfe: Cone beam computed tomography (CBCT) is no doubt a major advancement in the imaging armamentarium available to the orthodontic profession. Together with personal computer-based analysis software, this technology is now capable of providing accurate 3D visualization capabilities of the maxillofacial skeleton and facilitates an understanding of complex osseous and soft tissue relationships. The foundations of our current understanding of craniofacial growth has, for the most part, resulted from prospective longitudinal growth data and image analysis from independent cohorts such as the Bolton-Brush, Burlington and Iowa groups. These studies have provided trend data that have been used successfully for decades. However, such studies involving CBCT imaging would not be

possible today because repeated indiscriminate exposure of radiosensitive patients to ionizing radiation over many years at higher levels than conventional imaging would not be condoned. Nonetheless, we are not convinced that repeating such studies by substituting 3D for 2D imaging would provide us with the data that we really need. As the goal of applying growth trends is to understand the individual growing pattern of each young patient in order to plan and modify treatment, perhaps CBCT imaging provides us with an opportunity to re-think our approach to growth forecasting. As radiation exposure considerations will most likely restrain CBCT imaging to patients who receive treatment it is perhaps more important to define on whom forecasting is appropriate. There is no doubt that software-based virtual modeling to extrapolate growth tendencies will expand exponentially. But it will have to rely on multi-center collaborations. In addition, the role of the soft tissue and airway on skeletal growth will be further elucidated. 3D CBCT is merely the available tool—it should be applied appropriately to allow us to expand our understanding of growth and the influence of the application of various treatments for specific individuals.

The orthodontic profession has done a poor job at recruiting faculty. In the long run, this negatively affects the resulting quality of graduating orthodontists, and ultimately patients care. What do you think the biggest obstacle to recruiting high quality orthodontic educators, and how can we overcome it? Jason Cope

This is so true. We are victims of our profession's great success. The biggest obstacle to recruiting high quality educators has been the financial limitation of most educational institutions to compete with the private sector in offering competitive remuneration for scholastic careers in orthodontics. In the short

term, our Program has been taking a multi-pronged approach to alleviate these problems. Our core full-time faculty is utilizing many qualified part-time orthodontists from the community to fill some of our needs. In addition, the distance learning program promoted by the AAO has allowed us the interaction to share resources with other universities here in the United States and around the globe. In the long term, we are working on ways to foster academic careers within our institutions through a combination of suggesting loan forgiveness for academic service, better research and pedagogical training, offering allocation of time for private faculty practice, increasing fringe benefits and promoting fellowships that would train future educators.

Do you envision distance learning education as the future for orthodontic educators in the United States and around the world? José Bósio

We are fortunate and have had the opportunity to experience distance learning education first-hand. Our residents participated in a research project funded by the American Association of Orthodontists Foundation directed by Dr. William Proffit from the University of North Carolina that involved three graduate orthodontic programs (Louisville, North Carolina and Ohio State). The project consisted of orthodontic faculty teaching interactive seminars via videoconference with residents at distant locations. Our residents felt it was worthwhile, and learned a significant amount while participating in these interactive seminars. Although distance learning and interactive videoconferencing will likely never replace face-to-face instruction and interaction entirely, such a use of technology can be a great supplement to graduate orthodontic education, especially for programs with limited numbers of faculty in their department. Presently, these videoconferences have been

extended to orthodontic programs in Canada and Australia. We at Louisville, appreciate the efforts and leadership of Dr. Bill Proffit throughout this project.

Suddenly, the “new” starts to occupy space in orthodontics. Many times, scientific evidence is left aside and many procedures and techniques are incorporated into the daily clinic without scientific support. What are your thoughts about this situation? Eustáquio Araújo

As educators, one of our greatest challenges is to deeply impress upon our students the importance of the use of evidence-based methods of treatment that have been proven through scientific research. As described by the ADA, “Evidence-based dentistry (EBD) is an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient’s oral and medical condition and history, with the orthodontist’s clinical expertise and the patient’s treatment needs and preferences.”

There is no question that orthodontics has become a vast and growing successful enterprise that has become prone to commercialization and the pressures of the free market that make claims that have not been substantiated by independent and reliable research. There are many in our specialty who claim that orthodontics is more of an art than a science. I believe that it is primarily a science which also requires artistic appreciation and esthetic ideals. In the future we will probably see more orthodontists practicing EBD in orthodontics due to more reliable statistical methods (such as meta analysis, prospective studies, etc.) that will substantiate or disprove claims of “new” innovations.

Some orthodontic treatments are unforgettable, because of the success or because of the difficulties during its course. What was

your most difficult orthodontic case and what have you learned from it? José Bósio

Aglossia: A rare birth defect where the tongue is missing or underdeveloped and where other anomalies are also often present (e.g., missing parts of hands and feet, small jaw and oral webbing).

The absence of the tongue can have a huge impact on the structure of the jaws as there is no tongue to provide pressure against the teeth which normally helps maintain good oral structure and function. Consequently, without a tongue, the patient often presents with severe collapse of the bite and jaws especially if there are missing teeth—as happened in this case.

This particular case was a very challenging one. In addition to the conditions that have already been mentioned above, there were several other issues. The patient presented with only four teeth on the lower arch; two first molars, one bicuspid and a deciduous molar on the left side of the mandible. For this case we used a surgical technique called Mandibular Symphyseal Distraction Osteogenesis (DO) with an expansion device directly attached to the symphyseal region as an alternative to orthodontic treatment to resolve the mandibular anterior width deficiency.

Compliance by the patient with the distraction was a major issue, however in addition, the maintenance of the expansion was a difficult one since the patient had no muscle function or equilibrium without the tongue. Needless to say, the result was not what we had hoped for.

What I learned from this experience was the lesson that my mentor Dr. J. Daniel Subtelny always stressed: “Form follows function and promotes change with time”. In other words, the interaction of muscle, bone and function ultimately determine the shape and outcome of the jaw structure and without one of the factors present you cannot have good long-term retention.

Aligners have been introduced to the orthodontic community many years ago. In 1999, a new company improved the quality of the aligners and developed easier ways to achieve orthodontic results without having to use metal/porcelain/plastic braces. Recently, the same company started to merchandise its products not only to orthodontists, but also to general dentists and directly to the general public. What is your opinion about the marketing strategies used by the company? And what is your experience and results with these methods of orthodontic treatment? José Bósio

I must confess that I have never been happy with the marketing approach of the Clear Align Technology (CAT) companies that expose their products to the US public. In the first place, the technique should have had been initially introduced to orthodontists, tested and then exposed to the public at large. Instead, the company's approach was to introduce the technique through a blaze of television publicity and mass marketing that was designed to create consumer interest before careful research evaluation had identified and solved problems which have become apparent during its use over the ensuing years. The strategies and policies of marketing to general dentists without regard to their abilities and knowledge continue to be a concern for many of us in the field of orthodontics.

At the University of Louisville Orthodontic Program, all residents are trained to prescribe and treat a number of cases with Clear Aligner Therapy. The company has donated a number of cases to our program to provide residents with the opportunity to treat patients using this technology, and of course to provide them with exposure to their product.

Our experience with clear aligners has generally shown that they can be successful at producing certain movements and treating cases that would be relatively simple with

traditional fixed appliances; however, its use in more complex cases is more challenging and the results are more unpredictable. CAT is relatively effective at aligning teeth with mild to moderate crowding (often with a great deal of IPR), closing mild to moderate spacing, intruding individual teeth and tipping teeth. It is less effective for aligning teeth with severe crowding, aligning teeth that are severely displaced labially or lingually, extruding incisors, positioning ectopic canines, closing bicuspid extraction spaces, and translating teeth.

Although a number of case reports have been documented in the literature, at this time, almost no long term data for the outcome of CAT treatment has been published in refereed professional journals. Currently, the University of Florida and UCSF are conducting long term studies into the efficacy of this technique and the results will certainly be published in the future.

Computer aid orthodontic treatments used to bend pre-adjusted wires is currently being used in orthodontics. Companies and orthodontists are claiming that better and faster results can be achieved using this method. What is your opinion, experience and concerns with this type of procedures?

José Bósio

A computerized treatment approach and appliance customization system should offer some advantages over conventional orthodontic systems by reducing some margins of error. This technology is based on the premise that fixed appliance therapy is effective, but subject to error due to many factors. Fixed appliances and a straight-wire approaches to orthodontic treatment do not always produce an ideal result because of morphologic variation of teeth, bracket positioning errors, and appliance prescription details. The computer-aided approach and technology have been designed and customized to offer the orthodontic practitioner

the opportunity to minimize these errors by providing the clinician with a 3-D computer model (captured with the OraScanner or CBCT) of their patient. The practitioner uses the 3-D images and computer-based 3-D planning software program to produce a virtual simulation of the teeth in ideal occlusion. Automation technology then takes the virtual occlusion and creates precision bracket placement trays and robotically fabricated precision archwires to be used in treatment.

Like most orthodontic programs in the US, we at the University of Louisville have not yet incorporated this technology into our program. The company has focused its marketing on private practice orthodontists, and we have not used it yet because of the high cost. I do believe, however, that this technology has merit and potential in the future as the cost decreases. The ability to visualize an individual case in 3-D could have great potential benefit in giving clinicians more precision in determining the final positions, tips, angulations and inclinations of teeth within the arch that should lead to a better treatment result.

However impressive the technology appears, it is important to recognize that this technique does not incorporate essential aspects of orthodontic treatment planning such as growth and development, occlusal function and interactions with other structures in the orofacial complex. I frequently remind our residents during seminars that the explosion of technology in recent years has not replaced the need for a clinician to think, diagnose, and control other factors we all encounter in the daily practice of orthodontics.

At the end of the day, when you leave the office, what do you like to do in your spare time? What, besides orthodontics, makes Anibal Silveira happy? Jason Cope

In addition to spending time with my family and traveling, I have developed a passion for

the game of golf and I enjoy this along with my interest in many other sports.

What message can you leave to the young professional initiating their career in the orthodontics specialty? Jason Cope

Love what you do, and you'll never work a day in your life. Be the most ethical professional that you can possibly be, and you'll never regret it.

Never forget from where you came, and you will never be forgotten. And most important, never forget the people who have helped shape who you are. This may not be much of a message, but it is what I thoroughly believe in and live by.

NOTE: I would like to express my sincere appreciation to my colleague Dr. José Bósio for facilitating this interview in this prestigious journal.

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Study of the cephalometric features of Brazilian long face adolescents

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Abstract

Objective: To set skeletal and dental cephalometric values for Brazilian long face adolescents. **Methods:** The sample comprised lateral cephalograms of 30 long face patients, 17 females and 13 males, and 30 Pattern I adolescent patients, 15 males and 15 females, with permanent dentition. The features that characterize the long face pattern were defined clinically by facial analysis. The following cephalometric measurements were assessed: 1) Sagittal behavior of the apical bases (SNA, SNB, ANB, NAP, Co-A, Co-Gn), 2) Vertical behavior of the apical bases (SN.PP, SN.MP, gonial angle, TAFH, LAFH, MAFH, PFH, TAFHperp, LAFHperp), 3) Dentoalveolar behavior (1-PP, 6-PP, 1-MP, 6-MP, 1.PP, IMPA), and 4) Facial height ratios (LAFHPerp/TAFHPerp, LAFH/TAFH, MAFH/LAFH). **Results and Conclusions:** The vertical error of the long face pattern is concentrated in the lower third. The maxilla exhibits a greater dentoalveolar height and the mandible, given its more vertical morphology, displays greater clockwise rotation. These morphological and spatial features entail sagittal and vertical skeletal changes as well as vertical dentoalveolar changes. The angles of facial convexity are increased in the sagittal direction. Vertically, the total and lower anterior facial heights are increased. The dentoalveolar component is longer.

Keywords: Face. Adolescent. Cranial circumference.

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Editor's summary

Excessively vertical faces are referred to as “long faces” and their features reflect a disparity between facial thirds, whereby the lower third is increased, resulting in no passive lip seal, overexposed maxillary incisors at rest, gingival exposure on smiling and double chin in an attempt to seal the lips (Fig 1). As is the case with other frontal errors, long faces cannot be corrected by orthodontics and/or orthopedics alone. Patients and therapists share identical perception of this issue. Orthodontists are therefore aware of the vital role played by orthognathic surgery in reducing the vertical excess that characterizes this facial pattern. Two morphological criteria lead to the indication of orthognathic surgery for long face reduction, i.e., compromised facial aesthetics and inability to treat the existing malocclusion. This research aimed to put into perspective the cephalometric characteristics of the long face pattern in adolescence.

Pretreatment lateral cephalograms of Caucasian patients of both genders were selected, with permanent dentition and excessively vertical faces. Excessive verticality was diagnosed by the presence of incompetent lip seal and exposure of upper incisors with the upper lip at rest, as seen in facial photographs. The control group consisted of pretreatment lateral cephalograms of Caucasian Pattern I

patients of both genders, with permanent dentition.

The maxilla behaved similarly in both the long face and Pattern I groups, regardless of gender. The position of the mandible relative to the cranial base (SNB) exhibited greater retrusion among long face subjects. Facial convexity of long face subjects was reduced. Mandibular angles (gonial angle and mandibular plane angle) were increased in long face subjects while the palatal plane was identical in both facial patterns. Total facial height and lower facial height tended to be higher in long face subjects. Dental arch heights were increased among female long face subjects. Maxillary incisors also behaved identically in long face and Pattern I subjects whereas mandibular incisors were more proclined in long face subjects.

It was concluded that in the long face pattern group the maxilla exhibits a greater dentoalveolar height and the mandible, given its more vertical morphology, shows greater clockwise rotation. These morphological and spatial features entail sagittal and vertical skeletal changes as well as vertical dentoalveolar changes. In the sagittal direction, facial convexity angles are increased due to a posterior displacement of point “B”. Vertically, the total and lower anterior facial heights are increased. The dentoalveolar component is longer.

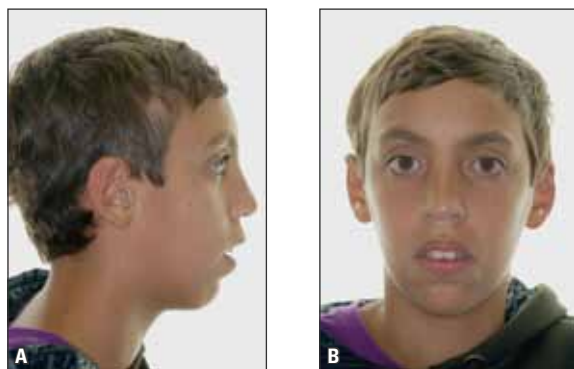


FIGURE 1 - Features of the long face pattern. **A)** In lateral view, the rotation of the mandible downwards and backwards may favor the diagnosis of mandibular deficiency. **B)** In frontal view the diagnosis is unmistakable: a disproportion between the facial thirds, with a disproportionate increase of the lower third, compromises lip seal competence and exposes the upper incisors at rest.

Questions to the authors

1) What is the essence of morphological changes in long face patients?

Firstly, long face diagnosis is based on the clinical evaluation of the face, that is, facial analysis. Long faces present with a skeletal discrepancy characterized by vertical excess in the lower third of the face in both front and side view. Although facial analysis is subjective in nature and vertical excess features a wide range of individual degrees of severity, it is not difficult to identify vertical excess in the lower third of the face, since its clinical consequences can be perceived by both orthodontists and patients.

The changes caused by vertical excess in the lower third of the face are: Lip seal incompetence; presence of double chin in an attempt to preserve lip seal, in which case lip seal is forced; excessive exposure of the upper incisors at rest; and gummy smile. This article was designed to cephalometrically establish the numerical errors which are responsible for these morphological changes in Caucasian adolescents since these cephalometric features have already been defined in adults. Interpretation of cephalometric measurements in adolescents allowed us to conclude that the vertical error in the long face is concentrated in the lower third of the face (LAFH). Cephalometric measurements were consistent with the morphological and clinical diagnosis of the face. The maxilla exhibits greater dentoalveolar height and the mandible, given its more vertical morphology, displays greater clockwise rotation. These morphological and spatial features entail sagittal and vertical skeletal changes as well as vertical dentoalveolar changes. The angles of facial convexity are increased in the sagittal direction. Vertically, the total and lower anterior facial heights are increased. The dentoalveolar component is longer and the symphysis appears narrower.

2) What motivated you to study the cephalometric characteristics of these patients?

The desire to evaluate the cephalometric features of the long face pattern in adolescent males and females arose from previous studies of adult long face patients, also conducted in Bauru, São Paulo State, Brazil. The idea was to repeat these cephalometric studies in a younger age group during the growth period of adolescence. Our expectation was to determine whether the numerical characteristics of the face change from adolescence to adulthood, or whether these characteristics would be present even before skeletal maturity. The results suggest that if you have a long face pattern, you will always be a long face. The cephalometric characteristics of the long face pattern are already present in adolescent boys and girls before skeletal maturity.

3) Is there a link between long face pattern and mouth breathing?

Long face pattern and mouth breathing are different problems. We could say that the long face pattern refers to a morphological condition of the facial skeleton and reflects a predominantly vertical facial growth. On the other hand, mouth breathing refers to some obstruction in the nasal respiratory tract that reduces the permeability of the upper airways, forcing the individual to supplement the airflow through the mouth. Given these different situations, one is a morphological condition and the other is a functional condition, diagnosis also involves different professionals and instruments. The diagnosis of mouth breathing should be made instrumentally by an otorhinolaryngologist. However, these conditions may overlap in a single patient. Long face morphology is likely to reduce nasal airway patency. For example, the morphological configuration of the long face pattern is also narrower and shallower. The design of the respiratory tract with this type of bone architecture would be more vulnerable to soft tissue obstructions along the respiratory tract. This should explain, for example, why mouth breathers tend to have a long face pattern. The cause/effect relationship in this case is determined by the morphology of the face and the individual's breathing. The long face pattern promotes oral breathing. Orthodontists are therefore more often concerned with the airways of long face patients. When mouth breathing is confirmed in a long face individual, the obstructions that reduce airway patency should be eliminated. However, a patent airway will not guarantee any changes in facial morphology.

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In vitro flexural strength evaluation of a mini-implant prototype designed for Herbst appliance anchorage

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Abstract

Aim: The purpose of this study was to evaluate the limit of flexural strength of a mini-implant prototype designed for Herbst appliance anchorage. **Methods:** After sample size calculation, four specimens with the new mini-implant were submitted to a single cantilever flexure test using a universal testing machine. The limit of flexural force strength was calculated. **Results:** The mini-implant prototype showed a limit of flexural force of 98.2 kgf, which was the lowest value found. **Conclusion:** The mini-implant prototype designed for Herbst appliance anchorage can withstand higher strength than the maximum human bite reported in the literature.

Keywords: Orthodontic appliances. Orthodontics. Herbst appliance. Mini-implant.

Editor's summary

The Herbst appliance is a treatment possibility for Class II malocclusion in growing patients. By protruding the mandible, the Herbst appliance aims to stimulate mandibular growth, resulting in improvement in its effective length. However, the major changes caused by the Herbst appliance are dentoalveolar, where the appliance is anchored. Due to the development of skeletal anchorage mechanisms, a question arises: How would be the effects of the Herbst appliance using skeletal anchorage? Before evaluating if the appliance's orthopedic effects

would be optimized changing the kind of anchorage, it is necessary to evaluate if the mini-implants are able to withstand the muscle strength that opposes to the mandibular advancement. The purpose of this study was to evaluate, in vitro, the limit of flexural strength of a mini-implant prototype especially designed for Herbst appliance anchorage.

Four specimens were used in this experiment. Each one had three parts: the mini-implant prototype; a metal support block, which acted as the support for the flexure force; and a straight telescopic tube (Dentaurum) of the Herbst appliance

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FIGURE 1 - Mini-implant prototype with screw, in lateral view.

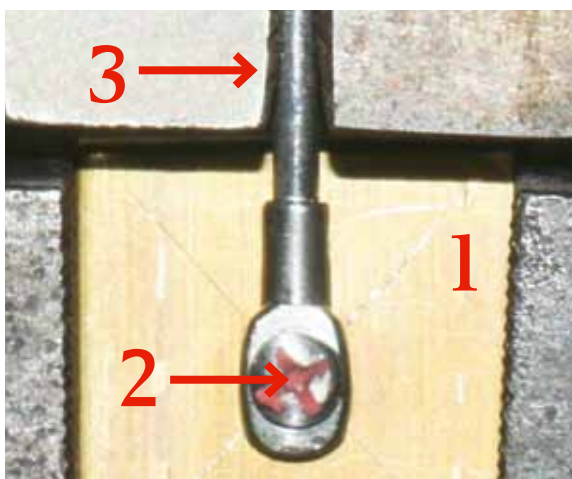


FIGURE 2 - Specimen used in test (1) metal block, (2) mini-implant prototype inserted in the metal block with the screw attached to the telescopic tube, (3) telescopic tube of Herbst appliance.

(Figs 1 and 2). A single cantilever flexure test was performed in which the point of force application occurs with a distance of the specimen base generating a momentum. Flexural traction was applied at 0.5 mm per minute until the maximum strength was reached. The values were recorded, and a graph of strength x dislocation was constructed, using a specific program of the testing equipment.

After the maximum resistance flexural essays performed on the specimens, a mean of 98.9 Kgf, with a standard deviation of 0.6, and a maximum and minimum value of 98.2 and 99.0 Kgf, respectively, were found. The mini-implant prototype, alone, could resist the flexural forces transferred by the Herbst appliance originated by human bite strength (75.6 Kgf).

However, speculations on the major risk of mini-implant failure used as Herbst appliance anchorage

are related to bone x mini-implant interface. Therefore, other in vitro tests should be performed to evaluate the resistance of the mini-implant prototype when it is inserted in bone before clinical experiments in humans can be performed.

Questions to the authors

1) After the verification that the developed mini-implant can withstand Herbst appliance anchorage, what would be the next step?

To prove that the mini-implants could be used as Herbst appliance anchorage, a clinical study should be done in humans. However, other studies are still necessary, like a study in animals using mini-implants for Herbst appliance anchorage, which will be our next study.

2) What are the clinical perspectives for Herbst appliance with mini-implant anchorage?

We have not sufficient information to answer this question based on scientific evidences. However, if this anchorage system becomes possible, we could imagine a mandibular advancement without the undesirable effects produced, especially, in the lower incisors.

3) What inspired you to search for this innovation for the Herbst appliance?

The possibility of using an orthopedic appliance without dental anchorage, expressing all the potential of skeletal stimulation and possibly avoid the undesirable effects on teeth.

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Orthodontic treatment in patients with reimplanted teeth after traumatic avulsion: A case report

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Abstract

Introduction: The high prevalence of individuals with dental trauma prior to orthodontic treatment justifies the precautions that should be followed before and during treatment, taking into account all possible effects of orthodontic movement on traumatized teeth. Among the major traumatic dental injuries, avulsion with subsequent tooth reimplantation entails a higher risk of complications, such as pulp necrosis, root resorption and ankylosis. Therefore, it gives orthodontists several reasons for concern. **Objective:** This case report aims to analyze the implications of tooth reimplantation after traumatic avulsion in patients requiring orthodontic treatment. **Conclusions:** Tooth movement of a reimplanted tooth after traumatic avulsion is viable, provided that no signs of abnormality are present. Ankylosed teeth, however, are not eligible for orthodontic movement but should be preserved as space maintainers until root resorption is completed, provided that the teeth do not present with severe infraposition. Should an ankylosed tooth be severely infraposed, crown amputation and root burial are indicated as a means to preserve the alveolar bone in the region, since resorption will occur by replacement of the buried root, as was the case in this report.

Keywords: Tooth movement. Dental ankylosis. Tooth trauma.

Editor's summary

Orthodontic movement after tooth reimplantation is not impossible. According to Malmgren et al,¹ however, after avulsion of permanent teeth followed by reimplantation,

a follow-up period of at least one year is necessary, since most root resorption occurs during the first year post-trauma. Boyd, Kinirons and Gregg² found that a time span ranging between 102 and 997 days³ elapsed before root

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resorption was detected, suggesting the need for a longer follow-up period before starting orthodontic treatment.

When the periodontal ligament experiences extensive damage a small amount of surviving cells near the root surface triggers a repair process through rapid osteogenesis, leading to ankylosis of the tooth⁴ and its subsequent loss and replacement. Alveolodental ankylosis involves fusion of the alveolar bone with the root substance and consequent disappearance of the periodontal space, which loses its structure and function. The close contact between dental tissues and alveolar bone structure furthers the bone remodeling process. This results in resorption of bone tissue and part of the tooth tissue, which will be partially or totally replaced by new bone formation. Resorption by replacement increases if the avulsed tooth is allowed to remain outside the oral cavity for extended periods of time. It ranges from only 9.5% resorption in short periods (fewer than fifteen minutes) to 100% resorption if periods exceed sixty minutes, in a dry medium.⁵

Extraction is recommended in cases of inclined adjacent teeth or extensive infraposition.¹ In other cases, teeth should be examined at intervals of six months until root resorption ceases and the tooth crown either comes loose or can be removed with forceps, after most of the root has been replaced by bone.⁶ Clinical experience has shown that extraction of ankylosed teeth involves substantial bone loss both horizontally and vertically, which affects, in particular, the thin buccal bone wall in the maxilla.⁶ To prevent this loss, Malmgren^{1,6} described a technique that involves removal of the tooth crown with subsequent closure of the alveolus with the root inside it. When resorption by root replacement takes place it preserves or even enhances alveolar bone height in the vertical direction. It also preserves the alveolar bone in the buccolingual direction, which improves the

conditions for orthodontic treatment—if necessary—and/or subsequent placement of a prosthesis and/or implant.

Ankylosed teeth should therefore be preserved as space maintainers until root resorption is completed, provided that the teeth do not present with severe infraposition. Should an ankylosed tooth be severely infraposed, crown amputation and root burial are indicated as a means to preserve the alveolar bone in the region, since resorption will occur by replacement of the buried root, as was the case in this report.

Questions to the authors

1) What precautions should professionals follow when planning orthodontic treatment for patients with a history of trauma?

Orthodontists should first perform a careful anamnesis looking for information about the history of trauma. Injuries to the teeth involve multiple consequences ranging from a small crack in the enamel to tooth loss. Some lighter injuries rarely pose a risk to the health or survival of a traumatized tooth, while others are more severe, such as intrusions and avulsions followed by re-implantation, and pose a greater risk of complications, including pulp necrosis, root resorption to the extent of marginal bone loss and subsequent tooth loss. The prognosis for several types of trauma seems to depend on the type and severity of the injury (measured by the extent of damage to the periodontal ligament). A detailed clinical-radiographic (periapical) assessment can provide a thorough diagnosis of pulp changes, crown fractures, root fractures, possible root resorption prior to orthodontic treatment, and ankylosis.

In some cases, a scan of the traumatized tooth may reveal images that go unnoticed in radiographs. Should the injured tooth show no clinical or radiographic changes, a post-trauma period should be observed—three months in cases of minor injuries such as coronal or coronaradicular fractures without pulp involvement, concussion and subluxation, and 1 to 2 years in cases of root fractures, intrusion, reimplantation after avulsion and lateral luxation with moderate or severe displacement—and then orthodontic treatment can be performed normally. Orthodontists will not be able to move ankylosed teeth because they are not amenable to orthodontic movement. Radiographic follow-up throughout the orthodontic treatment is also essential.

2) Is tooth reimplantation a contraindication to orthodontic treatment?

Tooth avulsion with subsequent reimplantation is the traumatic injury that involves the greatest risk of complications due to a high likelihood of bacterial infection through both the pulp and the periodontium. However, the orthodontic movement of reimplanted teeth is possible, provided that normal conditions are restored and maintained for period of at least one year with clinical-radiographic follow-up. According to Malmgren et al,¹ most root resorption after reimplantation occurs during the first year post-trauma. Boyd, Kinirons and Gregg² found that a time span ranging between 102 and 997 days³ elapsed before root resorption was detected, suggesting the need for a longer follow-up period before starting orthodontic treatment.

3) Is there general agreement in the literature regarding orthodontic treatment in patients with traumatized teeth or are there still different approaches to this issue?

The literature is indeed very consistent in this regard. Dental trauma does not contraindicate orthodontic treatment, provided there are no

pulp or periodontal changes and/or root resorption. However, some studies indicate that traumatized teeth are more predisposed to resorption. But these findings are not conclusive because the final outcome of traumatized tooth treatment can take more than five years to surface. This is one of the factors hampering the analysis of the effects of orthodontic movement on traumatized teeth. These studies involve a small number of patients, who present with different types of injuries and are treated by different researchers using a variety of orthodontic appliances. These factors combine to render inconclusive any findings regarding the effects of orthodontic treatment on traumatized teeth.

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Influence of the extraction protocol of two maxillary premolars on the occlusal stability of Class II treatment

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Abstract

Objective: With the purpose of evaluating the influence of two upper premolar extraction on the occlusal stability of full cusp Class II malocclusion treatment, a comparison was performed with a non-extraction treatment protocol. **Methods:** To this end, a sample consisting of 59 patients with complete Class II malocclusion was selected from the files of the Department of Orthodontics of the Dental School of Bauru. This sample was split into two groups according to the following characteristics: Group 1 included 29 patients treated without extractions and Group 2 included 30 patients treated with the extraction of two upper premolars. Using the TPI and PAR occlusal indices the subjects' study models were evaluated at the beginning and end of treatment, and at a minimum of 2.4 years after treatment. The occlusal conditions at the end of treatment and in the post-treatment period, the percentage of relapse and post-treatment occlusal changes were compared using Student's t-test. **Results:** The results showed no statistically significant differences between the nonextraction and the extraction of two maxillary premolars treatment protocols in terms of the occlusal stability of complete Class II malocclusion treatment in any of the evaluated variables. **Conclusions:** The extraction of two upper premolars in the treatment of Class II malocclusion did not influence the stability of the occlusal results achieved at the end of the orthodontic treatment. Therefore, a similar stability is achieved by finishing a treatment with either a Class II or a Class I molar relationship.

Keywords: Stability. Class II malocclusion treatment. Tooth extraction.

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INTRODUCTION

Angle Class II malocclusion has several correction protocols, which can generally be divided into treatments with or without extractions. Both professionals and patients, however, seek efficiency and excellence in any given treatment protocol. Research has shown that treatment of Class II with premolar extraction is more efficient than treatment without extraction or with the extraction of four premolars.^{4,17} Nevertheless, in addition to efficiency, long-term stability of the results, although difficult to achieve,³⁰ is among the main goals of orthodontic treatment. Longitudinal studies have shown that although improvements in dentition can be achieved with orthodontic treatment, relapse to the original malocclusion tends to occur many years after the removal of the orthodontic appliance.^{9,14,30} Orthodontists should, therefore, use all means available to them to minimize the risks of jeopardizing the results obtained by orthodontic treatment.

Tooth extractions do not significantly influence the success of long-term Class II treatment, which indicates that when fixed appliances are used adequate stability is likely to be achieved both with and without extractions.^{3,5,9,10,23,30} Although there are only studies that have assessed the stability of Class II correction with the extraction of four premolars,^{3,5,9,10,30} which entails maintaining a Class I molar relationship. In contrast, studies assessing the stability of treatment protocols involving the extraction of two upper premolars²² are scarce.

Today's orthodontics is still heavily influenced by the precepts advanced by Angle² and Tweed²⁹ that orthodontic treatment should be finished in a Class I molar relationship. Although Class II treatment with premolar extraction has shown higher efficiency,^{4,17} there still are doubts whether or not finishing treatment with a Class II molar relationship can affect treatment stability.^{21,26}

Therefore, to find an answer to these questions the influence of the two-premolar extraction protocol on Class II stability was evaluated, comparing it with the nonextraction protocol, which establishes a Class I molar relationship at the end of treatment.

MATERIAL AND METHODS

Material

For our retrospective sample selection, the records on file at the Department of Orthodontics, Dental School of Bauru, University of São Paulo were used.

Sample selection included the following criteria: Complete bilateral Class II malocclusion, treated without extractions or with the extraction of two upper premolars; the presence of all permanent teeth up to the first molars; absence of retained and supernumerary teeth; absence of abnormalities in tooth size and/or shape; treatment with fixed appliances using standard Edgewise mechanics; exclusion of cases treated with orthognathic surgery; complete orthodontic records and post-treatment time of at least 2.4 years.

The TPI¹¹ and PAR⁷ indices were used to evaluate the intra and inter-arch occlusal relationships in study models of the 59 patients selected, at 3 different stages: Pre-treatment (T1), post-treatment (T2) and a minimum of 2.4 years post-treatment (T3). The sample was divided into two groups (Table 1).

Group 1

This group consisted of 29 patients (14 male and 15 female) whose Class II malocclusion was treated without extractions. Regarding the type of malocclusion, this group included 24 patients with Class II division 1 and 5 patients with Class II division 2. As regards treatment time, group 1 took a mean of 2.51 ± 0.98 years (minimum of 0.88 and maximum of 4.70); while post-treatment time mean was

of 7.26 ± 3.43 years (minimum of 2.40 and maximum of 16.15). Ages mean was of 12.65 ± 1.38 years (minimum of 9.52 and maximum of 15.90) at T1, 15.17 ± 1.58 years (minimum of 12.94 and maximum of 18.72) at T2, and 22.44 ± 3.50 years (minimum of 16.29 and maximum of 31.76) at T3.

Group 2

This group consisted of 30 patients (17 male and 13 female) whose complete Class II malocclusion was treated with the extraction of two upper premolars. Regarding the type of malocclusion, this group included 22 patients with Class II division 1 and 8 patients with Class II division 2. As regards treatment time, group 2 took a mean of 2.24 ± 0.75 years (minimum of 0.93 and maximum of 4.19); while post-treatment time mean was of 9.60 ± 3.55 years (minimum of 3.23 and maximum of 15.99). Ages mean was of 13.32 ± 1.52 years (minimum of 11.21 and maximum of 17.09) at T1, 15.57 ± 1.71 years (minimum of 12.55 and maximum of 19.48) at T2, and 25.18 ± 3.97 years (minimum of 19.02 and maximum of 34.04) at T3.

Methods

The changes between values at T1 and T2 of the TPI (DIFTPI1-2) and PAR (DIFPAR1-2) indices were calculated so as to express the amount of improvement resulting from treatment. Based on these measurements we also obtained the percentage of improvement expressed by the TPI (PTPI1-2) and PAR (PPAR1-2) indices, described by the formulas shown below.^{4,5,17}

$$\begin{aligned} \text{TPI improvement rate (\%)} &= \frac{\text{TPI1} - \text{TPI2}}{\text{TPI1}} \\ \text{PAR improvement rate (\%)} &= \frac{\text{PAR1} - \text{PAR2}}{\text{PAR1}} \end{aligned}$$

The changes between values at T3 and T2 of the TPI (DIFTPI3-2) and PAR (DIFPAR3-2) indices were calculated so as to express the amount of relapse after treatment. Based on these measurements we also obtained the percentage of relapse expressed by the TPI (PTPI3-2) and PAR (PPAR3-2) indices, using the formulas below.

$$\begin{aligned} \text{TPI relapse rate (\%)} &= \frac{\text{TPI3} - \text{TPI2}}{\text{TPI1}} \\ \text{PAR relapse rate (\%)} &= \frac{\text{PAR3} - \text{PAR2}}{\text{PAR1}} \end{aligned}$$

All measurements relating to the amount of overjet, overbite, crowding and midline shift were obtained from the models using a Zürcher Modell (Seitz & Haag, Germany) caliper capable of yielding measurements with a 0.1 mm accuracy.

TABLE 1 - Description of abbreviations.

Abbreviations	Description
TPI1	TPI index at T1
PAR1	PAR index at T1
TPI2	TPI index at T2
PAR2	PAR index at T2
TPI3	TPI index at T3
PAR3	PAR index at T3
DIFTPI1-2	Change in the TPI index during treatment
DIFPAR1-2	Change in the PAR index during treatment
PTPI1-2	Improvement rate of the TPI index during treatment (%)
PPAR1-2	Improvement rate of the PAR index during treatment (%)
DIFTPI3-2	Change in the TPI index after treatment
DIFPAR3-2	Change in the PAR index after treatment
PTPI3-2	Relapse rate of the TPI index after treatment (%)
PPAR3-2	Relapse rate of the PAR index after treatment (%)

Statistical Analysis

Method error

Intrarater error was evaluated by performing new measurements and calculating a new index for the models of 25 patients, randomly selected between the two groups, totaling 50 models. The formula proposed by Dahlberg⁶ ($Se^2 = 2d^2/2n$) was applied to estimate the magnitude of random errors, while systematic errors were analyzed by applying the paired t test, according to Houston¹³ (Table 2).

Comparative analysis

Group compatibility as regards the proportion of Class II malocclusion types (Class II, Divisions 1 and 2) and gender compatibility were assessed by the chi-square test (Tables 3 and 4), whereas the t test was used to evaluate the compatibility of the severity of the initial malocclusion (TPI1 and PAR1), occlusal outcome after orthodontic treatment (TPI2 and PAR2), duration of treatment (TreatTime), initial age (AGE1) and final age (AGE2) (Table 5).

The t test was applied to variables TPI3 and PAR3 to compare the occlusal characteristics present at T3 between groups 1 and 2. A similar comparison was also performed for the variables that expressed the amount of relapse (DIFTPI3-2; DIFPAR3-2) and relapse rate in percentage (PTPI3-2; PPAR3-2) (Table 6).

To compare the scores given to each of the components of the PAR index at T3 and post-treatment changes between the two groups, the Mann-Whitney test was used (Table 7).

Since both groups had patients with and without a 3x3 lower retainer, the independent t test was used to compare intragroup stability of patients with 3x3 retainers with those who had no retainer at stage T3 in order to observe a possible influence of retainers on treatment stability for each group¹ (Tables 8 and 9).

In order to find a possible correlation of changes during treatment with changes after

TABLE 2 - Results of paired t-test and Dahlberg's formula⁶ as applied to the TPI and PAR variables to estimate the systematic and random intrarater errors, respectively.

VARIABLES	1 ST MEASUREMENT (n = 25)		2 ND MEASUREMENT (n = 25)		t	p	DAHLBERG
	$\bar{X}$	SD	$\bar{X}$	SD			
TPI	1.63	1.90	1.85	1.77	-1.39	0.1763	0.5915
PAR	5.12	5.83	5.00	5.46	0.42	0.6771	0.9899

TABLE 3 - Results of chi-square test to assess the compatibility of the groups in terms of the proportion of malocclusion types.

Group / Malocclusion	CL II 1	CL II 2	TOTAL
Group 1	24	5	29
Group 2	22	8	30
Total	46	13	59
$X^2 = 0.76$	df = 1	p = 0.3825	

TABLE 4 - Results of chi-square test to assess the compatibility of the groups in terms of the proportion of genders.

Group / Gender	M	F	TOTAL
Group 1	14	15	29
Group 2	17	13	30
Total	31	28	59
$X^2 = 0.42$	df = 1	p = 0.5188	

treatment according to the two aforesaid indices, was used the Pearson's correlation test (Table 10). The Spearman correlation test was used to assess whether the changes in overjet and overbite which occurred during treatment showed a correlation with post-treatment changes (Table 11).

The results were considered statistically significant for p values lower than 0.05.

TABLE 5 - Results of the independent t test applied to variables in groups 1 and 2.

VARIABLES	Group 1 - NONEXT (n = 29)		Group 2 - EXT 2 PM (n = 30)		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
TPI1	7.81	1.20	7.74	1.01	0.25	0.7971
TPI2	0.89	0.91	0.71	0.78	0.77	0.4410
TPI3	1.58	1.37	1.57	1.77	0.02	0.9806
DIFTPI3-2	0.69	1.19	0.85	1.73	-0.41	0.6794
PTPI3-2	9.28	16.48	11.15	24.08	-0.34	0.7304
PAR1	23.5	6.89	23.70	6.78	-0.10	0.9186
PAR2	3.55	3.50	2.03	2.59	1.89	0.0628
PAR3	4.41	3.71	5.13	5.53	-0.58	0.5613
DIFPAR3-2	0.86	3.49	3.10	5.24	-1.92	0.0594
PPAR3-2	3.60	15.80	15.13	32.33	-1.73	0.0889
TreatTime	2.51	0.98	2.24	0.75	1.19	0.2374
PostTreatTime	7.26	3.43	9.60	3.55	-2.56	0.0128
AGE1	12.65	1.38	13.32	1.52	-1.77	0.0816
AGE2	15.17	1.58	15.57	1.71	-0.92	0.3577
AGE3	22.44	3.50	25.18	3.97	-2.80	0.0069

TABLE 6 - Results of the independent t test, considering the compatibility of groups 1 and 2, in terms of post-treatment time and age at T3.

VARIABLES	Group 1 - NON-EXT (n = 28)		Group 2 - EXT 2 PM (n = 26)		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
TPI3	1.57	1.40	1.43	1.85	0.31	0.7527
DIFTPI3-2	0.71	1.21	0.77	1.82	-0.12	0.9001
PTPI3-2	9.61	16.68	10.04	25.35	-0.07	0.9422
PAR3	4.46	3.77	5.07	5.89	-0.45	0.6489
DIFPAR3-2	1.14	3.20	3.19	5.60	-1.66	0.1021
PPAR3-2	4.35	15.55	16.06	34.60	-1.62	0.1105
TreatTime	2.51	1.00	2.26	0.63	1.11	0.2690
PostTreatTime	7.31	3.48	8.89	3.16	-1.74	0.0871
AGE1	12.64	1.40	13.05	1.35	-1.09	0.2764
AGE2	15.16	1.61	15.31	1.48	-0.36	0.7132
AGE3	22.47	3.56	24.21	3.27	-1.86	0.0680

TABLE 7 - Results of the Mann-Whitney test applied in the post-treatment and post-treatment follow-up periods, and their respective change in the post-treatment period of each component of the PAR index in groups 1 and 2.

VARIABLES	Mean		z	p
	Group 1 – NONEXT (n = 29)	Group 2 – EXT 2 PM (n = 30)		
AP2	31.50	28.55	0.659	0.5095
AP3	33.72	26.40	1.637	0.1015
DIFAP3-2	32.60	27.48	1.144	0.2523
OVJ2	30.53	29.48	0.235	0.8142
OVJ3	28.50	31.45	-0.659	0.5095
DIFOVJ3-2	28.10	31.83	-0.833	0.4043
OVB2	31.09	28.95	0.477	0.6329
OVB3	30.28	29.73	0.121	0.9034
DIFOVB3-2	29.90	30.10	-0.045	0.9637
CROWD2	29.50	30.48	-0.219	0.8259
CROWD3	28.47	31.48	-0.674	0.4998
DIFCROWD3-2	28.93	31.03	-0.470	0.6383

TABLE 8 - Comparison, using the independent t test, of the stability of group 1 between cases with and without lower 3x3 retainer at stage T3.

VARIABLES	with 3x3 (n = 14)		without 3x3 (n = 15)		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
TPI2	1.03	0.97	0.75	0.87	0.79	0.4340
TPI3	1.88	1.62	1.30	1.09	1.12	0.2706
DIFTPI3-2	0.84	1.28	0.54	1.13	0.67	0.5080
PTPI3-2	10.94	17.61	7.74	15.80	0.51	0.6102
PAR2	3.71	3.53	3.40	3.58	0.23	0.8140
PAR3	4.78	4.50	4.06	2.91	0.51	0.6117
DIFPAR3-2	1.07	3.19	0.66	3.84	0.30	0.7613
PPAR3-2	5.19	15.93	2.12	16.08	0.51	0.6097

TABLE 9 - Comparison, using the independent t test, of the stability of group 2 between cases with and without lower 3x3 retainer at stage T3.

VARIABLES	without 3x3 (n = 17)		with 3x3 (n = 13)		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
TPI2	0.93	0.82	0.43	0.63	1.82	0.0784
TPI3	1.65	1.91	1.46	1.64	0.28	0.7792
DIFTPI3-2	0.71	1.93	1.03	1.50	-0.48	0.6284
PTPI3-2	9.44	26.78	13.39	20.86	-0.43	0.6641
PAR2	2.58	3.08	1.30	1.60	1.35	0.1847
PAR3	4.82	5.72	5.53	5.47	-0.34	0.7323
DIFPAR3-2	2.23	5.28	4.23	5.16	-1.03	0.3097
PPAR3-2	10.43	27.29	21.27	38.22	-0.90	0.3718

TABLE 10 - Results of the Pearson correlation test between changes during treatment (DIFTPI1-2, DIFPAR1-2, PTPI1-2, PPAR1-2) and changes after treatment (DIFTPI3-2, DIFPAR3-2, PTPI3-2, PPAR3-2).

VARIABLES	DIFTPI3-2	PTPI3-2	DIFPAR3-2	PPAR3-2
DIFTPI1-2	R = 0.0698 p = 0.599			
PTPI1-2		R = 0.1830 p = 0.165		
DIFPAR1-2			R = 0.0920 p = 0.488	
PPAR1-2				R = 0.1562 p = 0.237

TABLE 11 - Spearman correlation test applied to variables that assess changes in overbite and overjet during treatment (DIFOVJ1-2, DIFOVB1-2) and after treatment (DIFOVJ3-2, DIFOVB3-2).

VARIABLES	N	Spearman	t (N-2)	p
DIFOVJ1-2 X DIFOVJ3-2	59	0.166	1.27	0.2066
DIFOVB1-2 X DIFOVB3-2	59	0.093	0.70	0.4806

RESULTS

None of the variables showed statistically significant systematic and random errors (Table 2). Tables 3 and 4 show the compatibility of the groups, according to the chi-square test, for the proportion of Class II malocclusion types and gender proportion, respectively. Table 5 presents comparison results of the independent t

test between groups 1 and 2 regarding orthodontic treatment stability and group matching in light of variables TPI1, TPI2, PAR1, PAR2, TreatTime, AGE1 and AGE2. Table 6 presents the results of the comparison, using the independent t test, of orthodontic treatment stability in groups 1 and 2, considering the compatibility between post-treatment time (PostTreatTime) and age at T3 (AGE3). Table 7 presents the results of intergroup comparison of scores given to each component of the PAR index, using the Mann-Whitney test. Were compared the components of the PAR index in the models at T2 and T3 and the corresponding changes in the post-treatment period.

Tables 8 and 9 show the comparison, using the independent t test, of intragroup stability for cases with and without 3x3 retainer at stage T3, in groups 1 and 2, respectively. Table 10 correlates the changes during treatment with changes after treatment using the Pearson correlation test, and Table 11 correlates the changes in overjet and overbite during treatment (DIFOVJ1-2 and DIFOVB1-2) and after treatment (DIFOVJ3-2 and DIFOVB3-2) using the Spearman correlation test.

No variable used to assess orthodontic treatment stability showed a statistically significant difference between the two groups.

DISCUSSION

Sample description

After careful consideration of all the criteria mentioned above, a sample of 59 patients (29 from group 1 and 30 from group 2) was selected from approximately 4,000 orthodontic records pertaining to specialist, master's and continued education programs, archived at the Department of Orthodontics, Dental School of Bauru, São Paulo State. Assuming that the incidence of Angle Class II malocclusion is approximately 30%, the selected sample should have comprised a much larger number

of patients. One must consider, however, that the criteria used for selecting and matching the sample accounted for the elimination of a large number of patients who presented with this malocclusion. Furthermore, it should be emphasized that despite the efforts made to obtain complete records of all patients treated at the Department, some lacked an orthodontic documentation consistent with the specific needs of this study while others did not meet the minimum time period required by this study for post-treatment follow-up.

In Group 1, comprised of 29 patients, we used different orthodontic appliances and accessories to correct anteroposterior discrepancy. Among these, 25 patients wore headgear, 20 used Class II elastics and 12 used functional appliances, such as: bionator (7 patients), headgear with activator (3 patients), activator (one patient) and Cantilever Bite-Jumper (1 patient). For retention, we used upper Hawley plates in 27 patients and active retention with bionators in 2 patients for 1 year. A lower 3x3 retainer was installed in all patients. During consultation at stage T3, 15 patients were still using it.

The anteroposterior discrepancy of the 30 patients in group 2 was corrected by premolar extraction and retraction of the upper anterior teeth. We used headgear and Class II elastics as anchorage resources. For retention we used upper Hawley plates for 1 year and a lower 3x3 retainer in all patients. During consultation at stage T3, 13 patients still maintained the lower retainer.

Occlusal stability

The results of intergroup comparison between the TPI and PAR indices showed no statistically significant difference in occlusal stability between the non-extraction group and the group with the extraction of two upper premolars (Table 5). This conclusion contradicts the notion that treatments finished in a

Class II molar relationship could compromise treatment stability.^{21,26} These findings, therefore, confirm reports in the literature that the stability of Class II correction does not depend on whether or not the protocol involved tooth extraction,^{3,5,9,10,23,30} even though this is the first study comparing stability between non-extraction treatment and treatment involving the extraction of two upper premolars. Several studies have evaluated the stability of treatment without extractions and with the extraction of four premolars.^{3,5,9,10,30} Both are treatment protocols which establish a Class I molar relationship at the end of treatment.

Although relapse occurred in both treatment protocols assessed in this study, not only did they not exhibit statistically significant differences between them, but they also did not show significant clinical magnitude (Table 5). This finding supports most studies in the literature attesting to the adequate stability of Class II correction.^{10,27,30}

Treatment time and age at T3 might affect treatment stability.^{1,3,19} However, even though group 2 had a lengthier treatment time and, therefore, an increased age at stage T3 as well—which could comparatively benefit group 1—there were no statistically significant differences in all variables that assess treatment stability. After matching post-treatment time and age at T3, both groups continued not to show statistically significant differences in Class II correction stability (Table 6).

It can therefore be concluded that post-treatment time did not affect stability between the two groups. This finding corroborates other authors who assert that relapse occurs most often in the first post-treatment years, and that in the following years occlusion tends to stabilize, with the exception of the shift of lower incisor contact points, which tends to increase over the years.^{1,15,19}

None of the evaluated components that

were present in the PAR index, after it was split, showed a statistically significant difference when compared through the Mann-Whitney test, between groups with and without extraction of premolars (Table 7). This result confirms that the anteroposterior relationship of the arches does not change over time when orthodontic treatment is finished in a Class II molar relationship, contrary to the findings of Harris and Behrents,¹² which indicated that over time lower molars tend to move distally in patients with a Class II molar relationship.

After the corrective treatment of all 59 patients in the sample, 28 patients still had the 3x3 retainer at stage T3 (15 in group 1 and 13 in group 2). Thus, one may be led to believe that the use of a 3x3 retainer could influence the stability of dental changes in the lower arch. We therefore decided to make an intragroup comparison using the t test to assess the stability of patients with a 3x3 retainer who did not have a retainer at T3. The results showed no statistically significant difference in the stability of Class II correction in patients with and without 3x3 in both groups (Tables 8 and 9).

It can therefore be concluded that the presence of a 3x3 retainer did not influence the post-treatment results found in this study. However, since incisor irregularity shows a tendency to increase over time,^{1,15,19} 3x3 retainers should be employed to ensure stability of the lower incisors at the end of orthodontic treatment.^{1,25}

Changes during treatment had no bearing on Class II correction relapse, according to the Pearson correlation test (Table 10). This shows that the amount of Class II malocclusion correction was not a determinant of post-treatment relapse, although the initial severity of the occlusion and its outcome had been matched during sample selection. The decrease in overjet and overbite during treatment did not influence

post-treatment relapse, according to the Spearman correlation test (Table 11). This finding refutes other studies which concluded that the greater are the changes during treatment, the greater is the chance of post-treatment relapse.^{14,30} One possible explanation for this difference could be in the type of measurement. While other studies evaluated the changes during and after treatment by means of cephalograms, in the present study these changes were analyzed using study models. Moreover, the stability achieved by the two groups can be ascribed to the movements made during treatment, which remained within the limits of the soft tissues. This enabled a better balance of all orofacial muscles, thanks to the correction of the overjet and overbite, thereby improving the prognosis of long-term stability.

CLINICAL CONSIDERATIONS

The quest for efficiency in orthodontic treatment should be a constant goal in the life of every orthodontist.⁴ Therefore, adequate outcome quality combined with a treatment time that meets the expectations of professional and patient alike are essential stepping stones towards achieving excellence in orthodontics. Efficient orthodontic correction, however, is not enough. The search for lasting results should always be seen as a major goal of treatment.^{1,10,14,15} In this context, knowledge of result stability is particularly valuable in helping the orthodontist to choose more efficient and stable treatments.

In considering the treatment of Class II with or without premolar extraction, scientific evidence points to greater efficiency of treatment with extraction of two upper premolars.⁴ A major reason for this difference is that in non-extraction treatment it is necessary to correct the molar relationship,²⁹ which requires greater patient compliance¹⁷ and therefore reduces success rate.⁴ Furthermore, the argument

that this Class II treatment approach avoids tooth extraction is not sustained because non-extraction treatment requires a certain amount of distalization of the entire upper arch, significantly increasing the likelihood of impaction of third molars,¹⁶ whose surgical removal entails a greater risk to the patient and a greater burden to the treatment than the extraction of two premolars. Moreover, extractions performed in the upper arch may favor, or at least not hinder the eruption of third molars.¹⁶

There prevails in the literature a certain resistance to treatment with upper arch extractions in patients in the growth phase, which restricts the application of this protocol to adult patients.²³ This approach seems biased and certainly not at all based on scientific evidence. Evidence supports the implementation of these two treatment protocols during the active phase of growth. Moreover, non-extraction protocols undoubtedly impart a higher degree of difficulty to complete Class II treatment.⁴

Among the components evaluated in Class II treatment relapse, the anteroposterior relationship of the arches, crowding and overbite and overjet are worthy of note. Several studies show a consistent stability of Class I molar relationship after treatment of Class II malocclusion,^{27,30} whereas other studies on relapse have shown little clinical significance,^{10,30} as attested in this study. However, since there had been no studies comparing Class II correction stability with and without extraction of two upper premolars, uncertainty regarding the possible instability of a Class II molar relationship at the end of treatment still persisted.^{21,26} In line with this reasoning, we concluded that finishing a case with a Class II molar relationship after treatment of Class II malocclusion with extraction of two upper premolars showed excellent stability, similar to finishing it with a Class I molar relationship.

Overjet correction showed adequate stability after orthodontic treatment^{10,23} and its

relapse is related to post-treatment changes in incisor tipping, such as proclination of the upper incisors¹⁰ and retroclination of the lower incisors.¹⁰ In this study the stability of overjet correction was similar between the two groups, which corroborates the findings of other authors who claim that the stability of overjet correction does not depend on whether or not the protocol involves tooth extractions.^{10,23}

Overbite decreased during treatment and tended to increase after treatment^{20,27,30} due to relapse, although this occurred more frequently in cases of Class II, division 2.¹⁸ Therefore, one safe approach to overbite treatment would be to overcorrect this condition¹⁸ because the greater is the initial vertical overlap, the greater the relapse and the need for greater overcorrection.³⁰ Another way to reduce the potential instability of the incisors lies in appropriate torque control during mechanics implementation in order to ensure an adequate interincisal relationship at the end of treatment.⁸

This study concluded that overbite correction showed similar stability between the groups with and without extraction of premolars.

Regarding the relapse of lower incisor crowding, the motives underlying such instability²⁰ are still unclear since the same process can also be seen in normal, untreated occlusions.^{24,28} Therefore, for cases with dubious treatment stability prognoses and for patients who cannot tolerate mild irregularities of the lower incisors, we recommend the use of a 3x3 retainer for an unlimited period of time.^{1,25}

According to the literature, Class II correction is reasonably stable^{10,30} and it seems fair to say that this stability is independent of whether or not the therapy involves tooth extractions.^{3,5,9,10,23,30} As shown in this study, protocols for Class II treatment with or without extraction of two upper premolars feature similar stability of anteroposterior relationship, overjet, overbite and crowding. The choice of treatment should therefore be based on its efficiency.

CONCLUSIONS

The extraction of two upper premolars in treating complete Class II malocclusion did not influence the stability of the occlusal results achieved at the end of orthodontic correction, since no difference in stability was noted between the orthodontic treatment protocols with or without extraction of two premolars. Therefore, a similar

stability is achieved by finishing a treatment with either a Class II or a Class I molar relationship.

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Solitary median maxillary central incisor syndrome: Case report

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Abstract

Introduction: The presence of a single median maxillary central incisor is an uncommon event in the population. The prevalence of the Solitary Median Maxillary Central Incisor (SMMCI) syndrome is about 1:50,000 live births, occurring more in women. This alteration in the development of the dental occlusion is characterized by structural malformations, over all in midline region of the patient. The early diagnosis and the adequate treatment of this syndrome are of great importance, therefore this condition can be an indication that the patient can present other severe congenital malformations, not having to consider the SMMCI a simple dental anomaly. The orthodontic procedures, in these cases, vary depending on the degree of involvement of bone structures of the maxilla, the occlusion in itself, and mainly of the midpalatal suture. **Objectives:** To discuss, based on scientific evidence, important aspects related to the SMMCI and present a clinical case of female patient with SMMCI, which was submitted to orthodontic treatment in the Children's Dental Integrated Clinic of the Federal University of Santa Maria - RS/Brazil. **Conclusion:** According to the critical analysis of literature, it is very important to correctly early diagnose this condition, since there is the possibility of this syndrome to be associated with other problems of development. Moreover, the patients affected by SMMCI should be attended by a multidisciplinary health team in order to optimize the clinical results and recover the quality of life of these patients.

Keywords: Solitary median maxillary central incisor. Single median maxillary central incisor. SMMCI. Orthodontics.

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INTRODUCTION

The congenital absence of upper central incisors is a rare condition, while the presence of a single central incisor also is an uncommon event.²¹ The prevalence of the Solitary Median Maxillary Central Incisor (SMMCI) syndrome, also known as Single Median Maxillary Central Incisor Syndrome, occurs in 1:50,000 live births, with higher involvement of women. In this syndrome, developmental defects occur due to unknown factors operating *in utero* about the 35th–38th day from conception and are characterized by structural malformations, mainly midline defects in the patients.^{11,24}

Thus, the purpose of this study is to discuss, within a context based on scientific evidence, and illustrate, with a case report, relevant aspects concerning this condition.

CASE REPORT

A eight years and three months old patient, female, Caucasian, Brazilian, presented to the Children's Dental Integrated Clinic at Federal University of Santa Maria/RS (Brazil) for evaluation. After the initial clinical examination, the patient was selected and referred to the division of Orthodontics at the Children's Dental Clinic. Once accepted at the Division of Orthodontics of this clinic, the patient was well attended, her clinical history and the records of physical-clinical examinations were obtained and the orthodontic records necessary for diagnosis and treatment planning were requested. During clinical examination a very significant alteration was observed, the presence of a single central incisor, compatible with SMMCI, and maxillary atresia, as shown in figures 1, 2 and 3.

Regarding the presence of systemic changes,



FIGURE 1 - **A)** Right lateral view of the clinical status at diagnosis. **B)** Initial clinical aspect of the case, with the presence of a solitary maxillary central incisor. **C)** Left lateral view of the clinical status at diagnosis.

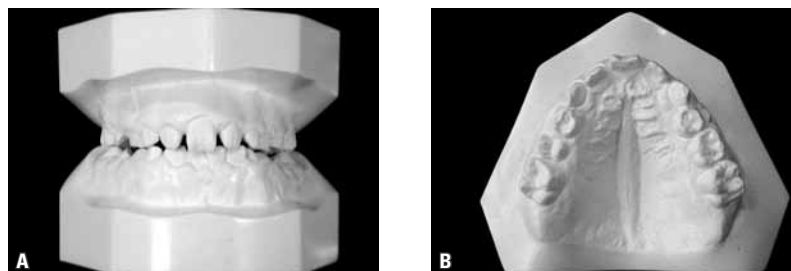


FIGURE 2 - **A)** Dental cast study models showing a single central incisor. **B)** Upper arch study model showing maxillary atresia and a solitary maxillary central incisor.



FIGURE 3 - **A)** Periapical radiograph, which confirms the presence of a solitary maxillary central incisor. **B)** Occlusal radiograph, confirming the presence of a solitary maxillary central incisor.

the patient's parent reported no involvement. This evaluation is important, since SMMCI may be associated with other developmental problems such as congenital nasal abnormalities,^{1,4,11,15,16,17} growth deficiencies,^{8,22} holoprosencephaly,^{6,28} format changes and craniofacial morphology,²⁵ congenital heart disease,^{8,10} among other local and systemic changes. However, there are studies that found no relationship between SMMCI and systemic changes.^{5,27}

Some authors also found associations between SMMCI and SHH gene mutations^{9,10,12,14,19,20} and deletions in parts of chromosome 18p^{2,7} and/or of chromosome 7q.^{10,18,26} Thus, an evaluation of a geneticist can find some association between SMMCI and chromosomal abnormalities.

The orthodontic treatment plan comprised a Phase I, which consisted of rapid maxillary expansion (RME), as well as support and interaction with Prosthetic Dentistry, Pediatric Dentistry and Oral and Maxillofacial Surgery specialties. At the end a Phase II was scheduled with fixed orthodontic treatment. Furthermore, the patient was referred to a multidisciplinary

health team, including pediatricians, geneticists, speech therapists and psychologists, since this anomaly may be associated with other developmental problems.

DISCUSSION

The involvement of SMMCI was initially reported by Scott²³ who described a girl with the presence of a solitary median maxillary central incisor, as an isolated finding. Another case of SMMCI was verified by Fulstow,⁸ but the patient showed apart from the single central incisor, short stature, congenital heart disease, microcephaly and scoliosis. Some factors that may be associated with SMMCI are the pituitary gland dysfunction and short stature, whereas in a study involving patients with SMMCI, 7 subjects had short stature and 5 were deficient in growth hormone production.²² However, Wesley et al²⁷ reported two cases of SMMCI in subjects with normal stature, while Cho and Drummond⁵ reported three cases of SMMCI in three Chinese girls with no growth deficiencies or systemic involvement.

According to DiBiase and Cobourne,⁶ the most common cause of a missing maxillary

central incisor is trauma, or more rarely hypodontia. When dental absence has no explanation in the patient's clinical history, a genetic analysis can show results. It is important to recognize the SMMCI when in an unknown etiology, because it may indicate a risk factor for holoprosencephaly. Thus, the role of the orthodontist is extremely important in the diagnosis of this condition, which must refer the patient for genetic testing to investigate other possible developmental disorders.

The SMMCI may be associated with various congenital nasal anomalies such as choanal atresia, intra-nasal stenosis and nasal pyriform aperture stenosis. Choanal atresia consists in a bone or membranous obstruction of the posterior nasal aperture caused by a failure in the oronasal disintegration. The intra-nasal stenosis is a bony narrowing of the nasal cavity between the pyriform aperture and the posterior choanae, whereas the nasal pyriform aperture stenosis is an anterior nasal obstruction secondary to the bone growth of the nasal processes of the maxilla. It is important to note that the clinical aspects of the above changes are similar, and often a computed tomography is required for definitive diagnosis,^{4,17} being that prenatal diagnosis of SMMCI can be done through magnetic resonance imaging.¹³

Thus, several studies have looked at the association of nasal obstructions and SMMCI. Arlis and Ward¹ evaluated six patients with congenital stenosis of the nasal pyriform aperture and found that of these, 4 had SMMCI. Lo et al¹⁷ found in their results that 63% of patients with congenital stenosis in the nasal pyriform aperture also presented SMMCI, while Hall et al¹¹ found that among 21 patients with SMMCI, all had a positive relationship with a history of nasal congenital obstruction, whereas choanal atresia and intra-nasal stenosis were found in 7 and 8 patients respectively. Already, Levison et al¹⁶ reported two cases of neonatal children

with nasal obstruction due to stenosis of the choanae, which had an association with single maxillary central incisor, a fact verified by computed tomography.

The presence of chromosomal defects was observed in some children who had SMMCI. Dolan et al⁷ found chromosomal abnormalities in children with a single central incisor, with deletion of parts of chromosome 18 (18p), which was also reported by Aughton et al.² Nonetheless, Masuno et al¹⁸ reported deletion in the terminal portion of chromosome 7q, which was also found by Hall¹⁰ and Tubbs and Oakes.²⁶ Another factor that seems to be associated with the SMMCI is a mutation of the SHH gene.^{9,10,12,14,19,20}

For Yassin and El-Tal,²⁸ the appearance of a solitary incisor in place of the two central incisors may occur due to fusion of two neighboring teeth or to agenesis of a tooth germ. However, this can be associated with other systemic disorders such as autosomal dominant holoprosencephaly, growth retardation and midline developmental defects. Becktor et al³ evaluated the intermaxillary suture, the eruption pattern of the single central incisor and growth of the maxilla in a group of patients with SMMCI. The sample consisted of 11 patients with SMMCI, who underwent orthopantomographs, dental and lateral cephalometric radiographs. The X-rays showed that the intermaxillary suture was abnormal anterior to the incisive foramen, however, the horizontal and vertical growth of the maxilla was normal.

Analyzing 10 patients (9 girls and 1 boy) aged between 8 and 17 years who presented SMMCI, Kjaer et al¹⁵ examined the clinical characteristics and craniofacial morphology of this group of patients. Intra and extra-oral photographs, profile radiographs, orthopantomograms and study casts were analyzed. The study results showed that the craniofacial morphology of nine girls with SMMCI compared with normal craniofacial

parameters, showed a short anterior cranial base, a short, retrognathic and posteriorly inclined maxilla, and a retrognathic and posteriorly inclined mandible, and morphological changes in the sella turcica were found in five patients examined. Moreover, this group of patients had characteristics such as: nasal obstruction, septal deviation, absence of the fraenum of the upper lip, and a complete or incomplete mid-palatal ridge. Thus, the presence of SMMCI should not be considered as a simple dental anomaly, because it may be associated with other clinical characteristics and craniofacial malformations.

Tabatabaie et al²⁵ evaluated the neurocranial and craniofacial morphology of children with SMMCI using profile radiographs and cephalometric analysis. The sample comprised 13 children (12 girls and 1 boy) aged between 7 and 17 years. Cephalometric evaluations were compared with standard measures. The study results showed that the size of the neurocranium, the maxillary prognathism and inclination, the mandibular prognathism and inclination of lower incisors are significantly decreased in patients with SMMCI. But, the mandibular inclination, vertical jaw relationship and mandibular angle are significantly increased in patients affected by SMMCI. The data from this study showed that the occurrence of SMMCI is a sign of anomaly development, associated with deviations in neurocranial size and shape and in craniofacial morphology.

According to Hall,¹⁰ the etiology of SMMCI is uncertain and may be associated with mutations in SHH gene (I111F) in chromosome 7q, with a positive correlation with congenital nasal malformations. These teeth erupt and develop in the midline of the maxillary arch, both in primary and permanent dentitions. The presence of SMMCI may be associated with some common congenital abnormalities such as moderate to severe intellectual disability, congenital heart disease, cleft lip and/or palate and less frequently,

microcephaly, hypopituitarism, strabismus, duodenal atresia, scoliosis, hypothyroidism, absent kidney, micropenis and ambiguous genitalia. Short stature can be found in children. The diagnosis of SMMCI should be performed at 8 months of age, but can be done at birth and possibly prenatal, between the 18th and 22nd week of gestation by ultrasound examination. In patients with SMMCI rehabilitation should be undertaken in accordance with the anomalies presented by individuals: choanal stenosis requires surgical treatment, short stature should be approached with growth hormone therapy, and the presence of single maxillary central incisor should be a requirement for an multidisciplinary treatment involving the specialties of Orthodontics, Prosthetic Dentistry and Oral Surgery.

Cho and Drummond⁵ suggest that early diagnosis of SMMCI is extremely important, because it is a sign that the patient may present with other severe congenital malformations. If they are pediatric patients they should be seen together with the pediatrician. In three patients evaluated by these authors,⁵ all were female and had no growth deficiencies or any systemic involvement. The dental management consisted in preventive and orthodontic approaches, and in two cases expansion of the upper arch was performed, moving the solitary central incisor to one side and obtaining space for placement of osseointegrated implant or prosthesis on the other side.

CONCLUSIONS

This case report has a great clinical importance under the viewpoint of the orthodontic treatment necessary to solve this dental occlusion anomaly. The simple fact of a malocclusion being present, associated to a maxillary atresia, synthesize the functional severity that this type of case represents, requiring adequate oral rehabilitation, as well as an integral attention to the health of patients suffering from SMMCI.

Dental procedures for patients with SMMCI vary with the degree of commitment that it causes. Orthodontic procedures are extremely important for the return of function and aesthetics to the patient, requiring an interdisciplinary approach with other dental specialties for optimizing clinical outcomes. Moreover,

it is important that the patient should be attended by a multidisciplinary health team, including pediatricians and other medical professionals, geneticists, speech therapists and psychologists, since this anomaly may be associated with other developmental problems and systemic changes.

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Evaluation of antimicrobial activity of orthodontic adhesive associated with chlorhexidine-thymol varnish in bracket bonding

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Abstract

Objective: To assess the antimicrobial activity resulting from the association of an orthodontic adhesive with chlorhexidine-thymol varnish. **Methods:** Thirty-two extracted human premolars were used, divided into four groups. In Group 1, the control group, the adhesive used to bond the bracket was not associated with any antimicrobial agent. Groups 2, 3 and 4 were bonded with an adhesive system associated with chlorhexidine-thymol varnish. Groups 3 and 4 were stored in water for 7 days and 30 days, respectively, while the specimens from group 2 were, soon after bonding, placed on agar seeded with *Streptococcus mutans* for 48 hours, at 37° C. **Results:** The experimental groups, with the exception of the control group, showed antimicrobial activity whose action tended to decline commensurately with the amount of time that they remained immersed in water. **Conclusions:** The association of chlorhexidine-thymol varnish with an adhesive system used in orthodontics proved to be advantageous due to its antimicrobial activity.

Keywords: Chlorhexidine. Adhesives. Antimicrobial agents.

INTRODUCTION

Nowadays, the use of orthodontic appliances is widespread. However, these appliances can be associated to difficulty in cleaning. During treatment, retentive areas are created that favor biofilm accumulation and bacterial growth. One of the greatest challenges in orthodontics consists in maintaining proper oral hygiene during treatment. Brackets, bands and other accessories further aggravate these condition by retaining dental plaque, which can lead to gingivitis and enamel

demineralization, causing white spots and caries.⁸

Microbiological studies have established that, after placement of a fixed orthodontic appliance, the number of bacteria rises significantly, particularly lactobacilli and streptococci, subjecting the oral environment to an imbalance and enabling the emergence of diseases. Although dental biofilm is composed of numerous species of bacteria, it is believed that *Streptococcus mutans* is involved in the early development of carious lesions.²⁰

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Thus, orthodontic treatment success lies in correcting occlusion in the best possible manner without, however, affecting the pre-existing health of teeth and supporting tissues. Otherwise, treatment benefits may be questioned.³⁰ Orthodontic practice undergoes constant progress with the use of new techniques and materials that benefit both patients and practitioners.² Attempts to inhibit the development of carious lesions in orthodontic patients have been focused on controlling the bacterial biofilm around the brackets.⁸ During therapy, orthodontists are also responsible for caries prevention.³⁰

In order to reduce the appearance of decalcified areas around the brackets, authors have suggested the use of orthodontic bonding resins which either contain or are associated with antimicrobial agents.^{2,17}

In orthodontics, composite materials are generally used for bonding brackets. These composites can act as a source of nutrition and agglomeration of opportunistic bacteria.⁸ Hahn et al¹³ concluded that microorganisms accumulate around restorative materials. Moreover, it has been previously reported that composites do not exhibit antibacterial activity after polymerization.⁶ It would be convenient to modify existing materials to perform additional functions. Considering that these materials would already be present in the mouth, they could serve as reservoirs or platforms for the dispersal of therapeutic agents.²¹

According to Korbmacher et al,¹⁷ orthodontic bonding systems that release antimicrobial agents to adjacent areas are useful because they reduce the need for patient compliance and can potentially decrease decalcification.

It has been suggested that the incorporation of chlorhexidine could impart antibacterial properties to composites. Chlorhexidine is a cationic chlorophenylbiguanide with antimicrobial properties and affinity for oral structures.

Its bactericidal activity results from coagulation of bacterial cytoplasm with subsequent rupture of cell membrane.²⁴ This agent is considered the gold standard compared to other substances designed to interfere with biofilm formation and development of gingivitis.³ Its spectrum is broad, covering Gram-positive and Gram-negative bacteria, yeasts, dermatophiles and some lipophilic viruses, in addition to having a selective effect on *Streptococcus mutans*.²⁵

However, composite resins are considered clinically insoluble since their components remain trapped inside and experience great difficulty in being released because the resin components restrict their displacement.⁶ Ribeiro and Ericson,²² however, observed antimicrobial activity after combining a composite resin with chlorhexidine to release antimicrobial components, although such activity decreased with time. Ehara et al,¹⁰ however, concluded that resins that release antibacterial agents have certain drawbacks, since their effects are transitory and decrease over time, they also impair mechanical properties and are potentially toxic.⁹

Bishara et al¹ and Damon et al⁷ found that a combination of chlorhexidine and orthodontic resins yielded sufficient shear strength for use in orthodontics, provided that the varnish is pre-mixed with the resin, applied to the etched enamel and cured. Karaman and Uysal¹⁵ agreed that shear strength becomes clinically acceptable when the varnish has been mixed with the resin in a 2:1 ratio, respectively.

The association of orthodontic bonding materials with chlorhexidine is useful as it is an adjunctive method to prevent the appearance of white spot lesions and caries around the brackets. It could play an important role as an auxiliary tool in preventing the demineralization of tooth enamel surfaces, thereby preserving the teeth during orthodontic treatment.

The purpose of this study was to assess the antimicrobial activity resulting from the

association of an orthodontic adhesive system with chlorhexidine-thymol varnish.

MATERIAL AND METHODS

An experimental, transverse laboratory study using 32 human premolars with healthy buccal surfaces, extracted for orthodontic purposes was conducted.

In this research, a modified version of the culture technique described by Ribeiro²³ for verification of growth inhibition was used.

The lingual surfaces of the teeth were flattened, both crown and root, so that the teeth had a buccolingual width of about 7 mm (Fig 1, A), and could be laid on a flat surface with their buccal surfaces facing upward. The mesial and distal surfaces of all teeth were also abraded down to 3.8 mm width, to match the width of the bracket to be bonded. The bonding area was demarcated with adhesive tape so that only the bracket base area was exposed and came into contact with the material being evaluated. The specimens were then subjected to a complete cycle of autoclaving (120°C for 20 minutes). Then, the brackets (MorelliTM, Brazil) were bonded in aseptic conditions and in a laminar flow, after sterilization of the bonding materials. The center of the buccal surface of each tooth was etched with phosphoric acid at 37% for 15 seconds, then washed with pyrogen-free sterile water and the etched enamel was dried with sterile filter paper.

This bonding protocol was described by Martinez,¹⁸ who achieved adequate shear strength with this method. In group 1 (control), 9µL of Ortho Primer MorelliTM was applied to each tooth, waiting up to 30 seconds for it to dry off slightly and curing it for 20 seconds. The metal brackets (MorelliTM) with the composite on them (Transbond XT, 3M, USA) were seated on each tooth with the aid of orthodontic tweezers, positioned and cured for 10 seconds on each side.

In Groups 2, 3 and 4 (Table 1) a mixture of 6µL chlorhexidine varnish (Cervitec, Ivoclar-VivadentTM, Swiss) and 3µL primer (Ortho Primer MorelliTM) at a ratio of 2:1 was used. This ratio is advocated in the literature as providing adequate mechanical properties for clinical use in orthodontics.^{2,7,15,18,22} The mixture was applied to the etched enamel surface and light-cured for 20 seconds. The metal brackets (MorelliTM) with the composite on them (Transbond XT, 3M) were seated on each tooth with the aid of orthodontic tweezers, positioned and light-cured for 10 seconds on each surface (Fig 1, B). After bonding the brackets, the adhesive tapes were removed.

The specimens in group 3 were kept separately in sterile pyrogen-free water for seven days in airtight jars. The specimens in group 4 were kept under the same conditions for 30 days and the water was replaced after 15 days. Groups 1 and 2 were bonded and cultured within up to four hours after bonding. All groups were cultured at the same time using the same bacterial culture.

With the purpose of placing each specimen on sterile Petri plates (100 mm diameter by 15 mm height), about 40 mL of Tryptic Soy Agar (TSA - Difco) culture medium were added to each plate. Each specimen was then placed in one of the plates, according to each group, with the flattened lingual surface seated on the bottom of the plate. Consequently, the buccal surfaces were facing upward, so that each bracket and the enamel adjacent to it were kept free from contact with the culture medium (Fig 1, C). After complete solidification, about 15 mL of the same molten culture medium, cooled to 50°C and seeded with *Streptococcus mutans* (ATCC 25175) was added. The inoculum consisted of a suspension of 8.0×10^{12} CFU of *Streptococcus mutans*/mL of medium, with an optical density of 1.6 in DO_{600} , which was added to the plates containing the specimens.



FIGURE 1 - A) Abrasion of palatal surface. B) Bracket bonded to an area bounded by adhesive tape. C) Tooth fixed in agar without contact with bracket tie-wings.

TABLE 1 - Description of study groups.

Group	Storage time in water	Adhesive	Association with chlorhexidine and thymol (Cervitec™)
1	-	Ortho Primer	Absent
2	-	Ortho Primer	Present
3	7 days	Ortho Primer	Present
4	30 days	Ortho Primer	Present

An amount of agar with *Streptococcus mutans* culture that was sufficient to cover the base of the brackets and enamel surface surrounding the bonding area without covering the tie-wings was added to each plate. The medium was let to dry off and then the plates were placed in a bacteriological incubator for 48 hours at 37°C. After culture, the presence or absence of a zone of inhibition of bacterial growth was evaluated. In cases where a zone of inhibition was formed, its diameter was measured with the aid of a bow divider and a millimeter ruler. The results were subjected to statistical analysis of variance (ANOVA) and Tukey's test.

RESULTS

ANOVA demonstrated significant differences in the results obtained by the groups (p value = 0.000). The control group had no evidence of a zone of inhibition. In group 2, the mean value

was 4.125 mm, with standard deviation of 0.991. The mean value found in group 3 was 3 mm, with standard deviation of 0.756. In group 4, the mean value was 2.625 mm, with standard deviation of 0.518 (Table 2). Statistically significant differences were found between the results obtained in group 1 and other groups and between group 2 and other groups. Between groups 3 and 4, however, no statistically significant difference was found, although, as can be seen in Figure 2, values exhibited a declining trend.

DISCUSSION

A gold standard method is not yet available for in vitro evaluation of antimicrobial agents in bonding agents.²⁶ Several in vitro studies have evaluated the antimicrobial effectiveness of bonding materials by the agar diffusion method.^{14,16} The agar diffusion test is an acceptable method for differentiating the antimicrobial activity of substances at an early stage.²⁹ The zones of growth inhibition are dependent on the toxicity of the material used against the bacteria and the diffusibility of the material inside the culture medium.¹¹ In this study, it was used the agar diffusion method to observe the activity of the agent against one of the most common bacteria associated with caries: *Streptococcus mutans*. These bacteria also feature considerable affinity for composite resins.¹⁹

TABLE 2 - Obtained results ($p = 0.000$).

	Group 1	Group 2	Group 3	Group 4
Zone mean (mm)	0.000	4.125	3	2.625
SD	0.000	0.991	0.756	0.518

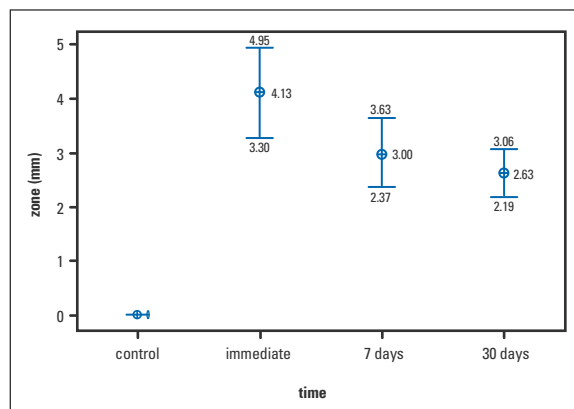


FIGURE 2 - Reduction tendency of the obtained zone when evaluated by the mean for each group.

Cervitec varnish was used because it is a compound widely used as a source of chlorhexidine in many studies.^{1,7,18,23}

This study further disclosed the antimicrobial action of chlorhexidine, whose effectiveness is well established in dentistry,⁵ where it is associated with bonding resins used in orthodontics. However, further *in vitro* and *in vivo* studies are needed to determine the clinical significance and duration of antimicrobial properties on a variety of oral cavity microorganisms involved in the pathogenicity of bacterial biofilms and caries.

Similarly to Ribeiro's²³ findings, it appears that given the formation of a zone of inhibition the combination of chlorhexidine varnish and orthodontic bonding material enabled antimicrobial activity by releasing the antimicrobial substance into the culture medium,

thereby inhibiting *in vitro* bacterial growth in areas surrounding the bracket. It is likely that a small amount of chlorhexidine was released from the portion below the bracket since only a thin layer of adhesive associated with varnish was exposed to the culture medium.⁴

The reduction in the effects of chlorhexidine over time may be due to a reduction in the release rate or a reduction in the actual amount of material present. According to Couto Júnior et al,⁶ although component release seems larger at first, the decrease in this rate indicates that the components in the outer layer are depleted or dissolved in the water. On the other hand, the components trapped inside the resin mass are released with immense difficulty because resin components restrict such displacement.⁶ The literature reports the sustained release, in aqueous environment, of compounds initially located within orthodontic adhesive resins for 150 days,²⁸ or even up to two years.¹²

Often, the therapeutic agents of dental biomaterials are released from materials and exhibit a decreasing release rate. The water in the oral cavity diffuses into the resin matrix. The agent trapped in the adhesive dissolves and disperses in ever smaller concentrations. Over time, the agent is released and extracted from an increasingly deeper matrix layer, which means that the time needed for diffusion to the external environment increases as the rate of release declines.²¹ This may also explain the absence of statistically significant differences between the antimicrobial activity of the group that was stored in water for seven days and the group stored for thirty days. However, we observed a significant reduction in antimicrobial activity between the group that was never stored in water and the group stored for seven days. It has been reported that immersion in water in the first three hours causes 50% of releasable components to be released from the resin.²⁷

There is no way of telling how long the system will display antimicrobial activity, mainly in the oral environment. It is clear, however, that this is an association whose antimicrobial effects display a decreasing trend, although it is probably an inexhaustible source of chlorhexidine. Therefore, these benefits do not last throughout the orthodontic treatment and changes may occur in mechanical properties after the release of the substance. However, it is likely that this activity will last through the most critical period of biofilm accumulation, when proper oral hygiene is a key issue. This period spans from the time of orthodontic appliance installation through the following four months,²⁰ thus justifying its benefits.

Damon et al⁷ and Bishara et al¹ found that a combination of chlorhexidine and orthodontic adhesives yielded sufficient shear strength for use in orthodontics when applied to the etched enamel and cured. Karaman and Uysal¹⁵ agreed that shear strength becomes clinically acceptable when the varnish has been mixed with the

adhesive in a 2:1 ratio, respectively. Ribeiro²³ and Martinez,¹⁸ after evaluating the bond strength of bonding systems whose adhesives had been pre-mixed with Cervitec chlorhexidine varnish, concluded that there was no statistically significant change in bond strength compared with adhesive alone. Further studies are needed to evaluate mechanical strength after the release of chlorhexidine, color stability, local and systemic cell and tissue compatibility, before the use of an adhesive/varnish combination in daily clinical practice is fully warranted.

CONCLUSIONS

Based on this study, it is possible to conclude that the association of chlorhexidine varnish with an orthodontic adhesive showed antimicrobial activity in vitro, even after immersion in water for seven or thirty days. It was also possible to notice a decreasing trend in antimicrobial activity with the increase of immersion time in aqueous media.

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Comparison of two extraoral radiographic techniques used for nasopharyngeal airway space evaluation

Mariana de Aguiar Bulhões Galvão*, Marco Antonio de Oliveira Almeida**

Abstract

Objectives: The goal of this research was to compare lateral cephalometric radiography and cavum radiography in nasopharyngeal airway space evaluation. **Methods:** The sample of this study consisted of 36 Brazilian mouth breathing children, no racial distinction, with ages ranging from 5 to 12. These children were selected in Recife/PE, Brazil (2005) and divided into 6 groups. In each group, the radiographs were taken on the same day. The sample was composed of 72 radiographs, 36 lateral cephalometric and 36 cavum. **Results:** The results were based on the Schulhof method and, at the end, an Index representing a summary of all measurements taken was calculated. Student paired t-test, chi-square, Pearson correlation and Kappa index scores were calculated to analyze the results. Only the values of the Airway Occupation Percentage were significantly different ($p = 0.006$) among the analyzed radiographs. A high degree of correlation was found for all measurements, including the Index values. **Conclusions:** It can be concluded that, both the lateral cephalometric radiography and the cavum radiography can be used for nasopharyngeal airway space evaluation.

Keywords: Adenoids. Nasopharynx. Radiography.

INTRODUCTION

Adenoid hypertrophy is very common in children and usually occurs between 2 and 12 years of age, reducing or preventing nasal breathing.^{11,14} This problem has been associated with several diseases, such as acute otitis

media, secretory otitis media, increase of the middle turbinates, septal deviation, obstructive sleep apnea syndrome and chronic recurrent pharyngeal infections.^{8,11} There is also an association between mouth breathing and craniofacial growth and development. Although it is not

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clearly defined whether it is the upper airway obstruction that leads to dentofacial deformities, or the existence of such deformities that leads to the airway deficiencies, the right diagnosis of the coexistence of both abnormalities is necessary, mainly to allow a good orthodontic treatment plan.

Due to the difficulty of establishing a definitive diagnosis only by clinical examinations, physicians and dentists use auxiliary exams to help the diagnosis of oral breathing. The additional routine examination for the child with a clinical diagnosis of adenoid hypertrophy is the radiographic examination.

Cavum radiograph is used by otorhinolaryngologists, while orthodontists use lateral cephalometric radiography. Although they are distinct X-rays, they have the same purpose in nasopharyngeal airway space evaluation.

A mouth-breathing patient requires a multidisciplinary approach in their treatment, mainly involving otorhinolaryngologists and orthodontists, so the comparison of these two radiographs would help to determine differences that may exist between the two radiographic techniques, considering the positive and negative factors, and probably avoiding the duplication of radiographs.

The purpose of the present study is to compare the lateral cephalometric radiographs, used by orthodontists, and cavum radiographs, used by otorhinolaryngologists, taken from mouth-breathing patients in order to:

1. Statistically compare the data obtained for the percentage of the airway space occupied by the adenoid tissue and the linear measurements in the assessment of nasopharyngeal airway space.
2. Evaluate the correlation of these values in both radiographic techniques.
3. Establish whether only one of the radiographic techniques could satisfy both orthodontists and otorhinolaryngologists.

MATERIAL AND METHODS

The anamnesis of 150 children, 67 girls and 83 boys was held by a single examiner, an orthodontist, in the Dental Clinic of Orthodontic Study Group (Ortogeo), in Recife/PE, Brazil. All children have Brazilian nationality, ages ranging from 5 to 12 years, without racial distinction, residents of the metropolitan area of Recife (PE).

The children were selected from three Dental Clinics: Dental Clinic of the Military Police of Pernambuco, Dental Clinic of Padre Antonio Manoel Hospital (Mirueira Hospital) and the Dental Clinic of Ortogeo.

Data regarding medical history were registered on a form specially designed for this study, including, besides personal identification data, questions related to the exclusion and inclusion of children in this study.

Were excluded patients according to the following criteria:

- Wearing orthodontic appliance;
- Taking any kind of medicine regularly;
- Had the adenoids removed;
- Had any congenital anomaly.

The inclusion criterion was the presence of mouth breathing habit. Initially, we considered to be mouth breathing those patients whose parents or guardians reported that their children were mouth breathers. Of a total of 150 children assessed, only 36 (21 boys and 15 girls) met the inclusion criteria established in this study.

The Ethical Committee of Pedro Ernesto University Hospital approved the study (n° 1082, CEP / HUPE) and also the Ethical Committee of Restauração Hospital (n° 0005.1.102.000-05). This study was registered in the SISNEP (National system of ethics in research).

An informed consent was obtained from parents or guardians, allowing children to participate in this study, according to Resolution No. 196, October 10, 1996, of the National Health Council responsible for regulating the principles governing research involving human beings.

A speech therapist examined all the patients. In the clinical examination the position of the lips, tongue and cheeks was observed, and speech-language tests were used to investigate proper speaking, breathing, chewing and swallowing. The results confirmed that 36 children were indeed mouth breathers.

In the next step, the radiographs of all the patients were taken on the same day using both extraoral radiographic techniques: Lateral cephalometric radiographs and cavum radiographs. To allow this, the patients were divided into six groups of six children each.

The lateral cephalometric radiographs were taken in the Radiology Clinic Radioface, Unit Derby in Recife (PE) and the standards for radiography were those described by Broadbent in April 1931.⁴

The cavum radiographs were taken in the Restauração Hospital and the standards for radiography were those described by Bontrager in March 2003.³

Demarcation of the cephalometric points and collection of the assessed measurements

All 72 radiographs were scanned in the Radioface Radiology Clinic by a single operator, a radiology technician, using the Epson Expression 1680 scanner. They were scanned with a 150 dpi resolution and processed in the CefX for Windows (CDT Company - Consultoria, Desenvolvimento, Treinamento em Informática Ltda., Cuiabá - MT, Brazil) cephalometric program. Using the same program, the cephalometric points were located in the 72 images, using the mouse, by another radiology specialist. Then, the same program generated the cephalometric and radiographic analysis of the adenoids.

The analysis used to evaluate the nasopharyngeal airway space was described by Schulhof.²² This analysis combines four cephalometric measurements used in the analysis of the nasopharyngeal region forming a system of four factors for assessing the nasopharyngeal airspace.

The first factor described by Handelman and

Osborne,¹⁰ corresponds to the percentage of airway occupied by adenoid tissue in the nasopharynx area (Fig 1).

The second factor was described by Linder-Aronson and Henrikson¹⁵ and it is represented by the distance from the point AD1 to the posterior nasal spine (D-AD1:PNS) (Fig 2).

The third factor, also described by Linder-Aronson and Henrikson,¹⁵ represents the linear distance from the point AD2 to the posterior nasal spine (D-AD2:PNS) (Fig 3).

The fourth factor described by Schulhof²² is represented by the linear distance from point AD to a point of pterygoid vertical line 5 mm above the posterior nasal spine (D-PTV:AD) (Fig 4).

Radiograph report

After measuring lateral cephalometric radiographs and cavum radiographs, a computerized report of the nasopharyngeal airway analysis was printed.

According to the CefX program, the assessment of each measurement would be (Table 1):

- Large space: when the percentage of space occupied by adenoid was lower than the normal range in the first factor and the distance was greater than the normal range in the second, third and fourth factors.
- Normal: when the measurement found in the analysis was within normal limits.
- Localized obstruction: when the percentage of space occupied by adenoid was larger than the normal range in the first factor and the distance was shorter than the normal range in the second, third and fourth factors.

At the end of the computerized report an Index representing a summary of all the factors was emitted by the CefX. This Index ranged from 0 to 4:

- 0 and 1: No adenoid hypertrophy problems;
- 2: Possible adenoid hypertrophy problem;
- 3: Probable adenoid hypertrophy problem;
- 4: Adenoid hypertrophy problem.

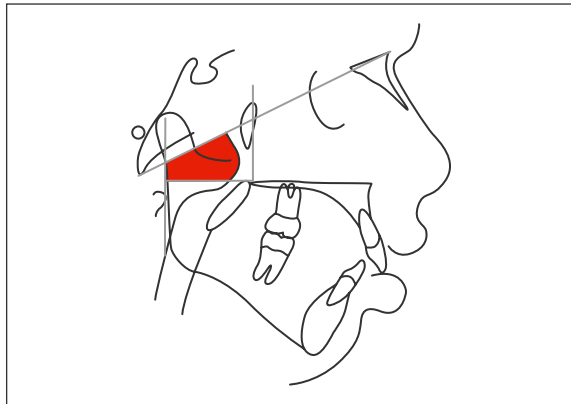


FIGURE 1 - Schematic drawing of the first factor (percentage of airway occupied by adenoid tissue), represented in red.

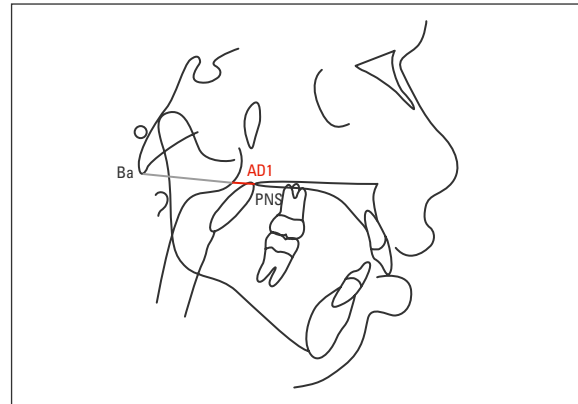


FIGURE 2 - Schematic drawing of the second factor (D-AD1:PNS) represented by the red line.

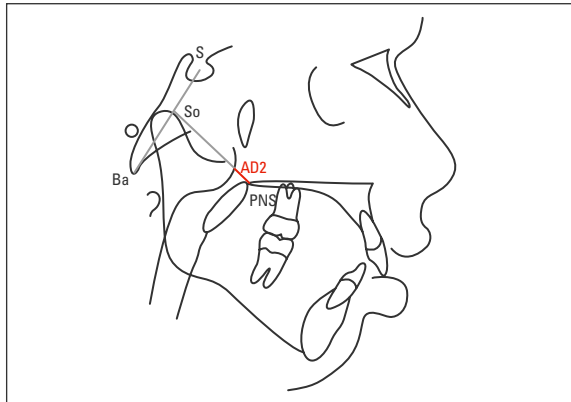


FIGURE 3 - Schematic drawing of the third factor (D-AD2:PNS) represented by the red line.

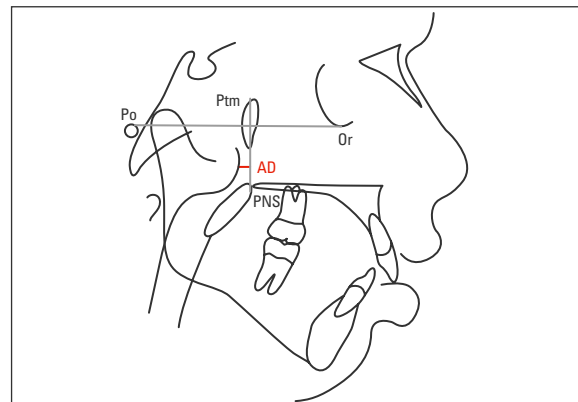


FIGURE 4 - Schematic drawing of the fourth factor (D-PTV:AD) represented by the red line.

RESULT	1 st FACTOR	2 nd , 3 rd and 4 th FACTORS
Large space	Values lower than the standard	Values greater than the standard
Normal space	Values equal to the standard	Values equal to the standard
Localized obstruction	Values greater than the standard	Values lower than the standard

TABLE 1 - Interpretation of nasopharyngeal airway space radiographic evaluation.

A zero Index means that all examined measures were within normal limits; Index 1 means only one measure was out of the normal range; Index 2 means two measures were out of the normal range; Index 3 means three measures

were outside the normal range and, finally, Index 4 means all four measures were out of the normal range.

Method errors

To calculate the intra-operator method error, all procedures for the nasopharyngeal airway space analysis were performed in ten lateral cephalometric radiographs and ten cavum radiographs. Starting with the scanning and ending with obtaining the radiographic measurements. These operations were repeated three times with a five-day interval between each essay. The results were statistically analyzed to verify the Kappa index score.

Kappa values	Degree of agreement
<0.00	Does not exist
0.00-0.20	Poor
0.21-0.40	Slight
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Excellent

TABLE 2 - Values used for the interpretation of the Kappa agreement index, according to Landis and Koch.¹³

The result showed an excellent intra-operator agreement level. The Kappa index score of agreement for the assessment of intra-operator test was $k = 0.89$ (Table 2).

Statistical Analysis

In the statistical analysis of results, paired t-test and chi-square (X^2) were performed. The computations were performed using the SPSS statistical software (Statistical Package for Social Sciences) version 14.0 for Windows operating system (SPSS Inc, Chicago, IL.).

This research adopted a 5% probability significance level ($p < 0.05$).

RESULTS

Statistical evaluation of results

After obtaining the measurements, the minimum and maximum values, medians, standard deviations, and coefficient of variation of variables (percentage of airway space, D-AD1:PNS, D-AD2:PNS, D-PTV:AD) were calculated (Table 3).

When the paired t-test was applied, a statistically significant difference between the lateral cephalometric radiographs and cavum ($p = 0.006$) was found, on data obtained from the percentage of airway space analysis.

For the others variables (D-AD1:PNS, D-AD2:PNS and D-PTV:AD) the paired t-test showed no statistically significant difference between the

two radiographic techniques and the values of $p = 0.05$, $p = 0.25$ and $p = 0.62$, respectively.

The Pearson correlation coefficient was used with the objective of correlating the values obtained from lateral cephalometric radiographs and cavum radiographs.

In all variables, the results of the correlation coefficient showed that there was a high correlation (Table 4).

In the statistical analysis of the variable Index, chi-square (X^2) was applied to compare the frequency distribution of this variable on lateral cephalometric and cavum radiographs. It was observed that there was no statistical significant difference in this variable in both x-rays in nasopharyngeal airway space analysis ($p = 0.71$).

The Kappa index score was used to check the degree of agreement of values obtained in the variable Index and the value obtained was good ($k = 0.63$), according to the values listed in Table 2.

Table 5 shows the percentages of the Index variable in the lateral cephalometric radiographs and cavum radiograph.

DISCUSSION

There are several causes to nasal obstruction: nasal septum deviation, tonsils and adenoids hypertrophy and increase of the middle turbinates.^{8,19} However, there is a consensus in the literature that adenoid hypertrophy is the most important etiological factor that induces nasal obstruction.^{9,17,19,24}

The accuracy of radiographic methods for the assessment of nasopharyngeal airway space has been questioned, due to the static two-dimensional viewing generated by radiographs for the evaluation of a three-dimensional dynamic structure. Several studies have shown a significant correlation between the results obtained in the radiographic evaluation and those obtained in the clinical evaluation,²⁰ in the direct observation during surgery,⁶ in posterior rhinoscopy¹⁴ and nasal endoscopy.^{12,18,25}

TABLE 3 - Minimum and maximum values, medians, means, standard deviations and variation coefficients of continuous variables.

	Airway Occupation Percentage		D-AD1:PNS		D-AD2:PNS		D-PTV:AD	
	LCR	Cavum	LCR	Cavum	LCR	Cavum	LCR	Cavum
Minimum	23.11%	26.14%	10.19 mm	7.11 mm	8.31 mm	6.59 mm	4.84 mm	4.74 mm
Maximum	78.28%	90.73%	29.72 mm	33.19 mm	21.60 mm	21.11 mm	22.95 mm	24.91 mm
Median	48.05%	53.51%	22.64 mm	21.11 mm	15.04 mm	14.49 mm	13.97 mm	12.41 mm
Mean	49.90%	53.36%	21.02 mm	20.24 mm	14.98 mm	14.67 mm	13.46 mm	13.24 mm
SD	14.27%	15.60%	5.15 mm	5.46 mm	3.82 mm	4.00 mm	4.55 mm	5.35 mm
Variation Coefficient	28.5%	29.2%	24.5%	26.9%	25.5%	27.2%	33.8%	40.4%

LCR = lateral cephalometric radiographs.

TABLE 4 - Values obtained in the linear correlation statistical analysis for the variables used in this study.

Variables	% airway space	D-AD1:PNS	D-AD2:PNS	D-PTV:AD
Correlation	r = 0.89	r = 0.90	r = 0.91	r = 0.87

TABLE 5 - Percentage of Index variable in the lateral cephalometric radiography and cavum radiography.

RADIOGRAPHY	INDEX				
	0	1	2	3	4
LCR	63.89%	13.89%	5.55%	13.89%	2.78%
Cavum	72.22%	5.55%	2.78%	13.89%	5.56%

LCR = lateral cephalometric radiographs.

The big difference between the lateral cephalometric radiography and the cavum radiograph is that the former uses the cephalostat to stabilize the patient's head. In the cavum radiography, the absence of the cephalostat during the procedure allows the patient to change the head position and requires more attention from the radiology technician.

According to Oliveira, Anselmo-Lima and Souza¹⁹ and Malkoc et al,¹⁶ a slight change in the patient's head position while the radiologic examination is performed could lead to important changes in the distances between the structures involved to assess the degree of obstruction of

nasopharyngeal airway space.

In this research, two different radiographic techniques were used to evaluate the nasopharyngeal airway space, and not the size of the adenoids, because there is a consensus among authors that it is not the size of adenoids that should be evaluated, but rather the space in which it is inserted.^{5,7,15,21,23}

The Schulhof²² analysis was used in this study because it combines four cephalometric measurements, used in the nasopharyngeal region analysis, forming a system of four factors for assessing the nasopharyngeal airspace.

Regarding the data obtained through the evaluation of nasopharyngeal airway space, the averages of the D-AD1:PNS, D-AD2:PNS and D-PTV:AD were within the limits of nasal breathing according to Haldelman and Osborne;¹⁰ Linder-Aronson¹⁴ and Schulhof.²² But our aim was not to verify the presence or absence of adenoid hypertrophy, but rather, to compare two radiographic methods used to measure the nasopharyngeal airway space.

The use of lateral radiographs in nasopharyngeal airway space evaluation is a practical and simple way to diagnose nasopharynx obstruction. Besides, it's a simple and low-cost available technique.^{1,2}

Since studies comparing the two techniques used in this research were not found in the literature, it's essential that new studies using the Schulhof²² method or other methods of

nasopharyngeal airway space measurement be compared with the results found in this research.

CONCLUSION

Based on the results of this research, it can be concluded that:

1. Only in the percentage of airway occupied by adenoid tissue there were significant differences between lateral cephalometric radiographs and cavum radiographs. However, in the other measures (linear variable D-AD1:PNS, D-AD2:PNS, D-PTV:AD) and the Index there were no statistically significant differences between the two radiographic techniques.

2. A high degree of correlation was found in all variables used to analyze the nasopharyngeal airway space in both radiographs, demonstrating equivalence between the two techniques.

3. For the nasopharyngeal airway space analysis, the lateral cephalometric radiograph or the cavum radiograph satisfy the needs of both orthodontists and otorhinolaryngologists.

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Condylar hyperactivity: Diagnosis and treatment - case reports

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Abstract

Introduction: Condylar hyperactivity is a condition triggered by an imbalance in bone growth factors, which causes facial asymmetry. It can be classified into three different types: hemimandibular hyperplasia (HH), hemimandibular elongation (HE) and a hybrid form. It is essential that a correct diagnosis of these hyperactivities be reached since each type of anomaly requires a different approach. Treatment options include surgery and high condylectomy. **Objectives:** The purpose of this article is to present two cases of facial asymmetry caused by condylar hyperactivity, showing the importance of an accurate diagnosis and the means used to achieve it while seeking an appropriate treatment for each case.

Keywords: Maxillomandibular anomalies. Facial asymmetry. Condylar hyperplasia.

INTRODUCTION

Skeletal asymmetries of the mandible caused by condylar hyperactivity can pose serious functional, esthetic and psychosocial problems for patients. Although their etiology is still unknown, some authors believe they can be caused by trauma, inflammation, hypervascularity, genetic factors and hormonal disorder.^{4,7,11,13}

Several classifications are available. Some are etiology-related while others divide these anomalies according to the growth factors involved in its development. Asymmetries can therefore be acquired or developmental, and since each situation presents with different features a differential diagnosis can be more easily established. Acquired asymmetries involve pain, symptom changes, alterations in facial appearance and

function with time. The volume of facial muscles remains unchanged. Other features include TMJ crepitation (crackling/popping sounds), limited mandibular movements (rotation, protrusion and mouth opening), severe crossbite and irregular condyle anatomy. Developmental changes do not involve pain, symptoms usually remain unchanged over time, changes may occur in the size or function of the facial muscles, no functional changes take place in the TMJ, there may be limited protrusion without limiting mandibular rotation movements, a pronounced dental compensation in the asymmetric mandible may be present and the condyle remains pronounced and smooth, even in the presence of volumetric changes.¹⁵

According to Obwegeser and Makek,¹³ hy-

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peractivity can be classified into three different types: hemimandibular hyperplasia (HH), hemimandibular elongation (HE) and a hybrid form. Many authors use the term condylar hyperplasia to refer to these three forms, but this is not appropriate, since it is only in HH and hybrid cases that a true condylar hyperplasia is found.

Condylar hyperactivity is common to these three forms and occurs primarily due to an imbalance in the growth regulatory factors located in the cartilaginous layer of the condyle. One such factor is responsible for height growth (Factor L), and manifests itself in hemimandibular elongation; the other factor is responsible for bone mass growth (Factor M) and remains active in hemimandibular hyperplasia.¹²

Hemimandibular elongation may occur as an extension of the condyle or ramus in the vertical plane, or as an extension of the body in the horizontal plane. Combined vertical and horizontal elongations are possible.⁹ Their main clinical feature are an elongation of one side of the mandible with no increase in bone mass production. Both the chin and the midline of the lower teeth are shifted to the side opposite to the elongation and, typically, a crossbite is also present. The teeth on the affected side are usually in infra-occlusion when compared with the teeth on the opposite side.¹⁶ A flattening of the gonial angle in the affected side can also be observed.^{9,12,16} Typically, elongation stabilizes when patients cease to grow.

Hemimandibular hyperplasia is characterized by a three-dimensional increase in the affected side of the mandible extending to the symphysis region.^{2,12} Its major characteristics are: lower border of the mandible on the affected side positioned further down when compared with the contralateral side; increased distance between tooth apices and mandibular canal.^{2,12} An inclination of the occlusal plane and rima oris on the affected side can also be observed. Depending on the stage in which

asymmetry development occurs it may cause maxillary inclination in response to mandibular growth.² Otherwise, there will be unilateral posterior open bite.¹³ The dental midline is usually shifted to the malformed side. The gonial angle is either normal or more acute¹⁶ and, in general, a growth period elapses after the patient's asymmetric growth is completed.

The hybrid form can produce the strangest forms of facial and mandibular asymmetry. The condyle may have an increased bone mass, there may be a crossbite, chin deviation toward the opposite side and a vertical increase in the affected hemimandible, creating an oblique occlusal plane. Different signs will emerge depending on which growth factor is being activated.¹²

It is important that clinicians learn to identify such hyperactivities because development time, dentoalveolar compensation and the likelihood of an intervention achieving success are different for each type of anomaly.⁹

Diagnosis must be based on anamnesis, an evaluation of previous medical and dental history, clinical examination, model analysis, complementary tests such as computed tomography and bone scintigraphy.^{6,14,16}

The purpose of this article is to present two cases of facial asymmetry caused by condylar hyperactivity, showing the importance of an accurate diagnosis while seeking an appropriate treatment for each case.

CASE REPORT

Case 1

A female Caucasian patient, aged 17, sought orthodontic treatment with the chief complaint of asymmetrical facial growth, which made her different from her identical (monozygotic) twin sister. No history of trauma or asymmetry cases in the family were reported. She presented with a swelling in the left side of the mandible, chin deviation to the opposite side, posterior open bite on

the left side and inclined maxillary occlusal plane (Fig 1). Radiographs showed a three-dimensional increase of the hemimandible and an increase in distance between root apices and mandibular canal (Figs 2, 3 and 4). Bone scintigraphy showed active growth of the left condyle (Fig 5). Through the association of clinical and imaging features we

concluded that this was a case of condylar hyperactivity of the hemimandibular hyperplasia type. Treatment comprised presurgical orthodontic preparation, orthognathic surgery (upper maxillary repositioning and reduction of body, ramus and gonial angle height) and high condylectomy with external access.



FIGURE 1 - Initial facial appearance.

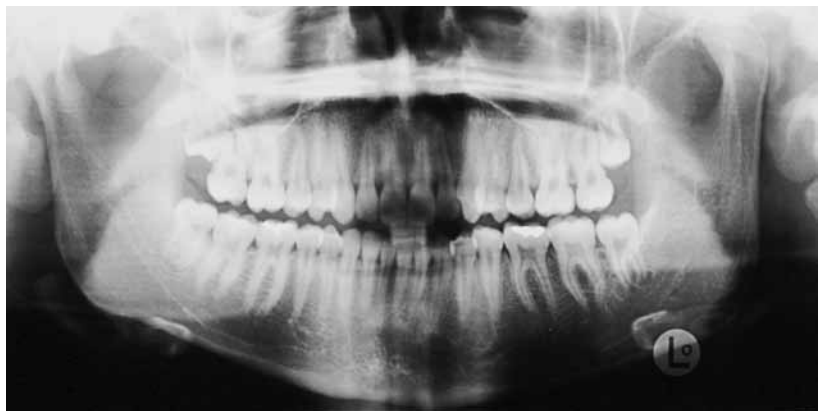


FIGURE 2 - Initial radiographic appearance.



FIGURE 3 - Computed tomography showing size differences between condyles.



FIGURE 4 - Three-dimensional reconstruction.

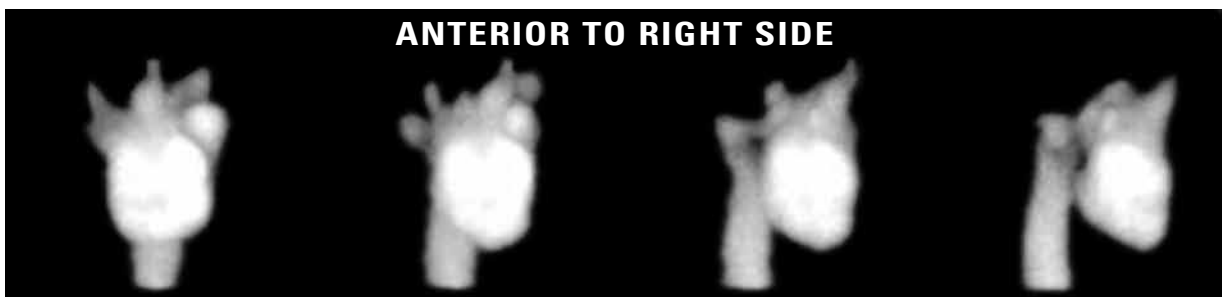


FIGURE 5 - Bone scintigraphy showing increased uptake in the left condyle.

Case 2

A male Caucasian patient, 16 years old, sought dental care because of a facial asymmetry. He had no history of trauma. Clinically, he showed a mandibular deviation and lower midline shift to the right side, inclined maxillary occlusal plane, chin deviation and misalignment in a typical case of hybrid form condylar hyperactivity (Fig 6).

Radiographs showed a volume increase in condylar mass on the left side and increased distances between root apices and mandibular canal (Fig 7). Treatment consisted of presurgical orthodontic preparation, unilateral maxillary intrusion with skeletal anchorage provided by a miniplate and, at the final growth stage, mandibular orthognathic surgery and genioplasty, without condyle removal.

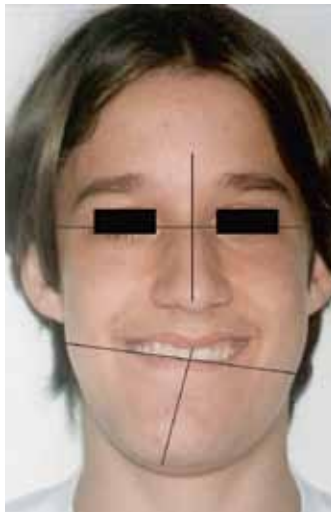


FIGURE 6 - Initial facial appearance.



FIGURE 7 - Initial radiographic appearance.

DISCUSSION

An accurate diagnosis of the different types of anomalies is essential for a suitable treatment plan. Besides clinical analysis and the use of conventional radiographs, computed tomography with three-dimensional reconstruction (3D) allows for greater visualization of the skeleton and better assessment of the affected areas. Bone scintigraphy is an auxiliary diagnostic method that makes it possible to detect diseases or metabolic changes and has proven effective in monitoring bone growth. It normally uses

technetium pyrophosphate 99, which identifies areas with increased osteoblastic activity.^{1,3} It is noteworthy, however, that some procedures that cause osteoblastic or osteoclastic activity, such as dental extractions, can interfere with imaging results.¹⁶ Therefore, one should always associate imaging results with other clinical data.

The treatment of choice for condylar hyperactivity is debatable and varies among different authors. Patient age, clinical progress and severity of the deformity² should be taken into account before treatment planning.

In the past, asymmetry treatment consisted only of orthognathic surgery. However, relapse occurred if condylar hyperactivity was still active. Nowadays, thanks to the development of new diagnostic techniques growth can be assessed, and with it the risk of relapse, making it possible to administer a more suitable therapy, such as orthosurgical treatment and high condylectomy when necessary.⁴

In case 1, the patient presented with maxillary occlusal plane inclination and mandibular asymmetry. Given the fact that orthodontic anchorage methods with the use of miniplates for intrusion of maxillary segment were not yet reported in the literature, the treatment consisted of orthognathic surgery. A Le Fort I type osteotomy was performed with gradual intrusion of the left side, leveling the maxillary occlusal plane. In the mandible osteoplasty of the body, ramus and gonial angle were performed and since there was active growth in the left side, a high condylectomy was chosen, thus removing the growth center responsible for the asymmetry (Figs 8, 9 and 10).

Different approaches can be adopted for the treatment of condylar hyperactivity. Some authors believe that high condylectomy should be performed as soon as possible after diagnosing hyperactivity and when there is a tendency towards further development of asymmetry. This would result in the removal of the center responsible for hyperactivity, but the need may arise for a second procedure to correct deformities.¹² Currently, it is known that the condyle is a center of regional growth and not responsible for the overall growth of the mandible. An intervention in the condyle can therefore be performed without causing major changes in facial growth.^{5,10} Moreover, when condylectomy is performed before the end of growth it has the additional advantage of spontaneously remodeling soft tissue and the condyle in the articular fossa.²

Some authors base their treatment choice on patient age and asymmetry development speed. In young patients with active hyperactivity they usually perform a high condylectomy.² However, if asymmetry development is slow and does not cause an unsightly facial appearance, treatment should only be carried out after growth has ceased. In adult patients whose growth is inactive the recommended therapy is orthognathic surgery, but if condylar growth is active, condylectomy and orthognathic surgery are indicated. Other authors, however, disagree.⁹ They believe that a longer time period should elapse to allow for latent or continuous hyperplastic growth to manifest.

Currently, complex cases such as the intrusion of posterior teeth⁸ can be resolved with the aid of miniplates. These devices are installed temporarily in the maxilla or mandible and afford stable and effective skeletal anchorage, enabling the performance of orthodontic movements¹⁷ and thereby restoring the occlusal level.

In case 2, as the patient's maxilla was involved, orthodontic anchorage was performed with miniplates, which allowed the intrusion of the posterior segment of the left maxilla (Figs 11 and 12). Thus, the maxillary occlusal plane was aligned, setting the stage for a less invasive surgical treatment plan and the correction of asymmetry through intervention in the mandible (vertical technique) and chin, for esthetic correction. No intervention was made in the condyles as the bone scintigraphy performed preoperatively showed symmetrical uptake in the condyles, showing that there was no hyperactivity but only the patient's normal growth (Figs 13 and 14). The two cases demonstrate different behaviors in the timing and form of intervention as new techniques emerged, allowing the administration of less invasive treatments. Satisfactory results were achieved even with different approaches, i.e., occlusal stability was gained and maintained during a monitoring period of four years in case 1 and one year in case 2.



FIGURE 8 - Postoperative facial appearance.



FIGURE 9 - Postoperative radiograph showing a remodeled left condyle.



FIGURE 10 - Postoperative panoramic radiograph.



FIGURE 11 - Preoperative facial appearance after leveling of upper occlusal plane.

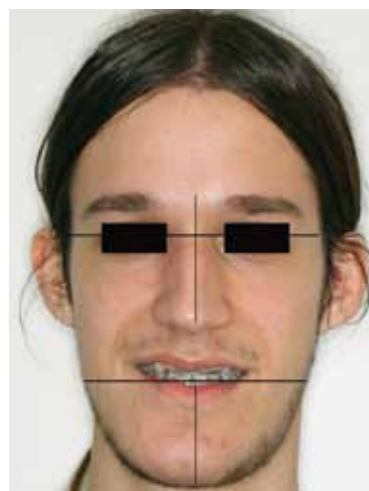


FIGURE 13 - Postoperative facial appearance.



FIGURE 12 - Panoramic radiograph showing leveling of upper occlusal plane with the use of miniplates.



FIGURE 14 - Postoperative panoramic radiograph.

CONCLUSIONS

Facial asymmetries caused by condylar hyperactivity can cause considerable inconvenience to patients. Early diagnosis and the establishment of an appropriate therapy is of utmost importance to avoid development of secondary deformities, which would render the treatment more complex. Therefore, we must conduct a proper clinical examination as well as complementary examinations such as radiography, 3D computed tomography and bone scintigraphy.

After diagnosis, an appropriate treatment must take into account patient age, deformity development rate, whether or not hyperactivity is present, asymmetry severity level and functional constraints. Only then, the best possible procedure should be selected

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Comparison of soft tissue size between different facial patterns

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Abstract

Objective: This study was designed to compare the soft tissue morphology of individuals according to their facial patterns. **Methods:** Were used cephalograms of 90 patients of both genders, aged 12 to 16 years, which were divided into three distinct groups, according to their morphological patterns, i.e., mesofacials, dolichofacials and brachyfacials. The groups were compared in terms of thickness and height of the upper and lower lips, and thickness of the soft tissue chin. Correlations between soft tissue variables and dental and skeletal cephalometric measurements were also investigated.

Results and Conclusions: Thickness of upper lip, lower lip and soft tissue chin showed no differences in all morphological groups. However, upper and lower lip heights were significantly greater in dolichofacials. Brachyfacials showed smaller upper lip height compared with mesofacials, although no differences were found between those two groups in terms of lower lip height. Assessment of the correlations between soft and skeletal/dental variables evidenced vertical development of the upper and lower lips, commensurate with the vertical development of the skeleton. The vertical positioning of upper incisors significantly correlated with the same parameters related to the lips, which ensured a similar exposure level of these teeth in all groups.

Keywords: Vertical pattern. Cephalometry. Lip. Chin.

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INTRODUCTION

The orthodontic literature often describes and classifies the different facial types according to their vertical skeletal features.^{15,20,23,24,25} This skeletal pattern classification stems from the need to ensure the use of discrete approaches based on the diagnosis, treatment and prognosis of each group.

On the other hand, less emphasis is given to the description and comparison of aspects related to the soft tissue of different morphological classes. Most research in this area focuses on investigating soft tissue responses to movements resulting from orthodontic treatment.^{1,5,8,17,22,28} Some correlate soft tissue characteristics with malocclusions of horizontal origin.^{6,11} However, few address soft tissue characteristics of malocclusions from a vertical perspective. Moreover, investigations that do address these issues^{3,4,13} fail to conduct an in-depth examination of the origin or possible causes of any differences that may be found. Thus, we need to generate further information about these morphological groups and their soft tissue characteristics. The provision of such information may also assist in planning orthodontic cases according to these characteristics while helping to establish a specific soft tissue prognosis for each pattern.

Therefore, this study was designed to compare facial groups classified according to their vertical skeletal characteristics (mesofacial, dolichofacial and brachyfacial) and to their respective soft tissue morphological features, particularly those relating to the lips and chin. Moreover, it also aims to determine the skeletal and/or dental features of the sample, which correlate more significantly with the morphology of the lips and chin, thereby allowing inferences to be made regarding the origin and possible causes of any differences detected between groups.

MATERIAL AND METHODS

This is a cross-sectional, comparative and de-

scriptive study approved by the Ethics in Research Committee of the institution where it was conducted (File Nº. 2003. 1. 1045. 58. 4).

Were used lateral cephalograms of patients aged between 12 and 16 years of both genders whose records were archived at the Orthodontics Clinic of the university where the study was conducted. Were excluded from the final sample those patients who had undergone orthodontic treatment in the period prior to when the radiographs were taken. Furthermore, subjects who had made obvious efforts towards achieving a lip seal were also excluded from the study.

Once selected, the radiographs were divided into three groups consisting of 30 subjects each, according to the morphological patterns displayed by the patients (mesofacial, dolichofacial and brachyfacial). The criterion used to divide the sample into groups was the measurement of the facial axis (BaN.PtGn), whose normal value¹⁸ is 90°. The groups were defined taking into account the 3° variation proposed by McNamara,¹⁴ as explained below.

- Mesofacials: facial axis equal to or above 87° and equal to or below 93°.
- Dolichofacials: facial axis above 93°.
- Brachyfacials: facial axis below 87°.

VARIABLES	
Skeletal	Dental
SNA	1-NA
SNB	1.NA
ANB	1-NB
SNGoGn	1.NB
LAFH (ENA-Me)	1-PP
TAFH (N-Me)	1.PP
	IMPA
	1-St _s

TABLE 1 - Skeletal and dental cephalometric variables.

The radiographs were then traced and subsequently dental and skeletal cephalometric measurements were determined (Table 1).

The following assessments of soft tissue dimensions were also performed (Fig 1).

- Upper lip thickness (ULT): distance between the junction of the contour of the maxillary incisor and the pre-maxilla, and point UL, located in the anterior-most region of the upper lip contour.
- Upper lip height (ULH): distance between the palatal plane (ANS-PNS) and a parallel line going through St_u (located at the bottom of the contour of the upper lip).
- Lower lip thickness (LLT): distance between the junction of the contour of the lower incisor and the anterior contour of the chin, and point LL, located in the anterior-most contour of the lower lip.
- Lower lip height (LLH): distance between the mandibular plane and a parallel line going through St_l (located at the upper border of the contour of the lower lip).

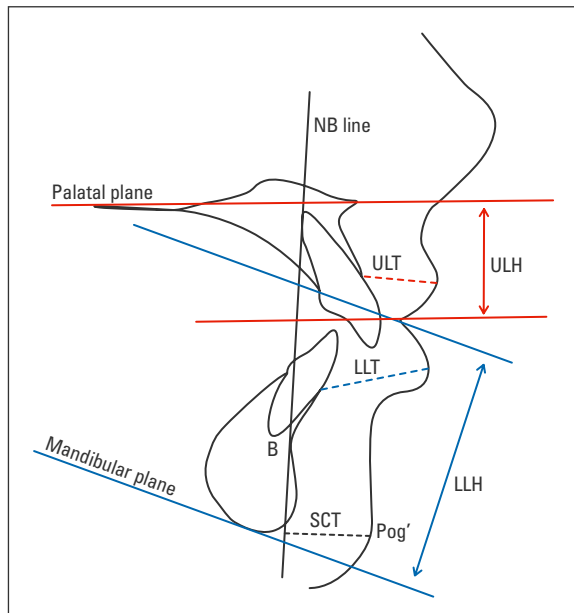


FIGURE 1 - ULT, ULH, LLT, LLH and SCT.

- Soft chin thickness (SCT): shortest distance between Pog' and NB line.

The measurements were performed by a single orthodontist trained for this purpose, who did not know to which group each radiograph belonged.

Statistical Analysis

Group characterization was conducted through descriptive data analysis. To check data normality the Shapiro-Wilk test was applied. Due to the presence of normal distribution of data, parametric tests were used for inferential analysis.

Once assessed, the measurement values were compared between the groups. To check for differences in sample characterization in terms of gender, the Chi-square test was applied, and for age, analysis of variance (ANOVA). Comparisons between groups for each cephalometric measurement were assessed using ANOVA. For variables whose ANOVA value was significant ($p < 0.05$), the Tukey test for multiple comparison analysis was used. To check the correlation between soft tissue variables and skeletal and dental parameters the Pearson correlation coefficient was applied. Correlation strength was analyzed using the values proposed by Santos.¹⁹ The level of significance for statistical tests was 5% ($\alpha \leq 0.05$). All tests were performed by the computer program SPSS (10.0, SPSS Inc., Chicago, USA).

RESULTS

Most of the subjects in the mesofacial, dolichofacial and brachyfacial groups were male (60.0%, 56.7% and 53.3%, respectively), with mean age between 13 and 14 years (13.73 years, 13.43 years, 13.37 years, respectively). The three groups showed no statistical differences regarding composition by gender ($p = 0.873$) and age ($p = 0.555$).

The means, standard deviations, maximum and minimum values as well as the comparative

TABLE 2 - Comparison between morphological patterns in terms of skeletal measurements.

Variables	Morphological pattern	Mean	SD	Minimum	Maximum	ANOVA (p-value)	Tukey
SNA (degrees)	MESO	81.883	4.586	70.5	91.0	0.003	M-D 0.137
	DOLICHO	79.667	3.909	70.5	85.0		M-B 0.253
	BRACHY	83.717	4.815	73.5	92.0		B-D 0.002
SNB (degrees)	MESO	79.317	3.800	72.0	86.5	< 0.001	M-D 0.001
	DOLICHO	75.983	3.019	68.0	82.5		M-B 0.001
	BRACHY	82.817	3.497	75.0	91.0		B-D < 0.001
ANB (degrees)	MESO	2.733	1.770	-0.5	7.0	< 0.001	M-D 0.294
	DOLICHO	3.683	2.419	-1.0	8.0		M-B 0.013
	BRACHY	0.900	2.995	-6.5	5.0		B-D < 0.001
SN.GoGn (degrees)	MESO	31.317	7.023	24.0	60.0	< 0.001	M-D < 0.001
	DOLICHO	36.617	3.662	28.5	42.0		M-B 0.002
	BRACHY	26.750	3.674	17.0	33.0		B-D < 0.001
LAFH (mm)	MESO	66.800	6.400	58.0	85.0	< 0.001	M-D 0.003
	DOLICHO	71.600	4.773	61.500	82.0		M-B 0.232
	BRACHY	64.450	5.297	55.000	75.0		B-D < 0.001
TAFH (mm)	MESO	119.067	7.011	108.0	136.0	< 0.001	M-D 0.043
	DOLICHO	123.500	6.994	109.0	134.0		M-B 0.099
	BRACHY	115.300	7.011	102.0	132.0		B-D < 0.001

Level of significance = 5%.

analysis relating to skeletal and dental cephalometric measurements are depicted in Tables 2 and 3, respectively.

Soft tissue measurements (Table 4)

There was no statistical difference between the facial groups with regard to the thickness of both upper and lower lips.

However, the groups were considered different from each other in terms of upper lip height. Dolichofacials exhibited significantly longer lips, followed by mesofacials and brachyfacials, who displayed significantly shorter lips.

Regarding lower lip height, there were no

significant differences between mesofacials and brachyfacials. However, the dolichofacial group exhibited significantly higher means compared with the other groups, indicating that dolichofacials have lips that are vertically longer.

Regarding soft chin thickness, differences were detected in the analysis including all groups. In paired analysis, however, this difference did not reach a statistically significant level although it was more significant when dolichofacial and brachyfacial groups were confronted with each other. In this comparison, dolichofacials had thinner soft chin than brachyfacials, although this difference was not significant.

TABLE 3 - Comparison between morphological patterns in terms of dental measurements.

Variables	Morphological Pattern	Mean	SD	Minimum	Maximum	ANOVA (p-value)	Tukey	
1-NA (mm)	MESO	6.433	1.911	2.5	11.0	0.243	M-D	
	DOLICHO	7.467	2.655	3.0	14.0		M-B	-
	BRACHY	7.017	2.472	2.5	14.0		B-D	
1.NA (degrees)	MESO	23.167	7.091	9.5	39.0	0.128	M-D	
	DOLICHO	23.317	6.051	10.0	33.0		M-B	-
	BRACHY	26.467	7.843	4.0	44.5		B-D	
1-NB (mm)	MESO	6.117	3.042	2.0	19.0	< 0.001	M-D	0.005
	DOLICHO	8.033	1.875	5.0	12.0		M-B	0.076
	BRACHY	4.767	1.746	1.5	8.0		B-D	< 0.001
1.NB (degrees)	MESO	26.800	6.257	17.0	38.5	< 0.001	M-D	0.028
	DOLICHO	31.400	6.896	15.5	44.0		M-B	0.198
	BRACHY	23.583	6.890	7.0	34.5		B-D	< 0.001
1-PP (mm)	MESO	28.633	3.620	21.0	37.0	< 0.001	M-D	0.002
	DOLICHO	31.550	3.133	26.0	37.0		M-B	0.026
	BRACHY	26.417	2.758	22.0	32.0		B-D	< 0.001
1.PP (degrees)	MESO	112.433	9.119	93.5	140.5	0.016	M-D	0.818
	DOLICHO	110.200	5.609	97.0	120.5		M-B	0.224
	BRACHY	116.083	8.342	93.0	132.5		B-D	0.014
IMPA (degrees)	MESO	95.350	7.186	82.0	107.0	0.016	M-D	1.000
	DOLICHO	96.933	6.611	81.0	110.0		M-B	0.155
	BRACHY	91.933	6.302	79.5	102.0		B-D	0.015
1-St_s (mm)	MESO	4.033	2.117	-2.0	8.0	0.085	M-D	
	DOLICHO	5.100	2.966	-2.0	10.5		M-B	-
	BRACHY	3.783	2.012	-0.5	7.5		B-D	

Level of significance = 5%.

Correlation between soft tissue, skeletal and dental variables (Table 5)

Soft tissue variables were compared among themselves as well as with all dental and skeletal variables. The correlations that reached statistical significance are shown below.

Upper lip thickness correlated moderately with lower lip, so that as one increased, so did the other.

Upper and lower lip heights correlated with each other positively and with similar strength. Positive and stronger correlations were found between these two variables and the anterior lower and total facial heights. Lower lip height correlated very strongly with the anterior lower and total facial heights. The upper lip exhibited a strong correlation with the anterior lower facial height and only moderate with total anterior facial height.

TABLE 4 - Comparison between morphological patterns in terms of soft tissue measurements.

Variables	Morphological Pattern	Mean	SD	Minimum	Maximum	ANOVA (p-value)	Tukey
ULT (mm)	MESO	17.033	2.810	11.0	23.5	0.262	M-D
	DOLICHO	16.750	2.417	11.5	20.5		M-B
	BRACHY	17.817	2.541	11.0	24.0		B-D
ULH (mm)	MESO	25.267	3.919	19.0	33.0	< 0.001	M-D
	DOLICHO	27.417	3.135	22.5	35.0		M-B
	BRACHY	23.217	2.559	19.0	28.5		B-D
LLT (mm)	MESO	18.483	2.164	16.0	26.0	0.576	M-D
	DOLICHO	18.133	1.814	14.0	21.0		M-B
	BRACHY	17.917	2.301	15.0	25.5		B-D
LLH (mm)	MESO	44.633	3.924	38.0	56.0	< 0.001	M-D
	DOLICHO	47.617	3.718	40.5	40.5		M-B
	BRACHY	43.850	4.052	34.0	54.0		B-D
SCT (mm)	MESO	15.800	2.575	12.0	20.5	0.046	M-D
	DOLICHO	14.483	2.284	10.0	19.5		M-B
	BRACHY	15.933	2.515	12.0	23.0		B-D

Level of significance = 5%.

TABLE 5 - Significant correlations between soft tissue, skeletal and dental measurements.

		Soft tissue measurements				
		ULT	ULH	LLT	LLH	SCT
Skeletal measurements	SNA	-	-0.229*	-	-	-
	SNB	-	-0.286*	-	-	-
	ANB	-0.278*	-	-	-	-
	SN.GoGn	-	0.307*	-	0.327*	-0.246*
	LAFH	-	0.800***	0.309*	0.829***	-
	TAFH	0.270*	0.654**	0.341*	0.732**	-
Dental measurements	1-NA	0.251*	0.329*	-	-	-
	1.NA	0.364*	-	-	-	-
	1-PP	-	0.811***	-	0.613**	-
	1-PP	0.302*	-0.256*	-	-	-
	1-St _s	-	-	-	-	-
	1-NB	-	0.333*	0.210*	0.460*	-0.241*
	1.NB	-	0.329*	-	0.386*	-0.249*
	IMPA	-	-	-	-	-
Soft tissue measurements	ULT	-	-	0.549**	0.335*	0.471*
	ULH	-	-	-	0.590**	-
	LLT	0.549**	-	-	0.492*	0.415*
	LLH	0.335*	0.590**	0.492*	-	-
	SCT	0.471*	-	0.415*	-	-

Level of significance = 5%.

*Weak correlation level ($\pm 0.1 \leq r < \pm 0.5$)¹⁹. ** Moderate correlation level ($\pm 0.5 \leq r < \pm 0.8$)¹⁹. *** Strong correlation level ($\pm 0.8 \leq r < \pm 1$)¹⁹.

The degree of upper incisor extrusion, as given by the shortest distance from its incisal point to the palatal plane (1-PP), established moderate and positive correlation with lower lip height, and strong and positive correlation with upper lip height.

Regarding soft chin thickness, although significant correlations were observed, these were not so strong. All other measurements pertaining to soft tissue also displayed low strength correlations.

DISCUSSION

The literature states that the dimensions of facial soft tissues vary considerably as a result of sexual dimorphism and age.^{7,9,11,16} However, the groups compared in this study were uniform with respect to the distribution of both variables, which enabled us to undertake comparative studies.

Although the parameter used for determining the facial groups in this research (BaN.PtGn), departs from the criterion adopted by Blanchette et al,³ Lai, Gosh and Nanda¹³ and Boneco and Jardim,⁴ it was considered suitable for the morphological classification of patients. This is due to the fact that the groups determined by this criterion, especially the facial patterns at the two opposite extremes (brachyfacials and dolichofacials), differed significantly from the parameters used by the aforementioned authors^{3,4,13} to group their respective samples. We, therefore, found it appropriate to compare their results^{3,4,13} with those achieved in this study.

According to data obtained in this investigation, the facial groups did not differ significantly with respect to the thickness of the upper lip, lower lip and soft tissue chin. These data are consistent with research by Boneco and Jardim⁴ and Lai, Gosh and Nanda.¹³ These findings, however, differed from a study by Blanchette et al.³ According to the latter authors,³ the thickness of the soft tissues of the lip and chin vary to compensate for an absence or excess of underlying

hard structure. Thus, dolichofacial individuals, whose basal bones are usually more retruded, exhibit greater thickness of the lip and soft tissue chin. Moreover, according to these researchers,³ brachyfacials display lower horizontal soft tissue profile magnitudes given their significantly sturdier underlying structure. Although the results of this study demonstrate an effective distinction in the level of horizontal projection of the maxillary bones, as noted by Blanchette et al,³ no differences were found between the morphological types with respect to the thickness of both the upper and lower lip and the soft tissue chin. According to data derived from this study, the soft tissue is not able to compensate for any bone discrepancy through differential horizontal growth. This finding is corroborated by the fact that this study did not disclose relevant correlation levels between lip and soft chin thickness variables and horizontal skeletal magnitudes, such as SNA, SNB and ANB.

Blanchette et al³, Lai, Gosh and Nanda,¹³ as well as Boneco and Jardim⁴ confirmed that dolichofacials have longer lips, whereas brachyfacials' lips are shorter. These observations—although stemming from measures that diverge slightly from those employed here—agree with the data from this study. According to Blanchette et al³ and Boneco and Jardim,⁴ the size of dolichofacials' lips is greater in the vertical direction in order to compensate for lip seal difficulties, as these individuals are more prone than others to develop lip incompetence.^{26,29}

Lip “elongation”, observed particularly in dolichofacials in this study was large enough to prevent the upper incisor of these patients from being overexposed. As noted, dolichofacials' upper incisors are more extruded than those of other facial groups (1-PP), which has also been observed by other authors.^{10,21} However, the different facial groups did not differ in terms of incisor exposure at rest (1-St_u). This can be explained by the larger size

of dolichofacials' upper lips, which proved sufficient to compensate for the extrusion, or the lower position of the upper incisors. The reverse was observed in brachyfacials. These individuals had shorter lips and more superiorly positioned teeth, which ensured a level of incisor exposure similar to that of dolichofacials. With regard to this hypothesis, we highlight the fact that the variables that correspond to the vertical incisor position (I-PP) showed a positive and strong correlation with the height of the upper lip. According to data from this study and confirmed by Peck, Peck and Kataja,¹⁶ the greater the vertical length of the upper lip, the greater the "extrusion" of upper incisors. It is not advisable, however, to establish a cause and effect relationship between the level of extrusion of the upper incisors and upper lip height, although such link could be suggested.

The anterior lower and total facial height variables also strongly correlated with upper lip height. Both are significantly higher in dolichofacials and lower in brachyfacials, as reported in other studies.^{10,15,20,24} It is our opinion that the upper lip tends to follow the underlying vertical skeletal development. Therefore, dolichofacials—whose skeletal structure stands out in the vertical direction—exhibit upper lip dimensions also characterized by excessive vertical development. Brachyfacials, in turn, tend to display relatively smaller vertical bone structure as well as smaller upper lips.

This hypothesis is further reinforced in view of the vertical dimensions of the lower lip. This variable was significantly higher for dolichofacials than for brachyfacials. Furthermore, it exhibited a relevant correlation with the same vertical skeletal variables (LAFH and TAFH). Therefore, the dimensions of the lower and upper lips are commensurate with their underlying skeletal dimensions. Vig and Cohen²⁷ agree with this relationship and further report that—proportionately—the combined

growth of the upper and lower lips may even exceed the growth of the lower facial height.

Given its plasticity,² the stomatognathic system is highly capable of developing adaptive patterns. Therefore, above and beyond mere comparisons, we need to understand the interactions established between the hard and soft tissues in the different facial patterns. Although other authors^{6,8,12} have suggested that the soft tissues of the face are dynamic structures and, as such, can develop independently of the hard structures, data from our sample show evidence that the lip develops vertically in line with both the vertical skeletal development and vertical positioning of the upper incisors.

The analysis performed in this study allowed us, therefore, to disclose the morphological similarities and differences that should inform orthodontists and professionals from related areas in their approach to the different facial types.

The uniformity we noted in the thickness of the lips and soft tissue chin rules out the hypothesis of soft tissue compensation and recommends the adoption of therapies focused on the preservation of the soft tissue profile of patients with inherent maxillomandibular retrusion, such as dolichofacials.

Lip "elongation" was found to correlate with excessive vertical skeletal development, which reinforces the dominant paradigm and points to a favorable treatment prognosis for dolichofacial patients in terms of their motor and labial rehabilitation.

CONCLUSIONS

Through a comparative analysis of the different facial pattern groups, we were able to conclude that:

- Thickness of upper lip, lower lip and soft tissue chin did not differ significantly between groups.
- Upper lip height showed significant dif-

ferences between the three groups. It was greater for dolichofacials and lower for brachyfacials, when these two groups were compared between themselves, and with mesofacials.

- Lower lip height was significantly greater for dolichofacials when these were separately compared with the other morphological groups.
- Mesofacials and brachyfacials did not differ with respect to lower lip height.

In checking the correlations established between the soft and hard tissue variables, the

main findings should be highlighted:

- Upper lip height was very strongly correlated with lower anterior facial height. Furthermore, lower lip height correlated strongly with lower anterior and total facial heights. This indicates a tendency towards an “alignment” between upper lip and lower vertical facial development.
- Upper lip height correlated strongly with the vertical positioning of the upper incisors, which ensured—to a certain extent—a constant exposure of these teeth across the different morphological groups.

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Malocclusion prevalence and comparison between the Angle classification and the Dental Aesthetic Index in scholars in the interior of São Paulo state - Brazil

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Abstract

Introduction: The malocclusions are among the main buccal health problems all over the world, together with dental cavity and periodontal disease. Several indexes are being used for malocclusion registration. The present study verified the prevalence of this condition, using the Angle classification and the Dental Aesthetic Index (DAI), the severity and the necessity of orthodontic treatment registered with the DAI and the results of both indexes were compared, seeking to correlate collected data pattern and the viability of using them together. **Methods:** The sample consisted of 734 schoolchildren with 12 years of age, both male and female from the public municipal schools in Lins-SP, Brazil. The exams were performed at the school's playgrounds with the use of IPC probes with a naked eye. **Results:** For the Angle classification, it was found that 33.24% of the children presented normal occlusion and 66.76% presented malocclusions. It was observed, with the DAI, that 65.26% of the children had no abnormalities or had slight malocclusions. The defined malocclusion was present in 12.81%, severe malocclusion was observed in 10.90% and very severe or disabling malocclusion in 11.03%. Most of the children (70.57%) presented normal molar relationship and the anterior maxillary overjet was the most frequently observed alteration. When the indexes were compared there were similarities and divergences. **Conclusion:** DAI was not sensitive for some occlusion problems detected by the Angle classification, and vice-versa, demonstrating that both indexes have different points in malocclusions detection, so they could be used mutually in a complementary way.

Keywords: Malocclusion. Angle classification. Dental Aesthetic Index. Prevalence. Index.

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INTRODUCTION

Epidemiological studies allow to evaluate the distribution and severity of morbid conditions that occur in a population. It also allows checking the interference of etiological factors on the occurrence of diseases, providing data for planning preventive and curative actions. Currently malocclusions are third in the ranking of priorities among the problems of dental public health worldwide, surpassed only by dental cavity and periodontal diseases.¹¹ However, with the reduction of caries in children and adolescents in recent decades, this condition has received more attention.²⁵ In fact, malocclusions represent one of the studied problems, over time, using different classifications in different populations, often to learn about its prevalence, causes and establishing treatment protocols. Nevertheless, occlusal problems remain in direct relationship with the other two most prevalent in dentistry, i.e., dental cavities and the appearance of gingival inflammation with possible painful symptoms.⁷

The publication of the Angle classification in 1899 was a milestone in the development of orthodontics not only to classify the malocclusions, but also to include the first simple and clear definition of normal occlusion of the natural dentition.²⁷ This method has probably been the most used instrument to record malocclusions until now.²⁷

The World Health Organization (WHO), concerning to acknowledge the real malocclusion conditions in different countries, advocated the Dental Aesthetic Index (DAI) in the 4th edition of the Manual of Basic Oral Health Surveys,²² so that there would be a suitable instrument to gather epidemiological information. Data from the SB Brazil 2003 survey,⁸ as well as several papers in the literature^{2,4,7,10,19} used DAI for malocclusion analysis.

Because both the Angle classification and DAI represent highly used indexes in the as-

essment of malocclusions, it becomes relevant the verification of the similarities and differences in collected data by both, in comparative terms, as well as the feasibility of using both together. So, the objective of this study was to check the malocclusions prevalence using Angle classification and DAI, its severity and the orthodontic treatment need with the DAI, and to compare the collected data in both indexes.

METHODOLOGY

This is an epidemiological study with 734 children aged 12 years old of both genders, from public schools in Lins-SP, Brazil. An analytical tool based on Angle's traditional classification¹³ and on the Dental Aesthetic Index (DAI)²² was elaborated, in order to assess the prevalence of malocclusions, its severity, the need for treatment and to compare both classifications. After the approval of the Araçatuba Dental School, UNESP (Univ. Estadual Paulista) Standing Committee on Ethical Research with Humans (Case 01649/2002), an initial calibration was performed where 20 children not participating in the study population were examined, aiming to find possible difficulties for the experiment.

In the experimental phase, tests were performed only by a professional dentist, orthodontic specialist, and occurred in schoolyards, with good lighting conditions, using wooden spatulas, masks, caps and IPC probes (designed by WHO) with a naked eye. Only those children whose parents have consented by signing the Consent Term were examined.

Criteria used for the Angle's classification

Class I (neutral occlusion)

Alteration of tooth position in which there is a normal anteroposterior relationship between the maxilla and the mandible. The triangular ridge mesiobuccal cusp of the upper first permanent molar occludes in the mesiobuccal groove

of the first lower permanent molar. Therefore, it was considered as Class I, a person who, having the aforementioned molar relationship, showed one or more of the following characteristics: rotation, diastema, crossbite, open bite, deep bite and/or dental arch atresia.

Class II (Distocclusion)

Malocclusion in which is observed a “distal relationship” of the mandible in respect to maxilla. The first permanent molar mesiobuccal groove occludes after the mesiobuccal cusp of the upper first permanent molar, where:

- Division 1: Distocclusion in which the upper incisors are typically projected.
- Division 2: Distocclusion in which the upper central incisors are nearly in its antero-posterior normal position or present a mild retroclination, while the upper lateral incisors have a labial and mesial inclination.

Class III (mesiocclusion)

Malocclusion presenting the mandible “mesial” to the maxilla. The mesiobuccal groove of the lower first permanent molar occludes previously to the upper first permanent molar mesiobuccal cusp.

Criteria used for the DAI²²

Absence of incisor, canine and premolar

We considered the number of permanent incisors, canines and premolars absent in the upper and lower arches. In this index, 10 teeth must be present in each arch, so if there are less than 10, the difference is the number of absences. The absence history of all anterior teeth was verified in order to really know if extractions were made with esthetic purpose. The teeth were not recorded as missing if the spaces were closed; if a primary tooth was in the position of his successor that had not yet erupted; or if an absent incisor, canine or premolar were replaced with fixed prostheses.

Crowding in the incisor region

The incisors region of the upper and lower arches were examined for verification of crowding. The crowding in the incisor region is the condition in which the space between the right and left canine is insufficient to accommodate all four incisors in normal alignment. The crowding in the incisor region was recorded as follows:

- 0 = No crowding.
- 1 = Only one region with crowding.
- 2 = Both regions with crowding.

Spacing in the region of incisors

For this condition the upper and lower arches were considered. As determined, when it is measured in the incisor region, spacing represented the condition in which the total available space between the right and left canines exceeds the required space to accommodate all four incisors in normal alignment. If one or more incisors had an interproximal surface without interdental contact, the region was recorded as having spacing. The space created because of a recently exfoliated deciduous tooth was not considered, if it was clear that the replacement by the permanent tooth would happen soon. The record considered:

- 0 = Without spacing.
- 1 = One region with space.
- 2 = Both regions with spaces.

Diastema

The space in millimeters between the contact points of the mesial surfaces of maxillary central incisors were considered.

Anterior jaw misalignment

We considered the positions and rotations in relation to normal alignment of teeth for the four incisors in the upper jaw. The misalignment location between adjacent teeth was measured by the IPC periodontal probe. The probe point was

placed in contact with the tooth's buccal surface that is positioned more lingually or rotated while the probe is maintained in a direction parallel to the occlusal plane and in a 90 degrees angle to the normal arch line. The misalignment in millimeters was estimated by the probe marks.

Anterior mandibular misalignment

The measurement was considered as described for the upper arch.

Anterior maxillary overjet

Was measured as the horizontal relationship between the upper and lower incisors with the teeth in centric occlusion. The distance between the labial-incisal edge of most prominent maxillary incisor and the incisor buccal surface was measured with the corresponding periodontal probe parallel to the occlusal plane. For edge to edge incisor occlusion, the score was considered zero.

Anterior mandibular overjet

The mandibular overjet was recorded when a lower incisor presented with anterior or buccal protrusion in relation to the opposite upper incisor, or in crossbite. The measurement was performed in the same manner as for the upper arch.

Vertical anterior open bite

Was considered as the lack of vertical overlap between any opposing incisor pair with the measurement performed with the periodontal probe.

Anteroposterior molar relationship

Evaluation often based on the upper and lower first permanent molar relationship. When the evaluation could not be made based on the first molars, due to the absence of these teeth or other reasons (dental cavity, incomplete eruption), the relationship between canines and premolars was assessed. The right and left sides were evaluated with the teeth in occlusion and only the largest

deviation from the normal molar relationship was recorded, considering the indexes:

0 = Normal.

1 = Half cusp: The first molar displaced half cusp mesial or distal to the normal occlusal relationship.

2 = One cusp: The first molar displaced a whole cusp or more to the mesial or distal of normal occlusal relationship.

Regression equation to calculate the DAI score

$$(\text{visible missing teeth} \times 6) + (\text{crowding}) + (\text{space}) + (\text{diastema} \times 3) + (\text{anterior maxillary misalignment}) + (\text{anterior mandibular misalignment}) + (\text{anterior maxillary overjet} \times 4) + (\text{anterior mandibular overjet} \times 4) + (\text{anterior vertical open bite} \times 4) + (\text{anteroposterior molar relationship} \times 3) + 13$$

For the diagnostic criteria maintenance, tests were performed in duplicate in 67 children (9.13% of total sample). Regarding Angle's Classification, the results were identical. There were three differences in the Dental Aesthetic Index for the 402 measurements performed in these children using a ICP probe, where the error was 1 mm in all of them, resulting in error rate of 0.7462%, which was disregarded (error smaller than 1.00%).

Malocclusion severity	Treatment need	DAI Score
Without abnormality or mild malocclusion	Little or no need	≤ 25
Defined malocclusion	Elective	26 to 30
Severe malocclusion	Highly desirable	31 to 35
Very severe or disabling malocclusion	Indispensable	≥ 35

TABLE 1 - Standard DAI values distribution, according to the malocclusion severity.

Table 1 shows the correlation index, malocclusion severity and treatment need, according to DAI.

After the examinations were done, a database was created using the EPI-INFO software version 6.04 for Windows, produced by Center for Disease Control and Prevention (CDC), Atlanta, Georgia, USA, in collaboration with the World Health Organization. Then statistical analysis was performed using Chi-square test to compare the sensitivity of the indexes, Angle's classification and DAI, in malocclusion diagnosis (scores obtained in DAI versus Angle's classes).

RESULTS

Considering the Angle classification of 734 examined children, 244 (33.24%) had normal occlusion (139 females and 105 males) and 490 (66.76%) had malocclusion (288 females and 202

males) according to classes shown in Table 2.

Among the 210 infants who had Class II malocclusion, 193 (91.9%) was registered as Division 1 and 17 (8.1%) as Division 2.

The Tables 3, 4 and 5 show the examined children's pattern according to the DAI. Tables 6 and 7 show the comparative result between the Angle classification and DAI.

TABLE 4 - Distribution of dentition, occlusion and space components, according to the Dental Aesthetic Index (DAI) in schoolchildren in the city of Lins, SP, 2002.

DAI components	Presence		Absence	
	n	%	n	%
DENTITION				
Upper tooth loss	1	0.14	733	99.86
Lower tooth loss	1	0.14	733	99.86
SPACE				
Crowding	245	33.38	489	66.62
Spacing	83	11.31	651	88.69
Diastema	64	8.72	670	91.28
Maxillary misalignment	174	23.71	560	76.29
Mandibular misalignment	258	35.15	476	64.85
OCCUSION				
Anterior maxillary overjet	278	37.87	456	62.13
Anterior mandibular overjet	8	1.09	726	98.91
Anterior open bite	25	3.41	709	96.59

TABLE 2 - Malocclusions distribution in 12 years old schoolchildren, according to Angle classification in the city of Lins, SP, 2002.

Malocclusions	Number	%
Normal occlusion	244	33
Class I	274	37.3
Class II	210	28.6
Class III	6	0.8
TOTAL	734	100

TABLE 3 - Distribution of orthodontic treatment need in 12 years old schoolchildren, according to the Dental Aesthetic Index (DAI) in the city of Lins, SP, 2002.

DAI score	Severity	Treatment need	n	%
≤ 25	Without abnormality or mild malocclusion	Little or no need	479	65.26
26 to 30	Defined malocclusion	Elective	94	12.81
31 to 35	Severe malocclusion	Highly desirable	80	10.90
≥ 35	Very severe or disabling malocclusion	Indispensable	81	11.03
TOTAL			734	100

TABLE 5 - Distribution of molar relationship component according to the Dental Aesthetic Index (DAI) in schoolchildren from the city of Lins, SP, 2002.

Molar relationship	n	%
(0) Normal	518	70.57
(1) Half cusp	57	7.77
(2) One cusp	159	21.66
TOTAL	734	100

TABLE 6 - Dental Aesthetic Index (DAI) association with normal occlusion and Angle classification in schoolchildren of the city of Lins, SP, 2002. ($\chi^2 = 150.51$, $p < 0.0001$ for the comparison of DAI scores versus Angle classification).

DAI score	Normal Occlusion		Angle's Class I		Angle's Class II		Angle's Class III		TOTAL	
	n	%	n	%	n	%	n	%	n	%
≤ 25	244	50.94	192	40.08	39	8.14	4	0.84	479	100
26 to 30	0	0	44	46.81	49	52.13	1	1.06	94	100
31 to 35	0	0	25	31.25	54	67.50	1	1.25	80	100
≥ 35	0	0	13	16.05	68	83.95	0	0.00	81	100
TOTAL	244	-	274	-	210	-	6	-	734	-

TABLE 7 - Dental Aesthetic Index (DAI) value 13 score distribution in Normal Occlusion and within the Angle Classification in schoolchildren in the city of Lins, SP, 2002.

DAI score	Normal occlusion		Angle's Class I	
	n	%	n	%
13	244	91.73	22	8.27

DISCUSSION

In 734 children examined using Angle's classification, 244 children (33.24%) with normal occlusion and 490 children (66.76%) with malocclusion were found. In the individual study of each class of malocclusion proposed by Angle and using the ratio test, it was verified that Class I (55.92%) was higher than Class II (42.86%) which was larger than Class III (1.22%), this difference was statistically significant (Table 2). These results have sustainability in the international literature.^{5,6,26,29}

Using the Dental Aesthetic Index (DAI), 479 children (65.26%) without abnormality or with mild malocclusion were found. The defined malocclusion was found in 94 children (12.81%), severe malocclusion was observed in 80 children (10.90%) and very severe or disabling malocclusion in 81 children (11.03%) (Table 3). Several authors obtained similar results,^{1,12,15,20,21} however others^{16,25} obtained different results, because the defined malocclusion, severe and very severe, were higher than the mild or absent malocclusions. Still analyzing Table 3, more than half of

children (65.26%) had no treatment need or slight need, indicating elective treatment for 12.81% of them, highly desirable to 10.9% and essential to 11.03%. Other surveys have highlighted the need to treat around 50%² and in the city of Recife (Brazil) also using the DAI, the need to treat was demonstrated in 77%, but at the age of 13 to 15 years.¹⁷

In relation to the dentition anomalies two cases of absence of lateral incisors were registered, one case in the upper arch and other in lower arch (Table 4). This condition was the lowest found in this study and corroborates with some works.^{20,21} Regarding the condition of space and occlusion, anterior maxillary overjet was the change more frequently observed (278 children = 37.87%), the second was mandibular misalignment (258 children = 35.15%), that was followed by crowding in the incisor region (245 children = 33.38%). The DAI component which had the lowest frequency (Table 4) regarding space and occlusion anomalies was anterior mandibular overjet (8 children = 1.09%), as found in others surveys.^{16,20,21,23} Previous observations using the DAI already showed dental crowding in 37%, maxillary overjet in 37.5%, and teeth absence and mandibular overjet in low frequency in children aged 10 to 14 years old.¹⁸

According to previous evidences,^{9,23} also in this study, most children (70.57%) presented normal anteroposterior molar relationship and a smaller portion (29.43%) characterized deviation

from normal molar relationship (Table 5).

The statistical analysis demonstrated that the considered indexes in this study had the same sensitivity ($X^2 = 150.51$, $p < 0.0001$) for malocclusion diagnosis (Table 6). In descriptive terms, from 479 children with mild malocclusion or without abnormality in the DAI, 50.94% were classified as normal occlusion, 40.08% as Angle's Class I, 8.14% as Angle's Class II and 0.84% as Angle's Class III, which suggested a diagnostic sensitivity difference between the methods. Of the 94 children with defined malocclusion by the DAI, 46.81% were classified as Class I Angle's malocclusion, 52.13% as Class II Angle's malocclusion and 1.06% as Class III Angle's malocclusion.

Considering the 80 children with severe malocclusion, by the DAI, 31.25% were classified as Class I Angle's malocclusion, 67.50% as Class II Angle's malocclusion and 1.25% as Class III Angle's malocclusion. Considering the 81 children with very severe or disabling malocclusion, by the DAI, 16.05% were classified as Class I Angle's malocclusion and 83.95% as Class II Angle's malocclusion, showing a good correlation between the indexes considered in the data analysis.

Naturally, according to the technique principles, in the regression equation used to calculate the values for the standard DAI, a constant value of 13 is added—therefore all the cases considered as normal occlusion in this index, had a score of 13. Of the 266 children with the DAI 13 value, the vast majority (244 or 91.73%) were classified with normal occlusion in Angle's classification, but 22 (8.27%) of them, were positioned as Class I Angle's malocclusion (Table 7). These children had posterior crossbite and/or posterior open bite and/or deep bite, situations that are not evaluated in the DAI. These factors may have a considerable impact on diagnosis of orthodontic treatment needs, which may impair the index validity.

Of the 6 children with Angle's Class III

malocclusion, four were, according to the DAI, without abnormality or with mild malocclusion, one with slight malocclusion and one child with severe malocclusion. Out of these, 50% had lower anterior overjet and when in centric occlusion the incisors occluded edge to edge, so there is more disagreement in the ranking, while the majority of cases found in Angle's Class III malocclusion didn't fit, in the DAI distribution, in the real severity of the malocclusion.

With the DAI, the WHO attempted to create an easy index, universally accepted and that could be used in epidemiologic research to establish the orthodontic treatment need and the priority of orthodontic care in public programs. This index has the characteristic of being measurable, objective, simple and easy to use, but regarding the results obtained in this study, it wasn't sensitive to some occlusion problems. Another factor that limits this index is the fact that it was developed for the permanent dentition, therefore inadequate for the deciduous and mixed dentition, being unable to identify malocclusion cases in its early stages, which hampers the prevention and early treatment.^{17,24}

Angle's classification has limitations too, because the first upper permanent molar is not stable in the craniofacial skeleton. It is based only on the positioning of teeth, not elucidating bone and muscular aspects, in addition, it only considers the sagittal changes disregarding the vertical or transversal alterations.¹³ Angle's classification feasibility and reliability for epidemiological studies has been questioned because it is a qualitative method and not a malocclusion quantitative index.²⁷ Despite these factors, over time and in order to overcome the technique limitations, problems such as anterior and posterior crossbite, anterior and posterior open bite and upper and lower crowding, diastemas, individual tooth malposition, overjet and overbite were subjected to additional studies with their own classification criteria.¹⁴

As an example, the DAI could also receive modifications in order to overcome limitations. A critical analysis of several methods of malocclusion registration showed that it was not yet proposed an ideal classification that could be used as standard in the malocclusion studies.²⁷

CONCLUSIONS

- The malocclusions (66.76%) were more prevalent than the normal occlusion (33.25%) and the Class I malocclusion prevailed among them (55.92%).
- In the DAI the item "no abnormality or mild malocclusion" (no need or slight need of treatment) was found in most children (65.26%).
- The anterior maxillary overjet was the al-

teration observed with greater frequency.

- Most of the children had normal molar relationship (70.57%).
- Not all children with a DAI score of 13 (no abnormality) in fact, have normal occlusion because they had abnormalities that this index doesn't identify.
- The majority of cases with Angle's Class III malocclusion were classified in the DAI in treatment needs non-consonant with the severity of the problem.
- The DAI was not sensitive to some occlusion problems, when it was compared with Angle's classification.
- The differences found in both indexes exposes the alternative of using them in a mutually complementary form.

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Qualitative photoelastic study of the force system produced by retraction T-springs with different preactivations

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Abstract

Objective: Evaluate the force system produced by the T-spring used for space closure. **Methods:** By means of the experimental photoelastic method, we evaluated the T-spring—used for space closure—with two different preactivations on its apical portion, i.e., one with 30° and one with 45°. The springs were fabricated with rectangular 0.017 X 0.025-in titanium-molybdenum alloy (TMA), centered in a 27.0 mm interbracket space and activated at 5.0 mm, at 2.5 mm, and in a neutral position. For more reliable results, tests were repeated on three photoelastic models duplicated and prepared by the same operator. To better understand the results, the fringes seen in the polariscope were photographed and analyzed qualitatively. **Results:** Through qualitative analysis of the fringes order in the photoelastic model it was noted that at the retraction and anchoring ends the T-spring with 30° apical activation showed a slightly greater accumulation of energy relative to the force system that was generated.

Keywords: Closing of orthodontic space. T loop. Photoelastic study. Retraction.

INTRODUCTION

The extraction philosophy advocated by Tweed in the 1940s raised a new perspective for orthodontic treatment, arousing the interest of orthodontists in mechanical retraction. Since then several mechanical devices have been de-

veloped for this purpose and knowledge about the force system generated by each of them has become a constant focus of research.^{16,17}

In performing retraction movements, orthodontists must be knowledgeable of the mechanical principles involved in this system

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to ensure that tooth movement occurs with maximum effectiveness and minimum strain on adjacent periodontal tissues.^{1,12} Ideally, space closure should be accomplished by retraction movement resulting from “loop” type orthodontic appliances. In this case, forces become predictable as they are in close relationship with archwire size, loop design, alloy type, spring position, amount of activation, force constancy, force magnitude and momentum magnitude.^{2,3,10,11,13,14,18-21,23,24}

In “sliding” type retraction appliances, however, the force system that is generated becomes less predictable since the magnitude of force is difficult to measure as part of it is dissipated by friction during movement.^{1,12}

Burstone,² in 1982, cited three properties that any device should display during retraction movement: a momentum/force ratio, achieved by incorporating Gable-like bends and preactivation bends; force magnitude during activation and a load/deflection ratio, represented by the amount of energy lost during deactivations.

Another important property of the treatment plan is the anchorage type one wishes to obtain to ensure adequate dental relationship.^{2,14} In this context, the T-spring designed by Burstone and Koenig³ adds several ideal efficiency features that optimize space closure. The biomechanical properties of this spring have been the subject of many studies in the orthodontic community and its force system has been widely disseminated^{2,3,10,11,19-22,24} in investigations involving mechanical tests^{3,10,11,17-24} and finite elements method.¹³ Hence the interest in evaluating this system by the experimental photoelastic method.^{5-9,15,25}

The T-spring is often utilized in research undertaken at the Graduate Orthodontic Clinic of the School of Dentistry of Araraquara, São Paulo State, Brazil. The purpose of this study was to evaluate, by means of photoelasticity^{5-9,15,25}, the force system of a T-spring centered in the interbracket space using two different preactivation types.^{14,20,21}

MATERIAL AND METHODS

Initially, tests were performed on 5 experimental pilot models in order to determine proper methodology research, materials to be used, number of repetitions needed, model fabrication technique, reading technique and researcher calibration to ensure result accuracy.¹⁵

Two photoelastic models were obtained from a master model, built of Formica, with the following dimensions: 60.0 mm in length, 40.0 mm in height and 20.0 mm in thickness (Fig 1).

After obtaining a matrix box, we used two acrylic teeth (MOM™, Brazil) to be positioned and bonded to it. With the purpose of standardizing the positioning of these teeth, a negative model was made from the pilot model using ASB-10 Blue silicone rubber and rubber catalyst (POLIPOX™, Brazil) (Fig 2), mixed and manipulated according to manufacturer's recommendations.

In the following step, a utility wax box was made with the following dimensions: 120.0 mm wide, 140.0 mm long and 90.0 mm in height so as to allow the master model to be positioned and the addition silicone subsequently added according to manufacturer's specifications, thereby obtaining the negative model (Fig 3).

At this stage, other teeth were positioned in their respective sites while carefully preventing contamination by moisture or grease on the root surfaces and silicone. At this time, the photoelastic resin (POLIPOX™, Flexible CMR-201, component A code: 584-4. Lot: 17680) and the hardener component (CME-252 Flexible, Code: 1322-6, Lot: 17873) were manipulated in a glass container graduated in milliliters (Fig 4).

Both components were added and carefully manipulated for 10 minutes, and then this mixture was poured into the obtained mold. This mold was placed in an oven at a constant temperature of 25° C for 24 hours for complete curing (Fig 5). In these two phases, the resin was handled carefully to avoid incorporation of air bubbles.

The model was then removed from the mold



FIGURE 1 - Matrix made of Formica to serve as a replicator. Positioning of the canine crowns that will serve as parameters for the photoelastic model.



FIGURE 2 - Silicone rubber and catalyst.

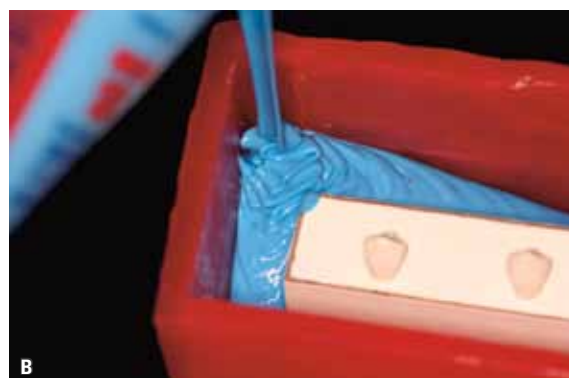


FIGURE 3 - Matrix was positioned inside the wax box (A) and the silicone (B) was poured to obtain a negative.



FIGURE 4 - Epoxy resin, components A and B.



FIGURE 5 - After epoxy resin manipulation, it was poured carefully to avoid incorporation of air bubbles.

and, at this stage, the optical conditions of the photoelastic model was checked in the polariscope. Should the model fail to produce adequate optical properties,¹⁵ which would undermine the analysis, it would be discarded and the aforementioned steps repeated until an ideal model was produced (Fig 6).

Once both photoelastic models had been defined a Morelli™ (Brazil) 'crossed' tube was attached to each tooth (Fig 7), and to this end, a vertical slot was made using a cylindrical drill at low speed, where the tubes were fitted and bonded with acrylic resin.

For each model, a T-spring made with 0.017 X 0.025-in titanium-molybdenum archwire (TMA)

(Ormco™, Glendora, CA, USA) was used. In order to maintain the standard, the T-springs were made with the aid of a template with the following dimensions: 10.0 mm long and 7.0 mm in height.

Two activation criteria were utilized, i.e., a T-spring with 45 degrees^{14,21} preactivation on the apical base was inserted into one model and a T-spring with 30 degrees²⁰ preactivation on the apical base into the other model (Fig 8).

After checking the T-springs in the neutral position, they were inserted into the horizontal slots of the 'crossed' tubes, centered at an interbracket distance of 27.0 mm¹⁰ and evaluated at three activations: 5.0 mm, 2.5 mm and in neutral position. To ascertain reliability, these tests were repeated twice again and showed identical results.

The tests were performed in the laboratory of Mechanical Engineering, Federal University of Uberlândia-MG (Department of Physics), assessed with a polariscope refraction equipment and photographed with digital Canon Rebel EOS 300D (6.3 mega-pixels, 100.0 mm Canon macro lens and ultrasonic circular Canon Flash Macro Ring Lite MR-14EX) (Fig 9).

RESULTS

The results were obtained by reading the photoelastic fringes in the models using Burstone's²

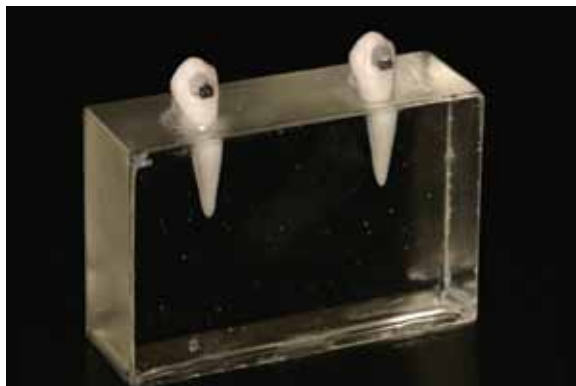


FIGURE 6 - Photoelastic model.

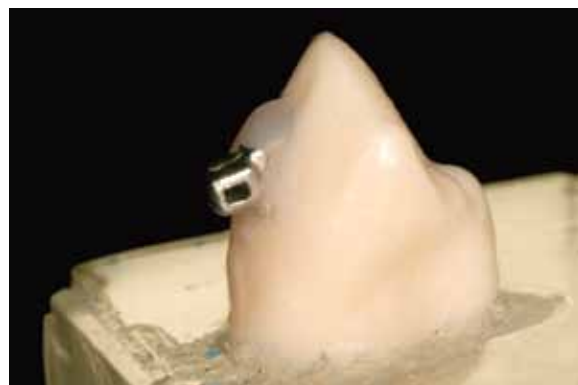


FIGURE 7 - Photoelastic model with 'crossed' tubes in position.

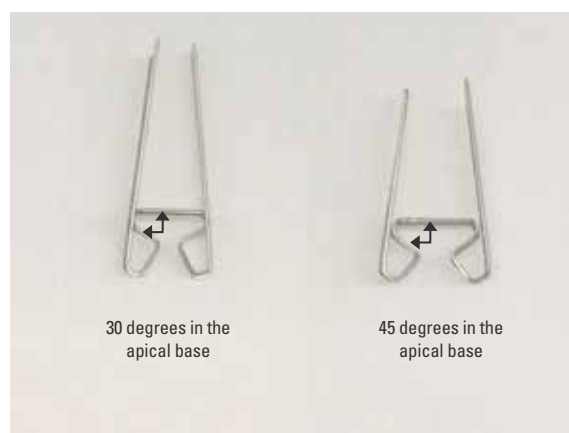


FIGURE 8 - Template to standardize the fabrication of Souza standard (30 degrees) and Marcotte standard (45 degrees) T-springs.

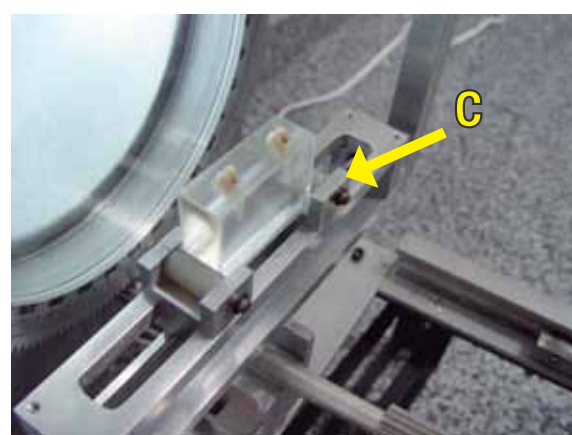
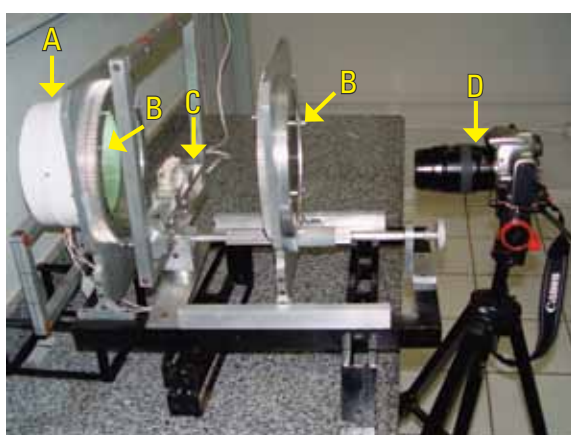


FIGURE 9 - Flat circular polariscope: (A) light source, (B) polarizers, (C) photoelastic model and (D) digital photographic equipment.

T-springs with two different types of preactivation.^{14,20,21} The spring was analyzed in three different positions: (1) in a neutral position, (2) with 2.5 mm activation, and (3) with 5.0 mm activation.

The interpretations were evaluated descriptively and the readings made in charts divided into the three portions of each tooth, i.e., one mesial, one apical and one distal, which were evaluated one by one separately and then compared with the adjacent teeth (Fig 10).

The reading of the fringes order was accom-

plished through the interface of the violet and blue colors, formed on the distal, mesial and apical surfaces of each tooth, using the distance as reference for building the analysis charts. On an increasing scale, the following colors are formed: black, yellow, red, blue, yellow, red, green, yellow, red and green (Fig 11).

Figure 12 shows the fringe order of 0.0 in the photoelastic model due to the absence of a T-spring. In this case, the photoelastic model is free from any force interference.

Figure 13 represents a photoelastic model free

of tension, where the fringe order is 0.0 across the root surface of both teeth.

Fringe order and interpretation of the T-spring with preactivation recommended by Souza et al²⁰

In neutral position, the T-spring, with the preactivation proposed by Souza et al²⁰ exhibited a fringe order of 0.5 across the full root surface. This means that in this qualitative analysis, although stress was equally distributed from the cervical region down to the root apex, it suggests to us that a small amount of energy or a very low force

magnitude was applied to these teeth (Fig 15).

The representation in Figure 14 shows that the T-spring with preactivation recommended by Souza et al,²⁰ in the neutral position, formed a fringe order of 0.0 across the mesial surface, except the cervical mesial region of tooth 23. In this region, the fringe order ranged from 0.0 to 0.5 and had no relevance.

Figure 16 shows that the T-spring with Souza et al's²⁰ preactivation in a neutral position generated a fringe order of 0.0 across the full apical extension for both teeth.

Figure 18 demonstrates that the T-spring with Souza et al's²⁰ preactivation in a neutral position presented a fringe order of 0.0 across the full distal extension.

Analyzing Figure 17, it can be observed that in the cervical and middle thirds of teeth 13 and 23 the fringe order ranges from 1.5 to 2.0. On the other hand, in the distal apical region of teeth 13 and 23 the fringe order is 0.5, which reflects a reduced amount of energy generated in that region suggesting a controlled tipping movement. A slight asymmetry was observed in the distal apical region of tooth 13 but with no significance to the qualitative analysis. It is suggestive of asymmetric activation or slightly decentered positioning, or perhaps some interference while fabricating the spring.

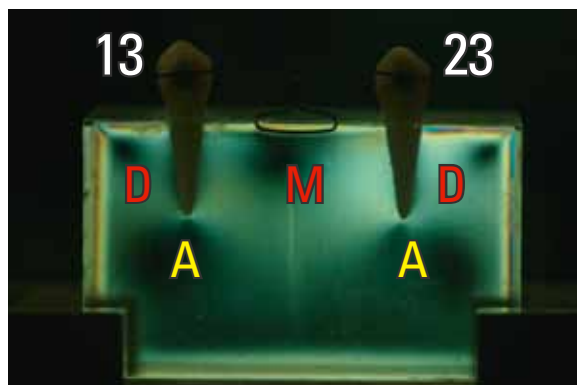


FIGURE 10 - Nomenclature suggested for reading and interpreting fringe order on the photoelastic model.

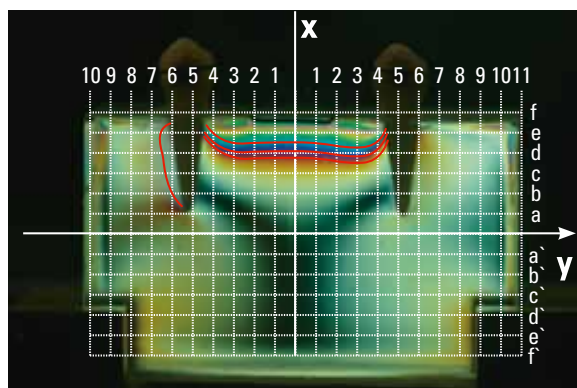


FIGURE 11 - Layout of the Cartesian axis to facilitate the reading of fringe order points on the photoelastic model.

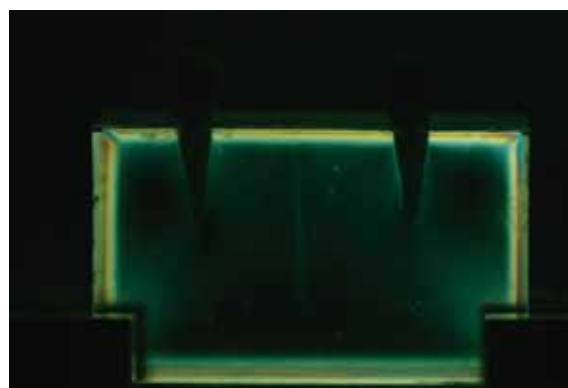


FIGURE 12 - Fringe order of 0.0 due to the absence of a T-spring, as observed through the polariscope.

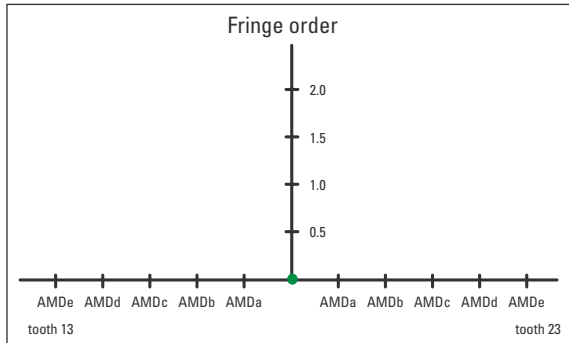


FIGURE 13 - The green point in the vertex of the chart represents fringe order equal to zero.

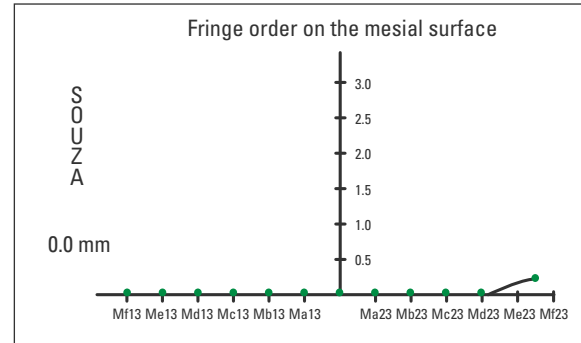


FIGURE 14 - Representation of the mesial surface with Souza's preactivation in neutral position.

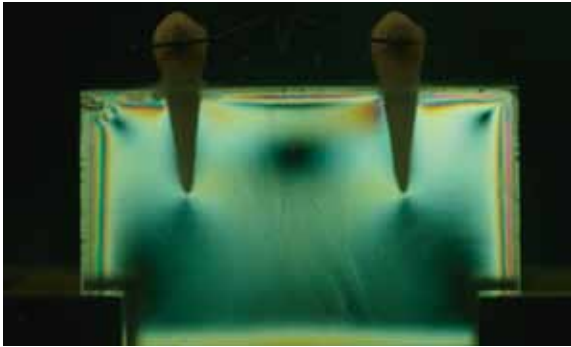


FIGURE 15 - Activation in neutral position (0.0 mm activation).

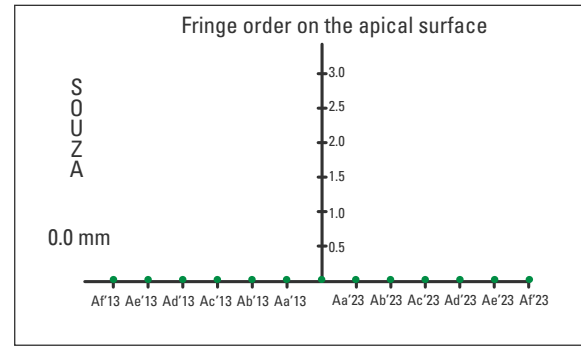


FIGURE 16 - Representation of the apical surface with Souza's preactivation in neutral position.

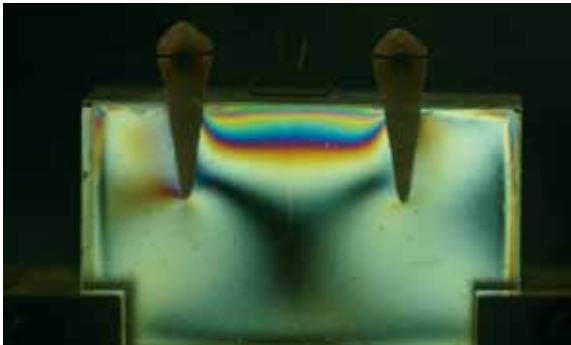


FIGURE 17 - T-spring activation at 2.5 mm.

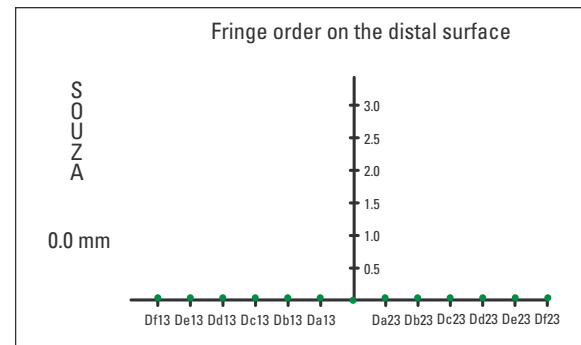


FIGURE 18 - Representation of the distal surface with Souza's preactivation in neutral position.

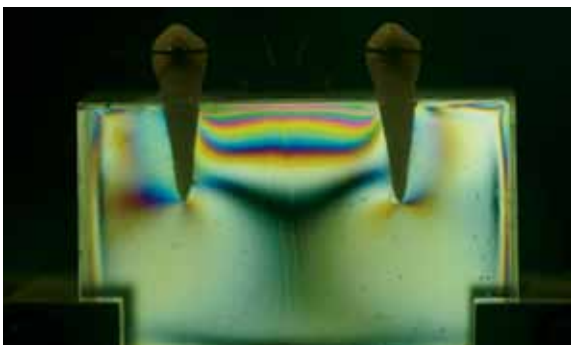


FIGURE 19 - T-spring activation at 5.0 mm (maximum activation).

Figure 20 describes a T-spring with 2.5 mm activation and preactivation proposed by Souza et al²⁰ showing a concentration of fringes at 1.5, with the fringe order spread out in a symmetrical pattern.

Figure 21 depicts a T-spring with activation of 2.5 mm and with pre-activation proposed by Souza et al²⁰ forming a fringe concentration close to 0.0, but discretely greater for tooth 13.

In Figure 22 a T-spring is shown with 2.5 mm activation and preactivation proposed by Souza et al²⁰ presenting a concentration of fringes at 0.5 on the distal cervical third of tooth 23, along with a fringe order of 0.5 on the distal lower third of tooth 13.

Figure 19 shows a fringe order slightly greater than 2.5, demonstrating that a T-spring with 30° preactivation displays a greater accumulation of energy than one with 45° preactivation, in the same activation.

In Figure 23 a T-spring with 5.0 mm activation and preactivation proposed by Souza et al²⁰ showed a concentration of fringes ranging from 0.5 on the middle third root region to 2.5 on the cervical middle third region.

Figure 24 shows a T-spring with 5.0 mm activation and preactivation proposed by Souza et al²⁰ demonstrating a concentration of fringes ranging from 0.0 to 0.5 for tooth 23 and slightly greater than 0.5 on the apical region, for tooth 13.

Figure 25 depicts a T-spring with 5.0 mm activation and preactivation proposed by Souza et al²⁰ showing a concentration of fringes at 0.5 across the full extension of the distal root surface of teeth 23 and 13.

Fringe order and interpretation of the T-spring with preactivation recommended by Marcotte¹⁴

In neutral position, the T-spring with the preactivation proposed by Marcotte¹⁴ exhibited a fringe order of less than 0.5 across the full root surface. This means that in this qualitative analysis, although stress was equally distributed from the cervical region down to the root apex, it suggests to us that a small amount of energy or a very low force magnitude was applied to these teeth (Fig 29).

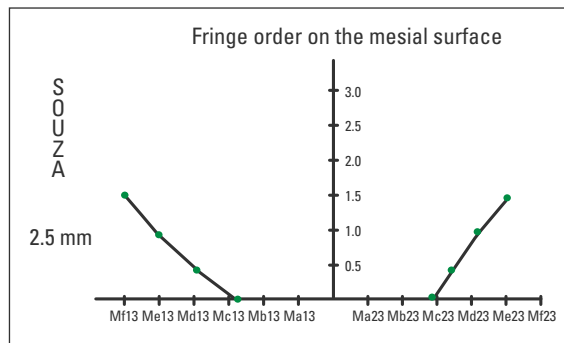


FIGURE 20 - Representation of the mesial surface with Souza's preactivation and 2.5 mm activation.

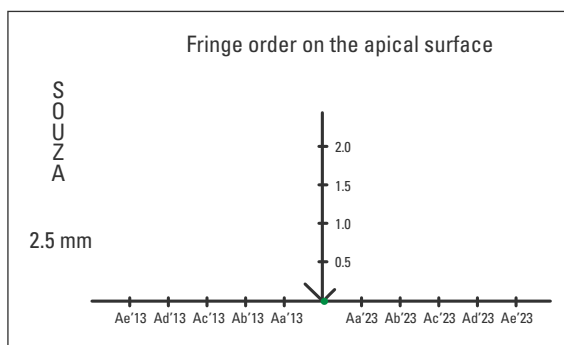


FIGURE 21 - Representation of the apical surface with Souza's preactivation and 2.5 mm activation.

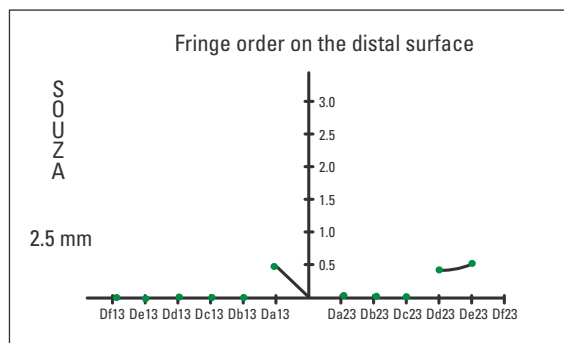


FIGURE 22 - Representation of the distal surface with Souza's preactivation and 2.5 mm activation.

Figure 26 is a representation of T-spring with Marcotte's¹⁴ preactivation in neutral position, exhibiting across the full mesial extension a fringe order of 0.0.

In Figure 27 a representation of T-spring with Marcotte's¹⁴ preactivation in neutral position

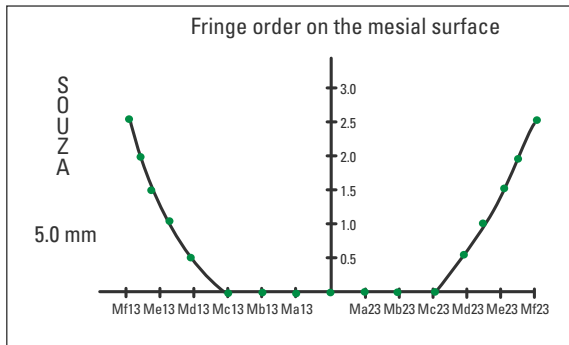


FIGURE 23 - Representation of the mesial surface with Souza's preactivation and 5.0 mm activation.

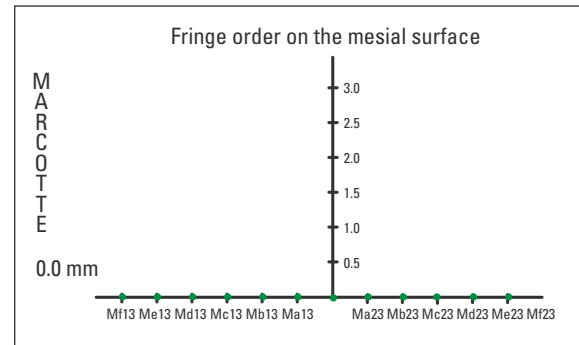


FIGURE 26 - Representation of the mesial surface with Marcotte's preactivation in neutral position.

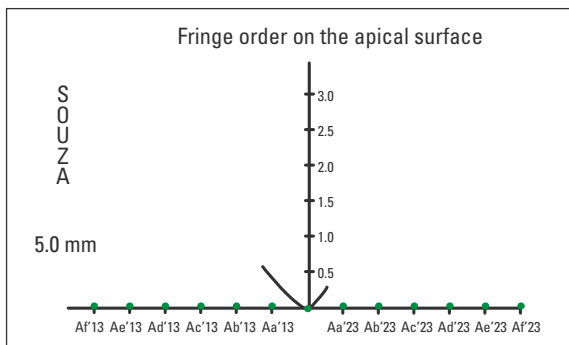


FIGURE 24 - Representation of the apical surface with Souza's preactivation and 5.0 mm activation.

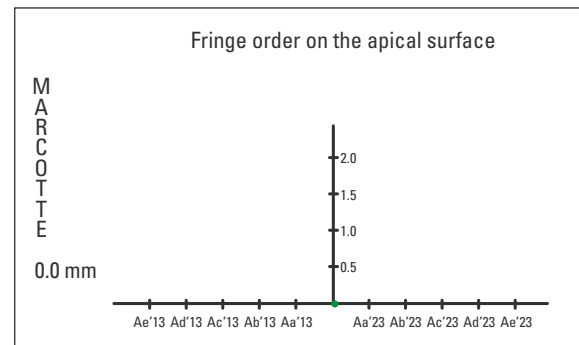


FIGURE 27 - Representation of the apical surface with Marcotte's preactivation in neutral position.

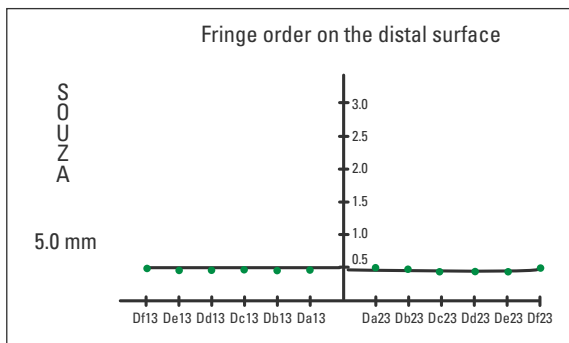


FIGURE 25 - Representation of the distal surface with Souza's preactivation and 5.0 mm activation.

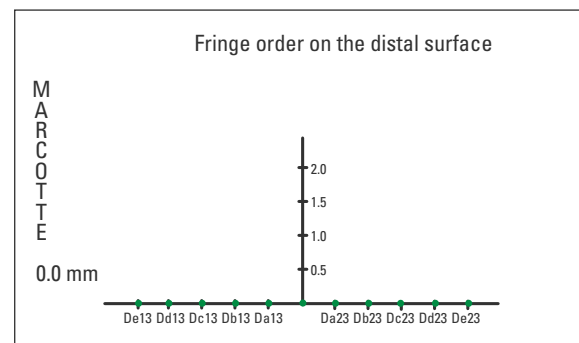


FIGURE 28 - Representation of the distal surface with Marcotte's preactivation in neutral position.

tion, exhibiting across the full apical extension a fringe order of 0.0.

Figure 28 is the graphical representation of T-spring with Marcotte's¹⁴ preactivation in neutral position, exhibiting across the full distal extension a fringe order of 0.0.

Figure 30 shows a fringe order slightly smaller than 1.5, demonstrating that a T-spring with 45° preactivation displays a slightly smaller energy accumulation than one with 30° preactivation, when activated at 2.5 mm.

Figure 32 demonstrates a T-spring activated

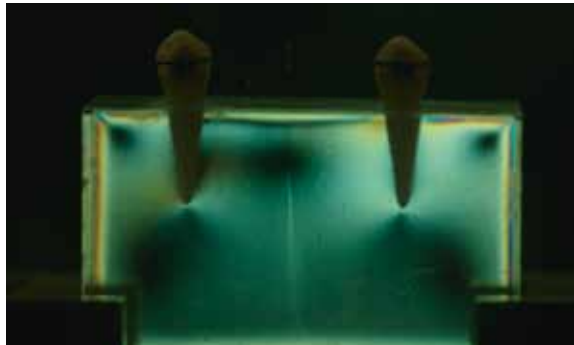


FIGURE 29 - Activation in neutral position (0.0 mm activation).

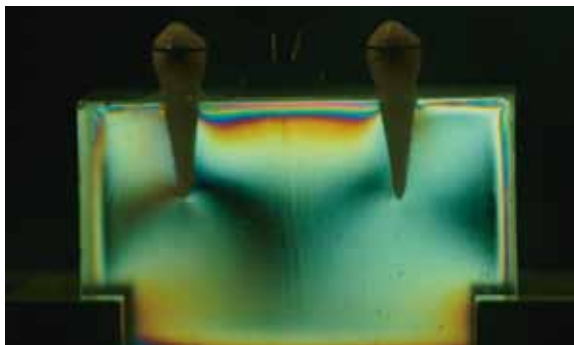


FIGURE 30 - T-spring activation at 2.5 mm.

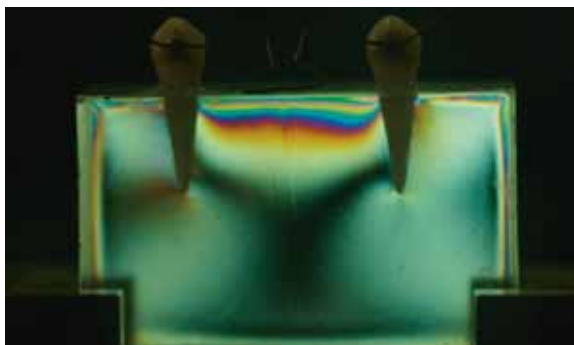


FIGURE 31 - T-spring activation at 5.0 mm.

2.5 mm according to Marcotte¹⁴ showing a fringe concentration ranging from 0.0 in the middle third of the root surface to 1.5 in the cervical third.

Figure 33 shows a T-spring with 2.5 mm activation and pre-activation proposed by Marcotte¹⁴

generating a concentration of fringes close to 0.0 on the apical third.

In Figure 34 it can be seen that a T-spring with Marcotte's¹⁴ preactivation at 2.5 mm presented a fringe order of 0.0 along the full distal extension.

Figure 31 shows a fringe order smaller than 1.5, demonstrating that a T-spring with 45° preactivation displays a slightly decreased accumulation of energy than one with 30° preactivation, when activated at 2.5 mm. When comparing Figures 30 and 31 a different fringe order between 2.5 mm and 5.0 mm activation was observed when using Marcotte's¹⁴ recommended preactivation. The 5.0 mm activation involved a greater amount of energy.

In Figure 35, a T-spring with 5.0 mm activation and preactivation advocated by Marcotte¹⁴ can be observed. It shows a concentration of fringes ranging from 0.0 on the middle third to 1.5 on the cervical third. A comparison between this figure and Figure 23 shows that the fringe order was more intense for T-springs preactivated according to Souza et al,²⁰ activated at 5.0 mm, revealing that these springs generate a greater amount of energy.

Figure 36 represents a T-spring with 5.0 mm activation and preactivation advocated by Marcotte¹⁴, revealing a concentration of fringes ranging from 0.0 to 0.5 on the apical third, although more energy was observed in tooth 13.

Figure 37 shows a T-spring with 5.0 mm activation and preactivation proposed by Marcotte¹⁴, revealing a concentration of fringes of nearly 0.5 on the distal cervical third of tooth 23, and a fringe order of 0.5 on the distal surface of the lower third of tooth 13.

By analyzing each figure, it was noted that for both pre-activations the energy concentration that is delivered is very similar and occurs symmetrically in all tests. The presence of a slight asymmetry was observed, possibly due to a slight decentralization of the spring upon installation and/or activation, or perhaps such asymmetry occurred during the spring fabrication process.

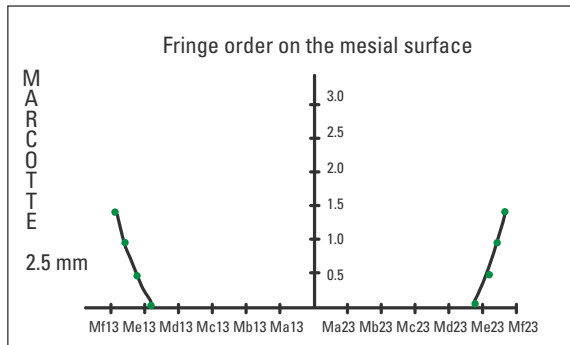


FIGURE 32 - Representation of the mesial surface with Marcotte's preactivation and 2.5 mm activation.

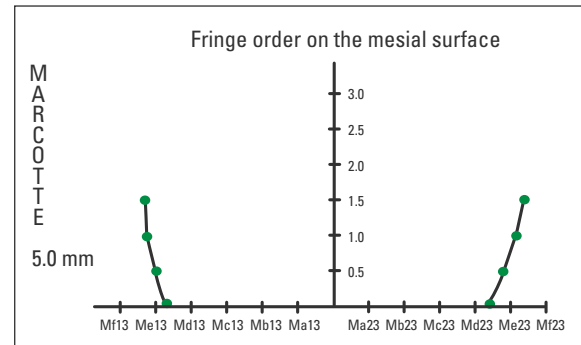


FIGURE 35 - Representation of the mesial surface with Marcotte's preactivation and 5.0 mm activation.

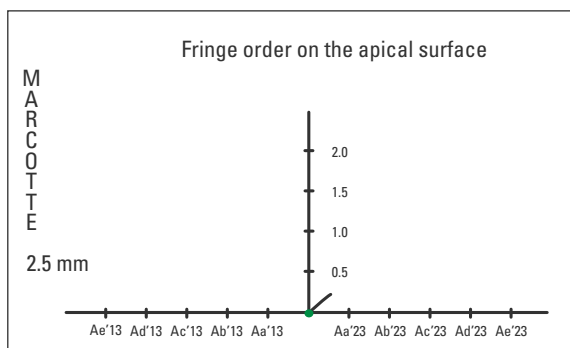


FIGURE 33 - Representation of the apical surface with Marcotte's preactivation and 2.5 mm activation

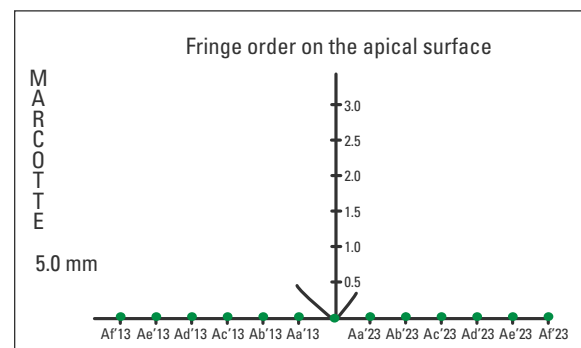


FIGURE 36 - Representation of the apical surface with Marcotte's preactivation and 5.0 mm activation.

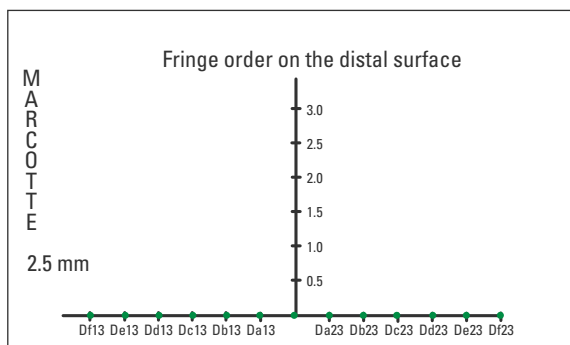


FIGURE 34 - Representation of the distal surface with Marcotte's preactivation and 2.5 mm activation.

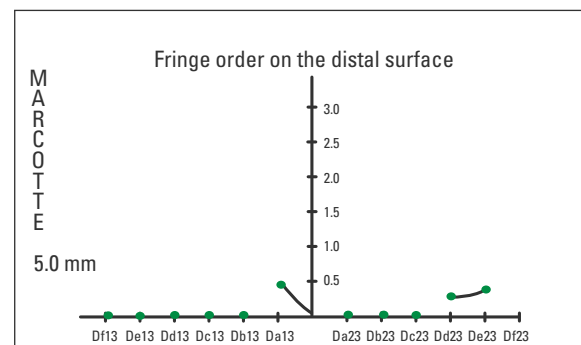


FIGURE 37 - Representation of the distal surface with Marcotte's preactivation and 5.0 mm activation.

DISCUSSION

Space closure in orthodontics should be performed as required in each particular case.^{2,3,4,6,11,13,14,17-24} An appropriate choice of mechanism requires in-depth knowledge of the biomechanics built into the different retraction

devices as well as the force systems they deliver. To this end, space closing springs should deliver a low load/deflection rate and a high momentum/force ratio, thereby enabling adequate tooth movement control.

The purpose of this study was to evaluate, us-

ing the experimental photoelastic method, the centered T-spring force system with two types of preactivation, 30 degrees²⁰ and 45 degrees.^{14,21}

The photoelastic phenomenon was introduced in 1935 by an orthodontist²⁵ who used sculpted resin teeth with photoelastic properties to assess the areas of pressure and tension in their roots under force application. Since then, photoelasticity has played a prominent role in any research aimed at evaluating the properties of dental materials that undergo some form of intraoral force.^{6,8,9,15} It is based on the fact that transparent materials become optically active under load situations when illuminated by monochromatic light. Thus, light and dark lines intersperse to form what is known as isochromatic and isoclinical lines. This optical effect is called photoelastic fringe and it reflects the stress or deformation experienced by a body, being measured both qualitatively and quantitatively.⁹

This method assesses the state of initial tension during the initial tooth movement phase¹³ as recorded by a device named polariscope, which uses the properties of polarized light in its operation. These waves are used to determine the tension state through the light interference pattern,⁷ comprised of a lighting system, a pair of polarizers and a structure to sustain and stabilize the model being analyzed.⁸

To determine the qualitative results of the order of isochromatic and isoclinical fringes a large number of points and measures is required, as well as time to obtain and interpret the fringes. After taking photographs, the images should be printed, parameters should be plotted and a fringe order map built to obtain the results.

Initially, tests were performed on pilot models in order to determine proper methodology research, materials to be used, number of repetitions needed, model fabrication technique, reading technique and researcher calibration to ensure result accuracy.¹⁵

For the construction of an ideal photoelastic

model some basic principles were followed to avoid errors. The use of multirooted teeth in photoelastic models can compromise result interpretation due to overlapping fringes, which may occur as a result of root proximity.^{4,6}

The use of resinous materials with slow return under stress conditions, providing residual stress before and after the withdrawal of forces were avoided. It should also, necessarily, have a low elasticity modulus, high strength and optical constant, while being easy to handle and be affordable.¹⁵

When the interest in studying the T-spring in photoelastic models aroused, considering that the study would be limited to initial tooth movements only, it was defined that only the initial activation pattern (neutral) would be analyzed, and eventually the spring's intermediate activation and finally its maximum activation would be evaluated. According to Burstone and Koenig,^{2,3} the maximum T-spring activation would be 6.0 mm and the neutral position, 0.0 mm. Other authors believe that maximum activation would be 5.0 mm and in a neutral position T-springs would exhibit an activation of 2.0 mm.^{14,20,21}

Titanium-molybdenum was the preferred alloy to fabricate T-springs, since it would be the most suitable, from a clinical standpoint, given its lower force magnitude²⁴ compared with stainless steel wire.^{19,22,23}

When a T-spring is centered in the inter-bracket space it displays similar values for the forces system delivered by the segments of the anchorage and retraction units^{10,17,20,21}, which result from the symmetrical V-shaped preactivation bend. Clinically, the outcome is a more symmetrical tooth movement.

In analyzing the charts, it was noted that, in neutral position, both the 30° and the 45° preactivations on the apical base caused the distribution of photoelastic fringes to occur symmetrically. A difference was found in the number of fringes, which increased gradually with increasing activation and consequently generated a greater

force magnitude. By comparing force magnitude between the two preactivations (Figs 23 and 35), it is clear that the greatest magnitude occurred in the 30° preactivation.

The position of the T-spring in the inter-bracket space and the amount of activation are directly linked to the type of movement produced by the spring. When the T-spring is activated at 5.0 mm, the M/F ratio is 7.6, which provides a controlled tipping movement because its center of rotation is positioned more apically.³ After 1.0 mm of deactivation, the M/F ratio is 9.1, which causes teeth to move by translation. Should this deactivation persist, tooth movement will occur by root movement³ and at this time the spring should be reactivated to avoid contact between the roots of teeth adjacent to dental extractions.

In this experimental study, which used photoelastic models, we observed a higher concentration of photoelastic fringes in the cervical mesial region and no fringes on the distal apical region, at maximum activation of both springs. As deactivation occurred, this fringe order decreased in the cervical mesial region and increased in the mesial apical region until the fringe order reached higher energy concentration in the mesial apical region and lower concentration in the cervical mesial and distal apical regions. In light of these qualitative features, we can deduce that at maximum activation the springs exhibited a tendency toward root movement at 0.0 mm activation, bodily movement at medium activation and ultimately, at maximum activation,

controlled tipping movement.

An analysis of Figures 14, 21, 22, 33, 36 and 37 showed that fringe orders lower than 0.5 were formed. Some asymmetry, observed in Figures 14, 20, 21, 22, 24, 33, 36 and 37, showed no significant values. Importantly, these asymmetries may be due to an eccentricity in the position of the T-spring or an asymmetry in its final design.

It is also noteworthy that the force system delivered in all test groups was symmetrical for both teeth (13 and 23). The results are consistent with those observed in mechanical tests,^{3,11,19,20,21,23,24} which were strikingly similar.

CONCLUSIONS

After implementing the experimental photoelastic method for qualitative analysis of the force system delivered by centered T-springs made with 0.017 X 0.025-in TMA wire, we concluded that:

1. The tension state in all root surface for the T-spring with preactivation according to Souza et al²⁰ was slightly greater when compared to the T-spring with preactivation according to Marcotte¹⁴.
2. With 2.5 mm or 5.0 mm activation, the fringe order exhibited a tendency toward controlled tipping movement.
3. The fringe order was not much different at 2.5 mm activation with 30° and 45° preactivations.
4. At 5.0 mm activation, the concentration of energy or force was clearly higher in both preactivations.

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Assessment of the accuracy of cephalometric prediction tracings in patients subjected to orthognathic surgery in the mandible

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Abstract

Objective: The purpose of this study was to assess the accuracy of cephalometric prediction tracings—performed for orthognathic surgery—by means of the cephalometric analysis of preoperative and seven-day postoperative tracings, in patients subjected to correction of mandibular deformities. **Methods:** The lateral cephalograms of 17 patients who had been submitted to mandibular orthognathic surgery, three years earlier, were used. Cephalometric tracings were performed in the preoperative and seven-day postoperative periods and the following landmarks were traced: condyle (Co), pogonion (Pog), gonial (Go), menton (Me), B (B) and incisor (I). The analysis was based on the difference obtained by superimposing preoperative, prediction and postoperative tracings. The landmarks were projected onto a Cartesian plane for measuring distances between points in millimeters. The data were statistically analyzed using the paired Student t test ($\alpha = 0.05$). **Results:** A statistically significant mean difference was observed between the planned change and the change effectively achieved in the postoperative cephalometric tracings for points Pog ($p = 0.014$) and I ($p = 0.008$) on the horizontal axis. No statistically significant difference was found for the aforementioned cephalometric points on the vertical axis ($p > 0.05$). **Conclusions:** Cephalometric prediction tracings contributed to the preoperative evaluation of the patients and consequently to treatment optimization. However, they was not entirely reliable in these cases due to a slight underestimation of horizontal skeletal changes. These changes should be considered in planning and postoperative follow-up of patients subjected to orthognathic surgery in the mandible.

Keywords: Surgery. Cephalometry. Mandible.

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INTRODUCTION

Correction of dentofacial deformities often requires a combination of orthodontic and surgical treatment to produce functional benefits, proper occlusion and masticatory function, in addition to positive psychosocial and aesthetic changes.^{3,13} The desire to improve facial appearance is a strong motivating factor in seeking treatment. Therefore, the ability to predict treatment outcome is essential.⁵

To establish a correct diagnosis and treatment plan for orthognathic surgery it is of paramount importance to combine a patient's clinical evaluation, model analysis, facial analysis, cephalometric study and model surgery.^{12,19,23} Although cephalometric analysis is a fundamental tool for diagnosis confirmation, it is not the only source of information worthy of evaluation. Facial aesthetics and occlusion must be analyzed together with cephalometry if a correct diagnosis and appropriate treatment plan are to be reached.²⁰

One crucial factor in the clinical protocol consists in the prediction of surgical procedures to assess their suitability for treatment and conduct optimization in each case. Cephalometric prediction tracings (CPTs) enable the study of profile changes, extraction planning and the necessary orthodontic changes. CPTs can also be used to assess treatment progress and stability of the surgical procedures in the postoperative follow-up period, allowing patients to become aware of the proposed treatment and expected outcome, thereby empowering them to provide enhanced compliance.^{7,15}

Friede et al⁹ found that the most complex surgical procedures were also the most difficult to predict and concluded that the usefulness of CPTs depends on the clinical ability to follow detailed planning.

Gjorup and Athanasiou¹⁰ asserted that CPTs allow prior consideration of the various treatment options, access to information on planned chang-

es and the psychological preparation of patients. Cephalometric analysis provides both examination and clinical implementation for the study of skeletal disproportion and malocclusions.¹⁶ In soft tissues, the quantification of movement is associated with decreased accuracy.²

By using a cephalometric study it is possible to compare CPTs with cephalometric tracings obtained in the immediate postoperative period, which allows consistency to be verified between planned outcome and achieved outcome in the immediate surgical treatment.

OBJECTIVE

The purpose of this study was to assess the reliability of cephalometric prediction tracings performed for orthognathic surgery by means of cephalometric analysis of preoperative and seven-day postoperative periods, in patients subjected to correction of mandibular deformities.

MATERIAL AND METHODS

The sample consisted of 17 adult patients, aged between 22 and 45 years, who had undergone orthognathic surgery in the mandible 3 years earlier, i.e., 12 mandibular advancement cases (ranging from 3 mm to 7 mm, with a mean advancement of 5.4 mm) and 5 mandibular setback cases (ranging from 3 mm to 10 mm, with a mean setback of 5.2 mm). These patients were treated at the Center for Research and Treatment of Orofacial Deformities (CEDEFACE, Araraquara, São Paulo, Brazil). The study included CPTs and lateral cephalograms of preoperative and seven-day postoperative periods. All radiographs were taken with the same radiographic unit (Funk Orbital X-15). The treatment of these patients involved prior orthodontic preparation and the surgical technique consisted of bilateral sagittal split osteotomy of the mandibular ramus associated with rigid internal fixation for

mandibular advancement or setback.

A single surgeon drew each cephalogram manually in random sequence on the acetate sheet over each of the 34 lateral cephalograms as well as the CPTs. Light intensity was controlled by means of black cardboard placed as a mask over the radiographs so that low-contrast structures could be conveniently viewed. A light box—under adequate light conditions—was used during cephalometric tracing.

A standardized cephalometric tracing method was used with two reference lines, one horizontal (HL) and one vertical (VL), illustrated in Figure 1, based on studies by Phillips et al.¹⁷ and Watzke et al.²⁴ Thus, the horizontal line was defined as a line traced six degrees below the sella-nasion line (SN), which corresponded to the X coordinate and the vertical reference line was defined as a line perpendicular to the horizontal line passing through sella, which corresponded to the Y coordinate.

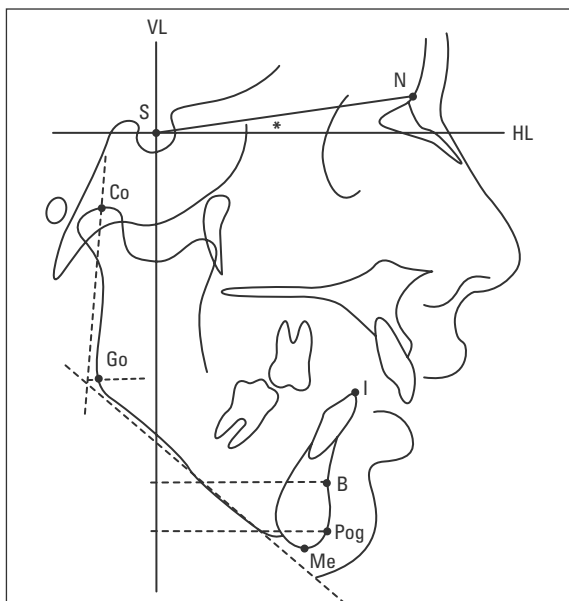


FIGURE 1 - Schematic illustration of cephalometric tracing showing the cephalometric landmarks analyzed in this study and the horizontal and vertical reference lines that correspond to the X and Y coordinates, respectively (* = 6 degrees).

The following cephalometric landmarks were traced (Fig 1): Condyle = Co (posterior superior-most point of the condylar head); Pogonion = Pog (anterior-most point of the contour of the chin in the sagittal plane); Gonial = Go (point where the bisector of the angle between the tangent to the posterior edge of the ramus and the tangent to the lower limit of the body of the mandible intercepts the mandibular contour); Sella = S (geometric center of the sella turcica); Nasion = N (meeting point between the suture of the frontal bone with the nasal bones); Menton = Me (inferior-point of the contour of the mandibular symphysis); Point B = B (deepest point of the anterior concavity of the mandibular symphysis); Incisive = I (point on the incisal edge of the lower central incisor).

For assessment, these cephalometric points were projected for the preoperative, prediction and seven-day postoperative tracings with the aid of a try square, for both the X and Y coordinates (HL and VL, respectively), enabling the evaluation of changes in each stage. The distance from the landmarks to the coordinates was measured with the aid of a pair of compasses and a millimeter ruler so that linear, perpendicular measurements were obtained for each operative time. Changes were calculated based on the differences between the values obtained in the preoperative tracing and the CPT, in the CPT and the postoperative tracing, and pre- and postoperative tracings, for all landmarks.

CPTs were compared with the corresponding change analyses resulting from treatment and the results were tabulated and analyzed using the Kolmogorov-Smirnov test. As it was found that the values were normally distributed, they were compared using the paired t test ($p < 0.05$). Thus, CPT accuracy was assessed by eliminating the potential interference of angular measurements.

TABLE 1 - Results of the difference between the horizontal position of cephalometric points evaluated in the preoperative stage, and the postoperative and cephalometric prediction tracings (results in mm, SD = standard deviation, CPT = cephalometric prediction tracing).

	B		I		Pog		Me	
	Postop.	CPT	Postop.	CPT	Postop.	CPT	Postop.	CPT
Mean	0.6	1.6	-0.4	1.5	0.4	0.8	-0.2	1.1
SD	3.4	4.0	3.9	3.9	3.6	4.8	3.4	4.1
Minimum	-5	-5	-7	-5	-8	-7	-6	-5
Maximum	8	7	6	7	6	9	6	7

TABLE 2 - Results of the difference between the vertical position of cephalometric points evaluated in the preoperative stage and the postoperative and cephalometric prediction tracings (results in mm, SD = standard deviation, CPT = cephalometric prediction tracing).

	B		I		Pog		Me	
	Postop.	CPT	Postop.	CPT	Postop.	CPT	Postop.	CPT
Mean	-0.6	-0.1	0.6	0.2	0.7	1.1	1.0	0.6
SD	3.9	4.4	4.2	5.2	3.2	4.8	3.8	5.1
Minimum	-7	-9	-7	-12	-6	-11	-8	-13
Maximum	6	6	6	8	6	9	6	10

TABLE 3 - Means and standard deviations (in mm) obtained from the difference between the cephalometric points assessed in cephalometric prediction tracings and postoperative tracings on the horizontal and vertical axes (CPT = cephalometric prediction tracing).

Axes (planes)	Cephalometric points CPT/Postoperative	Mean	SD	95% confidence interval		Significance
Horizontal	Point I	-1.82	2.48	-3.09	-0.54	0.008*
	Point B	-1.00	2.57	-2.32	0.32	0.129
	Point Pog	-1.29	1.92	-2.28	-0.30	0.014*
	Point Me	-0.47	3.12	-2.07	1.13	0.543
Vertical	Point I	0.47	2.34	-0.73	1.67	0.421
	Point B	-0.58	2.87	-2.06	0.88	0.411
	Point Pog	0.41	2.93	-1.09	1.92	0.571
	Point Me	-0.41	2.80	-1.85	1.03	0.554

*Statistical significance.

RESULTS

Changes were calculated for the differences between the values obtained in the preoperative tracing and the CPT, in the CPT and the postoperative tracing, and in the pre- and postoperative tracings, for all landmarks, marked on the horizontal and vertical planes (Tables 1 and 2) and no statistical difference was found

in mean values between the planned change (CPT) and the change effectively achieved in the postoperative cephalometric tracings for points Pog and I on the horizontal axis ($p = 0.014$ and $p = 0.008$, respectively). Table 3 represents the mean, standard deviation, confidence interval (95%) and statistical significance ($\alpha = 5\%$) after comparing the CPTs and

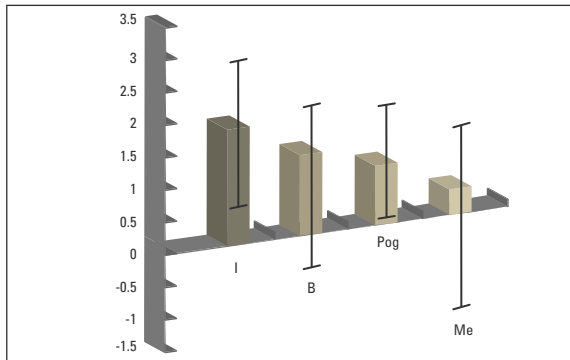


FIGURE 2 - Mean difference (in mm) between planned changes and changes effectively achieved in the cephalometric tracings on the horizontal axis. Error bars represent confidence intervals at 95%.

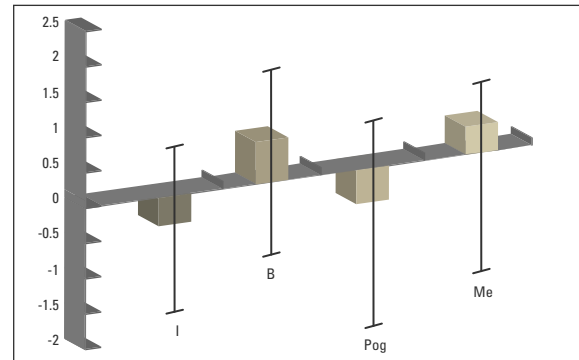


FIGURE 3 - Mean difference (in mm) between planned changes and changes effectively achieved in cephalometric tracings on the vertical axis. Error bars represent confidence intervals at 95%.

postoperative tracings for points I, B, Pog and Me on the horizontal and vertical axes, considering the changes observed in all 17 patients.

Figures 2 and 3 show the mean difference (in mm) between the planned changes and the changes effectively achieved in the cephalometric tracings on the horizontal and vertical axes.

DISCUSSION

Sample selection, in studies that involve humans, is crucial for increasing CPT uniformity and accuracy.^{5,22} In the present study the sample consisted of patients who had undergone surgical-orthodontic treatment, including correction of retrognathia or mandibular prognathism using bilateral sagittal osteotomy of the mandibular ramus. This technique was described by Trauner and Obwegeser²¹ and was later improved, modified^{4,6} and with the use of rigid internal fixation became a technique that provides adequate stability and outcome.¹⁸

A seven-day postoperative analysis was performed as considerable postoperative complications may occur after satisfactory accommodation of soft tissues and regression of the edema.^{1,8} The need was therefore felt

to evaluate the recent postoperative period. Hack et al¹¹ evaluated the stability of postsurgical patients who had undergone orthognathic surgery and found that the most significant changes in soft tissue took place in the first year after surgery.

Among the steps in planning for orthognathic surgery, preoperative cephalometric tracings and CPTs are noteworthy and should be performed with accuracy since, when associated with facial analysis and model surgery, both contribute greatly to the information necessary for planning surgery.

Cephalometric analysis, among other purposes, allows us to assess whether tooth inclination is correct with respect to bony bases, or whether facial height requires correction. In addition, by providing the thickness of the bone plate it helps in determining the most appropriate osteotomy to be performed. Nevertheless, cephalometry should be seen as a complementary diagnostic method which, in conjunction with facial analysis, CPT and model surgery, help to determine planning.²³

This study revealed, among other findings, that CPTs contributed to patient evaluation

and treatment optimization. In performing CPTs, surgeons can determine the direction and amount of the surgical procedures to be carried out, based on the patients' facial features and chief complaint. Kiyak et al¹⁴ claimed that if a surgeon achieves in surgery the same results predicted in the CPT, the patient's chief complaint will be resolved.

In this study, CPT accuracy was not absolute as it showed a slight tendency towards underestimating horizontal skeletal changes. The reason may lie in the fact that tracings were performed manually and were therefore error-prone. Eckhardt and Cunningham,⁵ after comparing computerized with manually performed tracings of patients who had undergone surgical correction of mandibular deformities, concluded that there were significant differences in the accuracy of both tests. This finding confirms the high predictability of manual tracings when we are confronted with lower third of the face correction. Horizontal skeletal changes should be taken into account in planning and postoperative follow-up of patients subjected

to orthognathic surgery in the mandible, especially in the long term, since a lack of stability may compromise future results.

Planning for the correction of dentofacial deformities is a challenge in the field of orthognathic surgery. The aesthetic demands of patients further increases dental surgeons' responsibility. When planning these surgeries surgeons should therefore ensure that each procedure is performed carefully so that the desired results are achieved. Further research is needed to increase CPT accuracy and provide a deeper understanding of the changes most often associated with these tracings.

CONCLUSIONS

CPTs contributed to the preoperative evaluation of the patients and consequently to treatment optimization. However, they were not entirely reliable in these cases due to a slight underestimation of horizontal skeletal changes. These changes should be considered in planning and postoperative follow-up of patients subjected to orthognathic surgery in the mandible.

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Evaluation of indirect methods of digitization of cephalometric radiographs in comparison with the direct digital method

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Abstract

Objective: To evaluate the indirect digitization method of cephalometric radiographs in comparison with the direct digital method. **Methods:** The sample was composed of ten cephalometric radiographs acquired by Orthopantomograph OP100/Orthocef OC100 (GE – Instrumentarium), digital direct. In the Adobe™ Photoshop program, five cephalometric landmarks were set in the images and the impression in transparencies was made. The indirect digitization of the images was performed through the Sony™ DSC-W5 and Canon™ Rebel XT/EOS 350D digital photographic cameras—fixed in a copy stand, at the distances of 25 cm and 60 cm—and through the Hewlett Packard™ Scan Jet 4C scanner. The direct digital images and the indirect ones were inserted and gauged in the Radiocef Studio (Radiomemory™, Brazil) software and the center of the previously marked landmarks was set. The cephalometric computerized analysis generated three angular measurements and four linear ones which were submitted to statistical analysis. **Results:** The images from the scanner demonstrated small statistically significant alterations, without clinical significance. When digitizing the radiographs at 60 cm, both cameras caused distortions which were statistically significant, but clinically acceptable. At 25 cm, the cameras caused the largest distortions, being more expressive and with clinical significance in the images of Canon™ Rebel XT. **Conclusions:** The Hewlett Packard™ Scan Jet 4C scanner with transparency reader and the Sony™ DSC-W5 and Canon™ Rebel XT/EOS cameras operating at 60 cm were shown appropriate for the digitization of cephalometric radiographs. In 25 cm, the digital cameras caused distortions in the image which altered the linear measurements with possibilities of jeopardizing the orthodontic diagnosis.

Keywords: Digital dental radiography. Orthodontics. Radiographic image interpretation. Computer-assisted cephalometrics.

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INTRODUCTION

The direct digital X-ray has become an alternative to the conventional X-ray due to the possibility of image manipulation, radiation dose reduction to the patient, better filing and information access.^{1,2} However, in many radiological clinics this is not a reality yet and the traditional film continues to be the image receiver. In computerized cephalometry, the information of the radiographic image must be introduced in the software, through the direct acquisition or by the indirect digitization of the radiographs. The indirect digitization was initially made by plotting in digitizer tables³ and later by video cameras.⁴ Since 1993 it was observed that the conventional radiographic images could be converted into a digital sign by using a high resolution scanner,⁵ and then it became recommended by the manufacturers of cephalometry softwares. It is very similar to a Xerox machine and is available in three types: laser, rotating drum and flatbed.⁶ They are all endowed with light source in line shape that scans the image by measuring the amount of reflected or transmitted light in each dot. The captured light is turned into an electric sign, with the aid of photodetector groups which also form a line, and the electric sign is digitized and sent to the computer. The flatbed scanner was shown sensitive to the scanning arrangements, power state and image locations, while such inconsistencies were not observed in the rotating drum scanner (VXR-12),⁶ what can be explained by its design. However, the space resolution, geometric distortion and CCD (charge coupled device) structure interference of this scanner require further studies.⁶ When comparing the manual cephalometry to the computerized one, by using the VXR-12 scanner as a digitizer, there were statistically significant amplifications in both linear and angular measurements, although 21 out of the 27 presented differences smaller than 2 degrees or 2 mm, what is within of the norms of most of the cephalometric analyses and therefore without clinical significance.⁷ Another researchers scanned thirty lateral cephalograms in 300 dpi, and the findings demonstrated

that the use of computer software for cephalometric analysis carried out on scanned images does not increase the measurement error when compared with manual tracing.⁸ High quality image equipment are very expensive and this is an unfavorable factor that added to the time consumption to digitize radiographs into a scanner has been motivating clinicians to use digital photographic cameras, with the aim of replacing the scanner. However, the literature in such field is scarce, leading to lack of standardization and consequent unreliability of the results.

The digitization systems based on cameras, unlike the scanning systems, present lower reproducibility because they require position and zoom adjustment.⁶ The lens of the camera usually focus the light into a plan behind it, and in conventional cameras such plan contains the photographic film. Nevertheless, in the digital cameras it is replaced by a sensor which captures luminous pulses and transforms them into electric pulses which are converted into digital image; in other words, the sensor generates the pixels.⁹ Not only the size of the pixel is important, but also the size of the sensor, because the larger the area to absorb light the better the final image. Most of the popular cameras use 1/1, 8-in or 2/3-in sensors.⁹ The sensor can be CCD (charge coupled device) or CMOS (complementary metal oxide semiconductor). As the lenses of the cameras are not plane, the digitized images may present distortions in barrel or pincushion shapes.¹⁰ In the former the images seem to be inflated, and take place where the focal distance is smaller, as for the latter there is a compression of the image in its own center and it is registered in larger focal distances. Such distortions are more visible in the images with perfectly straight lines, mainly when they are close to the edge,¹⁰ therefore also visualized in the radiographs digitized by the cameras. When comparing the manual cephalometry to the computerized one, by using a Pulnix TM-760 (512 x 512 pixels resolution) digital camera as a digitizer, it was observed that the calibration of the digital image produces tiny significant errors associated to the angular and

linear measurements and to the demarcation of the cephalometric landmarks, which tend to be larger in the digital images than in the conventional ones; and that the space resolution of the digital image is lower than in the conventional X-ray.² To digitize radiographs with digital photographic cameras a light box is recommended with a high frequency fluorescent lamp and intensity enough for the films to be clearer and sharpen for the sensor to accomplish the acquiring. The further the camera is from the light box using the zoom to frame the X-ray, the better it will be for the sharpness of the focus, the depth of the field and the homogeneity of the lighting.¹¹ For radiographs presenting clear center and dark extremities, a dark mask is used around it to compensate the automatic exposure which is focused in the center of the image.¹¹ When testing an amateur digital camera to digitize images of forty bone trauma films and to transmit them through Telemedicine net to be assessed by specialists, it was observed that there was no significant difference in the diagnostic precision between the conventional film and digital image, as well as the quality of the image, which was classified as excellent.¹² The direct digital radiograph obtained by storage phosphor technique has already been recognized as reliable in computerized cephalometry, when compared to the manual cephalometry in conventional radiographic films.^{13,14}

This work aimed to evaluate the reliability of using—in computerized cephalometric studies—the indirect digitization of lateral cephalometric radiograph by means of two models of digital photographic cameras, as well as an flatbed scanner with a transparency reader, in comparison with direct digital radiograph obtained in CCD.

MATERIAL AND METHODS

Ten lateral cephalometric radiographs from the Orthopantomograph OP100/Orthocef OC100 (GE – Instrumentarium) digital direct unit were randomly selected; the files belonged to São Leopoldo Mandic Post-graduations Center. In the Adobe™ Photoshop program, using the Paintbrush tool,

five cephalometric landmarks were set: N = nasion, S = sella, Ar = articulare, Go = gonion and Me = menton. The radiographs were printed, in 100% size, in 3M™ transparencies with a HP™ Laser Jet 1320 printer and indirectly digitized by HP™ Scan Jet 4C scanner with transparency reader, in 75 dpi, and by the following digital photographic cameras: Sony™ DSC W5 (5.1 megapixels) and Canon™ Rebel XT/EOS 350D (8.0 megapixels, 55 mm lens). The cameras were fastened in a Incaf™ copy standy (Fig 1), perpendicularly, 25 cm and 60 cm away from the printed radiographs, positioned with a Desetec™ millimeter ruler on a negatoscope (four Osram™ Dulux F 36W/21-840 fluorescent lamps) in an semi-dark room. The cameras operated in the automatic mode, without flash and using optical zoom until the image filled out the entire camera visor. The distance and parallelism of the cameras and radiographs were verified with a Starret™ measure tape and a Tramontina™ level. All the direct and indirect digital images were inserted into the Radiocef Studio (Radiomemory™, Brazil) cephalometry software. For the calibration of the direct digital images, acquired in 350 dpi, the upper and lower borders of the image were marked, previously measured in the Adobe Photoshop™ (16 cm). For the indirect digital images of the cameras the numbers zero and sixteen were marked in the photographed ruler; and the images of the

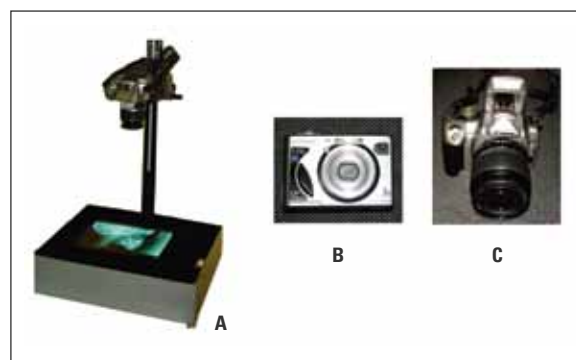


FIGURE 1 - **A)** Incaf™ copy stand, paralleled photographic camera, light box and X-ray. **B)** Sony™ DSC W5 digital camera; **C)** Canon™ Rebel XT EOS 350D digital camera.

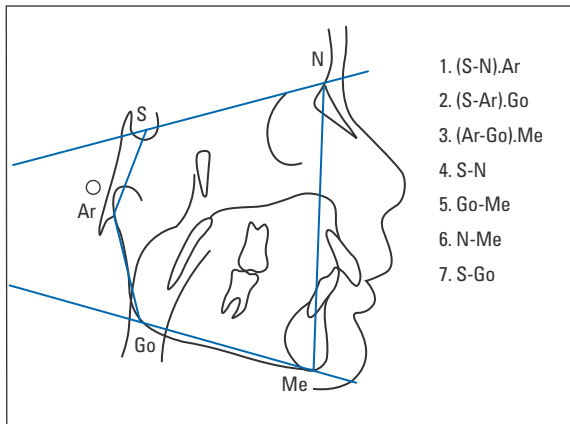


FIGURE 2 - Cephalogram created for this research.

scanner, in 75 dpi, were not gauged because this is the standard resolution of the software. An experienced radiologist, using the zoom tool of the software, marked the center of the landmarks, previously located in the Photoshop. The cephalometric analysis, created by planes with distant landmarks distributed in the center and in the periphery of the image, generated four linear measurements and three angular ones (Fig 2). The effects of variables Camera and Distance were statistically assessed through the variance analysis with repeated measures and the comparisons between mean pairs by Student t test for paired samples. The significance level of $p < 0.05$ was adopted for all tests.

RESULTS

Table 1 shows the mean values obtained from the measurements performed in the direct digital radiographs as well as in the indirect ones from the scanner and from the combinations of cameras and distances. The mean values of the combinations marked with an asterisk showed statistically significant differences at the level of 5% in relation to the correspondent mean obtained by the direct digital procedure. Figure 3 displays the distortions produced by the evaluated methods: In (A) direct digital image, without distortions; in (B) image digitized by the HP™ Scan Jet 4C scanner, without perceptible distortion in a visual observation; In (C, D, E and F) the images of cameras, in both distances, with the presence of distortions in the borders. It can be observed that within the distance of 60 cm (C, D) the images were less altered; while within 25 cm (E, F) there was larger distortion, mainly in the images digitized by Canon™ Rebel XT (E).

Table 2 shows the results of the variance analysis of repeated measures, indicating the measurements in which the values were significantly influenced by the distance and by the camera type. The angular measurement (Ar-Go).Me and the linear ones S-N and S-Go suffered statistically significant alterations ($p < 0.05$) according to the camera type, as well as the angular (S-N).Ar and

TABLE 1 - Mean values of the measurements, obtained on the direct digital cephalometric X-ray in comparison with the images from the scanner and from the combinations of cameras and distances.

CEPHALOMETRIC MEASUREMENTS	CEPHALOMETRIC DIRECT DIGITAL RADIOGRAPHS	HP SCAN JET 4C SCANNER	SONY DSC W5 CAMERA		CANON REBEL XT/EOS 350D CAMERA	
			25 cm	60 cm	25 cm	60 cm
(S-N).Ar	127.23	126.59	126.61	126.64	125.66*	126.37*
(S-Ar).Go	138.19	138.84	138.46	139.07	138.50	138.89
(Ar-Go).Me	127.52	127.32	127.42	127.71	126.72*	126.86*
S-N	66.88	67.43*	69.16*	68.41*	69.85*	68.21*
Go-Me	67.02	67.62*	67.82*	67.55	67.83*	67.61
S-Go	74.37	75.09*	76.80*	75.59*	79.37*	76.38*
N-Me	112.32	112.76	114.63*	114.16*	116.30*	113.64

*Significant at the level of 5% in relation to the mean of the direct digital method.

TABLE 2 - F test p-values for the variance analysis of the repeated measures in order to study the effect of the camera and distance factors on the measurements.

CEPHALOMETRIC MEASUREMENTS	CAMERA	DISTANCE
(S-N).Ar**	0.187	0.047*
(S-Ar).Go	0.693	0.101
(Ar-Go).Me	0.004*	0.129
S-N**	0.030*	0.052
Go-Me	0.762	0.474
S-Go**	< 0.001*	0.032*
N-Me**	0.256	0.047*

*Significant at the level of 5%.

** Significant interaction between camera and distance.

the linear ones S-Go and N-Me according to the distance ($p < 0.05$). Table 3 shows the mean values of the measured variables, according to the camera type and distance. Table 4 demonstrates the influence of the camera type and distance on the measurements, confirming the existence of statistically significant alterations ($p < 5\%$) for all images when the distance is changed. S-N horizontal line was the most affected ($p = 0.006$), followed by the vertical one N-Me ($p = 0.004$). The larger mean difference among the two distances was seen in Canon™ Rebel camera (2.99 mm) in the vertical measurement S-Go, which was located towards the center of the lens.

TABLE 3 - Mean values of the distances measured according to the camera type and distance.

	(S-N).Ar	(S-Ar).Go	(Ar-Go).Me	S-N	Go-Me	S-Go	N-Me
CAMERA							
Sony™	126.64	138.77	127.57*	68.78*	67.68	76.19*	114.39
Canon™	126.01	138.69	126.79*	69.03*	67.72	77.88*	114.97
DISTANCE							
25 cm	126.15*	138.48	127.01	69.50	67.82	78.09*	115.47*
60 cm	126.51*	138.98	127.28	68.31	67.58	75.98*	113.90*

*Significant at the level of 5%.

TABLE 4 - Influence of the camera type and distance on the N-Me, S-N, S-Go and (S-N).Ar measurements.

CEPHALOMETRIC MEASUREMENTS	CAMERA	DISTANCE		MEAN DIFFERENCE	P VALUE
		25 cm	60 cm		
N-Me	Sony™	114.63	114.16	0.47	0.004
	Canon™	116.30	113.64	2.66	
S-N	Sony™	69.16	68.40	0.76	0.006
	Canon™	69.85	68.21	1.64	
S-Go	Sony™	76.80	75.59	1.39	0.032
	Canon™	79.37	76.38	2.99	
(S-N).Ar	Sony™	126.64	126.64	0.00	0.047
	Canon™	125.66	126.37	- 0.70	

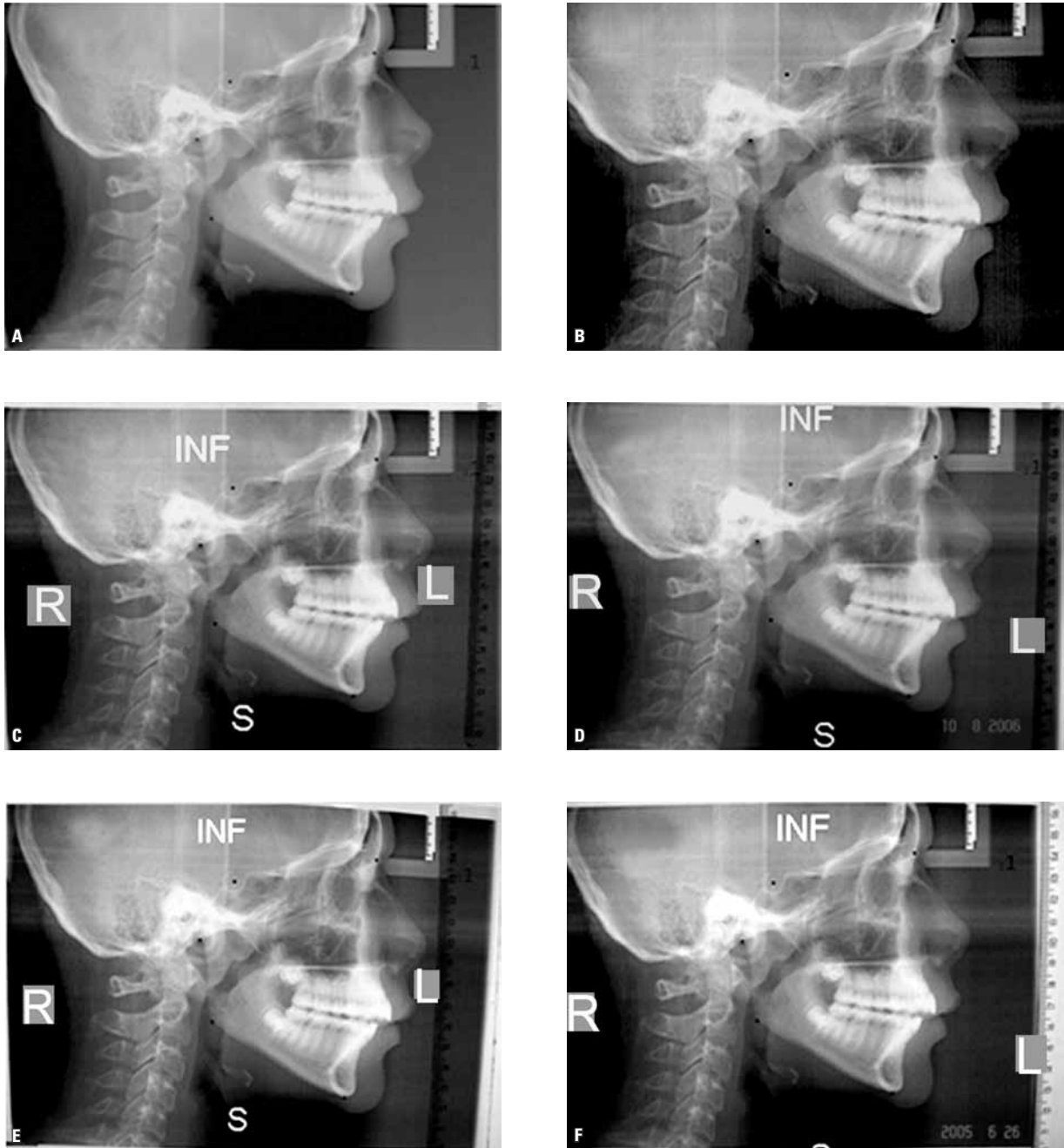


FIGURE 3 - **A)** Direct digital X-ray. **B)** Image digitized on the HP ScanJet 4C scanner. **C, D)** Images digitized at 60 cm by the Canon Rebel and Sony W5 cameras, respectively. **E, F)** Images digitized at 25 cm by the Canon Rebel and Sony W5 cameras, respectively.

DISCUSSION

The lateral cephalometric radiographs allow us to quantify facial and dental relationships,¹⁵ by the comparison of the cephalometric mea-

surements obtained from populational samples, making it possible to evaluate the extension of morphologic deviations in relation to normality, as well as to scrutinize such measurements

in relation to the morphologic characteristics of an individual. Among the several auxiliary instruments used to enhance orthodontic diagnosis, the cephalometric analyses are indeed valuable. Nevertheless, they are subject to erroneous and mistaken interpretations, in function of the necessary registrations to obtain them. In the computerized cephalometry, besides the mistakes committed in the conventional method, there is also the possibility of two other problems: the identification of the cephalometric landmarks in function of the loss of quality of the images^{2,16} and mistakes caused by calibration.² To identify these was not the aim of this study, which had just the intention of assess the alterations in the measurements performed in the images digitized by the digital photographic cameras and by scanner, considering that the latter is globally accepted, while the cameras are still little investigated. With the aim of not making location or demarcation mistakes, the cephalometric landmarks were previously marked in the direct digital images and confirmed in the cephalometry software on the images digitized with the scanner and the cameras.

Tradition imposes us to use angular and linear measurements for the evaluation of the structures of the craniofacial frame,^{17,18} however, individual measures are insignificant if they are not correctly interpreted in a global context. In a general way, linear measurements are more reliable than angular ones, and the latter can be influenced by the former ones. For instance: an increased or reduced length of the cranial base (S-N) may alter the (S-N).A, (S-N).B and (A-N).B angles,¹⁸ just the same way that an increased inclination of S-N¹⁹ in relation to the Frankfurt plane decreases the angular measurements (S-N).A, (S-N).B and (A-N).B, being able to bring about mistaken interpretations for the individual.

When comparing the image digitized by the HP™ Scan Jet 4C scanner in 75 dpi to the direct digital X-ray (Table 1), it was observed that all angular and the linear measurement N-Me did

not suffer statistically significant alterations. Significant amplification was verified in the linear measurements S-N (0.82%, 0.55 mm), Go-Me (0.89%, 0.60 mm) and S-Go (0.9%, 0.72 mm), however, those are clinically acceptable because the differences for the measurements in the direct digital X-ray were lower than 1 mm and 1 degree—which are below the norm of the most used cephalometric analyses. Therefore, as other scanner types studied,^{6,8} we can also consider the flatbed scanner with transparency reader reliable for digitization of cephalometric radiographs. The differences between the scanner and the direct digital X-ray can be explained because of the fact that the scanner is sensitive to the “scanning” arrangements, including the location and orientation of the image and power state.⁶ However, we believe that there may be a minimum difference in the distance between the two landmarks set in the digital image and the real distance between them, informed to the “software” in the moment of the calibration of the images, being this hypothesis corroborated by authors who have claimed that the calibration of the digital image produces few but significant errors.²

The Sony™ W5 camera did not show statistically or clinically significant alterations in the angular measurements at the distances of 25 cm and 60 cm (Table 1), because the differences of the means for the direct digital X-ray were all lower than or equal to 1 degree. All the linear measurements, in both distances, suffered statistically significant amplifications, except for Go-Me at 60 cm. In the cephalometric analyses, we can say that at 60 cm there was no clinical significance, because the largest alteration in comparison with the direct digital radiograph was lower than 2 mm (N-Me = 1.84 mm). At 25 cm three linear measurements showed differences a little higher than 2 mm (S-Go = 2.43 mm; N-Me = 2.31 mm; SN = 2.28 mm), alterations that are very close to the norm of most of the analyses and therefore without clinical importance.

The Canon™ camera showed statistically significant alterations in the angular measurements (S-N).Ar and (Ar-Go).Me, at distances of 25 cm and 60 cm (Table 1), however, all lower than 2 degrees. The largest difference was for (S-N).Ar (1.57 degrees at 25 cm and 0.86 degrees at 60 cm), which also meant no clinical significance. All the linear measurements of Canon™, at 25 and 60 cm, underwent statistically significant amplifications, except N-Me and Go-Me at 60 cm. At 60 cm, S-N and S-Go presented with statistically significant alterations, although considered clinically insignificant in agreement with the cephalometric analyses, because the highest difference was of 2 mm for S-Go. However, when digitized at 25 cm all linear measurements presented statistically significant alterations, being S-Go the most enlarged one (5 mm), followed by S-N (2.97 mm). S-Go is used to evaluate the subsequent vertical proportion of the face in comparison with the previous facial height (N-Me),²⁰ while S-N evaluates the length of the cranial base in relation to the mandibular plane (true horizontal:Go-Me), in the description of facial patterns (long face versus short face), and in the description of the vertical growth (low and high angles). Therefore the alterations caused by Canon™ at 25 cm could cause mistaken interpretations and might consequently interfere in the diagnosis as well as in the individualized orthodontic treatment plan.

When photographing, the cameras were with the upper part turned to the lower board of the radiographs (Fig 1), pointing to the less amplified horizontal measurement (Go-Me), in both cameras at 25 and 60 cm. The most amplified in the Canon™ at 25 and 60 cm, and in Sony™ at 25 cm was the vertical S-Go, located in the center of the lens, while in Sony™ at 60 cm was the vertical N-Me, in the left periphery of the lens. This fact confirms that the form and the convexity of the lens cause different distortions in different parts of the images¹⁰ and that there are construction differences between the lenses of both cameras, because they belong to different manufacturers.

Cameras can be useful to digitize cephalometric radiographs, but, before its clinical use, it is recommended to compare them to other well-known and reliable methods, observing the choice of the lens, lens-object distance, use of a copy stand, correct positioning and image calibration.

CONCLUSION

The Hewlett Packard™ Scan Jet 4C scanner with transparency reader was the best method and the Sony™ DSC-W5 as well as the Canon™ Rebel XT/EOS 350D, fixed in copy standy, operating at 60 cm were considered adequate for radiographic digitization. The cameras positioned at 25 cm caused distortions in the images, altering the linear measurements, and the Canon™ Rebel XT/EOS 350D may jeopardize the orthodontic diagnosis.

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Angle Class I malocclusion treated with extraction of first permanent molars*

Ivan Tadeu Pinheiro da Silva**

Abstract

Angle Class I malocclusion is characterized by normal anteroposterior molar relationship, which may or may not be accompanied by skeletal changes—in the vertical or transverse planes—or dental changes. Bimaxillary dental protrusion, characterized by pronounced labial inclination of maxillary and mandibular incisors combined with excessive overjet, expose patients to dental trauma and compromise aesthetics. In deciding which teeth to extract for Class I correction the first or second premolars are usually selected due to their location in the dental arch. However, the extraction of a first permanent molar compromised by caries or extensive restoration may be an alternative that ensures the preservation of a healthy tooth instead of one that has already been manipulated. This case, treated in an unusual manner by the extraction of four first permanent molars, was presented to the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) as representative of category 2, as part of the requirements for obtaining the BBO diplomate title.

Keywords: Angle Class I malocclusion. Tooth extraction. Corrective Orthodontics.

HISTORY AND ETIOLOGY

The patient, a Caucasian male, 13 years and four months old, presented for initial examination with the chief complaint of maxillary incisor protrusion. He was in good general health and reported a medical history of bronchitis and allergy. He had no sucking or postural habits and had normal swallowing and speech. Regarding oral health, his mandibular first molar crowns were significantly destroyed. The mandibular second molars and maxillary first molars showed carious lesions on the occlusal surface and the presence of dental calculi and gingivitis was observed.

DIAGNOSIS

The patient's facial aesthetics was compromised by a convex profile, lip protrusion, lack of passive lip seal and lower lip eversion. He presented a mesofacial pattern, Class I molar relationship, slightly altered canine relationship with a Class II tendency, a 6 mm overjet, 4 mm overbite, severely projected maxillary incisors, a 1.4 mm Bolton discrepancy with excess in the mandibular anterior teeth and developing third molars (Figs 1, 2 and 3).

Cephalometric evaluation revealed a Class I skeletal pattern ($ANB = 4^\circ$) with slight maxillary protrusion ($SNA = 84^\circ$) and a well posi-

* Case Report, category 2, approved by the Brazilian Board of Orthodontics and Dentofacial Orthopedics.

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FIGURE 1 - Initial facial and intraoral photographs.

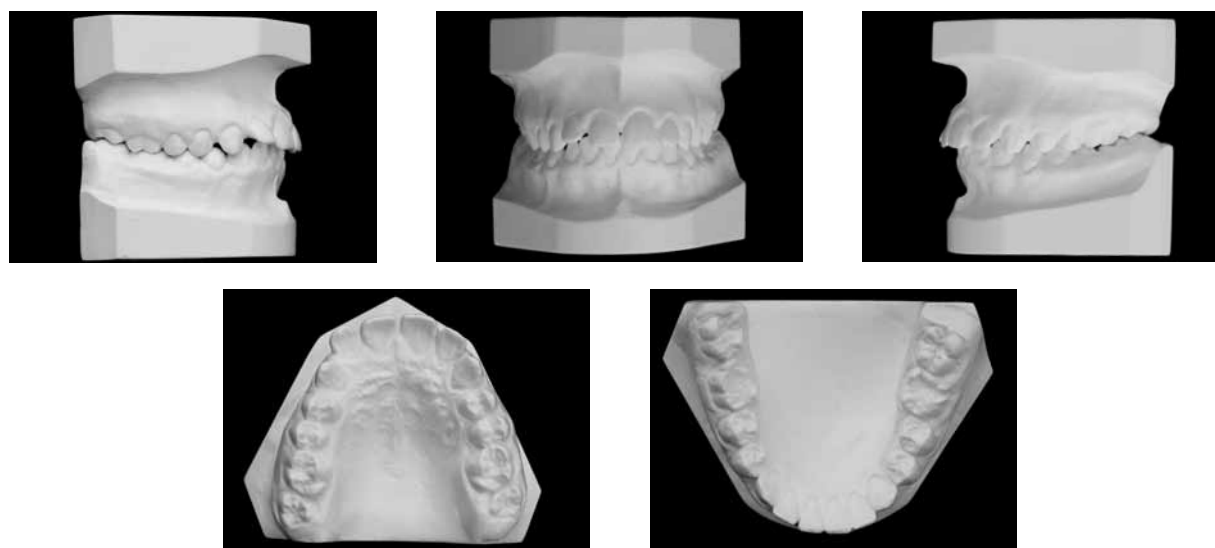


FIGURE 2 - Initial dental casts.

tioned mandible relatively to the cranial base (SNB=80°). He presented a divergent growth pattern (SN-GoGN = 38.5°) and a marked facial convexity (Convex. angle = 9.5°). His skeletal and cephalometric features can be evaluated in Figure 4 and Table 1.

TREATMENT GOALS

Treatment goals included improvement of facial aesthetics, obtaining a balanced labial musculature and a stable occlusion from the functional point of view, maintaining the existing



FIGURE 3 - Initial panoramic radiograph.

relationship between molars, improvement in the relationship between canines, correction of maxillary incisor protrusion, reduction of overbite and overjet, maintaining healthy teeth and eliminating any teeth with destroyed crowns.

TREATMENT PLAN

The treatment plan provided for extraction of the mandibular first molars given their crown destruction, and need of endodontic treatment and prosthetic rehabilitation, which would be convenient to avoid in such a young patient. In order to maintain mechanics symmetry while not depending heavily on patient compliance, maxillary first molar extractions were also planned.

The planned retention consisted of a removable maxillary retainer and an canine to canine bonded lingual retainer in the mandibular arch.

TREATMENT PROGRESS

At first, the patient was referred for periodontal treatment, restorations in the maxillary and mandibular second molars and extraction of the four first permanent molars. A 0.022-in Roth straight wire fixed orthodontic appliance was then

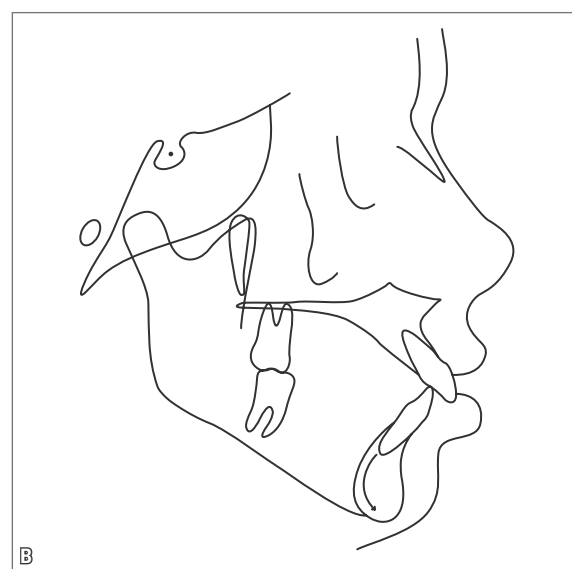


FIGURE 4 - Initial lateral cephalometric radiograph (A) and cephalometric tracing (B).

installed on both arches. Leveling and alignment were performed with round 0.012-in to 0.016-in nickel-titanium archwires followed by round stainless steel 0.018-in and 0.020-in archwires, and finally rectangular stainless steel 0.019 X 0.025-in archwire for space closure using sliding mechanics. Intermaxillary Class II elastics were used to control anchorage. During treatment, the patient was evaluated and monitored by the bimanual technique aimed at achieving coincidence of centric relation (CR) and maximal habitual intercuspation (MHI). At the end of treatment neuromuscular deprogramming was performed using transcutaneous

electrical neuromuscular stimulation (TENS), confirming the coincidence of RC and MHI.¹⁰

After finishing the orthodontic treatment and ascertaining that all planned objectives had been achieved, the fixed appliances were removed. A removable maxillary retainer was used for retention, to be used 24/7 in the first year, only nights in the second year, and three nights a week after that period, for an unlimited period of time. In the mandibular arch, a 0.036-in stainless steel lingual retainer was bonded to the canines.

Considering that orthodontic treatment was performed with extraction of the first perma-

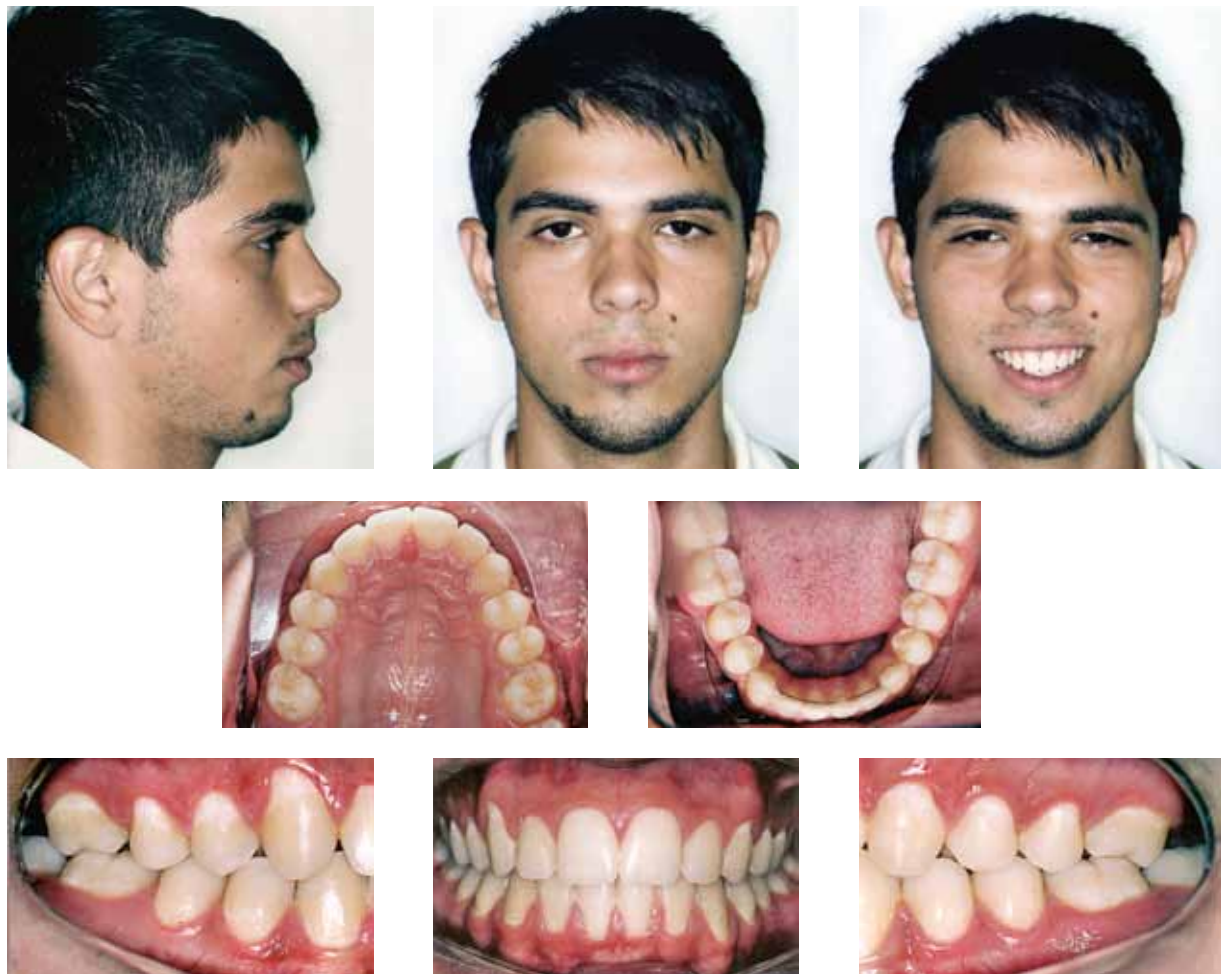


FIGURE 5 - Final facial and intraoral photographs.

nent molars, the space remaining for eruption of maxillary and mandibular third molars was increased, thereby reducing the likelihood of impaction.³ Thus, the patient was instructed to return periodically for monitoring third molars development and eruption.

RESULTS

After evaluating the patient's final examinations, it was found that the planned treatment goals had been achieved. From an aesthetic point of view, the facial profile was balanced with competent lip seal, reduced facial convexity and

a pleasing smile line (Figs 5, 6, 7, 8, 9 and 10). Therefore, the profile improved substantially, in contrast to what Stalpers et al⁶ reported, describing that orthodontic treatment involving extraction of maxillary first permanent molars exerts a minor effect on profile soft tissue.

The maxilla and mandible maintained their anteroposterior relationship, with the ANB angle remaining at 4°. Maxillary dentition improved with the correction of incisor protrusion and reduction of overjet. As can be seen in Table 1, the angular value of I-NA decreased from 32° to 23° and its linear value fell from 9 mm to 4 mm.

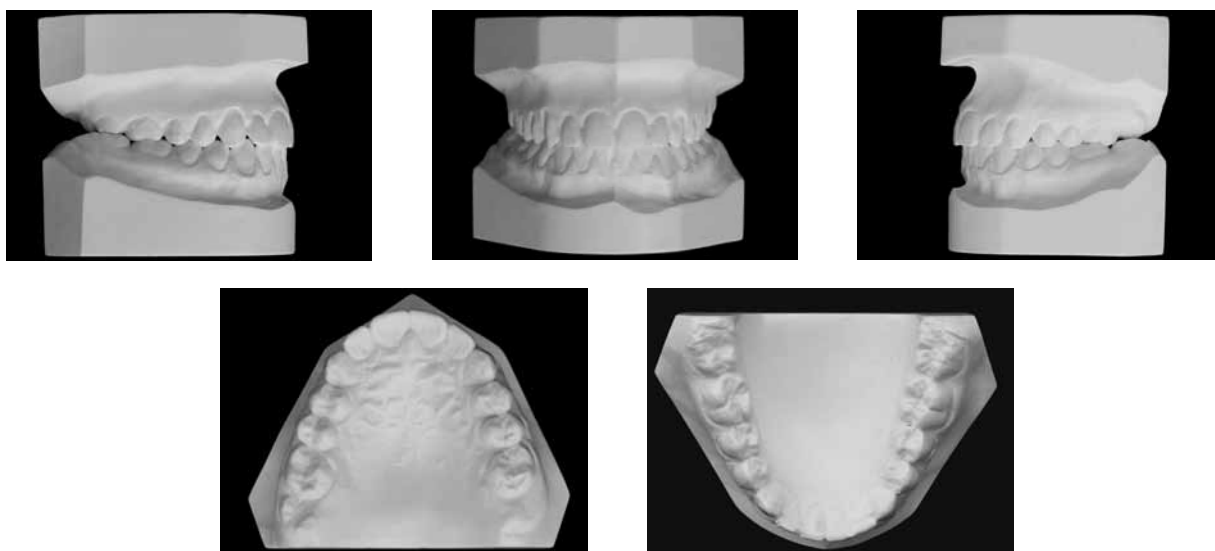


FIGURE 6 - Final dental casts.



FIGURE 7 - Final panoramic radiograph.



FIGURE 8 - Final periapical radiographs of maxillary and mandibular incisors.

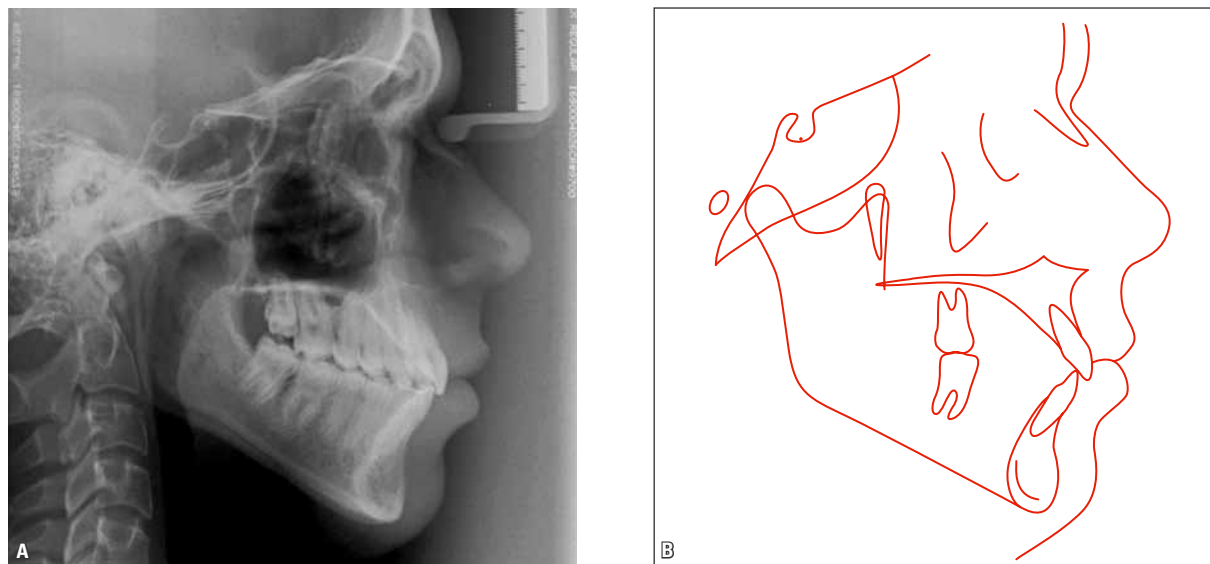


FIGURE 9 - Final lateral cephalometric radiograph (A) and cephalometric tracing (B).

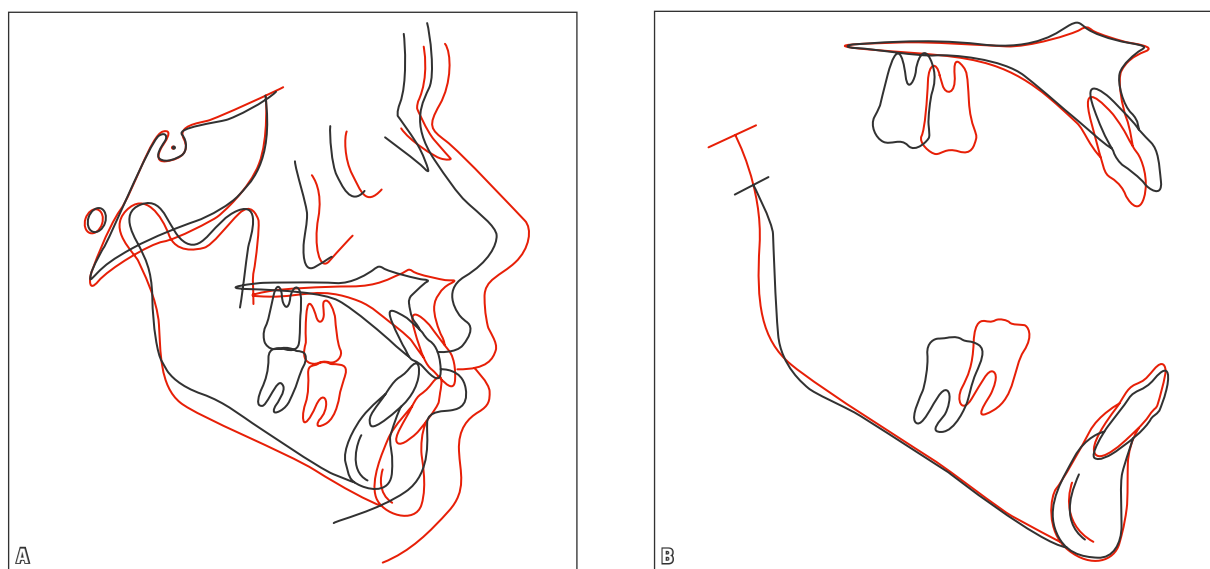


FIGURE 10 - Total (A) and partial (B) superimpositions of initial (black) and final (red) cephalometric tracings.

In the mandibular incisors a slight tipping decrease occurred, which caused a reduction in the IMPA and I-NB angles, as well as in the I-NB and I-APo linear measurements. By reducing the interincisal angle and thereby decreasing the distance between the S line and the upper and lower lips, the

profile was improved. The incisors were retracted and uprighted. Overbite was reduced as a result of mandibular molar extrusion. However, thanks to favorable vertical growth, a slight mandibular rotation occurred in the counterclockwise direction, with the SN-GoGn angle decreasing from 38.5°

to 36° (Table 1, Figs 11 and 12). The maxillary second molars, occupying the position of the first molars were not fully upright, but this inclination secured a greater settlement in the mesial marginal ridge of the mandibular third molar, occupying the second molar position, as described by Andrews,¹ and thus improving stability. The maxillary third molars, in the position of the second molars, were not placed in occlusion with their antagonists to avoid extending treatment time.

It should be stressed that the teeth used in the cephalometric tracings (initial, final and two years

after treatment) were the second permanent molars (Figs 4, 9, 10, 15 and 16). Thus, maxillary molars were moved mesially by translation (bodily movement) and maxillary incisors retracted. Mandibular second molars were moved mesially by translation to occupy the space of the first molars, as reported by Hom and Turley⁷ in their analysis of the effects of space closure on the area of mandibular first molars in adults.

The relationship between the arches was maintained at normal molar occlusion with the second molars occupying the position of the



FIGURE 11 - Facial and intraoral control photographs taken two years after treatment completion.

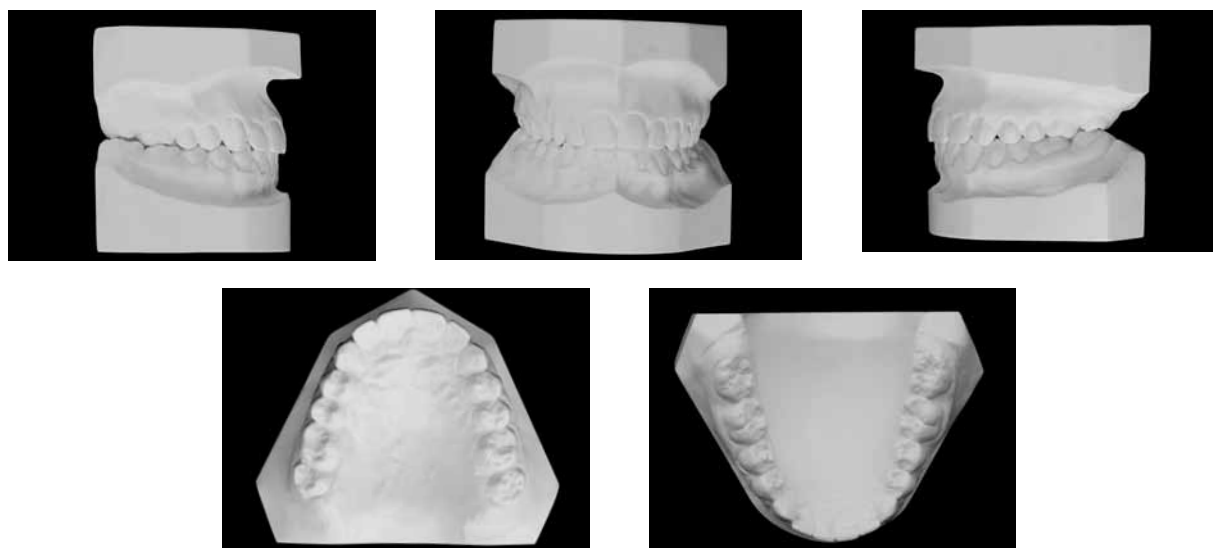


FIGURE 12 - Dental casts after two years.



FIGURE 13 - Panoramic radiograph two years after treatment completion.



FIGURE 14 - Periapical radiographs two years after treatment completion.

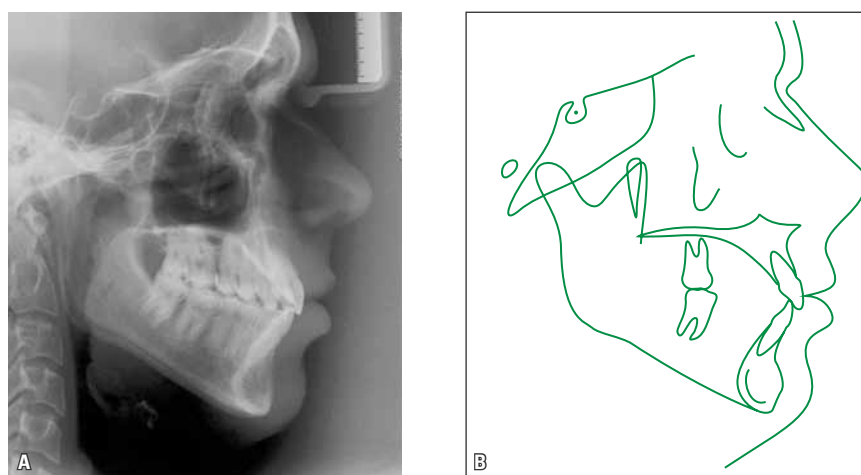


FIGURE 15 - Lateral cephalometric radiograph (A) and cephalometric tracing (B) two years after treatment completion.

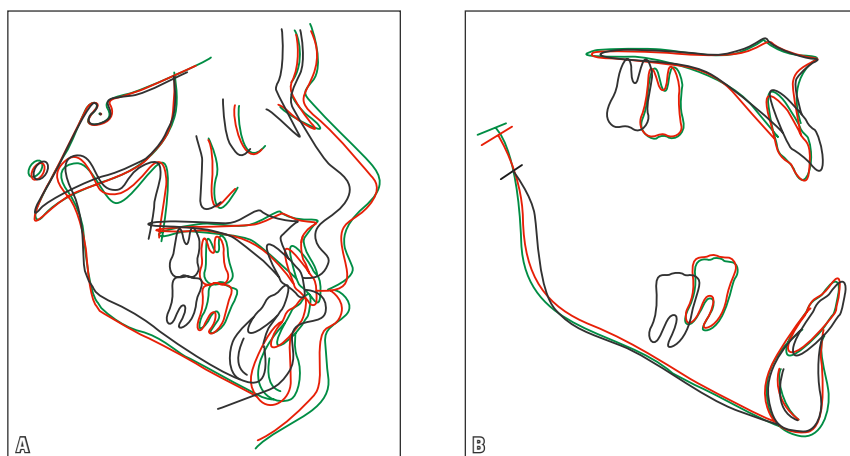


FIGURE 16 - Total (A) and partial (B) superimpositions of initial (black), final (red) and two-year posttreatment (green) cephalometric tracings.

TABLE 1 - Summary of cephalometric measurements.

MEASUREMENTS		Normal	A	B	A-B DIFFERENCE	C
Skeletal Pattern	SNA (Steiner)	82°	84°	85°	0	85°
	SNB (Steiner)	80°	80°	81°	1	82°
	ANB (Steiner)	2°	4°	4°	0	3°
	Convexity Angle (Downs)	0°	9.5°	8°	1.5	6°
	Y axis (Downs)	59°	61°	60°	1	58.5°
	Facial Angle (Downs)	87°	86.5°	89°	2.5	90°
	SN-GoGn (Steiner)	32°	38.5°	36°	2.5	36°
	FMA (Tweed)	25°	32°	30°	2	28.5°
	IMPA (Tweed)	90°	97°	94°	3	93°
Dental Pattern	$\perp$ - NA (degrees) (Steiner)	22°	32°	23°	9	21.5°
	$\perp$ - NA (mm) (Steiner)	4 mm	9 mm	4 mm	6	6 mm
	$\overline{1}$ - NB (degrees) (Steiner)	25°	37°	33°	4	31°
	$\overline{1}$ - NB (mm) (Steiner)	4 mm	9 mm	6.5 mm	2.5	7 mm
	$\frac{1}{1}$ - Interincisal angle (Downs)	130°	108°	121°	13	123.5°
	$\overline{1}$ - APo (mm) (Ricketts)	1 mm	6 mm	3 mm	3	2.5 mm
Profile	Upper Lip - S Line (Steiner)	0 mm	3 mm	0.5 mm	2.5	1 mm
	Lower Lip - S Line (Steiner)	0 mm	7 mm	2 mm	5	3 mm

TABLE 2 - Maxillary and mandibular intercanine and intermolar widths.

MEASUREMENTS (cm)	A	B	A-B	C
Maxillary intercanine width	39	38	1	38
Mandibular intercanine width	27.5	27	0.5	27
Maxillary intermolar width	50	52	2	52
Mandibular intermolar width	45	44	1	44

first molars and canines in normal occlusion. As a result, adequate stability would be expected given the adequate intercuspation that was achieved. In Table 2 it can be observed that the intermolar and intercanine distances were maintained. Figures 11, 12, 13, 14, 15 and 16 depict that the final facial, skeletal and dental results obtained with treatment were stable two years after treatment.

FINAL CONSIDERATIONS

Angle Class I malocclusion² is characterized by skeletal changes—in the vertical or transverse planes—, or dental changes. Bimaxillary dental protrusion, when coupled with excessive overjet, increases patient exposure to dental trauma while compromising aesthetics. When extractions are indicated the choice often falls on premolars due to their strategic position in the transition zone between the anterior and posterior segments. However, other approaches should be considered, especially when the patient presents with caries, extensive restorations, periapical lesions or prostheses.⁴ Despite advances in prevention, first

molar loss rate is still high, affecting nearly 35% of children with mixed dentition.⁹ The characteristics of malocclusion in this patient, with his significant mandibular first molars coronal destruction resemble those found by Normando,⁵ who reported an increased frequency of Class II canine relationship in patients with this teeth missing. Hom and Turley⁷ believe that space closure in the region of missing mandibular first permanent molars should be regarded as a therapeutic approach. In 1899, Angle² defined first permanent molars as “the key to normal occlusion,” considering them essential for dentition stability, probably because these teeth are the first permanent teeth of the posterior segment and thus provide guidance for the eruption of the others.

In 1973, Jensen⁸ asserted that the extraction of the four first premolars followed by the extraction of the four third molars is equivalent to the loss of 25% of the total dental material. In his view, the latter was unnecessary since most of the space left by the third molar is not used to accommodate the remaining teeth. Moreover, the extraction of four first molars is equivalent to 12.5% of the dental material, and virtually the entire space is used.

It can therefore be concluded that this case was successful for both the patient and his legal guardians. Treatment goals were achieved, with the establishment of a normal occlusion in canines and second molars, in the position of the first molars. Maxillary incisors protrusion was eliminated while overjet and overbite were reduced, thereby improving facial aesthetics. Teeth with destroyed crowns were eliminated, which would otherwise require endodontics and prosthetics, and healthy teeth were preserved. Muscle balance and functionally stable occlusion were accomplished.

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Alveolar corticotomies in orthodontics: Indications and effects on tooth movement

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Abstract

Introduction: The systematic search for increased efficiency in orthodontic treatment is shared by several areas of orthodontics. Performing alveolar corticotomies shortly before the application of orthodontic forces has been suggested as a method to enhance tooth movement and, consequently, orthodontic treatment as a whole. **Objective:** This article reviews the historical perspective of this therapeutic approach, presents and illustrates with clinical cases its main indications and finally discusses the biological reasons underlying its use.

Keywords: Alveolar corticotomies. Orthodontic tooth movement. Accelerated orthodontics. Orthodontic treatment.

INTRODUCTION

When are you taking off my braces? This is probably the question most often addressed to orthodontists in their daily practice. Which orthodontic patient is not enthusiastic about the possibility of reducing their treatment time? Given this constant demand for shorter treatments, orthodontists from around the world have increasingly sought ways to boost orthodontic treatment efficiency.

The search for this efficiency, i.e., new approaches to shorten treatment time without foregoing optimal results, has become a primary goal of all areas of orthodontics. Low friction and self-ligating bracket systems, robot preformed

archwires, rapid canine retraction and alveolar corticotomies are examples of approaches that aim to reduce the time required by orthodontic therapy. Since the promise of a faster treatment holds considerable commercial appeal, orthodontists are faced with a major challenge: To critically sift through the available options by distinguishing genuine breakthroughs in alternative treatment approaches from others more financially oriented and not committed to improving service quality for our patients.

Professionals intent on performing alveolar corticotomies to enhance orthodontic treatment are bound to be confronted by this challenge. Reintroduced in the late 20th century, this

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alternative treatment has aroused much curiosity and controversy, fueled, in part, at least by the promotional and commercial interest of the professionals who put it back into the orthodontic scenery. Despite some initial resistance, some researchers saw potential in the clinical reports and began to investigate the effects of corticotomies with a more scientific perspective. Currently there are at least ten centers and research groups studying this topic in countries like South Korea, the U.S., Japan and Brazil.¹

The upshot of this steady academic trend is reflected in the recent increase in the number of alveolar corticotomy articles published in prestigious scientific journals. Another example of this growing interest can be illustrated by an event that took place in the last Meeting of the American Association of Orthodontists, held in Washington in May 2010: The highest award for research in orthodontics in the United States and Canada (the Milo Hellman Award) was bestowed on a study that assessed the mechanism and morphological changes in alveolar bone following alveolar corticotomies².

Based on scientific publications and clinical experience, we aim to explain important aspects that should be taken into consideration in using alveolar corticotomies as an aid to orthodontic treatment. We also propose to discuss the historical perspective of this therapeutic approach,

indications for its clinical use, biological foundations for its use as well as its limitations and risks. We therefore hope to contribute to disseminate information on this topic, which will inform the decision-making process of those professionals desiring to use this procedure in their clinical activities.

WHAT ARE ALVEOLAR CORTICOTOMIES AND WHAT IS THE HISTORICAL PERSPECTIVE OF THEIR USE IN ORTHODONTICS?

Alveolar corticotomies (ACS) are defined as a surgical intervention limited to the cortical portion of the alveolar bone. Whereas in osteotomies both cortical and trabecular bone material is removed in considerable quantities, in ACS the incision must pierce the cortical layer, and at the same time, penetrate into the bone barrow only minimally (Fig 1).³ During the last decade, the performance of ACS was again suggested as a means to enhance orthodontic treatment.^{4,5,6}

Attempts to shorten the time needed for tooth movement can be divided into three categories: (1) local administration of chemicals, (2) physical or mechanical stimulation of the alveolar bone, such as the use of direct electrical current or magnets, and (3) surgery, including dental distraction and alveolar corticotomies.⁷ The first reports on surgical approaches to correct poorly positioned teeth are assigned to L. C.

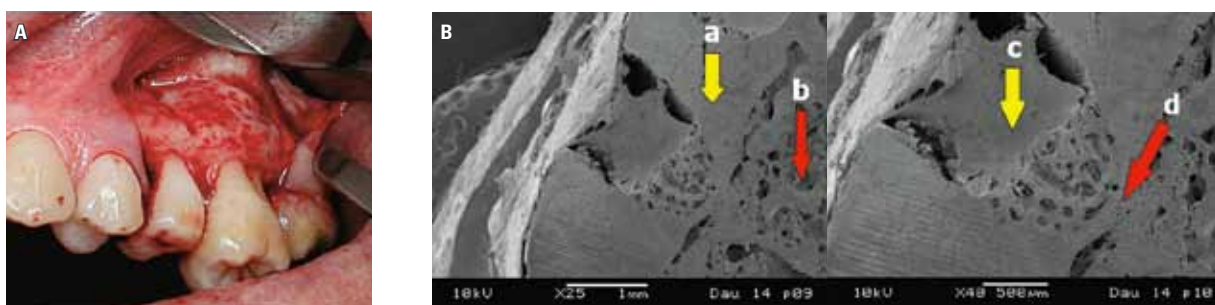


FIGURE 1 - **A)** Clinical aspect of alveolar corticotomy. **B)** Scanning electron microscopy (SEM) image showing the depth reached by the bur in the alveolar bone of dogs, where: **a)** cortical bone, **b)** trabecular bone, **c)** surgical injury being filled by young cortical bone, **d)** bur perforation as far as the limit between cortical and trabecular bone (Source: adapted from Oliveira³).

Brian, in 1892, and G. Cunningham, in 1893.⁸ The former reported such cases at the Meeting of the American Dental Society of Europe and the latter presented the possibility of immediate correction of irregular teeth during the Dental Conference in Chicago that year.

Some fifty-odd years later, in 1959, Köle⁹ used a combination of interradicular corticotomies and supra-apical osteotomies to speed up tooth movement. This treatment approach never gained widespread acceptance, probably due to the association of horizontal subapical osteotomies, which posed considerable risks to the periodontium and tooth pulp vitality.¹⁰ Furthermore, the use of removable orthodontic appliances provided poor control of tooth movement, which inevitably compromised orthodontic treatment outcome. In 1975, Dük-er¹¹ performed the first animal study replicating the technique described by Köle.⁹ A few years later, subapical osteotomies were replaced by cuts limited to the cortical portion of the alveolar bone. Hence the first description of a surgical attempt to enhance orthodontic treatment using only corticotomies, thereby reducing the risks inherent in the previous approach. Furthermore, the use of fixed orthodontic appliances increased the control and efficiency afforded by this therapeutic combination.¹²

Nevertheless, the use of ACS as an aid to orthodontic therapy remained limited. Since 2001, however, there have been renewed attempts at popularizing this therapeutic approach. A modified, more localized surgical technique proved very effective in helping to intrude supra-extruded molars with magnets.¹³ In addition, another variant—which expands the technique and combines it with lyophilized bone grafts—was presented as a means to accelerate and significantly shorten conventional orthodontic treatment time.⁴

As the Wilcko brothers—an orthodontist and a periodontist—reported⁴ a 1/2 to 1/3 reduction

in traditional orthodontic treatment time, their publications and conference presentations aroused intense curiosity, mainly because they were based solely on case reports. In this context, many clinical orthodontists and researchers began to study into this subject in order to gain an in-depth understanding of how alveolar corticotomies affect orthodontic movement.

WHEN ARE CORTICOTOMIES INDICATED IN ORTHODONTICS?

After the first reports by the Wilcko brothers,⁴ a wide array of combined ACS-orthodontic treatment techniques have been described in the literature. Reports can be found that describe the successful use of ACS in the enhanced correction of severe bimaxillary protrusion,¹⁴ closure of complex skeletal open bites,¹⁵ facilitated molar intrusion with removable appliances,¹⁶ intrusion and molar uprighting combining ACS and mini-implants,⁶ and optimization of treatment of patients with cleft lip and palate,¹⁷ among others. The indications for the use of ACS in orthodontics have been grouped into three main categories: (1) to accelerate corrective orthodontic treatment, as a whole, (2) to facilitate the implementation of mechanically challenging orthodontic movements, and (3) to enhance the correction of moderate to severe skeletal malocclusions.

Accelerating corrective orthodontic treatment

Conventional orthodontic movement is a biological process characterized by sequential reaction of the periodontal tissue and alveolar bone adjacent to the mechanical forces produced by an orthodontic appliance.¹⁸ Variables such as force system properties, turnover features of the periodontal ligament, and bone metabolism levels, play important roles in determining the type and amount of tooth movement to be achieved. The ability to speed up

orthodontic movement and decrease total treatment time was particularly highlighted by the Wilcko brothers in 2001,⁴ as explained in more detail in 2009.¹⁹

The technique described by these authors was named Accelerated Osteogenic Orthodontics (AOO)⁴ and subsequently renamed Periodontally Accelerated Osteogenic Orthodontics (PAOO).¹⁹ This approach combines multiple alveolar corticotomies, often extended from molar to molar. Grooves are cut in the cortical bone, both on the buccal and lingual surfaces, in one or both arches, followed by placement of lyophilized bone grafts before repositioning and suturing the gingival flap.

Fixed orthodontic appliances should be installed approximately one week before surgery. Corticotomies should then be performed around the teeth to stimulate the process of bone regeneration. The authors suggest that the bone grafts are aimed at increasing alveolar volume so that even if very large expansions were implemented to resolve severe crowding, the roots would still have sufficient support. Some cases were presented whereby tooth movement occurred two to three times faster than would have been achieved with orthodontics alone.^{4,19}

It should be commented that the presented cases showed significant dental expansion both in the transverse and anteroposterior direction. After the opening of the gingival flap, a larger than expected amount of fenestration and dehiscence was noted. Since the tooth movement was "buccal to the alveolar bone," grafts of lyophilized material would minimize the risks associated with such movement.^{4,19}

We have had no experience with the use of multiple corticotomies in orthodontic treatment and consider that, in our view, orthodontic treatment acceleration does not justify or outweigh the risks and invasiveness of the procedure. We also suspect that such substantial

anteroposterior and transverse expansion might jeopardize facial aesthetics and stability of the results. It is important, however, to recognize the historical importance of the approach by briefly describing it. Regardless of when ACS should or should not be indicated, it is undeniable that the results reported by Wilcko et al^{4,19} aroused our curiosity about other clinical situations where alveolar corticotomies could be applied. The ability to (a) facilitate alveolar bone response in complex dental movements, or (b) take advantage of a surgical procedure that was already originally part of the treatment plan, are examples of conditions where we believe ACS could be useful, as will be illustrated as follows.

Facilitating complex orthodontic movements

Given the fact that the efficiency of orthodontic tooth movement depends on adequate control of the forces delivered to the teeth and on how the alveolar bone responds to the mechanical stimuli generated by these forces, before considering the possibility of stimulating the alveolar bone through corticotomies, we must define what forces will be used and how unwanted reaction forces will be controlled. Managing the side effects of any orthodontic mechanics is often the most challenging aspect of treatment. Proper assessment of such side effects is therefore essential to improve efficiency. Moreover, it is undeniable that the introduction of temporary skeletal anchorage devices (TADs) represented a dramatic step forward in the control of complex orthodontic movements.

However, the use of mini-implants and mini-plates is not always possible, be it for anatomical or financial reasons. This may be the best window of opportunity for the use of alveolar corticotomies in orthodontics, i.e., when TADs cannot be used, or even when these devices can be combined with ACS. The clinical examples presented below illustrate these ACS indications.

Intrusion of posterior teeth

In growing patients, upper molar intrusion due to restricted vertical growth of the maxillary alveolar process is quite feasible with the use of extraoral appliances, provided that patients are compliant. Moreover, the actual intrusion of supra-extruded molars in adult patients is one of the most challenging dental movements in orthodontics. Skeletal anchorage devices are the first choice for these cases. However, clinical situations are sometimes encountered in which the unique anatomical features of a given patient preclude the placement of mini-implants in an ideal site, where pure intrusive forces could be applied.¹⁶ Furthermore, although mini-plates are a great alternative for tooth intrusion, many patients reject them owing to cost issues and the need for an additional surgery for their removal.²⁰ Under these conditions corticotomies can be viewed as an attractive alternative.

Corticotomies combined with skeletal anchorage devices

A 37-year-old female patient wished to improve her chewing function, compromised by the early loss of teeth 36 and 37 and consequent

excessive extrusion of the teeth 26 and 27 (Fig 2). The patient turned down a suggestion to fix the problem prosthetically, which would involve root canal treatment, lengthening of clinical crowns and full crowns on the extruded teeth. After the patient had been informed of the advantages, disadvantages and risks involved in the orthodontic-prosthetic approach, encompassing intrusion of upper molars and lower implant-supported prostheses, this option was chosen.

Due to the proximity of the roots, the mini-implants could not be placed in a site that would be ideal for the delivery of direct intrusive forces. On the same day that the skeletal anchorage devices were installed, the left upper third molar was extracted and alveolar corticotomies were performed around the roots of the teeth to be intruded (Fig 3). One week after performance of the ACS, cast metal bars were attached to mini-implants placed in the mesial region of tooth 25 and in the distal region of tooth 27. Then, 150 g of intrusive forces were delivered using nickel-titanium springs tied to these bars. Approximately four months into treatment, the maxillary molars were re-leveled with the adjacent teeth and dental implants were installed in place of teeth 36 and 37 (Fig 4).



FIGURE 2 - Pre-orthodontic treatment images. **A)** Intraoral photograph showing severe extrusion of teeth 26 and 27. **B)** Panoramic radiograph disclosing an uneven upper occlusal plane and the presence of tooth 28.

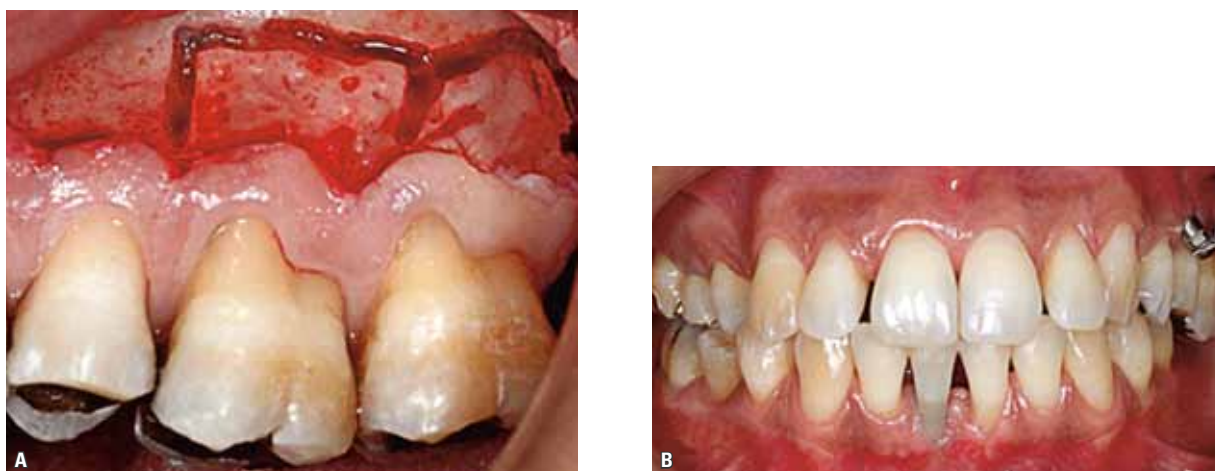


FIGURE 3 - Transoperative photographs. **A)** Corticotomies circumscribing the roots of the teeth to be intruded. **B)** Buccal mini-implants to support the cast metal bars.

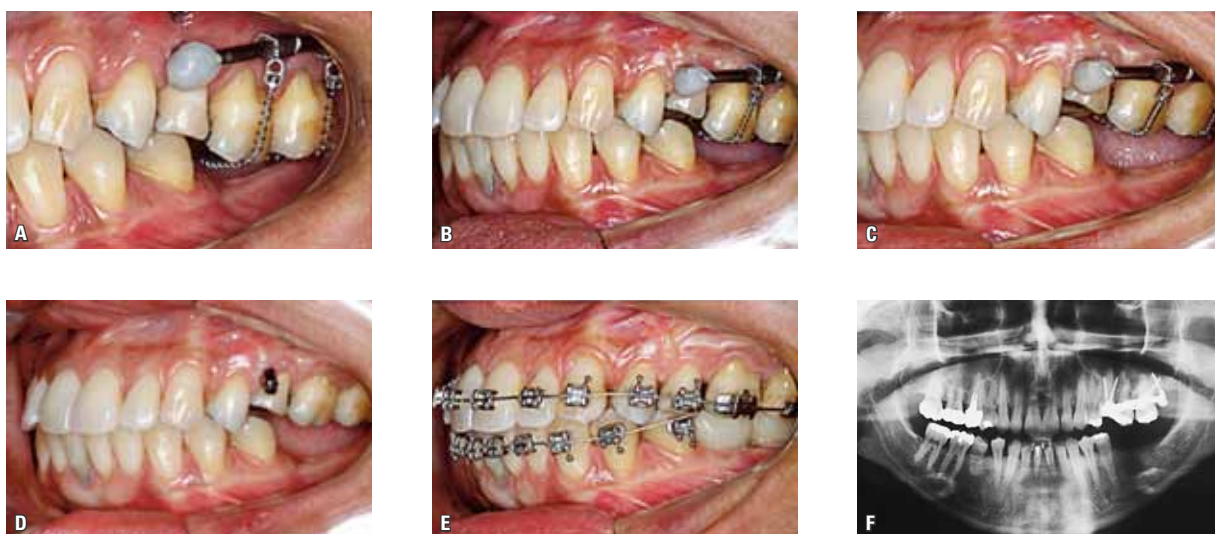


FIGURE 4 - Intrusion progress. **A)** Starting intrusive force application seven days post-corticotomies. **B)** Two months after the start of intrusion mechanics. **C)** Four months into treatment. **D)** Five months after performance of ACS, when the cast metal bars were removed. **E)** Patient with osseointegrated implant-supported provisional restorations replacing teeth 36 and 37, lost prematurely. **F)** Panoramic radiograph showing the levelling of the upper occlusal plane.

Corticotomies to enhance extraoral forces

Another female patient with impaired speech and mastication functions sought orthodontic treatment. She was 42 years old and had lost the mandibular premolars and second molars prematurely, which led to significant extrusion

of teeth 15, 16 and 17 (Fig 5). When she was referred to the Orthodontic Clinic at PUC Minas University, her name was on the waiting list for maxillofacial surgery, followed by subapical surgery and immediate intrusion of the bone block with her extruded teeth. She was interested in

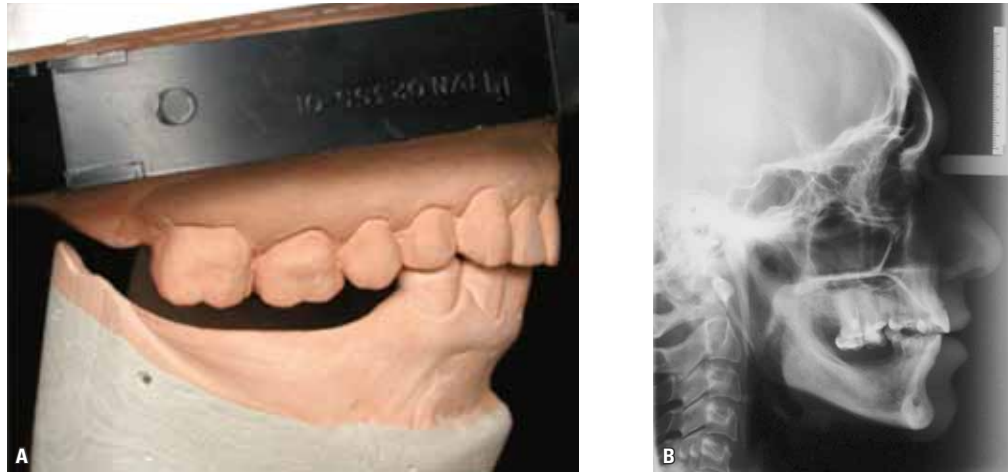


FIGURE 5 - Pretreatment images: **A)** Plaster models photograph showing severe extrusion of teeth 15, 16 and 17. **B)** Lateral cephalometric radiograph disclosing an uneven upper occlusal plane.



FIGURE 6 - Transoperative photograph illustrating alveolar corticotomies.

finding an alternative solution to her problem that would rule out the need for orthognathic surgery, which had been previously proposed.

The use of mini-plates or mini-implants was rejected by the patient for financial reasons. Aware of the difficulties entailed in intruding the molars of adults using extraoral forces and willing to comply with treatment, the patient opted for leveling of the upper occlusal plane with alveolar corticotomies to potentiate the effects of the headgear. One week after the ACS (Fig 6),

segmented orthodontic appliances were placed on the teeth to be intruded and intrusive forces began to be applied. In the fourth month of treatment, a lower partial removable denture was installed to add some occlusal force to the force system already in motion. Approximately seven months later the upper occlusal plane was leveled and osseointegrated implants had already been placed in the mandible (Fig 7).

Corticotomies and fixed orthodontic appliances

Although the intrusion approaches described above were successful, both had limitations. In the first case, mini-implants were needed and in the second, success would not have been achieved were it not for the patient's absolute compliance. Since we all know that finding patients who are willing to use headgear is increasingly difficult, especially among adults, the search for other alternatives that rely less on patient compliance is in order. The intrusion of extruded molars with fixed orthodontic appliances using straight archwires has always been regarded as inappropriate due to its extrusive effect on adjacent teeth.^{13,15,16} Could it be that a decrease in alveolar bone density around alveolar

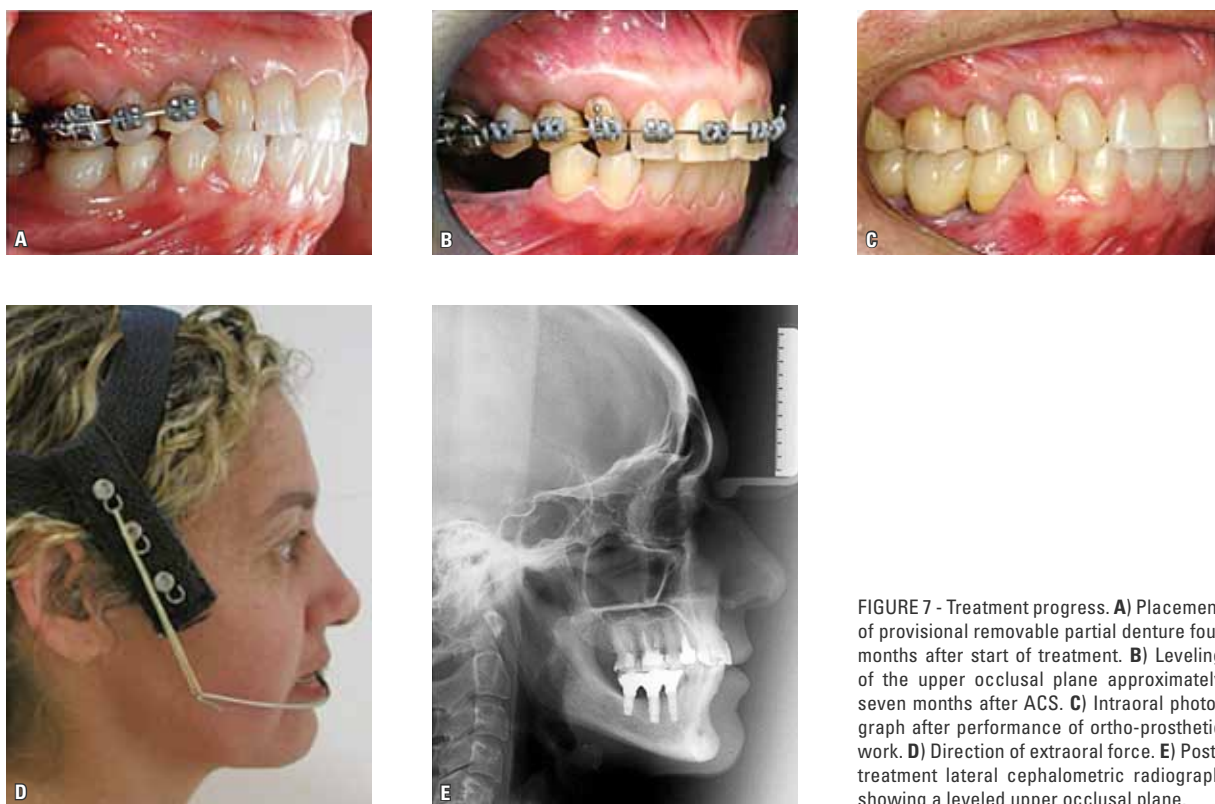


FIGURE 7 - Treatment progress. **A)** Placement of provisional removable partial denture four months after start of treatment. **B)** Leveling of the upper occlusal plane approximately seven months after ACS. **C)** Intraoral photograph after performance of ortho-prosthetic work. **D)** Direction of extraoral force. **E)** Post-treatment lateral cephalometric radiograph showing a leveled upper occlusal plane.

corticotomy sites would facilitate the intrusion of extruded teeth, thereby minimizing the extrusion of adjacent teeth used for anchorage? The case shown here suggests that this alternative might eventually deserve more attention.

A 21-year-old patient was referred for pre-prosthetic orthodontic evaluation. The prosthodontist was primarily concerned with an excessive extrusion of first molars, especially on the left side (Fig 8, A). Due to the patient's refusal to use skeletal anchorage devices, or even removable appliances specially designed for intrusion of upper molars, we suggested a combination of alveolar corticotomies and fixed orthodontic appliances with small but important adjustments to streamline the procedure. The patient was informed of all potential risks and signed a consent form authorizing the treatment.

Prior to the ACS, we prepared the upper arch orthodontically. After bonding the fixed appliances, the mechanical routine of alignment and leveling was conducted until archwire progress reached a 0.21 x 0.025-in stainless steel archwire, always bypassing the tooth to be intruded (Fig 8, B). We performed alveolar corticotomy around tooth 26 according to the protocol described above¹⁶ (Fig 9). A week after the ACS, a 0.017 x 0.025-in nickel-titanium archwire segment was inserted into the auxiliary slots of the second premolar and second molar tubes. Five weeks after the onset of force application, the archwire segment was replaced by another superelastic archwire size 0.018 x 0.025-in, which remained in place until the end of the intrusion, 2.5 months later (Fig 8, C). Adequate intrusion was confirmed



FIGURE 8 - Intraoral photographs illustrating the progress of the intrusion of tooth 16. **A)** Pretreatment. **B)** One week post-corticotomies and start of intrusive force application. **C)** Four months after ACS, leveling nearly complete.

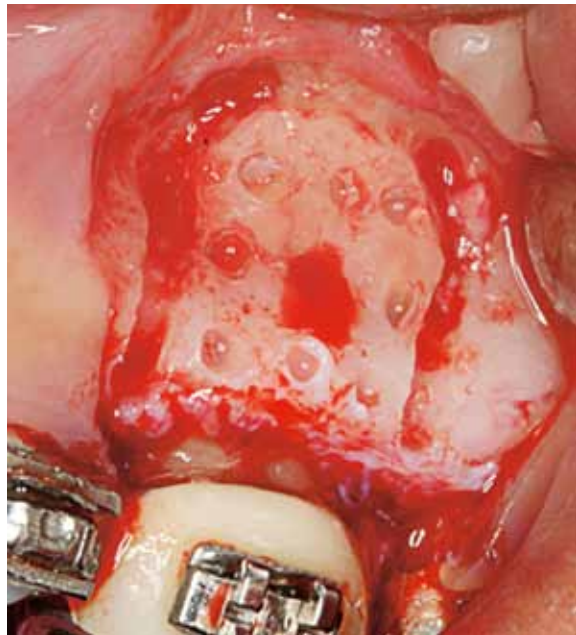


FIGURE 9 - Operative photograph showing corticotomies on the buccal surface of the tooth to be intruded.

both clinically and cephalometrically with no unwanted side effects on adjacent teeth.

Although the results demonstrate a successful treatment using this technique, they must be approached with caution. We should be aware that this posterior tooth intrusion method had not yet been reported in the literature. Souza²¹ evaluated periodontal, orthodontic and endodontic parameters of molars intruded using the technique illustrated above. None of the periodontal measures worsened during treatment.

Intrusion was satisfactorily performed without relevant side effects and no significant changes were found in the pulps of the teeth. Detailed results of this study were sent for evaluation and publication in relevant scientific journals.

Enhancing the correction of skeletal malocclusions

This is a widely reported indication when discussing the potential indications of ACS. It is also an option that can help to decrease the invasiveness of this approach, for example, by replacing orthognathic surgery to correct anterior open bite. Originally reported by Chung et al,²² this was the first corticotomy indication to be investigated in a clinical study. Akay et al¹⁵ evaluated the efficiency of ACS associated with buccal miniplates and palatal mini-implants for correction of anterior open bite in patients aged between 15 and 25 years. The authors reported a mean decrease of 4.64 mm in overbite within approximately 12 weeks, concluding that corticotomies combined with skeletal anchorage would be a viable alternative in cases where patients reject orthognathic surgery for correction of anterior open bite. The case described below illustrates this indication for ACS without the aid of skeletal anchorage.

A 33-year-old female patient was referred for orthodontic treatment to improve both function and aesthetics. She presented with severe anterior open bite and early loss of first molars, making the ortho-surgical approach the treatment of choice (Fig 10). Repair using

orthognathic surgery was rejected for financial reasons and the alternative treatment plan was implemented. At first, this approach consisted of posterior alveolar corticotomies in the maxilla, palatal expander with occlusal coverage and oblique headgear (Fig 11). After the open bite

showed some improvement, fixed orthodontic appliances were installed to upright the lower mesio-inclined teeth and the right mandibular lateral incisor was extracted to adjust the anterior occlusal relationship. The patient's occlusal conditions were improved (Fig 12).



FIGURE 10 - Pretreatment intraoral photographs.



FIGURE 11 - Implementing combination of ACS and orthodontics. **A)** Buccal corticotomy. **B)** Palatal corticotomy. **C, D)** Placement of palatal expander with occlusal coverage and spurs. **E)** Extraoral forces.



FIGURE 12 - Progress intraoral photographs showing open bite closure and finishing treatment stage.

WHY DO ALVEOLAR CORTICOTOMIES ENHANCE ORTHODONTIC TREATMENT?

To be considered effective, orthodontic treatment must meet the goals established during planning within the shortest possible time without compromising the quality and stability of the results and, finally, preserving the long-term health of periodontal tissues. Optimal tooth movement requires the combination of well planned orthodontic forces²³ and an alveolar bone that offers less resistance to movement, i.e., less dense and with increased bone metabolism.²⁴ Different force systems geared to improving the various types of tooth movements have been described in the literature.²⁵ However, it is unclear how best to create a biological environment which facilitates effective orthodontic movement.

When alveolar bone metabolism is increased, orthodontic movement is accelerated.²⁴ Effective tooth movement enhancement has been demonstrated in laboratory studies with animals after the administration of certain drugs,²⁶ or by changing the optimal levels of hormones involved in regulating bone metabolism.²⁷ Such methods, however, are not yet available for clinical application in humans.

Since the first reports about the combination of corticotomies and orthodontic movement, it was believed that ACS delineated bone blocks which were linked together only by bone marrow, which would be more easily moved by the forces delivered by the orthodontic appliance.⁹ It was suggested that due to the surgical cut, the greater resistance to tooth movement offered by the cortical bone would be reduced and, consequently, orthodontic movement would be increased.¹²

It was reported that the increased efficiency of orthodontic treatment was not due to greater ease in moving the blocks limited by bone corticotomies but rather by increased bone turnover in response to surgical trauma.⁴ This

change in bone physiology would result in a localized decrease in trabecular bone density, which in turn, would offer less resistance to tooth movement.¹⁹ Although providing satisfactory clinical results in reduced time periods, both studies afforded only indirect scientific explanations for these results.

In particular, the formulation of this latter theory to explain the effects of alveolar corticotomies was based on the physiological responses that occur during the bone healing process. After any trauma to bone tissue, remodeling, which is commonly found in the bone tissue structure, is greatly increased to accelerate the repair process and, consequently, functional recovery.²⁸ Soon after suffering structural damage, bone tissue goes through a biological stage called Regional Acceleratory Phenomenon, characterized by increased metabolism and decreased density, both transient and localized.

Recent animal studies have helped to broaden our understanding of what happens to the alveolar bone after an ACS. Oliveira³ noted that in dogs both localized and transient alveolar bone density appeared to be lower. The largest decreases in bone density were recorded immediately, and 7 days, after surgery. Measurements taken 14 and 28 days post-surgery showed gradual recovery, albeit partial, of pre-operative bone density. When surgical trauma was limited to the cortical bone, it caused significant changes in the structure of the trabecular bone near the surgical site and a decrease in both volume and density. There was an increase in trabecular bone size, reduced connection between these structures and a decline in trabecular bone density. These results are consistent with the characteristics of the Regional Acceleratory Phenomenon observed in long bone healing and thus suggest that this phenomenon is also present in alveolar bone following the performance of ACS.

A second trial of the same study showed a

significant increase both in speed and amount of orthodontic movement, when it was performed in combination with localized alveolar corticotomies. The amount of mesial movement of the teeth used for anchorage was lower when alveolar corticotomies were performed around the tooth to be distalized. In another study on the effects of ACS in dogs, Mostafa et al⁷ reported similar results. The amount of orthodontic movement was twice as large as had been achieved without the surgery. Histologically, bone remodeling was more active and extensive following corticotomies, which also suggests that the movement can be enhanced by an increase in bone metabolism resulting from the regional acceleratory phenomenon.

Lee et al²⁹ and Sebaoun et al³⁰ reported systemic and histological evidence supporting the theory that enhancement of tooth movement after ACS is due to an increase in the phenomenon of demineralization and remineralization observed in bone turnover. Results reported for rats showed a threefold increase in anabolic and catabolic processes up to 21 days after

performance of ACS, showing that the effects on trabecular bone were both intensive and extensive.³⁰ Finally, images obtained with a micro CT scanner confirmed that the alveolar bone adjacent to the ACS behaved quite differently from the bone located adjacent to areas that had undergone osteotomy.²⁹

WHAT ARE THE POSSIBLE CONTRAINDICATIONS AND LIMITATIONS OF USING ACS?

Despite an increasing number of reports on the use of alveolar corticotomies as an aid to orthodontic treatment, few studies have reported setbacks when employing this combined treatment. Recently, however, Wilcko et al¹⁹ gave an objective account of scenarios where the use of ACS-orthodontics should be avoided, i.e., (1) patients showing any sign of active periodontal disease, (2) individuals with inadequately treated endodontic problems, (3) patients making prolonged use of corticosteroids, (4) persons who are taking any medications that slow down bone metabolism, such as bisphosphonates and NSAIDs.

CONCLUSIONS

Interest in the use of alveolar corticotomies as an adjunct to orthodontic treatment is growing thanks to a deeper understanding of its effects and more solid evidence-based research.

The biological stimulus generated by corticotomies is reflected in the structure of trabecular bone, which provides an opportunity to enhance certain orthodontic movements.

Although corticotomies are primarily indicated to shorten orthodontic treatment time, we believe that the more rational indications for ACS are for cases where either skeletal anchorage devices cannot be used, or both (ACS and

anchorage devices) can be used in combination.

As well as shedding more light on how to use ACS in orthodontics, further studies should encourage the search for new and exciting, and hopefully, less invasive procedures.

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- Images must be submitted in separate files.
- In the event that a given illustration has been published previously, the legend must give full credit to the original source.
- The author(s) must ascertain that all figures are cited in the text.

5. Graphs and cephalometric tracings

- Files containing the original versions of graphs and tracings must be submitted.

- It is not recommended that such graphs and tracings be submitted only in bitmap image format (non-editable).
- Drawings may be improved or redrawn by the journal's production department at the criterion of the Editorial Board.

6. Tables

- Tables must be self-explanatory and should supplement, not duplicate the text.
- Must be numbered with Arabic numerals in the order they are mentioned in the text.
- A brief title must be provided for each table.
- In the event that a table has been published previously, a footnote must be included giving credit to the original source.
- Tables must be submitted as text files (Word or Excel, for example) and not in graphic format (non-editable image).

7. 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

Higuchi K. Osseointegration and orthodontics. In: Branemark PI, editor. *The osseointegration book: from calvarium to calcaneus*. 1. Osseointegration. Berlin: Quintessence Books; 2005. p. 251-69.

Book chapter with editor

Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wiczorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper

Kuhn RJ. Force values and rate of distal movement of the mandibular first permanent molar. [Thesis]. Indianapolis: Indiana University; 1959.

Digital format

Câmara CALP. Estética em Ortodontia: Diagramas de Referências Estéticas Dentárias (DRED) e Faciais (DREF). *Rev Dental Press Ortod Ortop Facial*. 2006 nov-dez;11(6):130-56. [Acesso 12 jun 2008]. Disponível em: www.scielo.br/pdf/dpress/v11n6/a15v11n6.pdf.

* www.dentalpress.com.br/submission

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,

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