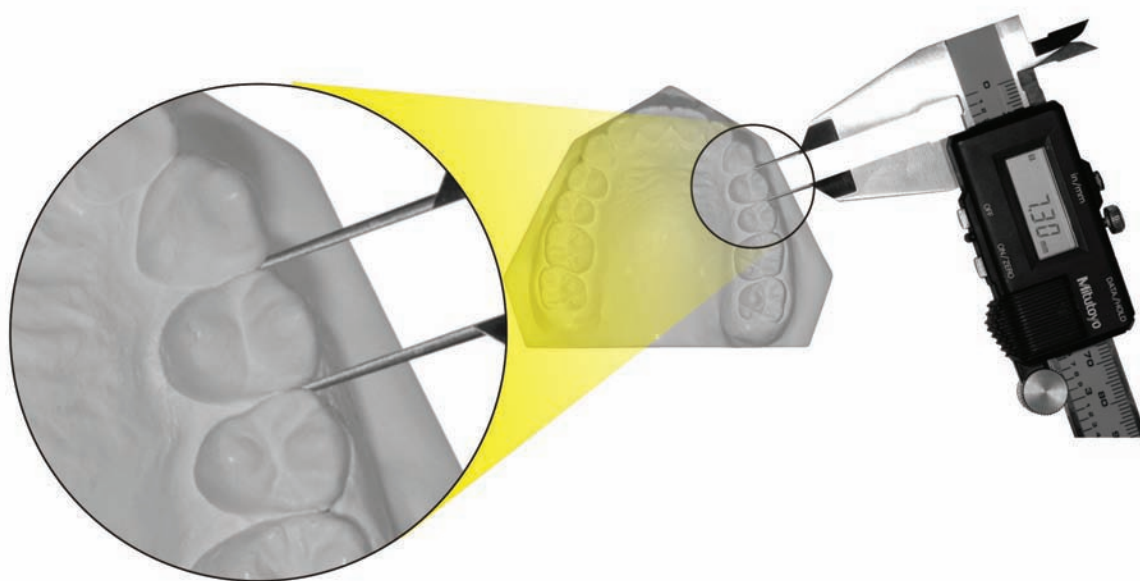


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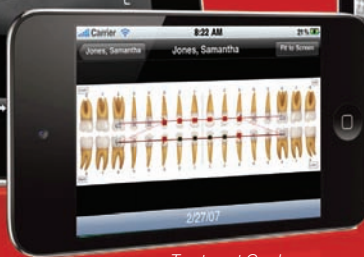
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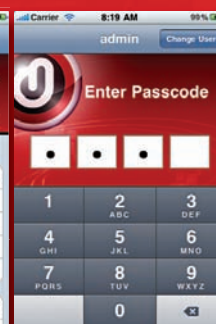
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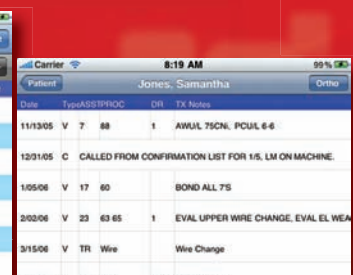
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Generation Z and the evolution of scientific journals

During his lifetime, Charles Darwin sent at least 7,591 letters and received 6,530. Albert Einstein, in turn, sent over 14,500 and received more than 16,200.¹ This means that they wrote, respectively, 0.59 and 1.02 letters every day in the last 30 years of their lives. Such impressive display of discipline compels one to imagine that the number of messages exchanged by them would be particularly astronomical if they had lived in the age of email and social networks. In 2010, it is estimated that in emails only, excluding spam, approximately 4.5 messages were sent out worldwide per day per capita.²

This increase in human interaction has forcibly reduced messages size. So much so that the golden rule of email etiquette demands briefness and conciseness.³ This increasing shrinkage of exchanged messages is among the factors that set the stage for the success of social networks. Proximity would never have allowed this phenomenon to emerge. In virtual environments information is transferred swiftly, often deploying resources that go beyond the written word. Ideas — both good and bad — are spread through words, images, videos and sounds, which can be used in isolation or not.

The internet and social networks have brought to light several simultaneous phenomena. Among these is the so-called Generation Z, which shares information in a compartmentalized manner as if each compartment was but a piece of the overall puzzle. No one is interested in assembling the whole puzzle. People just want to separate the parts that arouse their interest and provides themselves with the desired knowledge. Thus, consistency between the parts is not given by textual elements but by individual curiosity, the specific interest of each person.

That's why long informative texts have become so boring. Extracting meaningful content simply takes too long. It is a matter of cost-benefit. Why spend time trying to grasp what could be learned in minutes?

These selection pressures led to the evolution of a wide range of hardware and software technologies. To cite just one example, most current mobile phones — which have been expanded into tablets — were developed to meet the need for this information flow. They are not just phones. They give access to social networks, restaurant guides, GPS, email, games, etc. They are mini entertainment and communication centers.

Generation Z has never envisioned the planet without computers, chats, mobile phones. Their mindset was influenced from birth by a fast-track, complex world materialized by technology and they, therefore, conceive of a world devoid of geographical boundaries. They have reached the age of consumer decisions.

They consume video games, but also cars, real estate, e-books and, obviously, scientific literature.

All these selection pressures have come into play in the area of scientific journals, and are bound to keep pushing harder and harder. Whoever fails to keep track of this obvious reality is doomed to extinction.

We at the Dental Press Journal of Orthodontics are at the forefront of the teaching-learning process. We have become the first scientific journal of orthodontics available worldwide on the iPad. We can be proud of producing one of today's best graphic design, as well as versatility, in formatting published articles. However, we will certainly keep on evolving.

To be accepted, articles will have to limit the number of words to 3,500, including title, abstract and references. Authors are encouraged to utilize a wealth of multimedia resources and use the power of the Dental Press Portal to tap into these resources. Information not essential to the understanding of the article will be appended on the web, shedding light on key content. We will further strengthen the importance of clinical information by including a section in the article entitled Clinical Relevance. In this new section, authors will be able to highlight the key points in their study that can somehow improve clinical practice. Something along the lines of "evidence-based clinical tips." Finally, the authors will be encouraged to prepare questions for inclusion in the online version of their article. The goal is to give readers the chance to test their knowledge while encouraging teachers in undergraduate and graduate courses to expose their students to these themes.

Einstein once said that "it is important never to stop questioning." Only then can we truly evolve and accomplish something that really makes a difference.

Good reading!

Jorge Faber
Editor-in-chief
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Destaque

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

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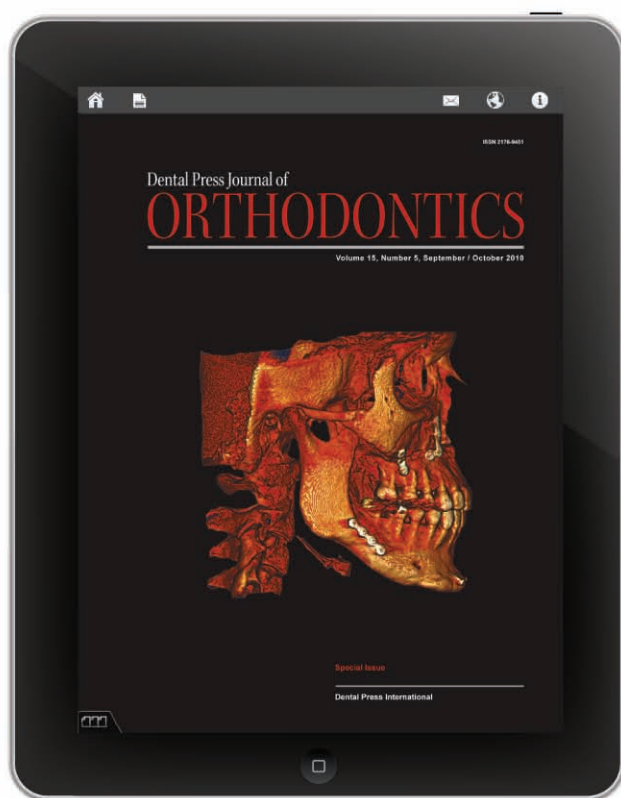
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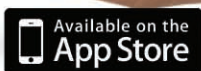
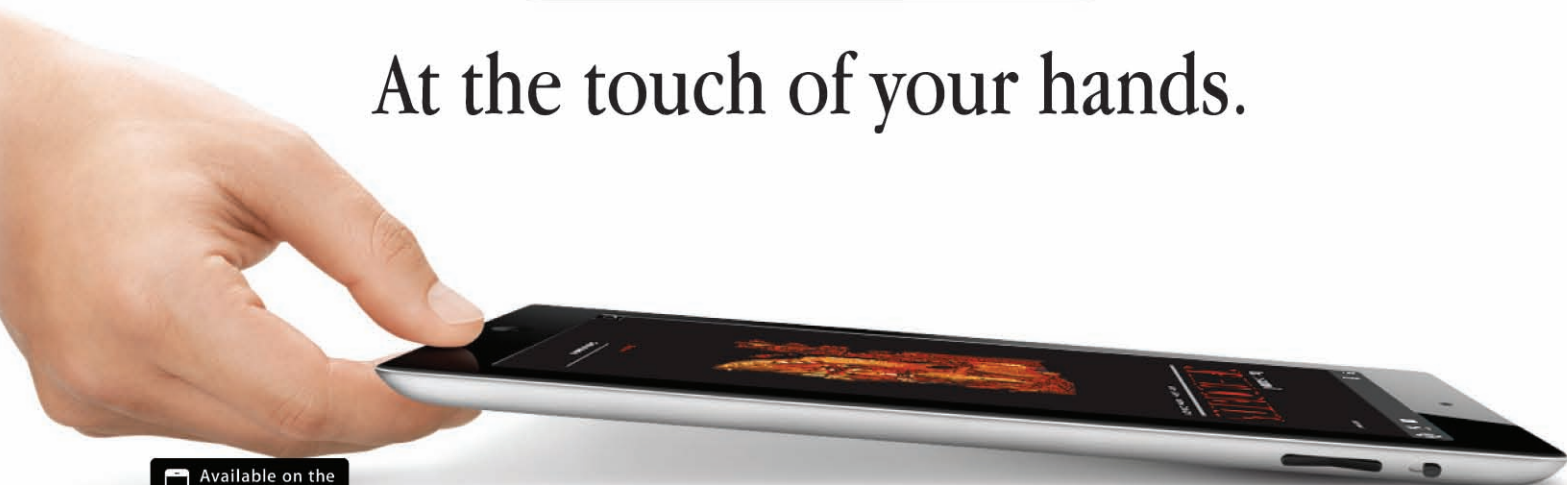
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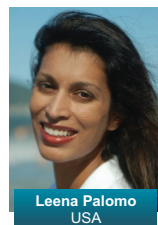
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Orthodontic records: new aspects of an old concern

Robert Willer Farinazzo Vitral*, Marcio José da Silva Campos**, Cleverson Raymundo Sbarzi Guedes***

In the last few years, there has been a growing concern about the amount of X-rays to which patients are exposed during radiographic examinations requested by the dentists responsible for their treatments. This concern has been identified in Reference Centers of Orthodontics all over the world. Evidence of that is an Editorial published in 2008,¹ in which the Editor of the American Journal of Orthodontics and Dentofacial Orthopedics (AJODO), David Turpin, analyzed the guidelines of the British Orthodontic Society² (BOS) for radiography in Orthodontics. In its general considerations, BOS basically reminds dentists that no safe level of exposure to radiation has been established and recommends a careful analysis of risks and benefits for the patient's health before each radiograph is requested and stresses that radiographs should be indicated only when there is an appropriate clinical justification. Therefore, according to the BOS, no indication or need is justified in the following orthodontic cases: routine radiographs obtained before clinical examination; set of routine radiographs for all orthodontic patients; full pretreatment periapical examination; cephalometric profile radiographs to predict facial growth; hand and wrist radiographs to predict

growth spurt; routine radiographs of the temporomandibular joints to evaluate dysfunctions; radiographs for medicolegal purposes; end-of-treatment radiographs whose sole objective is professional evaluation or clinical presentation; and cone-beam computed tomography (CBCT) as a routine examination.

Greater attention has been paid to exposure to radiation as CBCT became popular and the new focus of concern in dentistry. In another editorial in 2010,³ Turpin described a project of the European Atomic Energy Community, the SEDENTEXCT, which established temporary norms for the indication of X-ray examinations in dentistry while key data have not been fully gathered for the scientific development of guidelines for the clinical use of CBCT. In the USA, however, the American Association of Orthodontists and the American Association of Maxillofacial Radiology joined efforts to prepare a reference document⁴ to guide the choice of which imaging diagnostic technique is the most useful in specific orthodontic conditions, which is justified by the wide variety of imaging modalities available in orthodontics, from cephalometric radiographs to CBCT. Turpin recommended that, while those documents

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have not been completed, orthodontists should use CBCT carefully and always ask themselves whether the clinical problem may be solved by using conventional radiographs.

In Brazil, no specific recommendations have been made about the use of radiographic examinations in orthodontics, and no movement from professional associations or governmental offices has been made to create them. In our country, a set of initial and final examinations are usually obtained,⁵ as well as reexamination studies requested when the dentist sees the need to evaluate the treatment already completed to define the next steps.

A legal concern is associated with the clinical interest in making a diagnosis, planning and evaluating treatment that justify the requests of radiographs. Orthodontics is an activity whose duty, in its nature of provision of services, is to achieve results.⁶ Orthodontists are obligated to achieve a certain useful result by means of their activity, and the records at the end of treatment are irrefutable proof of proper clinical conduct. Moreover, during civil action against an orthodontist, the existence of the alleged damage to the patient has to be proven to characterize a causal connection (cause and effect relation) to the professional conduct, which may or may not be proven by the records collected during treatment.⁷ In turn, paragraph 6 of the Brazilian Consumer Protection Code⁸ allows the trier of facts to shift the burden of proof and to determine that the orthodontist has to prove no culpable neglect, and it is the orthodontist that will sustain damages in case these records are not available for forensic examination.

Differently from usual practices in the United States and European countries, in Brazil the Federal Prosecution Service has assumed the position of professional associations in those countries and has issued recommendations about indications and contraindications for radiographic examinations. The news article *Indiscriminate use of X-rays may lead to investigations of ethical violations*, published in the journal of the Regional

Concil of Dentists of the State of Minas Gerais (CROMG),⁹ describes how this takes place when private health care organizations are involved.

POSITION AND RECOMMENDATIONS OF THE FEDERAL PROSECUTION SERVICE

The 1988 Brazilian Constitution established that access to health care should be universal. After that, the Brazilian Unified Health System was created, and the operations of private health insurance companies were defined by law. One of the most significant features of the democratic Brazilian Constitution was to facilitate the access to the Judiciary system for all citizens, so that all individual and collective disputes have the opportunity to be taken to court. Federal Prosecutors, the best known representatives of citizens in this branch of the Judiciary System, gained the responsibility to protect, within the range of their legal obligations, the rights of users of the public and private health care systems.¹⁰ Along this line, several specialized Federal Prosecution Services have been created to protect health care rights.

In this context, the Health Care Federal Prosecution Service often issues recommendations to health care organizations, doctors or dentists to avoid all types of abuse. The Federal Council of Dentistry itself has issued Resolution 102/2010,¹¹ whose purpose was to fight the indiscriminate use of X-rays for exclusively or primarily administrative purposes or to replace forensic, auditing or fact-finding examinations easily performed using other means and less invasive or less damaging to the health of these patients. In a similar sense, it expressed its concern about the Directive 453/98 issued by the Brazilian National Health Surveillance Agency (ANVISA).¹²

In the same direction, Recommendation 05/2010¹³ was issued by the State Health Care Prosecution Service in Belo Horizonte, which, under the cloak of its legal and constitutional responsibilities and with the purpose to directly protect the health of insurance policy holders, is-

sued recommendations to avoid the abusive use of X-ray examinations in several dental procedures and to deal with two problems: (a) the abusive demands of health care insurance companies used as a means of controlling dental treatments; and (b) the abusive use of X-ray examinations that are potentially harmful to the user's health. These measures should be expected from the Prosecutors Service, particularly because they are explicitly described in the National Ministerial Plan of Action for Public Health.¹⁴

Clearly, such recommendation raises concerns among dentists working in the various dental specialties because abusive use cannot be taken to be the general rule among dentists and because of the justified fear of possible investigations due to ethical violations or, worse, of facing prosecution by the Prosecutors' office or cases filed by individual patients in the Court of Law.

Because of their specialization and expertise, dentists cannot be at the mercy of multiple recommendations that may hinder their actions. They should also not need to refrain from monitoring treatment using any examinations as a means of escaping civil, administrative or even criminal liabilities.¹⁵

On the other hand, the Federal Prosecution Service should not move away from its legal obligation of protecting health and issuing recommendations when their intervention, whether preventive or not, is necessary and indispensable in accordance with Section 67, Subsection VI of Supplementary Law 34/94-MG.¹⁶

As health care professionals, dentists should guide their actions according to responsibility, ethics and justifiable interventions (by themselves or others) to achieve the success of the treatment initially planned or later adjusted. If there is any need to control the treatment using complementary tests, either X-rays or others, this decision should be based on the nobleness of the dentist-patient relationship and produce accurate records to avoid the strains of a conflict that may end up in Court.

However, this will never have the power to rule out the possibility of a patient (citizen) going to Court through its several "entrance doors", because the access to the Judiciary is a fundamental right of all citizens in Brazil.¹⁷

CONCLUSION

This may be the moment to create, in Orthodontists Associations, committees capable of issuing recommendations or guidelines, based on scientific and legal principles, to their members and diplomates to use ionizing radiation not only in routine clinical procedures, but also in the design of studies based on imaging diagnoses. Associations should also approach other organizations and institutions, such as the Federal Prosecution Service, to plan joint preventive efforts to reach common aims, such as: provide specialized technical guidelines to the actions of the Federal Prosecution Service; not to inhibit professional actions; and to be effective in inhibiting the abusive use of X-rays examinations.

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The concept of root resorptions or *Root resorptions are not multifactorial, complex, controversial or polemical!*

Alberto Consolaro*

Abstract

The mechanisms of root resorptions are known, and their causes are well defined. They are clinically asymptomatic and do not induce pulp, periapical or periodontal changes; rather, they are usually consequences of these phenomena. Root resorptions are local and acquired defects, and not dental signs of systemic diseases. Root resorptions occur when structures that protect teeth from bone remodeling, particularly cementoblasts and epithelial rests of Malassez, are eliminated.

Keywords: Root resorption. Tooth resorption. Resorption. Orthodontics.

A concept is a mental representation of an object or phenomenon described by the mind using its general characteristics. A concept may also represent the formulation of an idea by means of words. Still, a concept may be defined as a synonym to conception, definition and characterization. In short, to establish a concept means to identify, describe and classify the different elements and aspects of reality.

In studies about root resorptions, the first para-

graph is invariably used to define their concept. In several cases, that concept is limited to a certain type of resorption or restricted to the context of a single clinical case, and does not take into consideration all the aspects of root resorptions. Concepts should be general because, if restrictive, may limit the understanding of the phenomenon as a whole. Therefore, we have set here to discuss the concept of root resorptions to serve as a humble contribution to the preparation of future studies about this topic.

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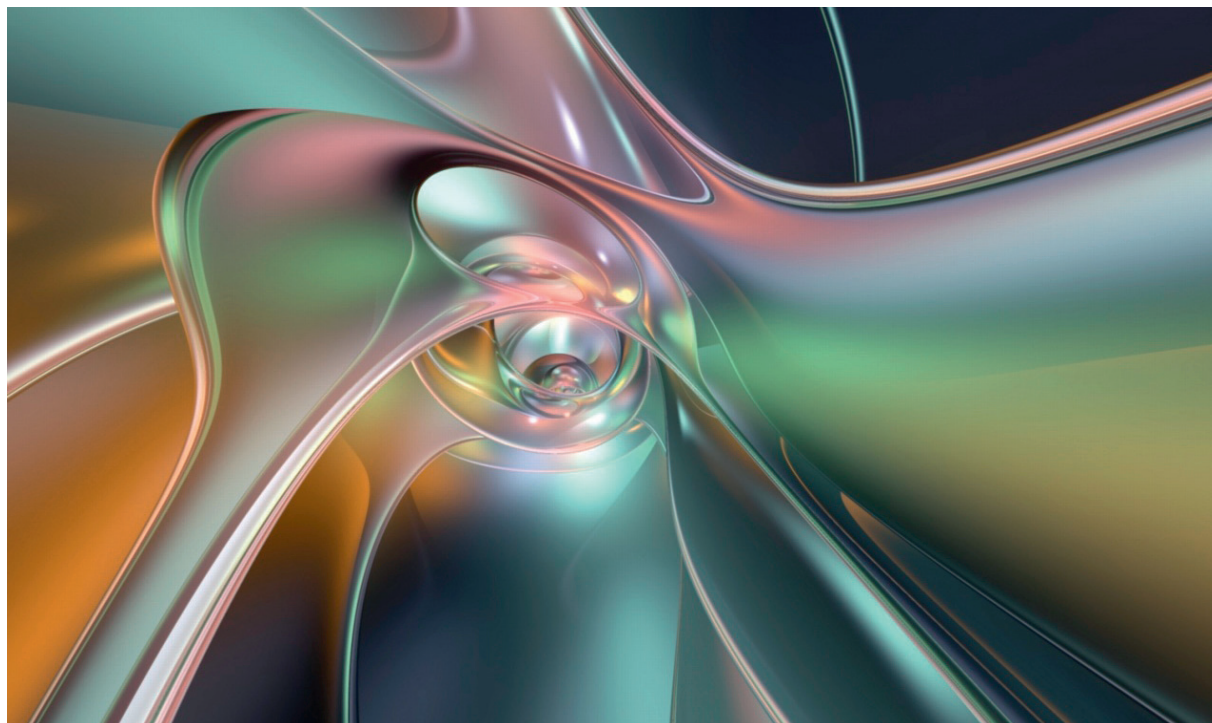


FIGURE 1 - Concepts are jewels of accurate communications between people at all levels, particularly in clinical and scientific exchanges. The accurate concept of root resorption implies in clear and concise classifications and definitions on the subject.

ROOT RESORPTIONS ARE NOT COMPLEX, POLEMICAL OR CONTROVERSIAL

Root resorptions have two basic mechanisms of occurrence, both very well understood: inflammation or replacement.

» **Inflammatory resorption.** Cementoblasts "recover" or "hide" the root surface, and the Sharpey collagen fibers are inserted among them. Teeth are very close to the bone and separated by the periodontal ligament, which has a mean thickness of 0.25 mm, ranging from 0.2 to 0.4 mm.

Bone is constantly under remodeling thanks to the stimulation of local and systemic factors. Bone dynamics contributes to the stable level of mineral salts in blood and grants it a great capacity to adapt to everyday functional demands. Bone remodeling depends on the receptors that

osteoblasts and macrophages have on their membranes, so that local and systemic mediators may manage osteoclast activities. Osteoclasts do not have receptors for bone remodeling mediators and are functionally dependent on osteoblasts and osteoclasts.

On the other side of the periodontium, cementoblasts on the root surface, although very close to the bone, do not have receptors for bone remodeling mediators. They do not respond to or "hear" the biochemical messages to resorb or form new mineralized tissue on the root surface: they are "deaf" to bone remodeling mediators, although they have receptors for other mediators that are essential to cell life, such as growth hormone and insulin.

Any cause that is active in the site where cementoblasts are found and that removes them

from the surface will expose the mineralized root surface; the bone cells, which are very close, will promote root resorption, though maybe only temporary. Root resorptions have local causes that eliminate cementoblasts from the root surface, and no systemic cause is known to produce the same effect.

» **Replacement resorption.** Bone remodeling leads to the constant resorption of mineralized structures, and, at the same time, constant new bone formation also on the periodontal surface of the tooth alveolus. Naturally, each new bone layer deposited on the alveolar periodontal surface is closer to the tooth and, at a mean thickness of 0.25 mm, dentoalveolar ankylosis may soon be seen. Cementoblasts and osteoblasts interfere and form areas of fused cement and bone, alternating with randomly distributed areas of resorption and new bone formation. However, that does not usually happen due to the presence of epithelial rests of Malassez, a net made up of cords that are 20 cells long and 4 to 8 cells wide and that form a structure that resembles a basketball basket in the periodontal ligament around the tooth root.

Epithelial rests of Malassez, as all other epidermal tissues in the organisms, constantly release epidermal growth factor (EGF) for self-stimulation to proliferate and maintain their structures. However, at the same time this mediator in the ligament stimulates bone resorption in the alveolar periodontal surface. Therefore, the periodontal space is preserved and dentoalveolar ankylosis is avoided.

Dentoalveolar ankylosis occurs practically only when epithelial rests of Malassez are eliminated, usually by dental trauma, which may range from light trauma, such as concussion, to more severe trauma, such as avulsion. Like dentoalveolar ankylosis, bone remodeling also affects mineralized dental tissues, which are gradually and inexorably resorbed and replaced with bone, which explains why it is called replacement resorption.

In teeth that remain unerupted for a long time, severe periodontal ligament atrophy due to lack of use may facilitate the development of dentoalveolar ankylosis.

Based on the descriptions of these two mechanisms of root resorption, it does not seem logical to say that they are complex or unknown. Also, it seems unacceptable to say, therefore, that their causes are polemical or controversial.

ROOT RESORPTION DOES NOT HAVE A "MULTIFACTORIAL ETIOLOGY"

The term "multifactorial etiology" suggests that a certain disease or phenomenon requires that several causes should act at the same time for their occurrence, although dictionaries do not explicitly assign this connotation to the strict meaning of "multifactorial".

Dental caries is a classical example of a disease with a multifactorial etiology. For dental caries to occur, there should be bacterial plaque on the tooth as a result of lack of oral hygiene, a diet based on carbohydrates, teeth with susceptible enamel, and time for these factors to interact and generate the disease. In other words, one cause depends on the other for the disease to occur.

Diabetes is also multifactorial because the disease occurs if individuals inherit the gene responsible for autoimmunity against the pancreatic insulin-producing cells and inherited factors interact with environmental conditions, such as obesity, inadequate nutrition, a sedentary life-style and stress.

Root resorptions have several causes that act independently from each other. In some special cases, the causes may be associated in root resorption, but that is not usual. From a conceptual point of view, we should avoid saying that root resorptions are multifactorial; rather, we may say, to be more accurate, that it has multiple or several causes. The term "multifactorial" may convey the equivocal connotation of simultaneity of causes for root resorptions to occur.

THE CAUSES OF ROOT RESORPTIONS ARE KNOWN

In inflammatory root resorptions, the causes remove cementoblasts from the surface, such as in the situations described below:

- » Chronic periapical lesions: toxic bacterial products, such as lipopolysaccharides, as well as other toxic agents resulting from microbial metabolism, are released in the periapical environment or reach the apical root surface via dentinal tubules.
- » Orthodontically applied forces may completely close the lumen of blood vessels, and nutrition may not reach them. Rarely, the contact between tooth and bone resulting from excessive force may physically eliminate cementoblasts from the root surface due to compression.
- » Unerupted teeth may compress blood vessels of neighboring teeth when they come closer due to eruptive forces, as it sometimes happens with maxillary canines and third molars.
- » Accidental dental trauma may break vessels and may put the tooth in contact with the alveolar bone surface. Dental trauma may be surgical, operative or anesthetic.
- » Long periods of occlusal trauma may lead to the death of cementoblasts and, in more severe cases, induce inflammatory root resorptions.

In cases of replacement resorption, the causative factors remove the epithelial rests of Malassez from the periodontal ligament. The main and practically single cause that eliminates this ligament component is dental trauma, which may range from concussion, in its milder form, to avulsion and replantation, in its more severe forms. Dental trauma may be:

- » Accidental, during leisure activities, car crashes, violence or other incidents.
- » Surgical, such as in cases of inadequate luxation of unerupted canines and trauma to second molars during maneuvers to extract unerupted third molars.

- » Trauma due to the action of laryngoscopes over teeth during intubation for general anesthesia.

In teeth unerupted for a long time, excessive periodontal ligament atrophy may create the conditions for dentoalveolar ankylosis and consequent replacement resorption.

ROOT RESORPTIONS ARE NOT SYSTEMIC OR HEREDITARY

In the human species, cell and tissue events occur according to genetic information and tend to be genetically determined, but that does not assign a hereditary nature to all events. Root resorptions, as biological phenomena, include genetically-determined cell and tissue events, but there is no hereditary determination in its initiation or in the development of individual or familial susceptibility.

In the human species there are no diseases, conditions or susceptibilities transmitted from parent to child that may assign a greater tendency towards or prevalence of root resorption. The causes of root resorptions are local and affect cementoblasts, epithelial rests of Malassez, or both. In endocrine diseases, as well as in other systemic diseases, root resorptions are not part of clinical or imaging signs.

Apical and root morphology, the crown-to-root ratio, and the shape of the alveolar bone crest affect the predictability of root resorptions during orthodontic treatment. If asked, we may even say that patients with triangular tooth roots, pipette-shaped or dilacerated apices and rectangular bone crests are more susceptible or predisposed to root resorption during orthodontic treatment, but these tendencies are morphological, and not genetic or hereditary.

ROOT RESORPTION TREATMENT AND PROGNOSIS

The main therapeutic principle for inflammatory root resorptions is the elimination of causes. When inflammation and cell stress are

removed from the area of resorption, bone remodeling units and their osteoclasts are demobilized and leave the root surface; that is, mediators disappear. The pH in the region goes back to neutral, and new cementoblasts are formed and colonize the root surface again in a few days. Immediately after that, new cement is formed, with the reinsertion of collagen fibers into the new cementoblast layer. The root surface is again biologically normal.

If the cause is bacterial contamination through the root canal, adequate endodontic treatment removes the cause, and inflammatory resorption is repaired. If the cause is an orthodontic force, appliance deactivation and the dissipation of forces stop the process. When the possible cause is eliminated and inflammatory root resorption does not stop, the true cause might not have been eliminated.

Replacement resorptions always follow denoalveolar ankylosis and, once established, the process cannot be stopped. When ankylosis is detected before it progresses into replacement resorption, luxation followed by extrusion may, in most cases, restore the periodontal ligament at the bridges or foci of bone-tooth connection. However, if dealing with replacement resorption in which part of the root was resorbed and replaced with bone, the physical union prevents the separation of both.

In summary, inflammatory root resorption may be controlled and cured, and its prognosis is good, but replacement resorption has a poor prognosis because the tooth will be lost, sooner or later.

ROOT RESORPTIONS DO NOT INDUCE PAIN OR PULP NECROSIS

No matter how close they are to the pulp, inflammatory or replacement root resorptions do not cause pain. The number of mediators present and necessary for mineralized tissue resorption is not enough to induce pain or discomfort for the patient. If there is a painful sensation in

teeth with any type of resorption, another cause should be investigated to explain the pain: root resorption is an asymptomatic and, after all, silent biological process.

Although very close to the pulp, or even in the structure of the pulp itself, as in the case of internal resorption, root resorptions do not induce pulp necrosis. Root resorption does not release products that are toxic to cells. The resorption of mineralized tissues has the only purpose of deconstructing them to recycle their mineral and nonmineral contents, which are reused as ions, amino acids and peptides.

Root resorptions alone are clinically asymptomatic and do not induce pulp, periapical or periodontal changes; rather, they are usually consequences of these phenomena, and not their cause.

FINAL CONSIDERATIONS

A way to express the concept of resorption in general and of root resorption in particular

Resorptions in the organism as a whole are phenomena seen in several clinical situations. They are part of the mechanism of structural disarrangement of mineralized tissues. In the interface between osteoclasts and odontogenic mineralized tissue, acids and enzymes are released, and the resulting molecules are carried along the cytoplasm inside vacuoles in a process known as transcytosis. They are then secreted into the extracellular space in the form of amino acids, peptides and ions. In the extracellular matrix and in the body fluids, such as blood and lymph, these components are used by other organs, tissues and cells.

Root resorption is a process to disarrange mineralized odontogenic tissues by the action of bone cells found on their surfaces when the structures that protect teeth against bone remodeling are removed, particularly cementoblasts and epithelial rests of Malassez.

Resorptions are pathological events in permanent teeth, and physiological in primary teeth. In some clinical situations, such as orthodontic treatment, root resorptions are frequent and acceptable, if predicted and mitigated, and are part of the biological cost to have esthetically pleasing and functional teeth.

The mechanisms of root resorptions are known and their causes are well defined. They are clinically asymptomatic and, alone, do not induce pulp, periapical or periodontal changes; rather, they are usually consequences of these phenomena. Root resorptions are local and acquired defects, and not dental signs of systemic diseases.

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Interview with Tiziano Baccetti

- Assistant Professor and Researcher, Department of Orthodontics, University of Florence, Florence, Italy.
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- Associate Editor of Progress in Orthodontics.



The only child of a small family in Florence, Tiziano Baccetti grew up surrounded by the most important works of art of the Italian Renaissance. He always enjoyed writing and, in youth, worked as a reporter for a university newsletter. However, he ended up entering the University of Florence to study Dentistry. Nothing raised his interest much until the day when he started studying facial growth. At that time, he decided to go deep into it, and set out to take his PhD in the same university. Professor Baccetti's passion for Dentofacial Orthopedics may still be felt today by those that attend any of his courses in dozens of countries around the world. In 1995, he started a partnership with the University of Michigan, where he is a visiting professor, without, however, resigning as a professor of the University of Florence. The talent of this professional, recognized as one of the best lecturers today, combined with his gift for writing resulted in the production of over 200 articles for major journals, 20 book chapters, as well as posters and abstracts published in conference annals. This year, he received one more award during the American Association of Orthodontics Annual Session. He gave the "Salzmann Lecture", a space reserved for the leading exponents in the field. He is not only the youngest lecturer, but also the first Italian to have such honor. A great admirer of Brazil, he has been to this country four times and, just after returning from his last visit, is already planning to come back to Rio de Janeiro in 2012. His favorite topics, in addition to his six-year-old son Vittorio, are dental anomalies and the orthopedic treatment of Class II and III malocclusions, with special interest in optimal treatment timing, which led him to develop the cervical vertebral maturation (CVM) method to accurately determine the stages of skeletal development. With the help of four renowned professors, who contributed with questions, we have the opportunity to know a little more about this great professor, whose charisma and friendliness have rarely been surpassed in Orthodontics.

José Augusto M. Miguel

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What do you see as the greatest clinical and scientific contribution of your studies? José Augusto M. Miguel

The most remarkable aspect of my work was probably the definition of an optimal time to treat malocclusions of many different types. In general, orthodontists conduct treatments in three dimensions (sagittal, transversal and vertical), and my effort was towards showing the importance of a fourth dimension, which is the optimal treatment timing. When treating growing patients, particularly when the objective is to achieve not only orthodontic, but also orthopedic changes, timing may be more significant than the appliance chosen for the treatment. Optimal timing depends on the skeletal maturation of each individual, which can be accurately determined by using the CVM method¹ (Figs 1 and 2). Other fundamental areas of my knowledge include the long-term comparison of different types of treatment to correct Class II and III malocclusions and transverse deficiencies, as well as the studies and scientific evidence about impacted canines.

Because of the difficulties in controlling mandibular growth, which orthodontists still face in the treatment of Class III malocclusions, what, in your opinion, should be further investigated, taking into consideration that the treatment of Class II malocclusions is more predictable?

Gerson Ribeiro

The results of treatments of Class III malocclusions are also predictable, and, in 2004, our study team published a method to predict the success of treatment using rapid maxillary expansion together with face mask therapy.² However, regardless of the type of approach, 20% to 25% of all patients with Class III malocclusion will need orthognathic surgery. It is important to note that, at the same time, early orthopedic intervention will give the surgeon the opportunity to produce a more stable result at the end of growth and reduce the amount of skeletal discrepancy (Fig 3).

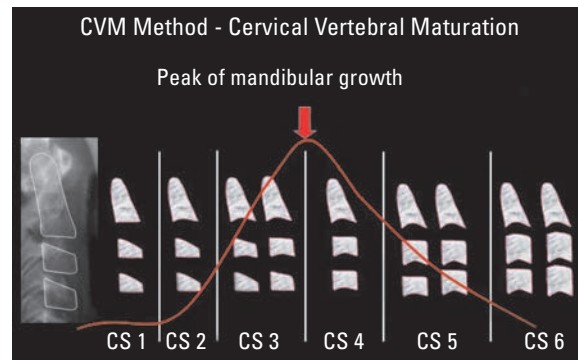


FIGURE 1 - Using the cervical vertebral maturation (CVM) method developed by Baccetti T, Franchi L and McNamara Jr.¹ in 2005, optimal timing for changes in mandibular growth is defined. In this case, ideal phases are CS3 and CS4, and the CS5 phase may also be favorable if mandibular protrusion appliances are used.

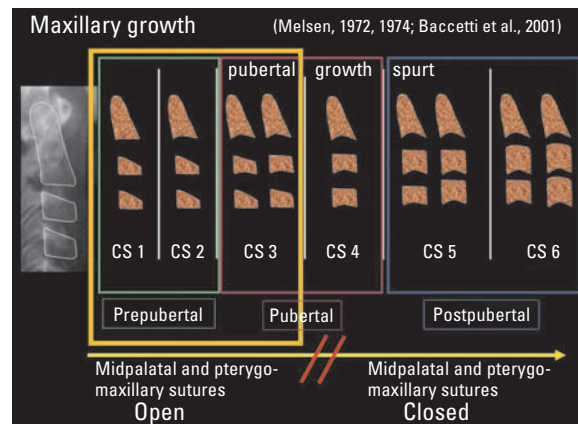


FIGURE 2 - Using the CVM method, optimal timing for changes in maxillary growth is defined. In this case, the ideal phases for treatment are CS1 to CS3.

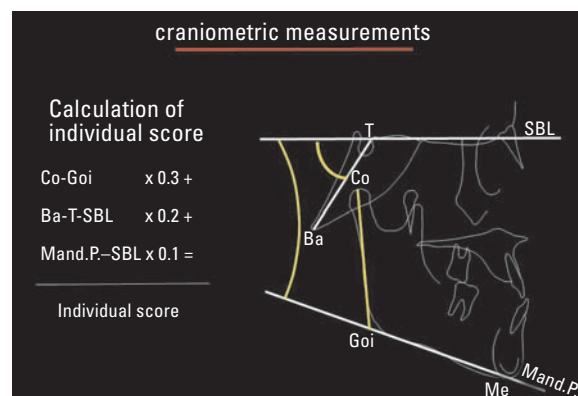


FIGURE 3 - Discriminating craniometric measurements to predict success or failure of orthopedic treatment of Class III malocclusion using rapid maxillary expansion and face mask therapy in patients 6-10 years of age. After the sum of 3 measures is multiplied by a constant, an individual score is calculated. The cut-off point for this measure is 30; lower values indicate a favorable prognosis, and greater values, a poor prognosis (Baccetti, Franchi and McNamara Jr.² AJODO 2004).

For the treatment with maxillary expansion, with or without face mask therapy, you always use bonded, and not banded, expanders. Is there any advantage in that?

Marcos Alan Vieira Bittencourt

Not, not really. In the long-term, the effects of the two types of expanders are indistinguishable, both transversely and vertically. However, the presence of stops may be very helpful when treating occlusal blocks due to tooth interference, such as those due to deciduous canines, in the treatment of transverse deficiencies during mixed dentition. I take the chance here to remind my colleagues that one of the fundamental measures to avoid relapse after rapid maxillary expansion is to keep the expander set passively for at least five months after the screw has been locked.

Today, you are one of the lecturers with the most international reach and engagements in four continents. How do you see contemporary orthodontics and what are its future trends? Weber Ursi

Orthodontics is going through a phase that I classify as “schizophrenic”, which we might perceive as either pessimistic or optimistic. The pessimistic view may be associated with the worldwide academic crisis, particularly in the US, where there are fewer professors and researchers willing to dedicate their lives to this specialty. One of the consequences is that we are losing a global perspective of facial growth and its anomalies because new professors are only interested in segmented aspects of our profession. Another negative aspect of contemporary orthodontics is the supremacy of commerce in science. Universities have become poorer, and researchers have been weakened; therefore, we have experienced a reverse reality, in which companies dictate or control results, rather than the opposite and supposedly proper direction. The optimistic aspects include ideas and efforts towards new solutions for old problems. In that sense, some of the best

examples are the trends and possibilities of Class II malocclusion treatment, with new horizons in both orthopedics and surgery. Finally, I would like to highlight the fact that products and protocols in orthodontics follow a cyclic pattern, in which an initial phase of wild enthusiasm is followed by scientific trials and disillusionment that eventually leads to a plateau of reality. This is going on right now for microscrews, self-ligating brackets with low frictional resistance, and 3D imaging. These topics will be less popular in the next five years because they have been excessively valued in the last five years. In contrast, biological aspects applied to diagnosis and treatment planning, such as biomarkers and genetic markers, will replace previous topics in the near future.

You mentioned orthopedic treatment with rapid maxillary expansion and face mask therapy. Are there new promising alternatives for patients with Class III malocclusion?

Marcos Alan Vieira Bittencourt

Today, we clearly understand that Class III is a challenge to orthodontists, and that a high relapse rate may be expected among patients treated during growth. Therefore, it is extremely important to adopt overcorrection. Recently, some methods have been suggested to increase the effectiveness of treatment results, such as the use of skeletal anchorage for maxillary teeth to enable the use of Class III mechanics. These techniques have variations, as seen in the studies conducted by Wilmes et al.,³ Kircelli and Pektaş,⁴ and De Clerck et al.⁵ However, they are all based on the principle of skeletal anchorage to minimize the dental effects of orthopedic treatment (Fig 4). Moreover, the effects of the use of the face mask may be even greater than those reported so far because they have been recently expanded, as seen in the publication of studies that used alternate maxillary expansion and constriction (Alt-RAMEC) to achieve greater maxillary mobility during protraction.⁶

In contrast, in case these approaches are not successful and patients need to undergo orthodontic surgery, some selected patients may benefit from faster treatments by means of early surgery or, also, anticipated benefits, areas in which I believe some centers in Brazil have already gained experience.

How do you see long-term results when comparing your maxillary expansion and protraction method with face mask therapy and the use of skeletal anchorage as prescribed by professor Hugo De Clerck, in the treatment of Class III malocclusions?

Gerson Ribeiro

Long-term results in patients treated with expansion and face mask therapy will be available soon, as the manuscript of a study that we conducted about it has been accepted for publication in AJODO, and postpubertal results have also been published. At the same time, we cannot expect much from the De Clerck protocol in terms of data generation. As far as I know, no prospective studies are underway to collect long-term data for that type of treatment.

Why did orthodontics took so long, when compared to medicine, to adopt a science-based treatment that takes into consideration the growth spurt and the optimal timing to initiate treatment? Gerson Ribeiro

The fundamental role of the pubertal growth spurt to increase treatment results in Class II malocclusion using functional and orthopedic appliances has been highlighted in international literature since the 1970s. Since 1969, several experimental trials conducted by Petrovic and Stutzmann have drawn attention to the significant impact of the pubertal growth spurt on the mandible and the final results of Class II malocclusion treatment. This information has been neglected, particularly when functional appliances were introduced in the US as “first



FIGURE 4 - The use of Class III mechanics together with skeletal anchorage, as suggested by De Clerck⁶ and other authors, produces a more effective orthopedic force and reduces dentoalveolar impacts.

phase” appliances. This has generated misunderstandings and improper treatments until today. I hope our research efforts contribute to bringing orthodontists back in track to analyze optimal timing to initiate treatment in the different types of malocclusion. I often say that adequate timing to treat growing patients may be more important than the type of appliance used in treatment.

Parallel to the studies about orthopedics, you have always dedicated some time to studying dental anomalies and the associations between them. What characteristic do you consider fundamental for the success of the treatment of impacted canines?

David Normando

Primarily, the ability to avoid canine impaction using interceptive treatment. The purpose of treatment is to avoid that a misplaced canine becomes impacted, which may be achieved by molar distalization, maxillary expansion and/or extraction of deciduous canines and, in addition, the use of space maintainers (transmaxillary arch). Using this method, it is possible to “save”

about 80% of the displaced canines and avoid their impaction.⁷ In case surgery is necessary, one of its main objectives should be not only to achieve orthodontic success, but also to preserve periodontal health. For that purpose, the tunnel technique may be recommended, which ensures that the canine will erupt in the center of the alveolar ridge, with the gingiva inserted around it.⁸

How do you see long-term results when comparing your maxillary expansion and protraction method with the use of face mask therapy and beta-titanium intraoral springs, as prescribed by professor Eric Liou, in the treatment of Class III malocclusions? Gerson Ribeiro

The protocol prescribed by Dr. Liou deserves close attention. The limitation of his studies, however, is the use of this approach in the treatment of children aged 11 to 13 years, often not the most favorable phase for the orthopedic movement of the maxilla. Moreover, the forces used on permanent teeth may be harmful for the periodontal health of anchorage teeth. Therefore, we have been conducting a RCT in the University of Florence using Alt-RAMEC followed by face mask therapy in children with deciduous or early mixed dentition, at about age 5 to 7 years, in an attempt to act on the prepubertal phases (CS1 and CS2). Preliminary results of this approach seem to be very interesting and effective.

In Brazil, it is relatively common to use functional orthopedic appliances, such as the Bionator and Twin Block. Do you prefer either of them? Would you define an order of effectiveness and efficiency when they are used in the orthopedic treatment of Class II malocclusions?

Marcos Alan Vieira Bittencourt

A systematic review conducted by Cozza et al,⁹ in 2006 and published in the AJODO determined an efficiency scale for this type of

treatment (Fig 5). At the bottom of this scale is the use of FR-2, which takes about two years to correct malocclusion and has an effectiveness of about 2 millimeters more than in the control patients. One level above in this scale are the activators, such as the Bionator, which takes about one year and a half for the correction and which produces an increase of about 2.5 to 3 millimeters in supplementary mandibular length. And, at the top of the scale, we find Twin Block and Herbst appliances, which produce more than 3 millimeters of mandibular growth during a treatment of about one year. Special consideration has been given to the fact that the Herbst does not require patient collaboration, similarly to the Twin Block, which is bonded. According to recent evidence, functional treatments should not be shorter than nine months to achieve true orthopedic changes with a low recurrence rate. We cannot forget to mention that the results of such treatments depend substantially on their timing, as they should initiate during or a little after the growth spurt. Moreover, patients should be carefully selected and should have a balanced gonion angle (Co-Go-Me <123 degrees, or the so-called fifth dimension).

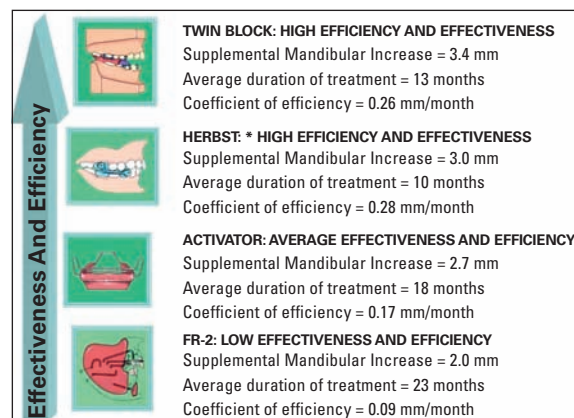


FIGURE 5 - Efficiency scale of therapies for Class II treatment according to Cozza et al,⁹ 2006.

Do you see any sense in separating orthodontics from facial orthopedics as two distinct specialties, a separation currently adopted by the Federal Board of Dentistry in Brazil?

José Augusto M. Miguel

The separation of teeth, alveolar bone and skeletal base was created in the 1970s and 1980s for teaching purposes. Almost all our orthodontic interventions have impacts that go beyond teeth and periodontium. Recent systematic reviews showed that there are significant dental effects when functional appliances, such as the Herbst, are used, and skeletal mandibular effects have been found with the use of extraoral appliances. To separate specialists to work with orthodontics or orthopedics would be the same as hiring a chef for the entrée only and another for the main course or dessert.

In the studies about the effectiveness and efficiency of orthopedic appliances, how should the group of dropouts be analyzed?

David Normando

One of the greatest errors in a prospective or retrospective study is not to include all patients in data analysis. In general, all groups will have cases with better or worse results and with more or less collaboration, which reflects, therefore, the reality of different treatments. In this case, dropouts should be those that do not return to follow-up. In American literature, this is reported as “picking cherries”.

What is your opinion about the unlimited use of protocols based on randomized controlled trials (RCTs)? Aren't there other methods, less sophisticated but equally useful? Weber Ursi

The concept that studies in orthodontics are not reliable because they are not double-blinded (that is, neither patients or researches know what type of appliance is used) seems to be undue because our specialty does not use pills; it is, rather, an art and a passion, and we provide treatment

to improve function and esthetics. As Sheldon Baumrind said in the past, the general RCT rules in other areas of medicine and pharmacology are limited for use in orthodontics because the major factor in treatment effectiveness is the sincere conviction of the professionals that they are offering the best that can be offered to that patient. Valid alternatives to classical RCT in orthodontics may be the use of consecutively treated cases compared with adequate control cases, that is, with characteristics that are similar to those of the individuals that receive the treatment under study. Moreover, we may also use discrimination analysis to detect borderline cases when comparing different treatment strategies, as described by Paquette et al.¹⁰

As you publish with several authors from several countries, what is your opinion about Brazilian orthodontists in the global scenario from both a scientific and a clinical perspective? Gerson Ribeiro

I have given lectures in Brazil in the last ten years, and have seen a great improvement in the Brazilian scientific level in this short period of time. I am not the only one to identify the enormous potential of this country. The number of publications in foreign journals by Brazilian researchers has increased very much. One thing that I would like to see are faces emerging from behind these publications; that is, we need more lecturers to show the world what Brazilian orthodontists have been up to. As for Italians, one of the greatest barriers for Brazilians is to become fluent in English. Moreover, it is necessary to build a line of research that may connect certain professionals to the fields in which they are experts. Finally, as in any other country, politics may be science's worst enemy. Therefore, my recommendation for the professionals involved in academic life is to get less involved in university politics and workers' unions and to dedicate more time to clinical research.

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Decodify® System: Cephalometrics as a risk manager applicative and administrative tool for the orthodontic clinic

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Abstract

Introduction: Cephalometrics may have limited use in orthodontics because of its subjective interpretation. An Artificial Intelligence (AI) system, the Decodify® System, was developed to allow the customized quantitative assessment of contextualized cephalometric data. In this article, the system is tested as an administrative tool in orthodontic offices. **Methods:** The development of algorithms includes the norms and standard deviations modeling of Brazilians' cephalometric data, measured in lateral radiographs. In order to test the system, initial cephalograms of 60 orthodontic patients of two different orthodontic offices (30 cases each) were processed and re-processed by three different technicians. The intra-observer and inter-observer reproducibility and reliability indices were checked by paired comparisons. The risk in each orthodontic case, assessed by the electronic analysis, was compared by covariance matrices and agreement coefficients. **Results:** Levels of paired agreement inter-observers (versus golden-pattern) for 23 pairs of variables ranged from 0.68 (S-Go distance) to 0.98 (Na-Me distance) in an orthodontic clinic (JU) and from 0.66 (L1.APg angle) to 0.98 (S-Go distance) in the other (SP). All the correlations were significant at the $p < 0.001$ level. The average of the agreement coefficients was 0.78 for one clinic (JU) and 0.75 for the other (SP). The agreement coefficients were significant at the $p < 0.001$ level. **Conclusions:** The results of such research support that the analyses provided by the Decodify® System are reproducible and reliable. Therefore, the system can be applied in order to contextualize conventional cephalometric measurements and to generate individualized risk indices. The system may be used by orthodontists as an administrative tool in the daily professional evaluations.

Keywords: Orthodontics. Diagnosis. Artificial Intelligence.

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» The authors declare to be developers of Decodify® System.

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Editor's abstract

Even with its limitations, cephalometrics represents an important tool for the orthodontic/orthopedic diagnosis. Essentially, cephalometrics allows the orthodontist to evaluate the existence of skeletal and/or dental components involved in the malocclusion of the patient and what is its severity. However, experienced orthodontists are aware of the variability to be considered throughout the cephalometric assessment of the patient, as imprecision in the location of the cephalometric landmarks, growth phase and craniofacial development of the patient, or moreover, biases associated to intrinsic methodological or geometrical problems associated to the cephalometric analyses. Facing that, the Decodify® System was proposed, a software of artificial intelligence algorithms, which provides decisions for the orthodontic cephalometric diagnosis, imitating the human being thinking. For that, the system associated the uncertainty and the inconsistency of each cephalometric number, increasing or decreasing its contribution for the final decision of the skeletal and/or dental commitment in each malocclusion. The objective of the present research was to evaluate the reproducibility and reliability in the assessment using the Decodify® System. For this purpose, 60

initial lateral cephalometric radiographs were traced and retraced by three trained technicians, being one of them considered the golden standard. Eighteen cephalometric landmarks were identified and, after digitalization, generated 23 cephalometric variables. The normal values were obtained from the Craniofacial Growth Atlas,¹ collected in Bauru-SP. The intra- and inter-examiner reproducibility were tested (in comparison to the golden standard), by correlation tests ($p < 0.001$). The risks involved in each orthodontic treatment, generated by the Decodify® System, were analyzed by covariance matrices and agreement indices. The indices of inter-examiner correlation varied from 0.68 to 0.98 for one examiner and from 0.66 to 0.98 for the other, in comparison to the golden standard. The agreement indices for the Decodify® System were 0.78 for one examiner and 0.75 for the other, in comparison to the golden standard. From the results, the authors concluded that the risk calculated by the Decodify® System was reproducible and reliable. Therefore, the Decodify® System represents an important cephalometric tool for the assessment of the malocclusion and can estimate with greater reliability the degree of severity and the treatment time expected for each individual treatment.

Questions to the authors

1) Which are the main advantages of the Decodify® System for the clinical orthodontic practice?

The best contribution of the Decodify® System for the orthodontic clinic is the identification of the severe cases and, consequently, the operational demand to achieve a good result in such cases (knowledge and experience of the orthodontist, necessary orthodontic supplies and time extension of the treatment to which the patient will be submitted).

2) Could the Decodify® System be associated with analyses from cone beam tomography assessments?

Not yet. Such algorithms rely on homogeneous norms, with minor variance. For tomographies or other exams of such nature we still do not have such norms. The drawback for such deficiency of data is economical and operational.

When an atlas with populational norms based upon such type of exam is published by the academy, the mathematical modeling will

be possible, as we have modeled the conventional cephalometric norms.

3) With these "intelligent software", how do the authors see the orthodontic diagnosis in the future?

The contribution of the electronic diagnosis will come in the administrative scope. For instance, dental insurance plans already use such technology to quantify the risk involved in each case. Risk for an insurance company means control of the degree of utilization and amount paid out in claims. And increase in the amount paid out in claims implies in increase in the nominal cost for coverage.

That is the reason why dental insurance companies are interested in the quantitative control that the Decodify® System provides and already use it. For orthodontists, it is an important IT tool, which differentiates and add value to their clinic. Many colleagues from all over Brazil have contacted me interested in using this technology in their orthodontic clinics.

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Influence of the cross-section of orthodontic wires on the surface friction of self-ligating brackets

Roberta Buzzoni**, Carlos N. Elias***, Daniel J. Fernandes****, José Augusto M. Miguel*****

Abstract

Objectives: The purpose of this study was to assess the surface friction produced between self-ligating stainless steel brackets equipped with a resilient closure system and round and rectangular orthodontic wires made from the same material. **Methods:** Thirty maxillary canine brackets were divided into six groups comprising Smartclip and In-Ovation R self-ligating brackets, and conventional Gemini brackets tied with elastomeric ligatures. This investigation tested the hypothesis that self-ligating brackets are susceptible to increases in friction that are commensurate with increases and changes in the cross-section of orthodontic wires. Traction tests were performed with the aid of thirty segments of 0.020-in and 0.019 x 0.025-in stainless steel wires in an EMIC DL 10000 testing machine with a 2N load cell. Each set of bracket/wire generated four samples, totaling 120 readings. Comparisons between means were performed using analysis of variance (one way ANOVA) corrected with the Bonferroni coefficient. **Results and Conclusion:** The self-ligating brackets exhibited lower friction than conventional brackets tied with elastomeric ligatures. The Smartclip group was the most effective in controlling friction ($p < 0.01$). The hypothesis under test was confirmed to the extent that the traction performed with rectangular 0.019 x 0.025-in cross-section wires resulted in higher friction forces than those observed in the 0.020-in round wire groups ($p < 0.01$). The Smartclip system was more effective even when the traction produced by rectangular wires was compared with the In-Ovation R brackets combined with round wires ($p < 0.01$).

Keywords: Brackets. Orthodontic wires. Stainless steel. Friction.

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Editor's abstract

Several *in vitro* studies have shown that self-ligating brackets display lower friction than conventional brackets. In view of this fact, it is believed that the use of self-ligating brackets yields better sliding mechanics for space closure. This study compared the friction exhibited by two self-ligating brackets using round and rectangular cross-section stainless steel wires. To this end, five metal brackets of different brands were evaluated, as follows: Smartclip (3M/Unitek, USA), In-Ovation R (GAC, USA), both self-ligating brackets, and the Gemini conventional bracket

(3M/Unitek, USA). For each set of brackets, five 0.020-in and 0.019x0.025-in stainless steel wire segments were adapted. The friction tests were performed in a universal testing machine EMIC DL 10000 (EMIC, Brazil). The results were analyzed by analysis of variance followed by the Bonferroni multiple comparison test ($p < 0.01$). All brackets were evaluated statistically and more friction was found when using 0.019x0.025-in wires compared to round 0.020-in wires. In addition, Smartclip brackets showed lower levels of friction compared to In-Ovation R brackets with all wires analyzed.

Questions to the authors

1) What clinical implications can be raised from the results of this study?

The results showed that self-ligating brackets provide greater surface friction control. However, caution should be exercised when applying this information in clinical routine practice. Orthodontic movements occur through small consecutive inclination movements, which cause alternate contacts binding between orthodontic wires, bracket slots and the closure system of these appliances. Thus, these contacts define a critical angle that modulates the frictional components which contribute to generating total friction. Extrapolation of clinical results is limited precisely because of this variation, unique to each clinical situation. The results observed in the laboratory setting with controlled variables showed lower friction intensities even when the self-ligating model combined with rectangular wires was compared to the traditional bracket

system combined with smaller round cross-section wires. These results indicate that the self-ligating model is more efficient in the laboratory setting, which encourages and warrants similar evaluations in the oral environment.

2) This study found that 0.019x0.025-in wires showed higher friction than 0.020-in wires in all self-ligating brackets investigated. In view of this finding, do the authors believe that there would be changes in sliding mechanics when using self-ligating brackets?

Comparisons should be drawn between the successful use of self-ligating versus traditional ligation systems. In this context, self-ligating appliances proved to be significantly superior in laboratory tests. The higher friction observed in rectangular wires can be explained by the greater contact, or greater likelihood of contact with the bracket slots, which affects the surface component that makes up friction forces. We will rarely observe friction values in rectangular wires that are lower than their

round counterparts. As for changes in sliding mechanics in the laboratory, the results showed that the self-ligating systems were superior to traditional ligation in all cases analyzed. In clinical settings, the application of forces increasingly closer to the center of resistance of the teeth to be moved will likely provide interesting benefits by reducing the importance of the critical contact between wires and orthodontic bracket slots.

3) What motives prompted the authors to conduct this study?

We felt there was a need to analyze the behavior of self-ligating brackets with respect to the multifactorial components of friction. This is a primary approach, which has already been combined with a number of other factors that influence how self-ligating systems can be optimized.

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Orthodontists' and laypersons' perception of mandibular asymmetries

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Abstract

Objective: To analyze orthodontists' and laypersons' perceptions of facial asymmetries caused by mandibular changes. **Methods:** The faces of two patients, a man and a woman, were photographed in natural head position, and additional photographs were produced with progressive mandibular shifts of 2, 4 and 6 mm from maximum habitual intercuspation (MHI). Intraclass correlation coefficients (ICC) and weighted kappa coefficients were used to test method reproducibility. The differences in scores for mandibular positions between orthodontists and laypersons were examined using Friedman analysis. All statistical analyses were performed at 95% confidence interval. **Results:** Orthodontists only perceived shifts greater than 4 mm from MHI position ($p < 0.05$), and laypersons had similar results when analyzing the woman's photographs. However, when examining the man's photographs, laypersons did not perceive any change in relation to MHI ($p > 0.05$). Although median scores assigned by orthodontists were, in general, lower than those of laypersons, this difference was only significant for the 6-mm shift in both patients. **Conclusions:** Orthodontists and laypersons evaluated mandibular asymmetries differently. Orthodontists tended to be more critical when asymmetries were more severe. The evaluation of facial asymmetries also varied according to what patient was being examined, particularly among lay examiners.

Keywords: Facial asymmetries. Mandible. Perception. Orthodontics.

Editor's abstract

Nowadays, one of the main motivations for individual seeking orthodontic treatment is the improvement of facial esthetics. Due to the sub-

jective aspects of facial esthetic, there must be a consensus between the orthodontist and patient, so that they can achieve common goals during the course of orthodontic treatment.

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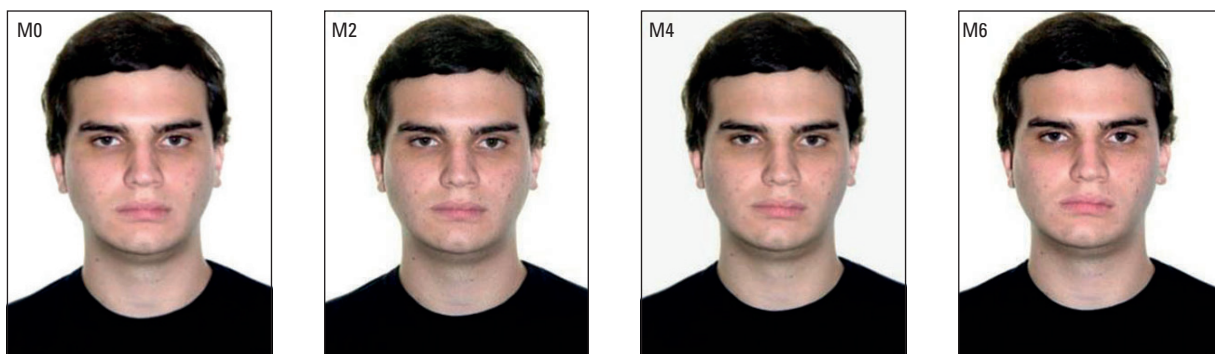


FIGURE 1 - Photographs of the male patient in MHI (M0) and with shifts of 2 mm (M2), 4 mm (M4) and 6 mm (M6).

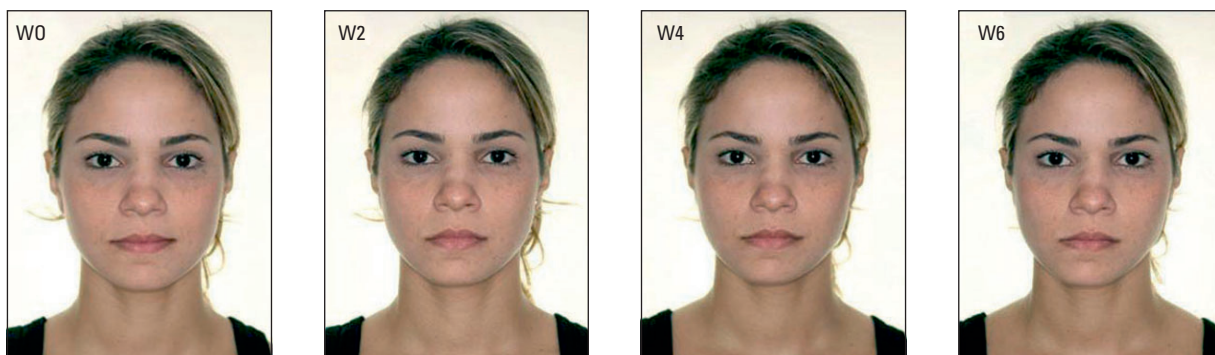


FIGURE 2 - Photographs of the female patient in MHI (W0) and with shifts of 2 mm (W2), 4 mm (W4) and 6 mm (W6).

The authors' proposal for this study was to evaluate the ability of orthodontists and laypersons in the perception of facial asymmetry as well as quantify how many millimeters of deviation, this asymmetry becomes noticeable for these groups.

Four photographs of two patients with normal occlusion, a male and a female (Figs 2 and 3) were obtained. The first was taken in maximum habitual intercuspation (MHI) and the others with mandibular shifts of 2, 4 and 6 mm. To simulate the facial asymmetry, mandible was manipulated to change occlusion at progressive 2-mm lateral shifts from the original position up to 6 mm using checkbite records obtained with #7 wafer wax and a ruler. Photographs were printed and, then, examined by 30 orthodontists and 30 laypersons. Photographs were evaluated randomly, and the examiners were previously told to assign scores from 0 to 10 according to their perception of facial harmony.

Results showed that, when evaluating the female's face, the scores assigned were higher than in MHI and decreased as the face became more asymmetrical. These findings, however, were not observed for the evaluation of the male's photographs. For this patient the scores assigned by both groups of examiners were similar for the photographs in MHI and with 2-mm shifts, but decreased progressively as the mandibular shifts increased (4 mm and 6 mm) when evaluated by orthodontists, and were not statistically different when evaluated by laypersons. Thus, orthodontists and laypersons evaluated mandibular asymmetries differently, and orthodontists tended to be more critical when asymmetries were more severe. The evaluation of facial asymmetries also varies according to the patient examined, either man or woman, particularly among lay examiners.

Questions to the authors

1) What reason could you give to the fact of observing a greater ability to perceive changes in facial females?

This perception may not be linked to the sex of the subject being evaluated, but will probably be due to other morphological characteristics of the patient used in this study, such as the thickness of the lips and others. This factor may have contributed to a more noticeable asymmetry. In addition, approximately 60% of evaluators (orthodontists and laypersons) were female, which may have led to be more critical when evaluating an individual of the same sex. These inferences, however, require scientific proof.

2) According to the statement in the results section (With regard to the laypersons, they were not able to notice differences in any of the shifts for the male patient...), I ask: In male patient asymmetries of up to 6 mm should be corrected?

We believe that each patient must be evaluated individually, taking into account not only esthetics, but also the function. We should consider mainly the self-perception or complaint of the patient. In this study, laypersons were unable to notice differences for the male patient, however, what can be perceived in a patient with certain characteristics cannot be applied in another. What we can say is that, in some cases, this asymmetry is only perceived by orthodontists, going unnoticed for most of the laypersons. Studies examining the esthetic perception have the great virtue of showing that the orthodontist may perceive esthetics differently of the patient's perception. In the past we treated our patients as if the treatment had to satisfy only ourselves. On the "esthetic" point of view, the patient's opinion seems to be the most important factor because he is the one who will have to deal with that facial esthetics. As health pro-

fessionals, we should focus our attention to the functional aspect, seeking to reconcile it to our patient's esthetical expectations. However, we must know that this is not always possible.

3) You have set as a limiting factor of this study, the fact that the asymmetry was evaluated only in the mandible, since in cases of a real asymmetry, usually occurs the commitment of muscle tissue. The manipulation with a specific software would be able to eliminate this limiting factor?

We would add the involvement of the maxilla, which is common in cases of mandibular asymmetry. To examine the face so that we can simultaneously assess the involvement of muscle and maxilla would be ideal, but what is observed in the literature is that in some cases, the computer programs used to manipulate digital images fail to predict surgical outcomes. Thus, we cannot say that the attempted manipulation of the muscles in images would be trusted by those that occur in patients with asymmetrical facial growth. In the future, with the development of programs using three-dimensional images, we believe that we can reduce the errors inherent in this type of evaluation. However, its elimination seems to be a utopia. Of course, to accept this limitation does not preclude its use, since many important clinical information could be obtained through them.

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Friction force on brackets generated by stainless steel wire and superelastic wires with and without IonGuard

Luiz Carlos Campos Braga**, Mario Vedovello Filho***, Mayury Kuramae****, Heloísa Cristina Valdrighi****, Sílvia Amélia Scudeler Vedovello****, Américo Bortolazzo Correr*****

Abstract

Objective: The aim of this study was to evaluate the friction forces on brackets (Roth, Composite, 10.17.005, 3.2 mm, width 0.022x0.030-in, torque -2° and angulation +13°, Morelli®, Brazil), with stainless steel orthodontic rectangular wire (Morelli®, Brazil) and nickel-titanium superelastic Bioforce wires with and without IonGuard (Bioforce, GAC®, USA). **Methods:** Twenty-four brackets/segment of wire combinations were used, distributed into 3 groups according to the orthodontic wire. Each bracket/segment of wire combination was tested 3 times. The tests were performed in a universal testing machine EMIC DL2000®. The data was submitted to ANOVA one way followed by Tukey's post hoc test ($p < 0.05$). **Results:** The rectangular orthodontic Bioforce wire with IonGuard presented significantly lower resistance to sliding than Bioforce without IonGuard. There was no statistical difference among the other groups. However, the coefficient of variation of Bioforce with and without IonGuard was lower than that of the stainless steel wire. **Conclusion:** The rectangular orthodontic Bioforce wire with IonGuard presented lower resistance to sliding than Bioforce without IonGuard, with no difference to the stainless steel wire.

Keywords: Orthodontic appliance design. Friction. Orthodontic wires.

Editor's abstract

Friction may be defined as resistance to movement when an object moves over another object with which it is in contact. Friction in sliding orthodontic mechanics is a clinical difficulty for the

orthodontist because high friction levels decrease mechanical effectiveness, reduce the speed of tooth movement, and make anchorage control difficult. Therefore, orthodontic wires and brackets should have the lowest friction coefficient possible.

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To reduce friction between the bracket and orthodontic wires, alternative surface treatments have been prescribed for these alloys, such as ion implantation. The objective of the authors in conducting this study was to evaluate friction forces of stainless steel wires and nickel-titanium wires with and without surface treatments inserted in the slots of the metal brackets.

For this purpose, segments of 0.019x0.025-in orthodontic stainless steel and nickel-titanium wires with and without IonGuard (surface treatment) were used. To evaluate sliding mechanics of a fixed orthodontic appliance, a specific device was built to simulate the distal movement of a canine in a previously established area (Fig 1). For the sliding and friction trial, samples were divided into 3 groups according to the wire used. Each group had 8 bracket/wire segment sets; each set was tested 3 times and the mean value was calculated. The sliding and friction forces between the brackets and the different types of wires was evaluated using a universal testing machine.

Results showed a higher friction coefficient for the nickel-titanium wire without surface treatment (no IonGuard), and the results for these groups were statistically different from those found for the groups of nickel-titanium wires with IonGuard and of stainless steel wires.

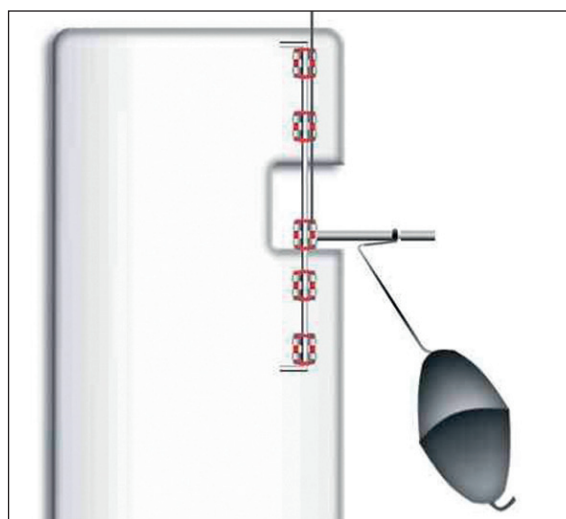


FIGURE 1 - Plate with wire segment and test bracket that simulated canine in sliding mechanics.

There were no statistically significant differences between groups of wires with IonGuard and stainless steel wires ($p>0.05$).

According to the results found, the authors concluded that the type of wire has an effect on the results of friction forces. They further suggest that the Bioforce wire with IonGuard is a good alternative when greater sliding is required in tooth movement.

Questions to the authors

1) The results that you found were obtained in tests with wires that had new surface treatment. Do you believe that the same results might be obtained if the tests included ageing of the specimens?

The process of ion implantation forms a thin layer over the wire surface. We believe that thermal ageing (thermal cycling) would not be capable of changing the wire surfaces and, therefore, would not change the results found in this study. However, any other form of ageing that removes the superficial layer of the wire may increase friction with the brackets.

2) According to Wichelhaus et al,¹ after 4 weeks of clinical use, there is a significant increase of friction in wires with ion implantation, and the advantages of these materials are limited to the initial periods of use. Our question is: Would the use of nickel-titanium alloy wires with IonGuard in cases of visits distant apart increase or decrease total orthodontic treatment time?

The results reported by Wichelhaus et al¹ showed that there was significant wire friction after 4 weeks. This increase was greater for the wires with surface treatment than for wires

without any treatment. However, after 4 weeks there were no significant differences between the wires. Based on these results, we may suggest that the prolonged use of wires with surface treatment might increase the friction coefficient even more when compared with wires without treatment, and might increase total treatment time, and would be a contraindication when visits are distant in time. It is important to stress that we do not know at which point in this time interval (initial and 4 weeks) there was this significant change in friction. Moreover, it has not been investigated whether the friction coefficient after the first 4 weeks is significantly lower, similar or greater than that of wires without surface treatment.

3) Do the authors believe that the results would be the same if self-ligating brackets were used instead of conventional brackets?

The results of friction found in the literature indicate that the greater friction coefficient of conventional brackets is assigned to the elastic ligatures, and not the bracket itself. Therefore, although the friction coefficient for self-ligating brackets might be lower than those found in this study, the differences between wires would probably be the same.

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Comparison of periodontal parameters after the use of orthodontic multi-stranded wire retainers and modified retainers

Marlice Azoia Lukiantchuki**, Roberto Massayuki Hayacibara***, Adilson Luiz Ramos****

Abstract

Objective: The objective of the present study was to compare two types of fixed orthodontic retainers (a multi-stranded wire retainer and a modified retainer) in relation to established periodontal parameters. The multi-stranded wire retainer is commonly used, and the modified retainer has bends to enable free access of dental floss to interproximal areas.

Methods: For this cross-over study, 12 volunteers were selected and used the following retainers for six months: (A) a multi-stranded wire retainer and (B) a modified retainer. Both retainers were fixed to all anterior lower teeth. After this experimental period, the following evaluations were made: Dental Plaque Index, Gingival Index, Dental Calculus Index and Retainer Wire Calculus Index. The volunteers also responded to a questionnaire about the use, comfort and hygiene of the retainers. **Results:** It was observed that the plaque index and the gingival index were higher on the lingual surface ($p<0.05$) for the modified retainer. Furthermore, the calculus index was statistically higher ($p<0.05$) for the lingual and proximal surfaces when using the modified retainer. The retainer wire calculus index values were also significantly higher ($p<0.05$) for the modified retainer. In the questionnaire, 58% of the volunteers considered the modified retainer to be less comfortable and 54% of them preferred the multi-stranded wire retainer. **Conclusion:** From the results obtained, it could be concluded that the multi-stranded wire retainer showed better results than the modified retainer according to the periodontal parameters evaluated, as well as providing greater comfort and being the retainer preferred by the volunteers.

Keywords: Orthodontic retainers. Gingival index. Plaque index. Calculus index.

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Editor's abstract

The main indication for fixed retainers bonded to the lingual surface of mandibular incisors is to avoid relapse after the active phase of orthodontic treatment. Since it is a fixed appliance in close contact with the lingual surface of teeth, it makes hygiene more difficult, favors the formation of plaque around it, leads to the formation of calculus and induces gingival inflammation and periodontal disease. After long periods under these conditions, it usually causes loss of hard and soft tissues adjacent to the wire. In an attempt to minimize these problems, a modified retainer was developed to facilitate hygiene and to ensure free access to dental floss. To achieve such characteristics, it was necessary to increase the length of the wire for retainer manufacture and to bond the retainer to all teeth.

Few studies in the literature evaluated whether this type of retainer actually facilitates hygiene. Based on this premise, the authors' purpose was to evaluate plaque and calculus accumulation along the wire and in the gingival margin and the gingival conditions resulting from the use of a modified

retainer (Fig 1) or a multi-stranded wire retainer (Fig 2), both fixed to all anterior teeth.

Twelve volunteers were enrolled for this study. All used both retainers, each for six months with a 15-day interval between them. Before each phase, the volunteers underwent scaling and root planing of mandibular anterior teeth and received oral hygiene instructions. After the end of each phase, they underwent clinical examinations (plaque index, gingival index, calculus index and retainer wire calculus index), and each volunteer completed a questionnaire about the type of retainer that they were using. All evaluations were made by a single examiner.

Results showed that plaque index, gingival index, calculus index and retainer wire calculus index were greater ($p < 0.05$) for the modified retainer. The analysis of the questionnaire revealed that 58% of the volunteers felt that the modified retainer was less comfortable, and 54% preferred the multi-stranded wire retainer. Therefore, the authors concluded that multi-stranded wire retainers had better results than the modified retainer according to the parameters under evaluation, provided greater comfort and were preferred by patients.



FIGURE 1 - Modified retainer, made with 0.024-in wire.



FIGURE 2 - Multi-stranded wire retainer after being fixed to all teeth.

Questions for the authors

1) Based on your results, would you advise against the use of modified retainers? If not, what would be their indications?

We would advise against their use from a periodontal point of view because they accumulate plaque and calculus and do not allow the patient to perform the adequate hygiene of the areas closer to the gingiva. We should remember that this type of retainer was developed to facilitate hygiene, but it does not meet that expectation. Orthodontically, as it is bonded to all teeth, it may be a good 3x3 retainer. However, it should receive routine attention because, in case one of the resin bonds breaks, the tooth affected may move. In this case, both the modified and the multi-stranded wire retainer, which are bonded to all teeth, should receive close attention from the orthodontist (regular follow-up). Although long-term crowding may happen in any patient because of changes in the arch as the patient ages, retainers bonded to all mandibular anterior

teeth should be reserved for cases of crowding that received orthodontic treatment.

2) What would you recommend to dentists that would like to use modified retainers?

The patient should receive careful instructions about the need of regular orthodontic and periodontal follow-up, as well as redoubled attention to oral hygiene as well as to that of the retainer itself. This type of retainer should only be recommended to patients that actually perform hygiene very well and have, therefore, a low tendency to accumulate calculus.

3) As mentioned in the Discussion, "volunteers had excellent dexterity and good oral hygiene because they were undergraduate dentistry students". If the sample were different and composed of individuals with less instruction, would the results be different?

Results could be more evident; the difference between retainers could be greater and overall index differences, more marked in both groups.

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Histological evaluation of the phenobarbital (Gardenal™) influence on orthodontic movement: a study in rabbits

Matheus Melo Pithon*, Antônio Carlos de Oliveira Ruellas**

Abstract

Introduction: The purpose of this study was to histologically evaluate the influence of phenobarbital on orthodontic tooth movement. **Methods:** Twenty-two New Zealand rabbits (*Oryctolagus cuniculus*) were divided into three groups: normal or non-tested (N), control (C), and experimental (E). In Group N (n = 2) no procedure was carried out, except to verify the condition of normality before treatment. In Groups C (n = 10) and E (n = 10) an orthodontic appliance was inserted between the first molars and lower incisors in order to promote a mesial molar movement. In Group E phenobarbital was administered during the course of the experiment, which differentiates it from the group C. The animals were sacrificed on days 7 and 14 so that anatomical sections could be prepared for further histological analysis. **Results:** Histologically no difference was observed between normal and experimental groups. **Conclusions:** Phenobarbital does not interfere with the orthodontic tooth movement.

Keywords: Tooth movement. Pharmaceuticals. Orthodontics.

INTRODUCTION

Orthodontic tooth movement occurs when forces are applied to teeth and are transmitted to the supporting periodontium, so as to change their position in relation to the surrounding structures, through alveolar bone remodeling.¹⁹ That is to say, bone apposition in the area submitted to tension and bone resorption in the area under pressure.^{17,19}

Although the histological mechanisms of this process have been studied for years, the mediators that initiate or facilitate them are not yet completely understood. As a result of this, several authors have found it necessary^{1,5,19} to evaluate the interaction of medications which, acting at cellular level, could interfere with these mediators, and consequently interfere in the process of orthodontic movement.

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Studies have shown that many patients under dental treatment make use of medications.¹² Some of these patients may be under orthodontic treatment, and some of the medications used by them could influence orthodontic movement.^{1,5}

Several medications have been studied with regard to the possibility of interfering in orthodontic tooth movement such as acetylsalicylic acid,¹⁵ diazepam,¹³ acetaminophen,¹⁷ contraceptives,¹⁸ corticosteroids,²¹ indomethacin²⁴ and bisphosphonates.^{5,8}

Phenobarbital is a recognized anxiolytic and anticonvulsant agent according to Davidovitch et al.⁶

Treatment with anxiolytic and anticonvulsant drugs in ambulatory patients (not only during the epileptic state) may affect the action of several hormones, such as inhibition of antidiuretic hormone secretion, calcitonin, insulin, adrenocorticotrophic hormone and PTH. One of the most remarkable side effects with this class of drugs is the alteration in calcium metabolism, which results in depletion of the serum level, in addition to inducing a condition of osteomalacia or rickets.⁷

Since anxiolytic and anticonvulsant drugs affect bone remodeling, they may also be capable of affecting orthodontic procedures due to the alteration in tissue reaction, and consequently, tooth movement.⁶ Based on this premise the aim of this study was to perform a histological evaluation of the influence of phenobarbital (GardenalTM) on induced orthodontic tooth movement in rabbits.

MATERIAL AND METHODS

Twenty-two New Zealand (*Oryctolagus cuniculus*) rabbits were used, 11 males and 11 females, divided into the following groups: non-tested, control and experimental. The animals were healthy, ranging from 10 to 14 months of age, which corresponds to the young adult stage. They weighed on average 3 Kg, were provided and kept at the Pharmacy and Nutrition Institute phytopharmacology animal lab of the "José do Rosário Velano University – Unifenas"

during the course of the experiment.

The animals were divided into five groups, named and characterized as follows:

- **Non-tested Group:** Represented by animals N1 and N2, which were not submitted to any orthodontic procedure or phenobarbital administration. They served as parameter for comparison with the other animals, and were sacrificed on the first day of the experiment.

- **7-day Control Group:** Represented by animals C1, C2, C3, C4 and C5, which were submitted to the orthodontic movement, did not receive phenobarbital administration and were sacrificed after seven days of tooth movement.

- **14-day Control Group:** Represented by animals C6, C7, C8, C9 and C10, which were submitted to orthodontic movement, did not receive phenobarbital administration, and were sacrificed after seven days of tooth movement.

- **7-day Experimental Group:** Represented by animals E1, E2, E3, E4 and E5, which in addition to being submitted to orthodontic movement, received phenobarbital (Gardenal Sanofi Aventis, São Paulo, Brazil Lot 042389), and were sacrificed 7 days after tooth movement.

- **14-day Experimental Group:** Represented by animals E6, E7, E8, E9 and E10, which in addition to being submitted to orthodontic movement, received phenobarbital, and were sacrificed 14 days after tooth movement.

In the Experimental Groups the medication was administered orally, once a day. Each animal received 30 International Units of medication per kilo of weight; on average, each animal received 90 International Units.

The appliance used to promote tooth movement was similar to that described by Ruellas,¹⁸ and consisted of a pre-fabricated closed stainless steel coil spring (Morelli, Sorocaba, Brazil), which extended from the mandibular first permanent molars to the incisors on both sides (Fig 1) under 80 cN of force application $\pm$ 5cN, measured with a tensiometer (Ormco, Glendora, USA).

After euthanasia, the mandibles were separated from the soft tissues, and prepared for histological sections.

Histological evaluation

The structures were histologically evaluated with an optical microscope (Nikon Eclipse E 600, Tokyo, Japan) and the regions of interest photographed with a digital camera (Nikon Coolpix 4500, Tokyo, Japan).

RESULTS

The results demonstrated that animals not submitted to orthodontic movement, they presented periodontal support with normal characteristics. Animals subjected to orthodontic movement, both control and experimental groups presented with areas of pressure and tension (Figs 2-5).

Tissue reactions in the pressure and tension sides of the periodontal ligament were similar in both control and experimental groups at 7 and 14 day period (Figs 2-5).

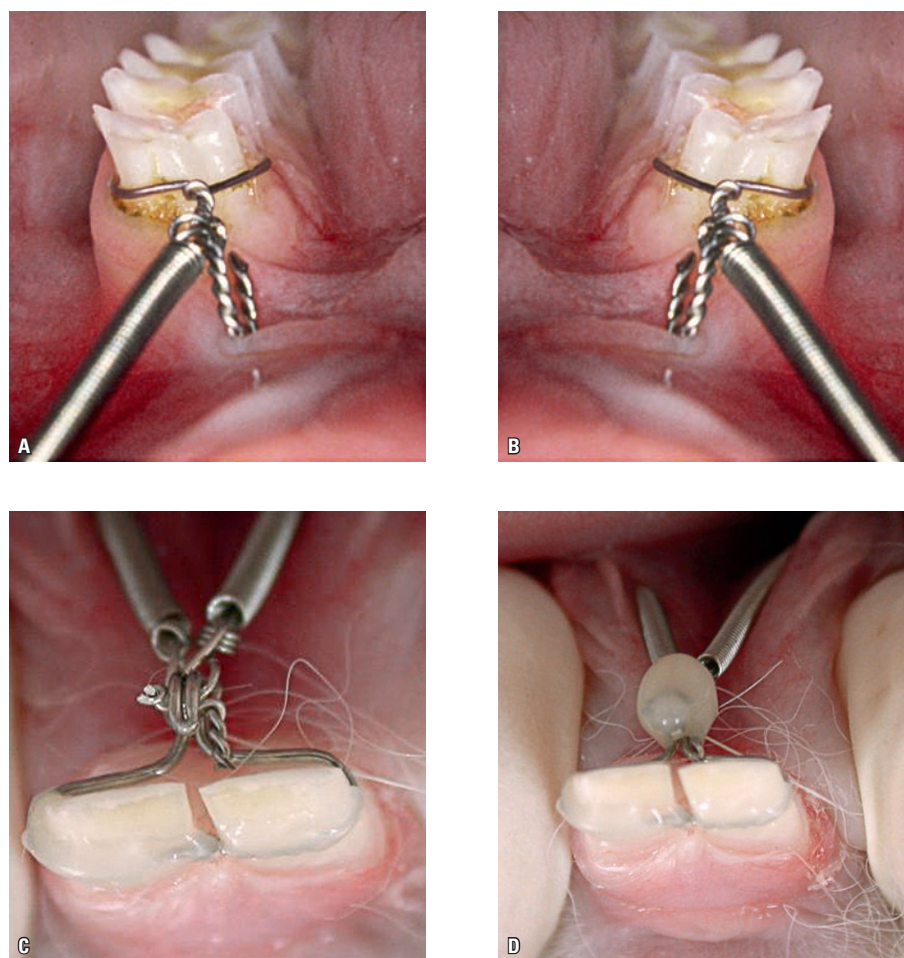


FIGURE 1 - Appliance used to induce tooth movement: **A** and **B**) coil spring tied to the first molars; **C**) coil spring tied to the mandibular incisors; **D**) complete assembly of the appliance.

DISCUSSION

Phenobarbital is a derivative of barbituric acid, and was synthesized for the first time in Germany, in 1912, and patented under the brand name of Luminal.⁷ It acts on the GABA receptor, blocking the entry of calcium into the presynaptic terminals,

inhibiting the transmission of the neurotransmitter glutamate.¹⁶ As all barbiturates, chemically phenobarbital is a cyclic diamide of six carbons.

According to the literature, the treatment with drugs that have an anxiolytic and anticonvulsant action may affect the action of various hormones.^{7,16}

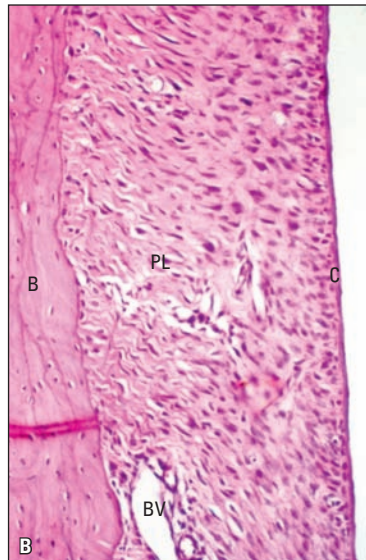
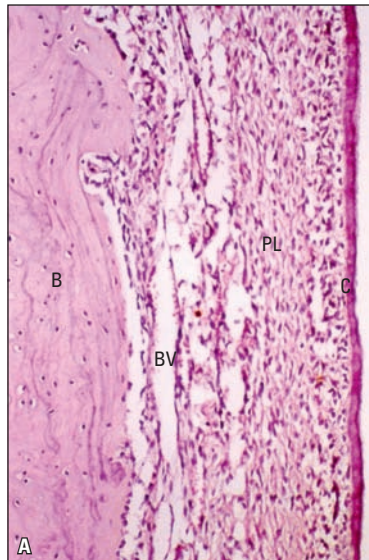


FIGURE 2 - A) Area of inter-radicular pressure, Group C, after 7 days of orthodontic movement. Note the narrowing of the periodontal ligament space, disorganized fibers and cells, discrete inflammatory infiltrate, dilated vessels, bone surface without resorption lacunae, partially covered with osteoblasts. **B)** Area of inter-radicular pressure, Group C, after 7 days of orthodontic movement. Note the discrete increase in the ligament thickness, stretched fibers, discrete inflammatory infiltrate, irregular bone surface with areas of active resorption. Normal cement surface.

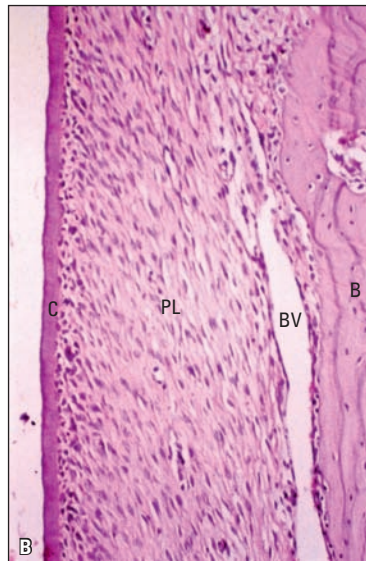
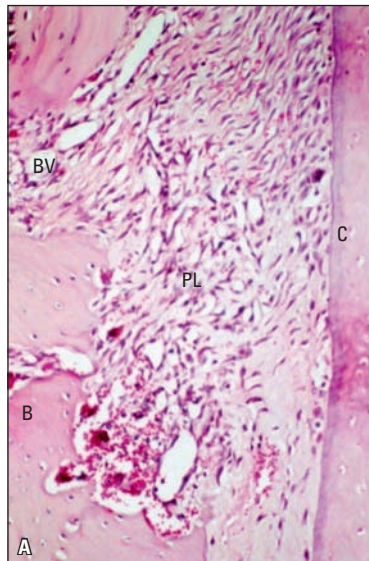


FIGURE 3 - A) Area of inter-radicular pressure, Group E, after 7 days of orthodontic movement. Note the narrowing of periodontal ligament space, disorganized fibers and cells, moderate inflammatory infiltrate, dilated and hyperemic vessels, area of intense maxillary bone resorption. **B)** Area of inter-radicular traction, Group E, after 7 days of orthodontic movement. Note the discrete increase in ligament thickness, stretched fibers, discrete inflammatory infiltrate, irregular bone surface without active resorption. Normal cement surface.

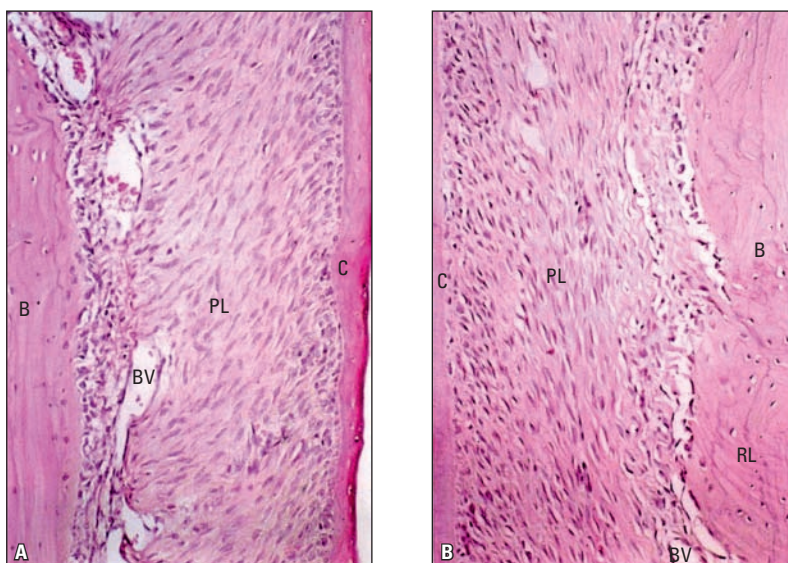


FIGURE 4 - A) Area of inter-radicular pressure, Group C, after 14 days of orthodontic movement. Note discrete narrowing of periodontal ligament space, with slightly compressed cells, there is rich cellularity and there are dilated blood vessels. Note discrete mononuclear leukocytes. **B)** Area of inter-radicular tension, Group C, after 14 days of orthodontic movement. Note discrete increase in ligament thickness, rich cellularity and few blood vessels. Predominant fusiform cells, cement surface preserved and covered with cementoblasts, notable reversal lines.

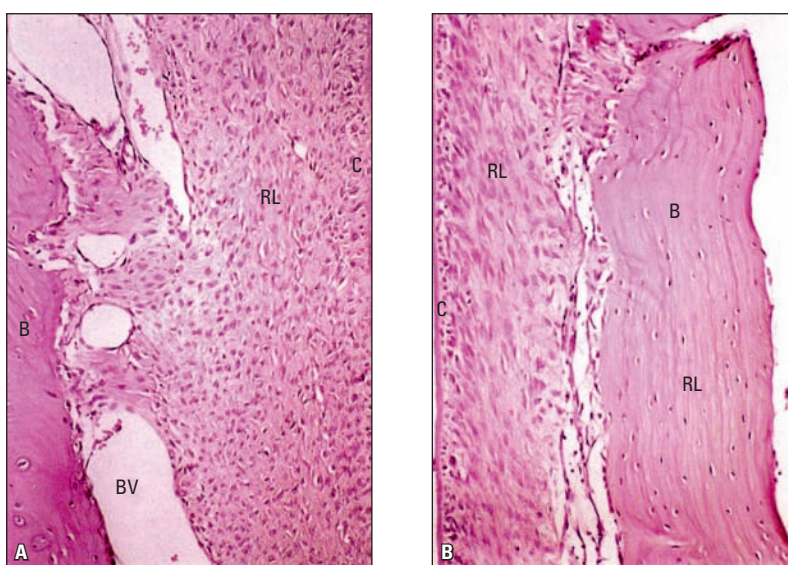


FIGURE 5 - A) Area of inter-radicular pressure, Group E, after 14 days of orthodontic movement. Note discrete narrowing of periodontal ligament space, with slightly compressed cells, there is rich cellularity with ovoid and irregular cells. Well dilated and non hyperemic blood vessels. **B)** Area of inter-radicular traction, Group E, after 14 days of orthodontic movement. Note discrete increase in ligament thickness, rich cellularity with fusiform cells, without organization and stretching of collagen fiber bundles, cement surfaces without resorption lacunae.

One of the most remarkable side effects in therapy with this class of drugs is the alteration in calcium metabolism, which results in depletion of the serum level, in addition to inducing a condition of osteomalacia or rickets.^{7,16} Since it alters the metabolism of calcium, phenobarbital may have an influence on tooth movement. Therefore, the present article proposed to evaluate the influence of this

medication on induced tooth movement.

For this purpose, a New Zealand (*Oryctolagus cuniculus*) breed of rabbits, frequently used in several studies on the effects of drugs on orthodontic tooth movement was used.^{18,21,20} In order to induce the tooth movement similar to what would be seen clinically, a coil spring was extended from the maxillary incisors to the molars.

Tooth movement was evaluated after 7 and 14 days which reflects the intermediate and final periods of tooth movement in the rabbit periodontium.¹⁸

When the histological preparations from the animals not submitted to orthodontic tooth movement were analysed, the supporting periodontium presented characteristics of normality. There was a uniformity in the periodontal ligament width along the roots of the teeth, intense vascularization, high cellularity with various types of cells, particularly fibroblasts, in addition to lymphocytes, undifferentiated mesenchymal cells, osteoblasts and cementoblasts distributed in the amorphous fundamental substance, as referred to by Junqueira and Carneiro⁹ and Ten Cate.²²

The bony tissue was shown to be of the lamellar type, covered by a non lamellar bone layer. Superficially to the lamellar bone, in some areas, there was deposition of a thin layer of osteoid tissue covered by osteoblasts aligned along it. The presence of osteocytes distributed throughout the bone was also observed. This condition of normality demonstrated in the normal animals was mentioned by Junqueira and Carneiro.⁹

In the histological preparations of the animals submitted to orthodontic movement, both in the control and experimental groups, the presence of area of pressure in the periodontal ligament region corresponding to the mesial surface of the first permanent molar and in the area under tension on the distal surface was characterized, in agreement with findings of other experimental studies on orthodontic tooth movement.¹¹ Tissue reactions on the pressure and tension sides of the periodontal ligament were similar in the control and experimental groups both at 7 and 14 days, and were characterized as described below.

The pressure side in animals of the 7-day Control and Experimental Groups

Seven days after force application, a reduction

in the width of the periodontal ligament space was observed, in addition to a discrete inflammatory infiltrate next to the bone surface, discrete hyaline zones, fibers and disorganized cells. Absence of alterations at the tooth margin (cement) and a discrete bone resorption with an irregular surface were also observed. Another condition found was lacunae without clasts in the majority of the laminae while in others, a discrete distant resorption with clasts in lacunae could be observed (Figs 2 and 3).

The tension side in animals of the 7-day Control and Experimental Groups

On the tension side, the presence of inflammatory infiltrate next to the bone was observed, as well as hyaline zones, increased periodontal ligament space, well distended periodontal ligament fibers, dilated vessels and discrete hyperemia. Some empty lacunae and distant clasts were also observed, as well as absence of bone and cement resorption, demonstrating a normal tooth surface and presence of bone formation with reversal lines (Figs 2 and 3).

These characteristics observed at 7 days are in agreement with those that presented in the literature by Ruellas,²⁰ demonstrating that there are no differences between the normal and experimental groups.

The pressure side in animals of the 14-day Control and Experimental Groups

Discrete reduction in the periodontal ligament space was observed with slightly compressed and irregular cells without an organized distribution pattern. No hyaline zones were observed, however, but rich cellularity and dilated blood vessels, some of them hyperemic, were observed. Discrete mononuclear leukocytes, bone and cement surface resorption were noted, with the bone surface being uniform at times and cut at others. The events are compatible with the healing process (Figs 4 and 5).

Areas of cement resorption occurs even with the use of light orthodontic forces, according to Kurol and Owman-Moll,¹¹ which explain all the histological characteristics observed on the pressure side at the 14-day period.

The tension side in animals of the 14-day Control and Experimental Groups

The space of the periodontal ligament presented with rich cellularity and a few blood vessels. Cells were predominantly fusiform and the fiber bundles were distended. The cement surface was preserved and covered with cementoblasts. The bony surface was slightly cut, without resorption lacunae, and reversal lines indicative of bone deposition were noted. No inflammatory infiltrate or hyaline zones were noted (Figs 4 and 5).

It is important to point out that Group E presented characteristics similar to those of Group C at 14-day period. However, a lower quality in the healing process in Group E could be noted as compared to Group C. These characteristics observed on the pressure and tension sides are corroborated by previous findings,^{19,20} therefore demonstrating no difference between the control and experimental groups after 14 days.

Histological differences at 7 and 14-day period, were found by Chao et al³ and Tenshin,²³ when prostaglandins were used. The authors found an increase in vascularization and significant changes in its morphology, representing greater bone resorption, thus obtaining double the movement, without promoting damage to the periodontal tissues.

Other medications have also been tested such as parathyroid hormone,¹⁰ vitamin D metabolites,⁴ indomethacin,²⁴ aspirin,² ibuprofen, acetaminophen¹⁴ and bisphosphonates¹⁴ and have demonstrated histological differences between control and experimental groups.

Although no differences were found in the periodontium of animals treated with phenobarbital, it is important for the clinician to be aware of patients being treated with this kind of drug particularly because there is no reference in the literature on the long-term effect on tooth movement.

The results of this study were based on subjective and overall analysis by an experienced and trained examiner involving various parameters described for optical microscopy. The use of optical microscopy and hematoxylin-eosin staining was shown to be practical, low cost and allowed overall analysis of all tissues, with a high degree of fidelity, without the need of any special and specific analytic or staining technique.

CONCLUSION

The results of this study demonstrate that phenobarbital did not interfere with tooth movement, as tissue reactions on the pressure and tension sides on both groups, were similar and in agreement with those reported in the literature. Nevertheless, a lack of organization was observed in the bone formation process of animals treated with phenobarbital in the 14-day period.

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A new stainless steel wire for orthodontic purposes

André Itman Filho*, Rosana Vilarim da Silva**, Roney Valdo Bertolo***

Abstract

Objective: To develop a method to manufacture austenitic-ferritic stainless steel orthodontic wires (SEW 410 Nr. 14517) using conventional rolling and wiredrawing processes. **Methods:** Austenitic-ferritic steel was produced in an induction furnace. Tensile tests and microhardness measurements were used to evaluate the wires quality. Orthodontic components were fabricated to assess ductility and malleability. **Results and Conclusions:** Austenitic-ferritic stainless steel wires meet the BS 3507:1976 and ISO 5832-1 standards and have excellent ductility for the fabrication of orthodontic parts with complex folds.

Keywords: Duplex stainless steel. Orthodontic wire. Orthodontic wire properties.

INTRODUCTION

The practice of surgical implants was already known in the beginning of the Christian era, although the first documented case in 1565 was the restoration of a patient's palate using a gold plate.¹³ Although in use since the 16th century, little is known about the fabrication and quality of the elements used in these procedures. It was only after 1895, when it became possible to visualize metal fixation and bone healing of fractures

using X-rays, that the use of metal biomaterials in human implants received greater attention. At first, gold alloys, silver and platinum were used because of their high degree of biocompatibility and malleability.^{12,15} Since 1930, metal alloys containing nickel, cobalt, chromium and molybdenum have been used to manufacture partial dentures. The combination of low cost and good mechanical properties made them a good replacement for nobler metals.^{10,11} These alloys, called

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basic, require high fusion temperatures and special equipment for surface finishing of the products manufactured. Alloy metallurgy used to be extremely complex, and the chances of success depended on important variables, such as the appropriate chemical composition of the material and the evaluation of its mechanical properties, as well as knowledge about casting techniques.^{4,13} In the same technological field, these nonferrous alloys have been gradually replaced with ASTM 300 austenitic stainless steel for orthodontic purposes. This type of steel, in addition to having a lower density than basic alloys, feature appropriate mechanical strength, good resistance to corrosion and sufficient biocompatibility at a lower cost.^{1,9,12} In orthodontic treatments, metal wires undergo mechanical strains resulting from mastication, which produces permanent deformation and localized residual stresses. Therefore, the mechanical resistance of wires should be high enough to undergo plastic deformation because they will be exposed to the stresses of joint movements. The ASTM 302 and ASTM 304 types of steel are the most commonly used, whereas the austenitic ASTM 316L stainless steel is more appropriate for surgical implants (Table 1). Currently, knowledge of the mechanical properties of the several alloys may lead

to the optimization of orthodontic treatments. In general, wires manufactured using austenitic stainless steel are appropriate for use in the final stages of treatment due to their excellent rigidity and resistance to corrosion in the oral environment.^{3,5,8} Other properties, such as toughness, fatigue resistance and ductility contribute to their choice as the most adequate material for these uses. The ideal alloy should be sufficiently resistant to withstand the strains of joint movements, capable of absorbing mechanical impact without plastic deformation, inert to organic fluids and not release toxic products.²

Because of its mechanical and corrosion resistance, austenitic stainless steel has been replaced with austenitic-ferritic stainless steel in several industrial applications that require better resistance to stress-corrosion cracking.^{6,14} Results in the literature also show that the biocompatibility of austenitic and austenitic-ferritic steel is similar.¹ In the case of orthodontic treatments, the replacement of austenitic stainless steel with austenitic-ferritic steel reduces costs and nickel hypersensitivity to patients.

OBJECTIVE

In this study, austenitic ferritic stainless steel (SEW 410 Nr. 14517) wires were fabricated using

TABLE 1 - Chemical composition (% of weight) of the following stainless steel, mentioned in the text: standard SEW 410 Nr. 14517, austenitic-ferritic and austenitic.

	Cr	Ni	Mo	Cu	Man	Si	C	N	P	S
SEW 410 study	25.0	5.6	2.5	3.0	0.6	0.6	0.02	0.14	0.03	0.01
SEW 410 standard	24.5	5.5	2.5	3.0	1.0	1.0	0.03	0.12	0.04	0.03
	26.5	7.5	3.5	3.5	max	max	max	0.25	max	max
ASTM 316L commercial	18.0	8.0	2.0	-	2.0	1.0	0.03	-	0.04	0.03
	20.0	10.0	3.0	-	max	max	max	-	max	max
ASTM 304 commercial	18.0	8.0	-	-	2.0	1.0	0.08	-	0.04	0.03
	20.0	10.0	-	-	max	max	max	-	max	max
ASTM 302 commercial	17.0	8.0	-	-	2.0	1.0	0.15	-	0.04	0.03
	19.0	10.0	-	-	max	max	max	-	max	max

rolling and wiredrawing, processes that are similar to those used to manufacture commercial stainless steel austenitic wires used in orthodontic treatments. This duplex steel was chosen because it is very used in several industrial applications. To check whether the fabricated wires met the standards, tensile tests and microhardness measurements were used. Material ductility was evaluated using fractographic analyses and by means of fabricating orthodontic components.

EXPERIMENTAL PROCEDURES

Austenitic-ferritic steel was prepared in a 500-kg induction furnace in Grupo Metal (Tietê, São Paulo, Brazil). Liquid metal was poured into an agglomerate sand mold with phenolic urethane resin binder in the form of a keel block (ASTM A781-M) adapted to the commercial component. The chemical composition of steel was defined by means of analysis using optical-emission spectrometry. The starting bar measured about $\varnothing 11 \times 180$ mm in length. It was milled using a mechanical lathe to a diameter of 10 mm and later reduced to a diameter of 2.5 mm by rolling process. The rolled wires were about 1 meter long and were soldered to the ASTM 304 stainless steel wire and reduced to a diameter of 0.4 mm according to conventional cold drawing performed in Superfine Steel (Santa Bárbara D'Oeste, Brazil). To evaluate the tensile strength, wire samples cut during wiredrawing underwent tensile tests in a universal testing machine (EMIC DL 10000) at 1 mm/min strain rate according to the ASTM E 8-00 and NBR 6152/92 standards. These samples were also used for microhardness measurements according to the criteria established in the ASTM E384-89 standard. Orthodontic components were fabricated to evaluate wire malleability in comparison with commercial stainless steel wires. To check the morphological fracture characteristics after the tensile test, a sample of the wire with 0.9 mm in diameter was analyzed under scanning electron microscope.

RESULTS

Values shown as weight percentages in Table 1 revealed that the element contents met the chemical composition specifications for austenitic-ferritic stainless steel (SEW 410 Nr. 14517).

Table 2 shows mean values of ultimate tensile strength and standard deviations after trials with five specimens. These values meet the requirements of the BS 3507:1976 and ISO 5832-1 standards. The same table shows the microhardness values of the samples used in the tensile tests.

Figure 1 shows a Bionator manufactured using austenitic-ferritic stainless steel wires. Figures 2A, 2B and 2C show representative fractographic features of a sample that underwent tensile testing.

DISCUSSION

The greatest difficulty in this study was to develop a wire manufacturing process in conventional equipment used for large amounts of material, differently from our initial austenitic-ferritic steel sample, which weighed about 500 g. In general, furnace fusions are run for at least 500 kg of steel, which makes it very expensive to obtain material for research purposes. Therefore, to obtain an initial austenitic-ferritic stainless steel sample it was

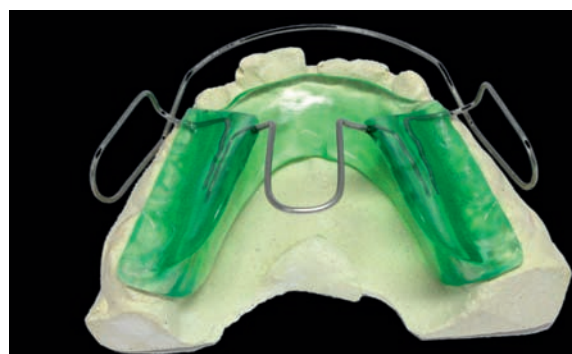


FIGURE 1 - Bionator manufactured using SEW 410 Nr. 14517 steel wire.

TABLE 2 - Ultimate tensile strength and Vickers microhardness of wires manufactured using SEW 410 Nr. 14517 steel.

	$\varnothing$ 2.5 mm	$\varnothing$ 1.1 mm	$\varnothing$ 0.9 mm	$\varnothing$ 0.4 mm
σ_t (MPa)	1,423 $\pm$ 16	1,596 $\pm$ 26	1,726 $\pm$ 41	2,030 $\pm$ 25
Vickers (HV)	341 $\pm$ 13	427 $\pm$ 6	430 $\pm$ 5	509 $\pm$ 13

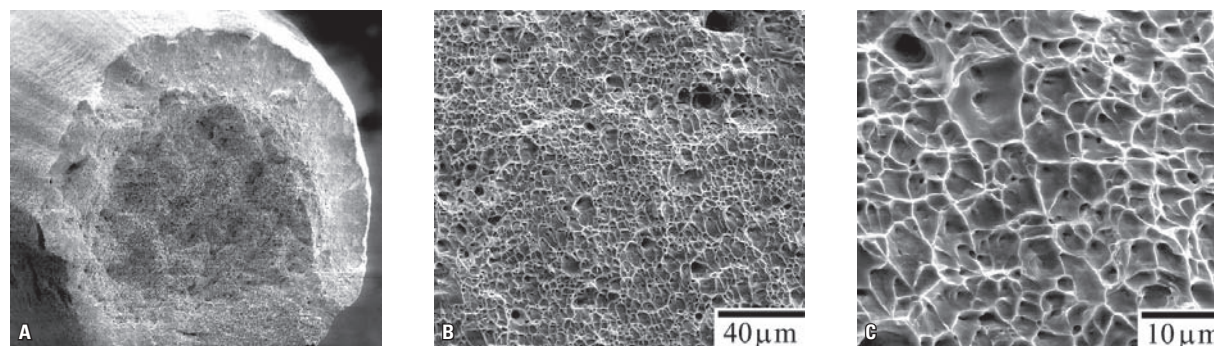


FIGURE 2 - Fractograph of $\varnothing$ 0.9 mm wire that underwent tensile testing in different magnifications: **A**) surface of wire fracture; **B, C**) enlargement of region shown in **(A)**.

necessary to adapt a keel block mold to the commercial specimen. The reduction down to a diameter of 2.5 mm was made in a laboratory, and wires of about 1 m in length were obtained. Industrial wiredrawing uses longer lengths to start the process. Therefore, $\varnothing$ 2.5 mm wires had to be soldered to ASTM 304 stainless steel wires, whose composition is compatible with that of austenitic-ferritic steel. The effect of the high degree of cold deformation during the shaping stages is described in Table 2, which shows a reduction of 80.2% in the last wiredrawing pass ($\varnothing$ 0.9 mm $\rightarrow$ $\varnothing$ 0.4 mm). Despite the significant increase of hardness in the final diameter after wiredrawing, there was no loss of ductility or malleability, which was confirmed by the fact that several parts with different folds were manufactured without any wire break. High mechanical resistance and hardness, a characteristic of stainless steel, are important parameters to ensure that the wire will keep teeth in the correct position after the conclusion of orthodontic treatments. Moreover, the shaping process to achieve the desired diameter was similar to that used in the fabrication of commercial stainless steel wires, which favors large-scale production without changes in steel manufacturing processes. The values of hardness and tensile strength, similar to those of commercial stainless steel orthodontic

wires (ASTM 302 and ASTM 304), are an indication that steel can resist to the wear of wire movements between brackets, and that its properties are adequate for use in orthodontics according to the BS 3507/1976 and ISO 5832-1 standards. Steel ductility was confirmed in Figure 2, which shows the classic cone-cup pattern, in which the crack starts in the center of the wire, it propagates along the edge and fractures by shearing.⁷ The evaluation of wire malleability revealed that the austenitic-ferritic stainless steel has adequate ductility for intense folding, as required in the fabrication of bionators, and it is appropriate for the fabrication of other orthodontic components as well. The comparison with commercial austenitic stainless steel wires used in routine procedures did not reveal any differences in the handling of the two types of wire.

CONCLUSION

The results of this study showed that austenitic-ferritic stainless steel may have a great area reduction during wire fabrication. Therefore, the value of tensile strength greater than 2000 MPa, associated with ductility, biocompatibility and processing characteristics, showed that austenitic-ferritic stainless steel may potentially replace austenitic wires in orthodontic uses.

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Agreement among orthodontists regarding facial pattern diagnosis

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Abstract

Objective: To assess agreement among orthodontists trained in facial pattern diagnosis through the morphological evaluation of the face. **Methods:** Facial photographs were taken in front and side views, as well as photographs of the smiles of 105 individuals randomly selected among patients seeking orthodontic treatment. The photographs were sent to orthodontists trained in facial pattern classification. Intra-rater agreement, agreement between raters and the Gold Standard, as well as inter-rater agreement were assessed using the Kappa index. **Results:** Intra-rater agreement was almost perfect, with Kappa index reaching 0.85. Agreement between raters and the Gold Standard was moderate (Kappa = 0.48), higher for Pattern I (Kappa = 0.62) and lower for the Short Face Pattern (Kappa = 0.33). Agreement between raters was significant (Kappa = 0.61) and even higher than agreement with the Gold Standard for all patterns. **Conclusions:** The criteria used by raters to determine the facial pattern were the same in the first and second evaluation. Agreement between raters and the Gold Standard was moderate, with raters exhibiting greater agreement between them than with the Gold Standard.

Keywords: Orthodontic diagnosis. Facial analysis. Facial pattern.

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INTRODUCTION

Disagreement on the diagnosis of orthodontic problems is still very prevalent among orthodontists¹⁰ despite efforts to standardize the classification of malocclusions.

Initially, Angle³ classified malocclusions according to the mesiodistal relationship of first molars. After studying the quality of cases finished by North American orthodontists, Andrews² noted a lack of standardization among different practitioners and designed the six keys to a normal occlusion, which would serve as a guide to diagnose and assess the quality of finished cases.

These classifications were based, however, only on dental relationships and would eventually prove insufficient to define the diagnosis of sagittal and vertical facial discrepancies.

In an attempt to create a diagnosis method supported by evidence-based treatment plans, Ackerman and Proffit¹ developed a classification system based on five key malocclusion characteristics: Facial profile, alignment, vertical, horizontal and sagittal deviations. However, little agreement was reached among professionals who teach this classification, and consequently on the treatment strategy indicated by each professional.¹⁰

Driven by the same concern, to organize a diagnostic method supported by protocols and capable of providing specific predictions, Capelloza Filho⁶ developed a classification system for orthodontic problems based on facial morphology. According to this classification, the morphological analysis of the face is the main diagnostic tool for facial pattern determination.

Organizing orthodontic diagnosis according to facial patterns allows orthodontists to treat malocclusions based on the location of skeletal discrepancies if present, or the etiology of the malocclusion, establishing treatment protocols that are tailored specifically to each pattern in each age group, with short-term protocols and predictable long-term prospects by taking into account discrepancy severity.

The benefit of this new approach to orthodontics begins, however, with appropriate facial pattern diagnosis.

Considering the limitation of facial measures in expressing form or normality,¹⁴ pattern classification should be performed by means of an evaluation of facial morphology in front and side views.

Individuals can be classified as Pattern I, II, III, Long Face or Short Face. Pattern I consists of a normal face. Whenever the malocclusion is present it is just a dental malocclusion not associated with any sagittal or vertical skeletal discrepancy. Patterns II and III are characterized, respectively, by a positive and negative sagittal discrepancy between maxilla and mandible. The Long Face and Short Face patterns feature vertical discrepancies. In patients with skeletal errors, malocclusions usually result from these discrepancies.

The use of concepts that have been long established in the orthodontic literature, applied under this new perspective, imparts greater predictability to orthodontic treatment and assurance to professionals who learn to use such concepts, in addition to patient security and comfort.

The aim of this study was to evaluate agreement among orthodontists trained on facial pattern determination through the morphological evaluation of the face.

MATERIAL AND METHODS

The study sample consisted of 105 adults of both genders, aged at least 18 years, selected from the records of offices belonging to specialists in orthodontics. The authors randomly selected patients with the five following facial patterns: Pattern I, Pattern II, Pattern III, Long Face Pattern and Short Face Pattern. Individuals who were still in the growth period and those with craniofacial syndromes were excluded from the sample.

This research project was approved by the Ethics Committee of the São Paulo University School of Dentistry number 14/07.

Standardized facial photographs in front and side views, as well as photographs of each patient's smile, were taken from their initial orthodontic records for use in the study. The photographs were inserted in a PowerPoint presentation, with the photographs of the smile of each patient and of their face in front and side views on the same slide.

The rater sample consisted of 20 orthodontists trained in facial pattern classification. Most were teachers who taught this classification at different institutions.

Each rater received by mail a CD containing a presentation with 105 slides, each comprising the photographs in front and side views, along with the photograph of the smile of the same patient.

Raters were instructed to classify the facial pattern of each patient according to the following classification: (1) Pattern I, (2) Pattern II, (3) Pattern III, (4) Long Face Pattern, and (5) Short Face Pattern.

The sample was also assessed by the author who developed the classification method,⁶ whose evaluation was set as the Gold Standard.

Thirty-five patients were randomly selected and subjected to the same classification with at least one week interval between the two evaluations with the purpose of assessing intra-rater agreement in terms of profile morphology.

Kappa coefficient, which evaluates agreement between two non-parametric variables, was used to analyze evaluation error.

Determining the value that defines a good correlation is inherent in each study, but in general, the following classification is acceptable:⁸

- » If $Kappa < 0.0$ = Poor agreement;
- » If $0.00 < Kappa < 0.20$ = Slight agreement;
- » If $0.21 < Kappa < 0.40$ = Fair agreement;
- » If $0.41 < Kappa < 0.60$ = Moderate agreement;
- » If $0.61 < Kappa < 0.80$ = Substantial agreement;
- » If $0.81 < Kappa < 1.0$ = Almost perfect agreement.

Kappa coefficient was used in the total sample and in the different patterns in order to assess agreement between raters, as well as between raters and the Gold Standard.

RESULTS

Eighteen of the 20 raters performed sample classification. As regards intra-rater assessment, the mean percentage of correct classifications found between the first and second evaluations was 84%. Kappa coefficient was 0.8 and showed substantial agreement between the first and second evaluation (Table 1). However, while most raters exhibited higher than 80% correct classifications between the two evaluations, two of them showed significantly lower agreement (60%, with $Kappa = 0.5$ - Moderate agreement) and were excluded from the sample, since these raters either did not master the method or did not implement it with due attention. The study was therefore conducted with 16 raters and the Gold Standard. Intra-rater agreement among the 16 raters was almost perfect, with Kappa index reaching 0.85 (Table 1).

Kappa coefficient was used in the total sample and in the different patterns in order to assess agreement between raters and the Gold Standard. The percentage of agreement was 59% with $Kappa = 0.48$ (moderate agreement).

TABLE 1 - Intra-rater agreement between first and second evaluations with 18 and 16 raters.

Number of raters	p(a)	p(e)	Kappa Index
18 raters	84%	16%	0.8
16 raters	88%	12%	0.85

p(a) = percentage of correct classifications, p(e) = percentage of error.

TABLE 2 - Agreement between raters and the Gold Standard.

Pattern	n (Gold Standard)	p(a)	p(e)	Kappa Index
I	27	70%	30%	0.62
II	37	56.5%	43.5%	0.46
III	17	53%	47%	0.41
Long Face	14	59%	41%	0.49
Short face	10	47%	53%	0.33
Total	105	59%	41%	0.48

p(a) = percentage of correct classification, p(e) = percentage of error.

TABLE 3 - Assessment of inter-rater agreement.

Pattern	n (Gold Standard)	p(a)	p(e)	Kappa Index
I	27	77%	23%	0.71
II	37	76%	24%	0.7
III	17	69%	31%	0.61
Long Face	14	71%	29%	0.64
Short face	10	61%	39%	0.51
Total	105	72%	28%	0.65

p(a) = percentage of correct classifications, p(e) = percentage of error.

For the different patterns the percentage of agreement with the Gold Standard was: 70% for Pattern I (Kappa = 0.62), 56.5% for Pattern II (Kappa = 0.46) and 53% for Pattern III (Kappa = 0.41), 59% for the Long Face Pattern (Kappa = 0.49) and 47% for the Short Face Pattern (Kappa = 0.33) (Table 2).

Kappa index was also employed to assess agreement between raters. A 72% percentage of correct classifications was found for the total sample, with Kappa index = 0.65 (substantial agreement). For Pattern I this percentage was 77% (Kappa = 0.71); for Pattern II, 76% (Kappa = 0.7); for Pattern III, 69% (Kappa = 0.61), for the Long Face Pattern, 71% (Kappa = 0.64) and for the Short Face Pattern, 61% (Kappa = 0.51) (Table 3).

DISCUSSION

Different diagnoses by different orthodontists for the same patient result in different treatment plans and outcomes which are not always compatible.⁹ Lack of agreement among professionals instills great uncertainty in patients, tarnishing the scientific credibility of orthodontics, a dental specialty whose literature is replete with studies that allow evidence-based practice.

Diagnoses based on occlusal classification and cephalometric landmarks lead to results that often fail to meet the esthetic expectations of patients.¹¹ Above and beyond seeking an ideal occlusal relationship one should seek the best possible esthetics.¹⁵ To this end, diagnoses should be

based primarily on the evaluation of facial morphology in front and lateral views, and evaluation of the smile, complemented by an assessment of the occlusion, whose discrepancy is often a consequence of skeletal error. Radiographs are also important complementary exams but 75% of orthodontic diagnoses are defined without radiographic evaluation and tend to remain unchanged after orthodontists have reviewed the X-rays.⁴

A diagnosis based on facial morphology constitutes the first step in facial pattern classification. By means of a correct diagnosis one can identify, in different age groups, treatment protocols substantiated by scientific evidence and, therefore, with well established short and long term prognoses.

After three years of clinical application of this concept, the authors decided to evaluate the degree of agreement of trained orthodontists who teach this methodology.

The study sample consisted of Brazilian adults past the growth period. Adults were intentionally chosen owing to the fact that facial pattern can only be established after complete facial growth. Some patterns, such as Long Face and Pattern III, tend to worsen during adolescence and are often identified only during that period. The inclusion of growing patients in this group might raise diagnostic issues related to the complete expression of each pattern.

Furthermore, only Caucasian individuals were included since the concept of normal facial features is specific to each population.⁵ For Caucasians, a normal facial profile, or Pattern I, should display a smooth convexity. In Asians, a less convex facial profile is accepted as characteristic of normality. In Afro-descendants, on the other hand, an increased vertical growth results in increased facial convexity in Pattern I patients.

Sample raters were selected for their specific training in this classification and for teaching it at different institutions. The photographs were sent to 20 of them and 18 completed the questionnaire.

The percentage of agreement found between the first and second assessment was 84%, with Kappa = 0.8, showing substantial agreement, i.e., high consistency among raters regarding facial pattern diagnosis. This result indicates that the criteria for determining the pattern was the same in both studied periods. All raters achieved Kappa indexes for the two evaluations that showed substantial or almost perfect agreement, with the exception of two raters for whom the Kappa index yielded only moderate correlation between the two assessments. Due to the vast difference between these two raters and the others it was decided that they should be excluded, either because they did not master the classification method, or because they failed to carry out the assessments with the required attention. After this exclusion, the general intra-rater agreement changed from substantial to almost perfect (Kappa = 0.85) (Table 1).

The diagnosis performed by the raters was then compared with the Gold Standard, whose agreement was moderate (Kappa = 0.48).

Patients classified as Pattern I are characterized by vertical and sagittal facial balance in front and side views. They are not necessarily beautiful, but sagittally and vertically balanced.

After analyzing separately the different individuals and their facial patterns it was noted that Pattern I had the highest percentage of correct classifications. Seventy percent of the 27 individuals classified as Pattern I using the Gold Standard as reference received the same rating by the raters (Kappa = 0.62 - substantial agreement).

Eleven percent of Pattern I individuals were classified as Pattern III, and another 11.3% as Long Face Pattern. Six percent were mistaken for Pattern II and 1.6% for Short Face Pattern (Table 4). Among the 27 Pattern I patients, only 2 (7.4%) were rated by most raters as Long Face Pattern. All others who showed discrepancies in classification were correctly assessed by most raters.

After a careful study of the sample, it was observed that all individuals rated as Long Face Pattern by the raters were dolichofacial. Noteworthy, however, were the presence of lip seal competence and the absence of excessive exposure of the upper incisors at rest, or of the gingiva when smiling, essential features for diagnosing the Long Face Pattern. This means that even in individuals with excessive vertical growth whose facial esthetics was compromised, normality may be present indicating that there is sagittal balance between the maxilla and mandible, lip seal competence and no excessive vertical growth of the maxilla (Figs 1 and 2). In dolichofacial Pattern I patients, only orthodontic treatment is indicated (Fig 3). For individuals with Long Face Pattern, on the other hand, orthodontic treatment can balance the occlusal relationships but it does not correct the skeletal discrepancy, nor does it benefit facial esthetics, which could only be achieved through a combination of orthognathic surgery and orthodontics.

In Pattern I patients who were classified as Pattern III, an expressive mandible can be observed in front and side views, although in balance with the maxilla. Among those rated as Pattern II there was again the influence of an increased vertical dimension, which enhances facial convexity. Once again it should be stressed that in Pattern I patients, maxillomandibular relationships are balanced and, therefore, no sagittal or vertical changes can be made.

Among the patients in the sample, 37 were classified as Pattern II according to the Gold Standard. This number is not surprising since

TABLE 4 - Percentages of diagnoses by Pattern.

Pattern	I	II	III	Long Face	Short Face	Total
I	69.8%	6.2%	11.1%	11.3%	1.6%	100%
II	30.5%	56.5%	0.5%	6.4%	6.1%	100%
III	30.5%	0.7%	53%	11.8%	4.0%	100%
Long Face	10.7%	26.8%	3.1%	59.4%	0%	100%
Short Face	23.7%	11.8%	17.5%	0%	47%	100%



FIGURE 1 - Pattern I, dolichofacial patient diagnosed as Long Face Pattern by 31.25% of raters. Lip seal competence and absence of vertical maxillary excess exclude Long Face diagnosis.



FIGURE 2 - Morphological evaluation of lateral cephalogram confirms basal bone balance.



FIGURE 3 - Class I malocclusion with upper and lower anterior crowding treated with extraction of tooth 32 and stripping in upper arch.



FIGURE 4 - Pattern II patient rated by 75% of raters as Pattern I. Raters overlooked discrepancy given its small size.



FIGURE 5 - Lateral cephalogram of patient in Figure 4 discloses mandibular deficiency and incisor compensation in opposite direction to skeletal error, which should be preserved with orthodontic treatment, influencing bracket choice.

the sample was collected in orthodontic offices and Class II malocclusion is very common, affecting 42% of Brazilians adults,¹³ 75% of whom also exhibit skeletal discrepancies.¹² Pattern II is characterized by increased facial convexity without, however, the presence of vertical discrepancy. Most of these patients present with mandibular deficiency in association (or not) with maxillary excess. Maxillary excess seldom occurs in isolation. Mandibular deficiency is characterized by a short chin-neck line,

deficiency in chin protrusion and lower lip eversion. Upper lip posture depends on the uprighting or protrusion of the upper incisors.

The major manifestations of Pattern II in frontal view are reduced height of the lower lip and chin, and lower lip eversion. Pattern II patients do not present with vertical maxillary excess or any deficiency in dental exposure when smiling. These are the key elements for differential diagnosis of the Long Face and Short Face patterns, respectively. Such diagnosis may be elusive at times, mainly because most patients with these patterns display a Class II malocclusion.

Among sample subjects with Pattern II, 56.5% were correctly classified by the evaluators (Kappa = 0.46, moderate agreement). The most frequent error was classifying individuals with mild Pattern II discrepancies as Pattern I, with raters tending to disregard the minor mandibular deficiencies (Figs 4 and 5). Thirty and half percent of Pattern II patients were rated as Pattern I (Table 4).

Even mild discrepancies between the maxilla and mandible should be identified as treatment differs from that of Pattern I patients. Patients with mild Pattern II should be treated by means of primary compensatory orthodontic treatment.⁶ The upper and lower incisors should normally

preserve any compensations that might be present, such as: Reduced buccal inclination of upper incisors, absence of incisor and canine tip, and buccal inclination of lower incisors⁷ (Fig 5). Depending on Class II size, compensatory atresia is common in the maxilla and should be preserved. Non-identification of Pattern II may affect the appropriate choice of brackets and bonding resources and the preservation and acquisition of adequate compensation.

In this study raters only evaluated facial photographs, which may have favored the error component. Complementary examination of lateral cephalograms assists in the identification of the skeletal discrepancies and dental compensations that should be preserved.

Six percent of Pattern II patients were classified as Long Face Pattern and another 6.5% as Short Face Pattern. Those rated as Long Face Pattern are the Pattern II dolichofacials, and as Short Face the Pattern II brachyfacials. Differential diagnosis must be made by identifying the treatment needs of each patient. When in doubt between Pattern II and Long Face Pattern, professionals must ask themselves if the patient requires upper replacement of the maxilla. If the answer is affirmative, the patient is Long Face, if negative he/she is Pattern II. For a differential diagnosis between Pattern II and Short Face the question is whether the maxilla needs to be repositioned inferiorly, and the patient is Short Face if the answer is positive.

Pattern III, in turn, is characterized by reduced facial convexity due to maxillary deficiency, mandibular prognathism or a combination of both. In patients with maxillary deficiency, infraorbital depression and zygomatic prominence are missing. The middle third is poor. The chin-neck line is long, less pronounced in prognathic dolichofacial patients. The differential diagnosis of these patients relative to the Long Face Pattern is determined by gingival exposure when smiling, which is normal in prognathic patients, who do not require upper replacement of the maxilla in orthognathic surgery.

Individuals with Short Face Pattern may also experience a reduction in facial convexity, which confuses them with Pattern III patients. Differential diagnosis is once again performed according to the amount of exposure of upper incisors when smiling. A reduced exposure, indicative of the need for lower repositioning of the maxilla, determines the diagnosis of individuals with Short Face Pattern.

In frontal view, Pattern III patients are mainly characterized by excessive lower lip and chin height, and deficiency in the middle third of the face, which is expressionless. Minor discrepancies are not perceived when evaluated in frontal view, improving the prognosis of nonsurgical treatment.

Seventeen patients were classified as Pattern III according to the Gold Standard. The percentage of correct classifications was 53%, with Kappa = 0.41 (moderate agreement). Once again, the worst confusion occurred between mild Pattern III and Pattern I individuals (Fig 6). Thirty and a half percent of Pattern III individuals were classified as Pattern I. Lateral cephalograms should be evaluated in order to facilitate differential diagnosis. Lateral cephalograms allow the identification of lower incisor uprighting, upper incisor protrusion and skeletal discrepancy (Fig 7). These characteristics should be preserved in the compensatory treatment of these patients, thereby influencing the choice of brackets.

Twelve percent of Pattern III patients were rated as Long Face Pattern. These patients, however, are Pattern III dolichofacials and show no vertical maxillary excess.

Patients with Long Face Pattern are characterized by excessive vertical growth of the maxilla, downward and backward rotation and lip seal incompetence, excessive gingival exposure when smiling and likewise in the upper incisors at rest. Due to excessive vertical growth and deficiency in the sagittal growth of the facial bones, these patients present with maxillary and mandibular retrusion. The percentage of

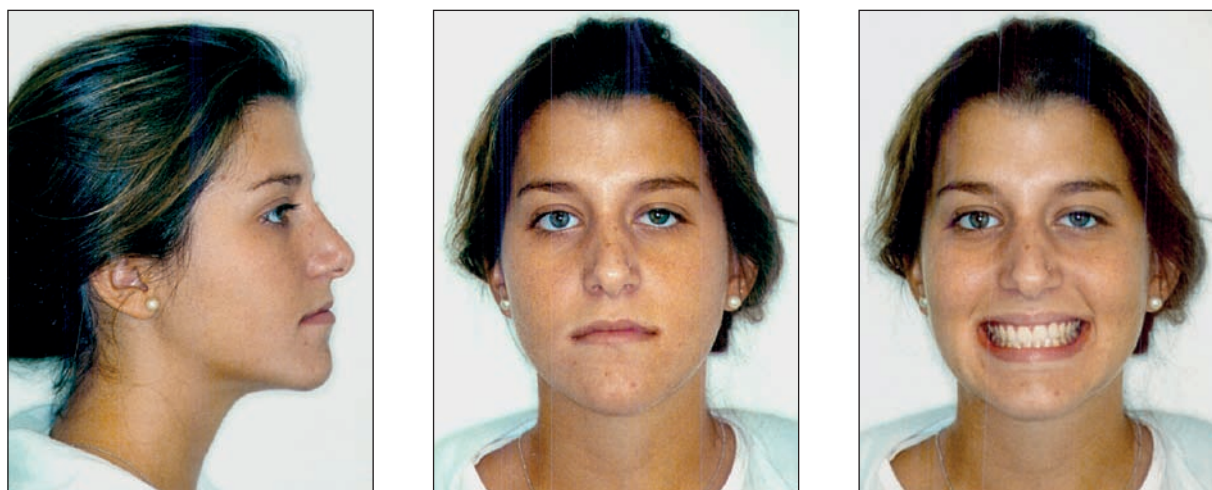


FIGURE 6 - Pattern III patients diagnosed as Pattern I by 68.75% of raters. Height of lower lip and chin increased relative to upper lip height allows discrepancy identification even in front view photograph.



FIGURE 7 - Lateral cephalogram of patient in Figure 6. Lower incisor compensation should be preserved with orthodontic treatment, influencing bracket choice.

correct classification for this Pattern was 59.4% ($Kappa = 0.49$, moderate agreement). Their facial convexity is increased due to mandibular rotation downwards and backwards. Therefore, 26.8% of the patients with Long Face Pattern were classified as Pattern II (Table 3 and Fig. 8). In defining the differential diagnosis one must check the sealing of perioral muscles typically present in Pattern II individuals and

the amount of gingival exposure when smiling, which is normal in Pattern II patients.

In evaluating the profile of Long Face patients one should check gonial angle opening, long and narrow symphysis, increased distance between molar apex and palatal plane, and excessive exposure of upper incisor at rest (Fig 9).

When lip seal is present in the patients, it is forced and forms a double chin.

These patients are usually esthetically unpleasant and require orthognathic surgery associated with orthodontic treatment to restore facial balance and allow proper sealing of the perioral musculature. Surgical planning of these patients includes maxillary replacement and expansion, upward and forward rotation, mandibular advancement or setback, and vertical chin reduction.

In 11% of Long Face Pattern evaluations these patients were classified as Pattern I and 3% as Pattern III (Table 4).

When Long Face patients fail to be diagnosed as such, the use of unsuitable orthodontic mechanics may lead to an increase in vertical dimension and the worsening of this pattern, compromising facial esthetics and occlusal function (anterior guidances) by reducing overbite.



FIGURE 8 - Patient with Long Face Pattern diagnosed as Pattern II by 43.75% of raters. Vertical excess results in lip seal incompetence and maxillary and mandibular retrusion.

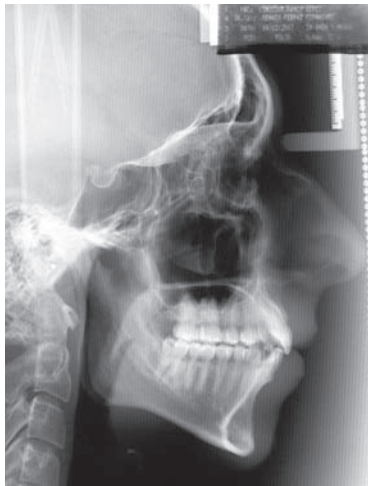


FIGURE 9 - Lateral cephalogram of patient in Figure 8. Opening of gonial angle, long and narrow symphysis, increased distance between molar apex and palatal plane, and excessive exposure of upper incisor at rest.

Patients with Short Face Pattern exhibit small vertical growth associated with upward and forward mandibular rotation. Their chin is usually prominent. There is little upper dental exposure when smiling even in young patients, and excessive lip compression at rest, indicating lower repositioning of the maxilla as a mandatory procedure in orthognathic surgery for these patients.

Short Face was the pattern that showed the least agreement between raters and the Gold Standard.

Only 47% of the evaluations of patients with this pattern were correct. Kappa was 0.33, indicating fair agreement between evaluations. Twenty-four percent of patients with this pattern were confused with Pattern I, 11.8% with Pattern II and 17.5% with Pattern III (Table 4). Individuals with Short Face Pattern may have slightly convex profile similarly to Pattern I, or a markedly convex profile, typical of Pattern II, or even reduced convexity, like Pattern III. This explains why there was such confusion in the evaluation of patients with this pattern (Figs 10, 11 and 12). Differential diagnosis is performed by studying photographs of smiles in which these patients expose very little of their upper incisors since childhood. Another important aspect is soft tissue excess, resulting in compressed lips and facial creases since youth. The impact of aging on this pattern is greater than on any other pattern. Ideally, the orthodontic treatment must be associated with surgery for lower replacement of the maxilla, downward and backward rotation with mandibular advancement or setback, and vertical increase of the chin.

When a patient opts for compensatory treatment, one should avoid procedures that reduce oral volume and vertical dimension, such as dental extractions. Orthodontic treatment of these



FIGURE 10 - Patient with Short Face Pattern diagnosed as Pattern III by 56.25% of orthodontists. Reduced facial convexity is due to reduced vertical height of maxilla and forward and upward mandibular rotation.



FIGURE 11 - Lateral cephalogram of patient in Figure 10, showing forward and upward mandibular rotation, compounded by subsequent tooth losses.



FIGURE 12 - Facial photographs of patient in Figures 10 and 11 after increase in vertical dimension by Surgically Assisted Rapid Maxillary Expansion and provisional prosthetic rehabilitation. Short Face Pattern is still present as it can only be corrected with orthognathic surgery, but significant improvement was achieved in smile esthetics.

patients is usually limited to improving esthetics and establishing satisfactory occlusion.

Evaluation of inter-rater agreement showed a higher percentage of accurate classifications for the entire sample and for all patterns compared with the percentage between raters and the Gold Standard.

Agreement was substantial for the total sample (Kappa = 0.65) and for Patterns I (Kappa = 0.71), II (Kappa = 0.7), III (Kappa = 0.61) and Long Face (Kappa = 0.64), and moderate for the Short Face Pattern (Kappa = 0.51). These results show that rater error tends to be in the same direction when classifying a patient in a pattern different from the Gold Standard.

CONCLUSIONS

Identifying points of problem in the diagnosis of facial patterns makes it easier to correct potential errors that might result in inappropriate treatment plans and unrealistic prognoses.

An almost perfect agreement was noted between the first and second evaluation by the same rater, which demonstrates that the criteria for diagnosis of facial pattern are well established.

Agreement between rater evaluation and the Gold Standard was moderate. A tendency was detected whereby raters disregarded minor mandibular deficiencies in Pattern II, and mild

discrepancies in Pattern III. Individuals with Long Face Pattern were often diagnosed as Pattern II due to increased facial convexity resulting from downward and backward mandibular rotation.

Short Face Pattern showed less agreement and these individuals were classified as Pattern I, II or III.

Agreement between raters in evaluating patterns was substantial, showing that raters tended to classify individuals under the same pattern, which was different from the Gold Standard. In other words, errors tend to be committed in the same patients and in the same direction.

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Shear bond strength evaluation of metallic brackets using self-etching system

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Abstract

Objective: To evaluate the shear bond strength of metallic brackets using the self-etching system after its activation and storage for 2, 5 and 9 day periods. **Methods:** A total of 64 bovine teeth were divided in four groups and prepared to receive the brackets. Initially (T1), 7 self-etching primer blisters were activated and used to bond the brackets of group I. The blisters were stored at a constant temperature of 4°C for 2 (T2), 5 (T3) and 9 (T4) days and used to bond the brackets of groups II, III and IV, respectively. **Results:** No statistic difference was found in shear bond strength comparing groups I, II and III. However, a significant difference was found in group IV. **Conclusion:** The shear bond strength seems not to be affected by activation and storage of the self-etching primer at a mean temperature of 4°C for a 5 day period. More studies are necessary to evaluate other characteristics of the material after its activation and storage for long periods of time.

Keywords: Shear bond strength. Self-etching system. Bovine enamel. Bond.

INTRODUCTION

Since Buonocore³ in 1955 proposed the acid etching technique, the concept of bonding to enamel allowed the development and application of various techniques and new materials in all dentistry fields.¹⁹ The use of phosphoric acid on dental surface results in microporosity into which composite can flow and be polymerized to form a mechanical adhesion to enamel. Therefore, several adhesive materials used in orthodontics have been

developed, making necessary new studies to prove its efficacy.^{12,17,18}

The use of direct bonding techniques allowed great benefits to orthodontists: esthetics improvement, less risk of enamel damage, easy control of dental plaque by the patient, minor gingival irritation and reducing patient chair time. These important gains were possible since direct bonding is easier than the adaptation of bands on all teeth.²⁰

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Among the huge variety of new materials, self-etching system (acid already incorporated into the primer) uses chemical and different etching technology than traditional products.¹⁴ It was first available for use in restorative dentistry⁸ and recently has been used for orthodontic accessory bonding.¹⁵

The adhesive used in this study is the Transbond Plus Self Etching Primer-3M. This adhesive has esters of phosphoric methacrylate acid (hydroxyethyl-metacrylate), forming a bifunctional molecule. When rubbed on enamel surface, the acid component exposes the enamel prisms while the primer components simultaneously penetrate on these exposed prisms. Phosphoric acid removes calcium of the hydroxyapatite. The phosphate group forms a composite with calcium which is incorporated to the product during polymerization, since there is no washing step in this system.⁵ The self-etching adhesive pH is around 1, promoting a good enamel penetration. The lower the pH of the substance, the greater its capacity of penetration in dental tissues. This product solvent is water, enabling the ionization of acid monomers and contributing for enamel demineralization.¹⁴ After applying the adhesive on dental surface, the tooth must be dried with oil and moisture-free compressed air, in order to permit solvent evaporation. If drying is not performed properly, the adhesion forces can be compromised.¹⁰

Some studies show no statistical significant differences between conventional and self-etching systems on shearing bond strength of metallic brackets.^{7,18}

Some authors defend the use of bovine teeth instead of human teeth in dental researches. The use of bovine teeth became well-documented and preferred due to its enamel composition (similar to human's enamel) and its easy acquisition.^{11,13,15,18}

The objective of the present study is to evaluate shearing bond strength of metallic brackets

on bovine teeth using self-etching system immediately after its activation and with intervals of time of 2, 5 and 9 days.

MATERIAL AND METHODS

Sixty-four bovine incisors were used. The teeth were selected based on the same criteria adopted by Sponchiado et al¹⁸ and included: Intact enamel surface, absence of prior application of chemical substances such as thymol, hydrogen peroxide, alcohol or formalin. The teeth were cleaned and preserved in distilled water at an average temperature of 4°C. A landmark was printed on the most labial projection of the vestibular surface of each tooth for later identification of the region to receive the brackets. The crowns were involved in acrylic resin (manipulated according to the manufacturer's instructions), and then pressed against a glass plate until the landmark became visible (Fig 1). In order to prevent the formation of porosities, polymerization occurred under hydrostatic pressure, inside a specific container.

After complete polymerization, the acrylic resin was worn using sandpapers (numbers 150, 400 and 600) until it was exposed the enamel surface with sufficient area for placement of an orthodontic bracket (Edgewise standard - dimensions of 3.3 mm by 3.6 mm and 0.022x0.028-in slot). The radicular



FIGURE 1 - Bovine incisor involved in acrylic resin. Vestibular landmark exposed.

portions of the teeth were included in PVC rings, filled with type IV gypsum (stone) manipulated according to the manufacturer's specifications. The teeth were positioned with their vestibular surfaces perpendicular to the base of the ring. A square template was specially constructed for this purpose (Figs 2 and 3). After gypsum crystallization, all teeth were immersed in distilled water and stored in an oven at a temperature of $37\pm 1^{\circ}\text{C}$. All test samples were equally and randomly divided into 4 groups.

Before bracket bonding, the teeth received prophylaxis with non-fluoridated pumice and rubber prophylactic cups at a low speed for 15 seconds. Then a water/air spray washed the surface for over 15 seconds. Enamel drying occurred using oil and moisture-free compressed air. The activation of the self-etching system proceeded according to the manufacturer's instructions in sufficient quantity (10 blisters) to bond 64 brackets. At the time of activation, 16 brackets of group I were bonded as follows:

- Adhesive was rubbed on the surface of each tooth for three seconds and dried with a hair dryer for the same period.

- Transbond XT was applied on bracket base following the manufacturer's recommendations. The accessories were positioned and pressed against the enamel surface. The excess of composite was removed. The polymerization occurred for 10 seconds on each side of the bracket perimeter with visible halogen light appliance (Photopolymerizer 3M - USA - 5560AF model), with intensity of $488\text{mW}/\text{cm}^2$ (measured by radiometer Demetron, model 100).

- The bracket slot was positioned perpendicular to the PVC ring (Fig 4). A template for this purpose was used.

The test samples of Group I were stored in distilled water at $37\pm 1^{\circ}\text{C}$ for 7 days. The activated blisters (containing the self-etching system) were stored inside a refrigerator at a mean temperature of 4°C for future use in groups II, III and IV.

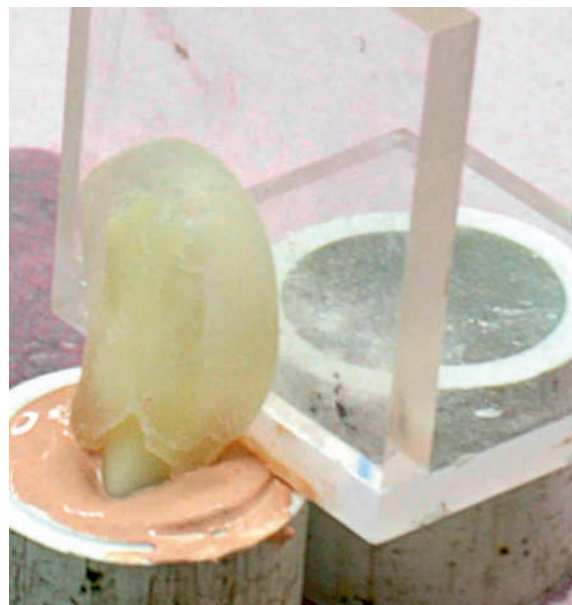


FIGURE 2 - Teeth were included in PVC rings.

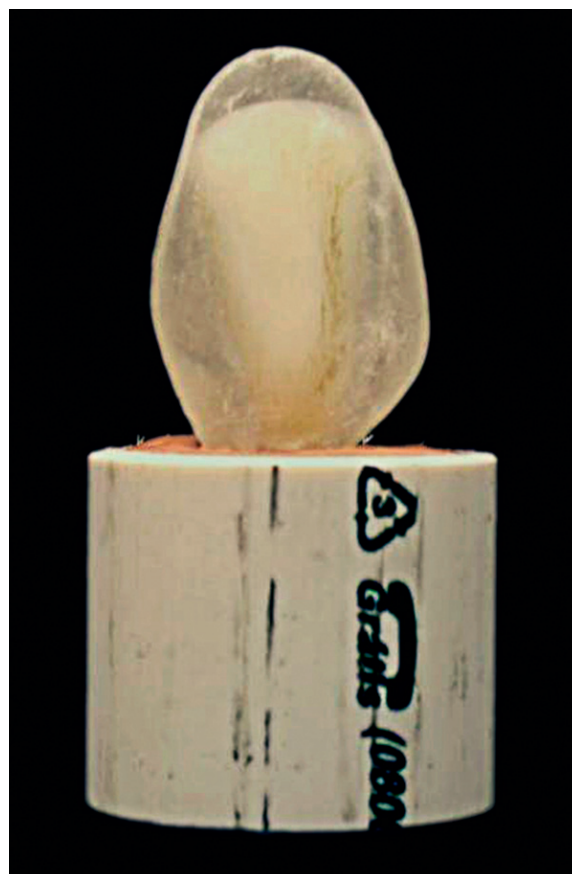


FIGURE 3 - Test sample finished.

Following the same methodology described before, 2 days after the activation of the self-etching system, 16 brackets of groups II were bonded. The 16 brackets of groups III and IV were bonded 5 and 9 days after initial activation of the blisters, respectively. All test samples of groups II, III and IV were also stored for 7 days in distilled water at a temperature of $37\pm1^{\circ}\text{C}$.

After the storage period, the shear tests were performed in an EMIC DL-10,000 testing machine of the Instituto Militar de Engenharia - RJ, Brazil, using MTest program version 1.01 (Figs 5 and 6). Non-paired t tests were used for statistical analysis.

RESULTS AND DISCUSSION

The results of shearing bond strength in Megapascal (MPa) can be visualized in Table 1, for all groups. The groups I and III presented, respectively, the smallest and the highest values of standard deviation: 2.2 and 3.56, respectively.

No statistical significant differences were observed when comparing the results of shearing

bond strength between groups I, II and III. However, a statistical significant difference can be observed when comparing these groups with group IV (Table 2).

Some studies^{9,16} suggested that bracket adhesion force should vary between 6 and 8 MPa, since these values would be sufficient to resist chewing and orthodontic forces. Other studies using this same kind of material found shearing bond strength with values ranging from 7.5 to 10.57 MPa.^{7,18} All results found in this study, including group IV, are near these values (Fig 7). The results indicate that the self-etching system could be used maintaining its characteristic of optimal shearing strength until 9 days after its activation. However, to obtain the best results using this material, the operator shall follow carefully all manufacturer's recommendations. Sponchiado et al¹⁸ stated that variations on the technique that uses the self-etching system can adversely affect shear resistance. Other factors that may affect the shear strength and should be considered are the bracket size, enamel chemical composition,¹ dental prophylaxis² and the conditions

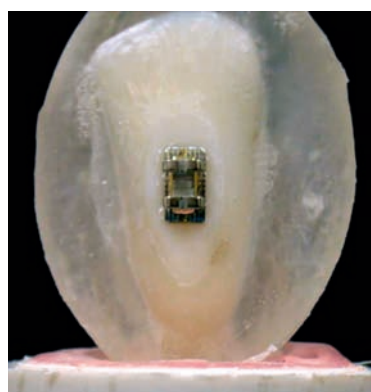


FIGURE 4 - Brackets bonded in vertical position.

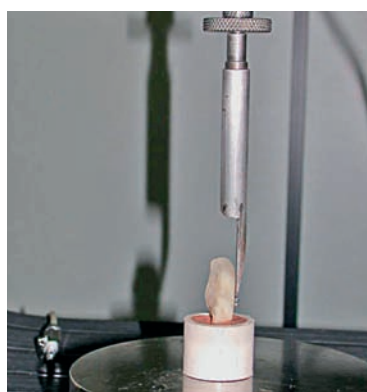


FIGURE 5, 6 - Shear bond strength tests.



TABLE 1 - Means, standard deviations, higher and lower values for shearing bond strength in groups I, II, III and IV.

Groups	Number of test samples	Shear Strength Tension (MPa)	Standard Deviation	95% confidence interval		Lower Tension (Mpa)	Higher Tension (Mpa)
				Lower	Higher		
I	16	12.33	2.20	11.15	13.50	10.01	18.14
II	16	13.12	2.95	11.55	14.70	7.40	16.75
III	16	13.92	3.56	12.02	15.82	9.11	22.10
IV	16	9.89	3.15	8.21	11.57	5.53	15.86

TABLE 2 - Comparison of shearing bond strength forces in groups I, II, III and IV. Significance $p \leq 0.05$.

Group comparison	Significance $p \leq 0.05$
G I x G II	0.3958
G I x G III	0.1404
G I x G IV	0.0168
G II x G III	0.4989
G II x G IV	0.0055
G III x G IV	0.0020

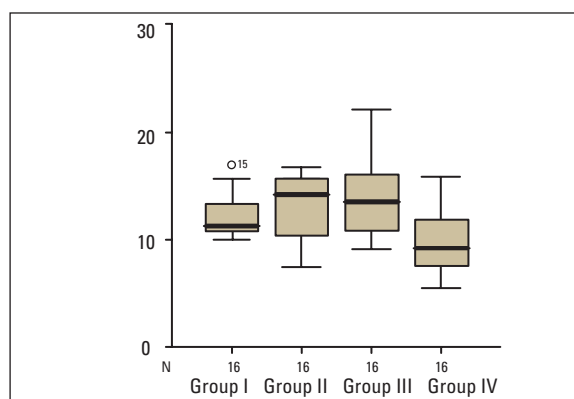


FIGURE 7 - Shear bond strength distribution in all groups.

in which the procedure was conducted.⁶ In exception of enamel chemical composition, all other factors can be controlled by the orthodontist.

Another aspect that must be considered is that bovine enamel offers different levels of adhesion, when compared to human enamel.¹¹

Besides, the manipulation, preparation and surface treatment during the experiment is crucial for reliable results.⁴ However, the use of bovine teeth in shearing bond strength studies became preferred due to its easy acquisition and histological and histochemical characteristics similar to human enamel.^{11,13,15,18}

CONCLUSIONS

Based on the results obtained in this study we can conclude that:

- » The shearing bond strength levels found in all groups were higher than the levels recommended by the literature.
- » The storage of the self-etching system for 5 days after activation at an mean temperature of 4°C seems not to affect shearing bond strength levels.
- » Compared to other groups, shearing bond strength levels presented significant statistical difference in group IV (9 days after adhesive activation).
- » New materials and technologies are daily presented. Self-etching system technique simplifies bracket bonding process without compromising its adhesion. However, it is very important to follow manufacturer's instructions to obtain best results.
- » New studies are necessary to evaluate the properties of the material when it is stored for a long period after being activated.

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GCS expansion appliance: Fixed-removable expander

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Abstract

This study describes a new fixation system for removable appliances that does not require the fabrication of clasps and is specially recommended for patients whose teeth provide little or no retention. This fixation system, called GCS, uses attachments fabricated with orthodontic buttons bonded to the teeth. It provides excellent mechanical retention, and the removable appliances, in this case an expander, can be activated as if they were fixed appliances cemented or bonded to teeth. An additional advantage is that they may be removed for cleaning and repairs, if necessary. This study also describes a GCS retention appliance that fits into the attachments and fixes the appliance in a certain position, which precludes the use of clasps and may be adapted for practically all active or retentive orthodontic devices as it combines high retentive efficiency and fabrication simplicity.

Keywords: Palatal expansion. Rapid maxillary expansion. Removable expander. Removable orthodontic appliances. Attachments.

INTRODUCTION

According to orthodontic literature, posterior crossbite is one of the most prevalent types of malocclusion in deciduous and mixed dentitions. Its prevalence ranges from 8 to 16% in children in this age group, and unilateral posterior crossbite with mandibular shift is predominant. This occlusal disharmony does not usually self-correct;

if not corrected at an early stage, it may affect the development of permanent occlusion, as well as lead to possible asymmetries and condyle displacement.^{16,17,18,22,23}

Posterior crossbite may be classified as: unilateral or bilateral; dental, due to poor axial tooth tipping, or skeletal, due to basal transverse maxillary deficiency. Therefore, removable maxillary

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expansion appliances are used to correct crossbites with dental origin or with mild skeletal discrepancy.^{6,16,21} In contrast, fixed maxillary expanders are used when the objective is to separate the intermaxillary suture, enlarge the maxillary basal bone transversally and, thus, correct crossbite with skeletal origin.^{7,8,11}

The greatest advantage of removable appliances is that they may be removed by the patient for cleaning or in accordance to the social occasion. On the other hand, its greatest disadvantages are: Possible poor patient cooperation in wearing the appliance, interrupted tooth movement, lack of appliance fitting and impossibility of applying intense (orthopedic) forces.

In fixed appliances, the pressure built due to activation of the expansion screw generates an orthopedic force that separates the midpalatal suture, and this is the greatest advantage of this appliance, together with the fact that patient cooperation is not as necessary. Among its disadvantages, the impossibility of its removal may result in poor cleaning and lead to irritation of tissues adjacent to the appliance.

Faltin Jr et al⁴ described a mixed or semi-fixed appliance for palatal expansion that has a fixed component and a removable part that fits into the acrylic plate which is cemented to the posterior maxillary teeth. According to the author, this method has the advantage of maintaining contact with the palatal surface and providing excellent retention, so that orthopedic forces may be applied for midpalatal suture expansion. Another advantage is that it may be removed for cleaning and possible relief in the palatal region, if necessary.

Removable appliances are the device of choice in the first stages of posterior crossbite correction,⁶ and the Haas expansion appliance is usually chosen when there is a skeletal maxillary constriction in the deciduous, mixed or permanent dentition, which corresponds to about 80% of the patients with posterior crossbite that affects two or more teeth.

Therefore, rapid maxillary expansion is a treatment option strongly supported in current orthodontic practice, in which the retention of the expander is important to achieve forces capable of expanding the midpalatal suture. Rapid maxillary expansion is a procedure that has been known for over a century. The first author to report it scientifically, Angell,¹ in 1860, described and used a device with a screw placed transversally to the midpalatal suture and fixed to the teeth of a 14-year-old adolescent.

Since then, several clinical and experimental studies have been described in the literature, and rapid maxillary expansion has become a common method to treat maxillary deficiencies in growing patients by applying intense orthopedic forces.^{2,5,9,10,12,13,15,19,20} These levels of force are achieved with the activation of 1/4 to 4/4 of a turn per day, because the amount of maxillary expansion and the effect of the tipping of anchorage teeth are similar in both activation protocols.

The present study describes the manufacture of the GCS expander whose main characteristic is the fact that it is a fixed and removable appliance that can receive the application of greater forces, more compatible with the purpose of obtaining orthopedic changes and that, at the same time, can be removed for cleaning. It also describes a removable appliance that uses a GCS device with a retention wire that supersedes the use of orthodontic clasps.

FABRICATION OF APPLIANCE

Before impression, the attachments are made using the round base of an orthodontic lingual button or crimped hook (30.21.104, Morelli, Sorocaba, Brazil). The active part is bent so that the device is made on a semi-spherical base of 1.4 mm height silver soldered (Figs 1A and B).

Before bonding the attachments to the lingual surfaces of the teeth that have been previously selected for this purpose these surfaces are

cleaned with a rubber cup and a prophylactic paste without fluoride. The surfaces are then rinsed and dried, relative isolation is placed, and direct bonding is performed using the same composite that orthodontists usually apply for bracket bonding. They use it according to manufacturer's instructions for operative sequence and working time.

After bonding the four attachments (two on each side) (Fig 1C), the composite excesses are removed, the working impression is produced using Coltoflax/Coltex (Coltène, Altstätten, Switzerland) and the mold is poured with type IV plaster (Fig 1D).

The expansion screw is selected according to the space available between arches and also the amount of expansion necessary. The plastic rod is removed and the screw is activated 10 times to about 2 mm opening. This previous opening is necessary so that the screw has no activation and the appliance width is reduced for the insertion and removal of the GCS expander. After initial activation, the space in the center of the screw is filled up with wax (Fig 1D) to avoid the flow of acrylic resin into this space, which would complicate finishing.

The plaster mold is isolated using Cel-lac (SS White, Rio de Janeiro, Brazil), and the screw is placed transversally over the midpalatal raphe to enable the anterior to posterior activation.

The self curing acrylic resin is prepared and placed in the plaster mold to make the palatal portion of the device, which extends to the middle of the lingual surface of all teeth (Fig 1E) and reproduces and involves all the attachments, particularly in the cervical portion, to ensure the best possible fitting and, therefore, optimal retention. Final resin curing is performed under pressure. The device is then removed from the mold for finishing and polishing.

The expander is sectioned in the anteroposterior direction using a carbide disk to produce two parts united by the expander screw. The gap between the acrylic margins should be 2 mm wide

so that the screw has no activation and the device can be closed transversally to be inserted or removed.

A relief in the acrylic should be produced in the portion that corresponds to the tip of the screw by placing a small wax ball before curing, or after that by drilling the acrylic material; this will ensure that the expander will close. The portion that is in contact with the buttons should not be drilled to ensure optimal fitting in this area.

APPLIANCE PLACEMENT

The screw must be totally deactivated because of the 1.4 mm increase in volume resulting from the bonding of buttons on the lingual surface of teeth: The first ten activations to put the expander in position should be undone.

The GCS expander is inserted first on one of the sides of the arch and fit into the attachments. After that, the opposite side is put in position and the screw is activated 10 times, so that the expander returns to its original width and fits into the attachments perfectly.

EXPANDER ACTIVATION

Activations should start in the morning after the expander placement allowing the patient to have time to adapt to its use, this way the discomfort at swallowing and speaking is reduced. Activations should be performed daily according to the same protocols used for fixed expanders, that is, 1/4 of a turn per day, or 1/4 of a turn in the morning and 1/4 in the evening, or 2/4 in the morning and 2/4 in the evening, depending on the individual sensibility of each patient. We prefer the 1/4 activation in the morning and 1/4 in the evening. The active expansion phase is completed when there is a transverse overcorrection of 2 to 3 mm.

EXPANDER REMOVAL

The GCS system allows the device to be removed daily for cleaning: Ten activations of the screw should be undone, and the device should

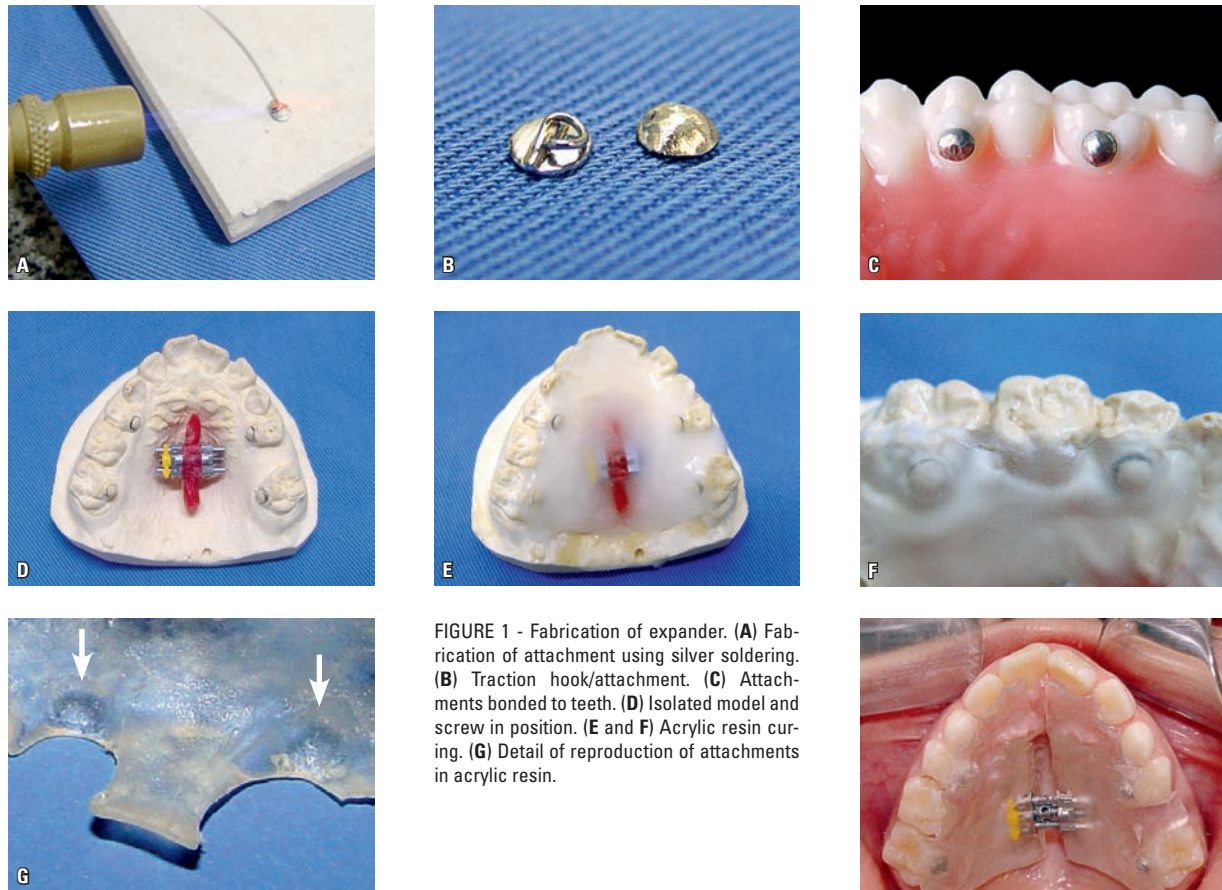


FIGURE 1 - Fabrication of expander. (A) Fabrication of attachment using silver soldering. (B) Traction hook/attachment. (C) Attachments bonded to teeth. (D) Isolated model and screw in position. (E and F) Acrylic resin curing. (G) Detail of reproduction of attachments in acrylic resin.



FIGURE 2 - Expander placement.

be removed in the occlusal direction. After the oral hygiene, the expander is repositioned and the screw activated 10 times to return to the level of opening achieved before removal. If necessary, it may be then activated 1/4 or 2/4 of a turn, according to the protocol used.

RETENTION

When the amount of desired expansion is achieved, the expander may be kept in place for retention. For that purpose, the screw is fixed with acrylic resin to avoid its closing. The acrylic material below the midline of the attachments

should be slightly drilled to ensure the device's easy insertion and removal. Another option is to make a GCS wire retainer, which provides excellent retention and is easy to remove. A new impression and working cast should be prepared to make the retention device.

Before curing, a piece of 0.024-in steel wire (55.05.560, CrNi elastic hard wire, Morelli, Sorocaba, Brazil) is fixed with wax to the cervical portion of the attachments. The ends of the wire should be included in wax to remain free after curing (Fig 3). This wire retainer works as a stop, that is, the wire deflection during insertion should

allow the passage of the device at the equator of the attachment where the retention wire will lock the device.

The model is isolated with Cel-lac (SSWhite, Rio de Janeiro, Brazil), and then the acrylic material is prepared and poured into the model to completely include the steel wire and cover the attachments. After curing, the device is trimmed and polished as usual (Fig 3D).

The GCS system provides an efficient retention, and it can only be removed if some anchoring device is used to support its removal. If the device has a Hawley archwire or a palatal crib, they may be used to help removing the retainer. Otherwise, a round clasp may be placed on one side of the appliance only to help removing it (Fig 6B).

CLINICAL CASE

Figure 4 illustrates the case of a 9-year-old girl that had functional posterior crossbite, anterior open bite and tongue interposition. A previous attempt to correct the malocclusion was not

successful because teeth provided little retention and the patient was uncooperative, as she removed the appliance for most of the day. A GCS expander was placed, and the parents were told to activate it 1/4 of a turn in the morning and 1/4 in the evening for 12 days. The expander was removed every day at night for cleaning and placed back after that. After the crossbite correction, a GCS retainer with a retention wire and palatal crib was used to avoid relapse and to correct the open bite.

Figure 5 shows an 8-year-old girl. Her clinical examination revealed bilateral posterior crossbite. A previous treatment attempt failed because the patient removed the expander for meals and forgot to place it back, in addition to removing it at night. A GCS expander with a buccal archwire was placed. The expander was activated 1/4 of a turn in the morning and 1/4 in the evening for 14 days. The expander was removed every night for cleaning and placed back after that. The incisors were separated (Fig 5E), and the radiograph showed the amount of palatal suture separation obtained (Fig 5F).

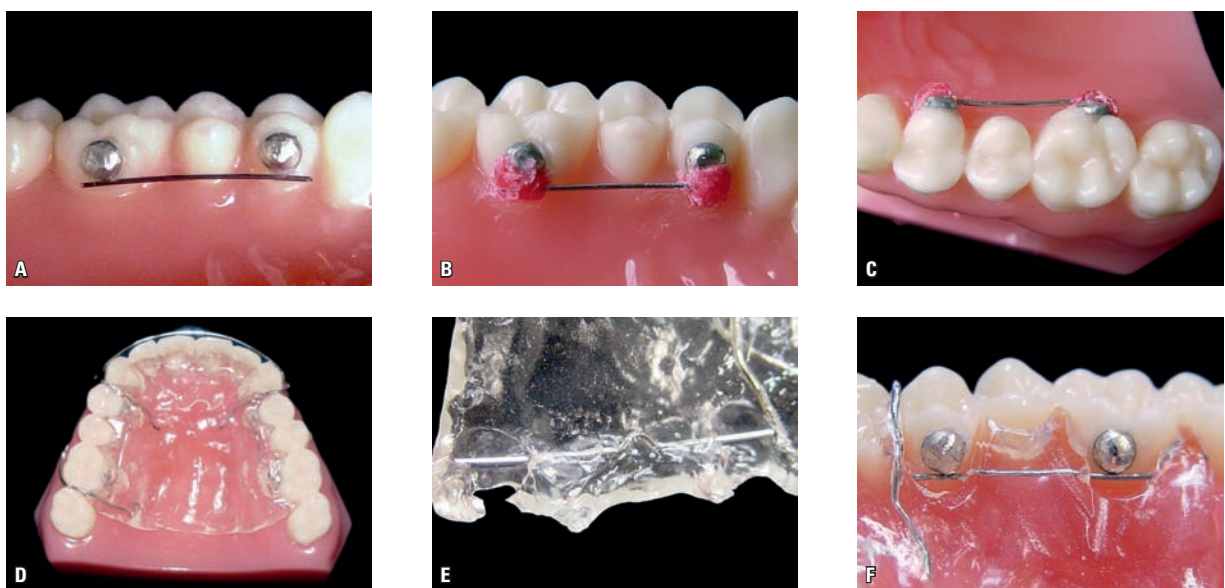


FIGURE 3 - Fabrication of retention device (A, B and C), 0.024-in steel wire positioned in attachments, wax application for wire fixation and production of space in acrylic resin for activation. (D) Retention. (E and F) Detail of attachment slot and retention wire.



FIGURE 4 - 9-year-old girl. Functional posterior crossbite, anterior open bite and tongue interposition. GCS expander placement. Activation of 1/4 of a turn in the morning and 1/4 in the evening for 12 days. GCS wire retainer and palatal crib. (A) Frontal view. (B) Occlusal view. (C) View after correction. (D) GCS retainer with palatal crib.

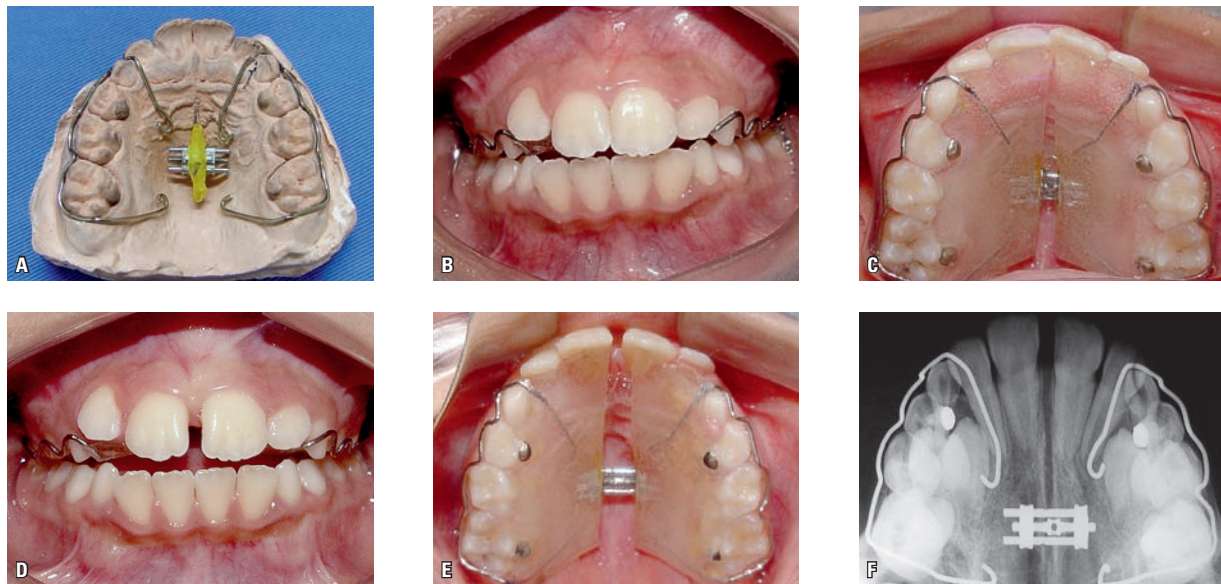


FIGURE 5 - 8-year-old girl. Placement of GCS expander with buccal archwire. Activation of 1/4 of a turn in the morning and 1/4 in the evening for 14 days. Incisors were separated; radiograph shows separation of palatal suture.

Figure 6 shows a GCS expander with indirect bonding of the attachments simultaneously with the placement of the appliance in a 8-year-old female patient that presented at the clinical examination a bilateral posterior crossbite with

little space for the correct alignment of the lateral incisors. Parents were asked to activate 1/4 of a turn at the morning and 1/4 of a turn at night for 16 days. The removal of the appliance for cleaning was performed every 2 days.

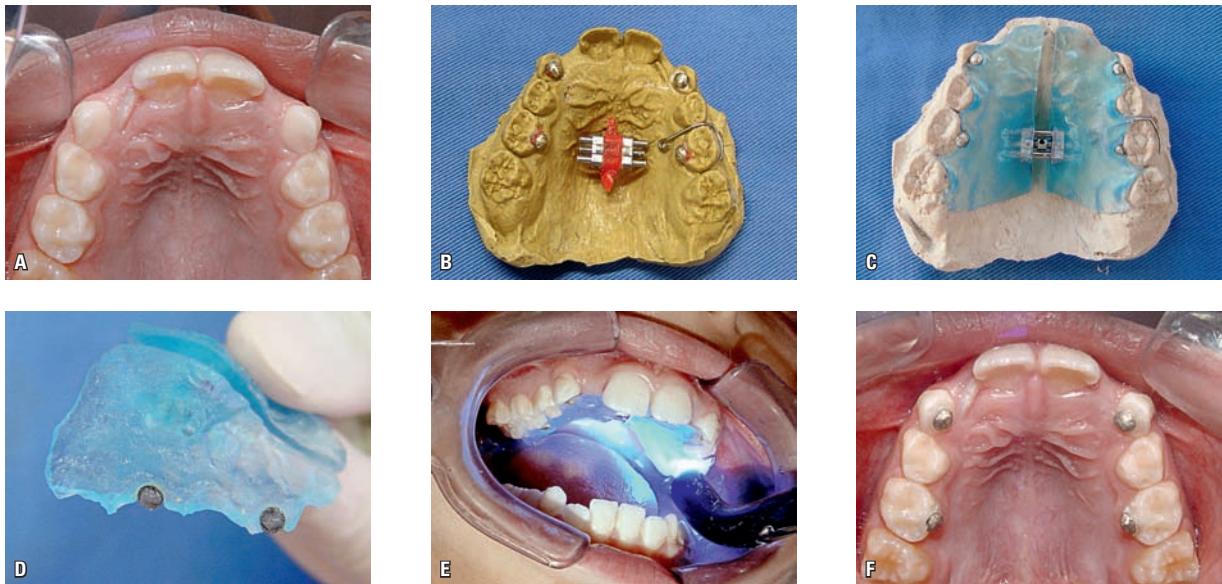


FIGURE 6 - 8-year-old girl with maxillary atresia. Fabrication of GCS expander and indirect attachment bonding. (A) Occlusal view. (B) Attachments bonded to model, pre-activated screw and clasp to help removing the appliance. (C) Expander with acrylic resin. (D) Buttons bonded to appliance with sticky wax for indirect bonding. (E) Resin light curing. (F) Attachments bonded to teeth.

FINAL CONSIDERATIONS

The GCS fixation system, both the GCS expander and the CGS retainer, was efficient in clinical practice, particularly because it provides excellent retention in all cases.

The GCS expander combines the characteristics of a fixed appliance and is practical like a removable appliance. Rapid palatal expansion may be achieved without the need of orthodontic bands. The appliance can be removed for cleaning when inactivated because of its attachments and characteristics. However, its removal is not possible at any time, as is the case with conventional removable appliances, which avoids that children, for example, remove it and don't place it back when not under their guardian's supervision, which rules

out the most common cause of poor adherence to treatment with removable appliances.

The GCS wire retainer supersedes any type of orthodontic clasps, particularly in cases of teeth that provide little or no retention, such as in deciduous and mixed dentitions. In some cases, only two attachments provide retention similar to that provided by a Hawley retainer.

The fabrication of GCS appliances takes less laboratory time and simplifies the production of orthodontic devices. Attachments may be previously made by the orthodontist, but we believe that, as this technique becomes popular, soon they will be produced and sold as orthodontic accessories by the companies that operate in this market.

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Association between malpositioned teeth and periodontal disease

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Abstract

Objective: To identify malpositioned teeth in patients referred to periodontal treatment in the Brazilian Association of Dentistry, Pernambuco Division and evaluate the association of these irregularities with periodontal health. **Methods:** The sample comprised 90 individuals aged 15 to 69 years. First, each participant was examined to identify the types of abnormal tooth positions by means of visual inspection. After that, their periodontal health was assessed according to the following clinical parameters: Gingival bleeding on probing, periodontal attachment loss, and probing depth. In bivariate analysis, a chi-square test was used to calculate significance of the associations. **Results:** Several types of changes in tooth position were detected in the participants, and the most significant were: Rotated teeth (86.7%); crowding (52.2%); and mesially tipped molar (48.9%). All participants had periodontal changes associated with these abnormalities: 100% had gingival bleeding; 67.8%, gingival recession; 54.4%, gingival enlargement; and 28.9%, chronic periodontitis. There were significant associations between gingival recession and the variables buccally tipped tooth and excessive proclination of maxillary incisors, and also between chronic periodontitis and mesially tipped molar, crowding, excessive proclination of maxillary and mandibular incisors, and diastema ($p < 0.05$). The need of multidisciplinary treatment was clear in all the cases. **Conclusions:** Malpositioned teeth negatively affected the health of periodontal tissues, which draws attention to the importance of a multidisciplinary approach that includes, primarily, periodontal and orthodontic care to improve the oral health of patients.

Keywords: Malpositioned teeth. Periodontal health. Orthodontic treatment.

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INTRODUCTION

The diagnostic combination of periodontics and orthodontics should be a usual practice in dental clinics, particularly among specialists. Early diagnoses of any type of abnormal tooth position provide information to direct treatment and, therefore, prevent periodontal diseases. Orthodontic treatments, as part of periodontal rehabilitation programs, may bring benefits, such as the improvement of access for dental hygiene, reestablishment of occlusal balance, and even adequate lip sealing. Orthodontics acts in the tooth repositioning and presents a close relationship with the periodontal tissues, both because its execution manner as for the results achieved, reducing the possibility of tooth loss and gingival infections caused by tooth malpositioning.

Of the several pathologies that affect the oral cavity, malocclusion is the third most important problem in the world population. Abnormal tooth positions may already be present in the deciduous dentition. Therefore, dental care professionals, such as pediatric dentists and orthodontists, should act preventively to ensure correct tooth positioning and to avoid or reduce malocclusion that may perpetuate in the mixed and permanent dentitions.^{3,5,6,12,13,18,25} This is clearly illustrated in Figure 1.

Malocclusion alone does not result in periodontal disease.^{1,2} Studies with children, adolescents and young adults evaluated the effects of several

types of malocclusion, as well as of isolated malpositioned teeth, on clinically healthy periodontal tissues. Results showed that most individuals had deficient oral hygiene and consequent accumulation of bacterial plaque, which may cause, in some cases, gingival inflammation, the most common periodontal problem. However, other individuals may have no periodontal changes (Fig 2). Those studies also revealed the importance of oral hygiene instructions and referral to orthodontic treatment as preventive measures. When the periodontium has already been affected, its response is different and, in addition to the physiological response to the accumulation of bacterial plaque, each individual's genetic susceptibility may affect the chances of an increase in disease severity, which is always positive.^{1,2,7,9,14,21-24,26-29}

All types of tooth malposition, such as diastemas, crowding, rotated teeth, incisor proclination and mandibular molar tipping, may result in early tooth loss due to the formation of periodontal pockets on the mesial surface of the tooth involved, because the bone crest tends to follow the cemento-enamel junction.¹⁵ When any type of malposition is diagnosed, teeth should be aligned to redirect occlusal forces that act along the tooth axis and are harmoniously distributed and to rule out occlusal trauma, which may affect periodontal health.^{15,20} According to Freitas et al,¹⁰ mandibular second molar movement enables easier oral hygiene in the mesial re-



FIGURE 1 - Clinical aspect of malocclusion in mixed dentition, with emphasis on tooth 41 proclined and with gingival recession.



FIGURE 2 - Young adult patient with malpositioned teeth and gingival hyperplasia.

gion of the tooth and eliminates the pathological periodontal environment, corrects the proximal bone defect, improves the crown/root ratio and prevents occlusal trauma. In the anterior teeth, excessive mandibular incisor proclination is a frequent cause of gingival recession.²⁹

Because of scientific and technological advances in orthodontics, the use of appliances with accurate control of the forces applied and the improved preparation of dental care workers for the correction of anomalies in tooth position, orthodontic treatments are no longer exclusively prescribed for children and adolescents. Adult patients may undergo orthodontic treatment primarily due to esthetic considerations, although dental care workers may stress the functional results of this type of treatment.^{4,9} Moreover, patients with periodontal disease or treatment sequelae should also undergo orthodontic interventions. Several authors pointed out the importance of a multidisciplinary treatment approach, combining orthodontics, periodontics, restorative dentistry, prosthetic dentistry and implant dentistry, to respond to all patient needs.^{4,8,9,11,17,19}

This study identified the types of tooth position anomalies in patients attended in an outpatient service and referred to periodontal treatment in the public healthcare system and investigated whether these anomalies were pathologically associated with periodontal health.

METHODS

One hundred and fifty adult men and women took part in the sample selection process. They had all been referred to treatment in the outpatient service of the Specialization Course in Periodontics of the Brazilian Association of Dentistry, Pernambuco Division, by professionals in the public healthcare system of the city of Recife, Brazil. All patients received written and oral information about the objective of the study, and all signed an informed consent term prepared according to the guidelines established in Directive #196/96

of the Brazilian National Health Council. This study was approved by the Ethics Committee of University of Pernambuco under number 03/05, SISNEP 065782. Visual inspection excluded individuals that had no malpositioned teeth, had orthodontic appliances or any systemic disease, or were taking any type of medication, as well as smokers, ex-smokers and mouth breathers. After checking these criteria, a convenience sample of 90 patients, aged 15 to 69 years, was selected. A clinical form was used to record, for each patient, the type of tooth malposition. Immediately after that, a periodontal diagnosis was made using the index made up of results of gingival bleeding on probing (marginal), probing depth and, by means of visual inspection, presence or absence of attachment loss (gingival recession) according to the parameter of whether the cemento-enamel junction was exposed.

All participants were examined by only one examiner previously trained and calibrated.

Data were analyzed according to univariate and bivariate analyses and described as absolute and percentage distributions of the variables in a nominal scale of descriptive statistical measures: minimum and maximum values, mean, standard deviation, and variation coefficient. A chi-square test was used for analyses and, when the conditions for its use were not met, the Fisher exact test was used. The level of significance was set at 5.0%.

RESULTS

Age of the 90 patients ranged from 15 to 69 years, and mean age was 28.18 years; 60% were women.

Table 1 shows the results of type of tooth position anomalies found in the study sample. One single patient might have one or more teeth with position anomalies. The most prevalent anomalies affected patients with rotated teeth (86.7%), crowding (52%) and mesially tipped molar (48.9%)

The distribution of periodontal changes seen

in Table 2, in which one patient might have one or more periodontal problem, shows that 100% of the patients had chronic marginal gingivitis defined by gingival bleeding on probing (Figs 3A and 3B), 28.9% had chronic periodontitis at different degrees of severity, 67.8%, teeth with gingival recession, and 54.4%, areas of gingival enlargement.

Table 3 shows the results of the analysis of malpositioned teeth and their association with teeth with or without gingival recession. Of all types of abnormalities found in the study sample and listed in Table 1, only isolated buccally tipped teeth and excessive maxillary incisor proclination had a significant association with gingival recession ($p<0.05$). These clinical findings

can be seen in Figure 4.

The association between chronic periodontitis and tooth malposition is described in Table 4. The greatest percentage differences for patients with chronic periodontitis were found among those that had a buccally tipped molar, excessive proclination of maxillary incisors, excessive proclination of mandibular incisors, crowding, generalized spacing between teeth or diastemas, which confirms the significant association between these variables and chronic periodontitis ($p<0.05$) (Fig 5).

The analysis of need of periodontal treatment in the study sample revealed that 100% of the patients should undergo basic periodontal treatment (oral hygiene instructions, scaling and root planing),

TABLE 1 - Distribution of types of tooth position anomalies.

Tooth position anomalies	Yes n (%)	No n (%)	Total n (%)
Mesially tipped molar	44 (48.9)	46 (51.1)	90 (100.0)
Isolated buccally tipped tooth	24 (26.7)	66 (73.3)	90 (100.0)
Crowding	47 (52.2)	43 (47.8)	90 (100.0)
Maxillary incisor proclination	20 (22.2)	70 (77.8)	90 (100.0)
Mandibular incisor proclination	16 (17.8)	74 (82.2)	90 (100.0)
Generalized spacing	25 (27.8)	67 (72.2)	90 (100.0)
Diastema	26 (28.9)	64 (71.1)	90 (100.0)
Rotated teeth	78 (86.7)	12 (13.3)	90 (100.0)

TABLE 2 - Distribution of pathological periodontal changes.

Periodontal Changes	Yes n (%)	No n (%)	Total n (%)
Mesially tipped molar	90 (100.0)	-	90 (100.0)
Isolated buccally tipped tooth	61 (67.8)	29 (32.2)	90 (100.0)
Crowding	49 (54.4)	41 (45.6)	90 (100.0)
Maxillary incisor proclination	26 (28.9)	64 (71.1)	90 (100.0)

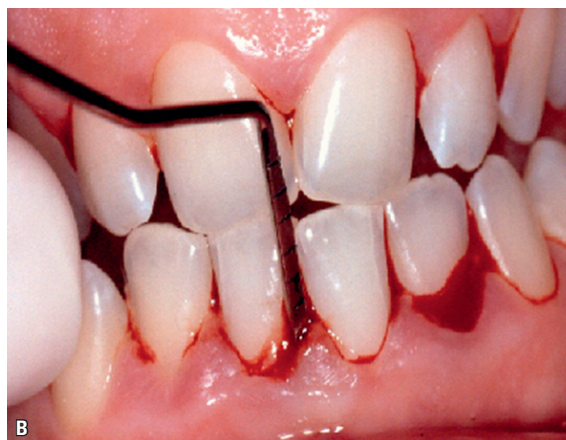


FIGURE 3 - Malpositioned teeth, gingival inflammation and gingival bleeding after marginal probing.

TABLE 3 - Percentage of patients with gingival recession according to types of tooth position anomalies that presented statistical significance.

Periodontal changes	Gingival recession			p
	Yes	No	Total	
	n (%)	n (%)	n (%)	
Buccally tipped tooth				$p^{(1)} = 0.0035^*$
Yes	22 (91.7)	2 (8.3)	24 (100)	
No	39 (59.1)	27 (40.9)	66 (100)	
Total	61 (67.8)	29 (32.2)	90 (100)	
Maxillary incisor proclination				$p^{(1)} = 0.0159^*$
Yes	18 (90.0)	2 (10.0)	20 (100)	
No	43 (61.4)	27 (38.6)	70 (100)	
Total	61 (67.8)	29 (32.2)	90 (100)	

(*) – significant association at the level of 5.0%.

(1) – chi-square test.



FIGURE 4 - Proclined lower tooth and gingival recession in adult patient with gingivitis and periodontitis.



FIGURE 5 - Malpositioned teeth in a patient with periodontitis.

TABLE 4 - Percentage of patients with chronic periodontitis according to types of tooth position anomalies.

Periodontal changes	Chronic periodontitis			p
	Yes	No	Total	
	n (%)	n (%)	n (%)	
Mesially tipped molar				$p^{(1)} = 0.0139^*$
Yes	18 (40.9)	26 (59.1)	44 (100)	
No	8 (17.4)	38 (82.6)	46 (100)	
Total	26 (28.9)	64 (71.1)	90 (100)	
Maxillary incisor proclination				$p^{(1)} = 0.0182^*$
Yes	10 (50.0)	10 (50.0)	20 (100)	
No	16 (22.9)	54 (77.1)	70 (100)	
Total	26 (28.9)	64 (71.1)	90 (100)	
Crowding				$p^{(1)} = 0.0004^*$
Yes	6 (12.8)	41 (87.2)	47 (100)	
No	20 (46.5)	23 (53.5)	43 (100)	
Total	26 (28.9)	64 (71.1)	90 (100)	
Mandibular incisor proclination				$p^{(1)} = 0.0022^*$
Yes	10 (62.5)	6 (37.5)	(100)	
No	16 (21.6)	58 (78.4)	(100)	
Total	26 (28.9)	64 (71.1)	90 (100)	
Spacing				$p^{(1)} = 0.0001^*$
Yes	17 (68.0)	8 (32.0)	(100)	
No	9 (13.8)	56 (86.2)	(100)	
Total	26 (28.9)	64 (71.1)	90 (100)	
Diastema				$p^{(1)} = 0.0049^*$
Yes	13 (50.0)	13 (50.0)	(100)	
No	13 (20.3)	51 (79.7)	(100)	
Total	26 (28.9)	64 (71.1)	90 (100)	

(*) = significant association at the level of 5.0%.

(1) = chi-square test.

TABLE 5 - Percentage of patients that needed periodontal or orthodontic treatment.

Treatment	Yes	No	Total
	n (%)	n (%)	n (%)
Basic periodontal treatment	90 (100.0)	-	90 (100.0)
Periodontal surgery	40 (44.4)	50 (55.4)	90 (100.0)
Minor orthodontic movement	60 (66.7)	30 (33.3)	90 (100.0)
Full orthodontic treatment	30 (33.3)	60 (66.7)	90 (100.0)

whereas 44.4% should also undergo surgery after those procedures. The analysis of need of orthodontic treatment revealed that 66.7% of the patients needed minor movement of malpositioned teeth, and 33.3% should undergo complete orthodontic treatments.

DISCUSSION

The results of this study confirmed that the diagnostic and therapeutic interrelation between orthodontics and periodontics is a consensus in the literature.^{7,8,10,13} Clinical periodontal health is essential for the success of any type of orthodontic treatment, in the same way that orthodontic correction should not result in damage to periodontal tissues. Therefore, dental care professionals should combine their efforts and act according to a pre-determined treatment plan for each patient.

Few studies in the literature investigated the interrelation between irregular tooth positioning and malocclusion with periodontal health in groups of adult patients. Most studies focused on children and adolescents. Our study examined patients referred to periodontal treatment and evaluated malpositioned teeth and their possible effects on periodontal tissues. Data showed that there were pathological periodontal changes associated with orthodontic anomalies, which corroborates previous findings.^{1,2,7,8,14}

Although the main etiological factor of periodontal disease is the bacterial plaque, other factors are usually associated and may lead to changes in host responses. Of these factors, malpositioned teeth are predisposing factors because oral hygiene becomes more difficult, bacterial plaque is retained and accumulates and, therefore, proliferates and leads to pathological periodontal changes. Our results contribute to the literature, as all patients that had malpositioned teeth also had some type of periodontal disease, such as chronic marginal gingivitis, gingival enlargement, gingival recession and chronic periodontitis in several degrees of severity. However, this predisposition does not

invariably lead to the development of periodontal disease, particularly in cases when there is regular follow-up by a dentist that gives instructions to patients about the correct oral hygiene procedures for their current anatomic condition.^{1,2,7,14,21-24,26}

Malocclusions, etiologically associated with several factors, such as poor tooth positioning, are sometimes detected in children and adolescents as a warning sign for early correction.^{17,22} Their prevalence is significant in the world population, regardless of the socioeconomic development of countries such as, for example, Brazil. It is classified as a public health problem, as clearly reported by Bello³ in 2004. However, in routine clinical practice, tooth malpositioning is often overlooked at the phase of early detection of dental problems, and teeth keep this preexisting condition until adulthood. Data from other studies are in agreement with our findings, and patients invariably report that tooth malpositions never received attention from specialists. Therefore, dental care professionals should make therapeutic decisions as early as in the first visit of a child or adolescent.^{5,6,12,13,18,25,27}

Occlusion trauma that results from tooth malpositioning in cases, for example, of excessive mandibular incisor proclination, is a destructive factor for the tissues that support the periodontium. In this study, it was significantly associated with gingival recession, a pathological condition found in a high percentage of patients in our sample, and as a co-destructive factor when associated with preexisting periodontal disease, leading to greater mobility of affected teeth, which was confirmed in the patients that had chronic periodontitis, and in agreement with findings described by Gutiérrez Izquierdo, Martínez Pérez¹⁴ and Vanzin et al.²⁹

Our study showed that all patients in the study sample needed basic or surgical periodontal treatment. It also demonstrated that a misaligned tooth in the dental arch may produce a disease or change the intensity of a previous disease, which may be the result of no specific dental care and poor instructions about controlled oral hygiene.

Another remarkable finding was that all patients needed some type of orthodontic intervention, either some minor tooth alignment or full orthodontic treatment. Moreover, several patients also needed other types of dental procedures, which draws attention to the need of a multidisciplinary approach and corroborates findings reported in studies that focused on treatment combinations. Orthodontic follow-up should be prescribed to patients that have attachment loss due to disease severity and periodontal treatment.^{4,8,9,11,17,19}

CONCLUSIONS

Various types of tooth position anomalies were found in this study sample, and they were significantly associated with periodontal changes, such as chronic marginal gingivitis, gingival enlargement, gingival recession and chronic periodontitis. Patients needed basic and surgical periodontal treatments, as well as orthodontic treatments. Therefore, the role of orthodontics and periodontics in the correction of tooth position should lead to improvements in oral health.

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Effects of low intensity laser on pain sensitivity during orthodontic movement

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Abstract

Objective: To evaluate the efficiency of infrared diode laser on pain reduction during canine initial retraction. **Methods:** Twelve patients in need of canine retraction were selected. The canines were retracted with closed NiTi coil springs activated to 150 g per side. One canine of each patient was randomly selected for laser irradiation immediately after activation and after 3 and 7 days. The contralateral canines were taken as control group and were submitted only to simulation of laser application. Diode laser (ArGaAl) was employed at wavelength of 780 nm, power of 20 mW and energy density in the target tissue of 5 J/cm², for 10 seconds per point, delivering an energy of 0.2 J per point and total energy (TE) of 2 J. The analgesic effect was evaluated with aid of a visual analogue scale (VAS), on which the patients indicated 0 to 10 according to the pain experienced at 12, 24, 48 and 72 hours after coil spring activation and laser application. The procedure was repeated after one month, upon reactivation of canine retraction. **Results and Conclusions:** There was no statistically significant difference between irradiated side (LG) and control side (CG). Thus, utilization of infrared diode laser (780 nm) according to the present protocol was not statistically effective to reduce pain sensitivity caused by orthodontic movement.

Keywords: Diode laser. Low intensity laser. Orthodontic movement. Pain.

INTRODUCTION AND LITERATURE REVIEW

In clinical practice, there is almost a consensus that therapy with low level laser (LLL) or laser therapy (LT) causes analgesic effect.^{3,10,13,15,19,24}

Thus, laser could become an important aid for orthodontic treatment^{6,9,13,14,20} since fear of feeling pain is one of the main factors which discourages many patients to undergo this kind of treatment.^{1,4,25}

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Low level laser reduces pain through two different mechanisms: Stimulating the production of beta-endorfine, a natural mediator produced by the organism to reduce pain, and inhibiting the release of arachidonic acid, from the damaged cells, which would generate metabolites that interact with the pain receptors. While arachidonic acid produces local effect, beta-endorfine produces analgesic effect throughout the body.^{17,18} Another type of laser action on the mechanisms for suppressing pain, consists in the repression of the conduction of nervous impulses, at the peripheral nerve endings, acting upon the mechanism of “sodium-potassium pump”, in order to impair the transmission of local painful impulse.¹²

Other mechanisms of pain suppression by the employment of laser therapy have been reported in the literature, as consequence of the enhancement of endorphin synthesis, demonstrated by Benedicenti in 1982 (apud Genovese⁸), or even the inhibition of prostaglandins E_2 (PG- E_2) and interleukine 1- β (IL-1 β),²³ well-known pain mediators, produced during the inflammatory process. Ataka² observed a decrease of nociceptive transmitters, such as bradykinin and serotonin, after low level laser irradiation. The nociceptors are the receptors present on the nervous terminals, free nerve endings of primary afferent neuron axon (thin myelinated A-delta fibers and unmyelinated C-fibers), capable to detect painful stimuli when the nociceptive transmitters are present.¹⁶

Some clinical research studies have also demonstrated the efficiency of laser to suppress pain.^{5,11,13,22,24} Lim et al¹³ in 1995, inserted elastic separators to induce pain in the interproximal contacts of premolars of 39 subjects. The diode laser (ALGaAs), 830 nm, 30 mW, 59.7 mW/cm², was applied on the middle third of the dental root and the subjects were divided into four groups: Three of them in accordance to the different periods of

laser application (15, 30 and 60 seconds) and one group with placebo laser therapy for 30 seconds. The procedure was performed during five days and a scale was employed to quantify the pain experimented in each quadrant (Visual Analogue Scale –VAS). The authors concluded that the group treated with laser, demonstrated lower levels of pain, when compared to the placebo group, suggesting that low level laser reduces the intensity of pain caused by orthodontic movement.

Turhani et al²³ evaluated the effect of diode laser (670 nm; 75 mW; 30 seconds per tooth) in 38 patients undergoing orthodontic treatment, with fixed appliances. The laser was immediately applied over the middle third of the teeth and also after 6, 30, and 54 hours after insertion of the orthodontic arches. A control group received placebo laser therapy only. The results showed lower levels of pain for the group that received laser irradiation until 30 hours after the orthodontic activation. The authors concluded that laser therapy may have positive effects suppressing pain during orthodontic treatment.

Recently, Fujiyama et al⁷ showed that the use of CO₂ laser seems to be efficient to control inhibitory effects on analgesia during the four first days, after force application, without interference on the amount of orthodontic movement, when 20 pulses of 2 W, 5 pulses per 1000 seconds, were applied at 2 mm focus.

It appears that there are still few studies which investigated the effects of low level laser for suppressing pain in orthodontics, and the protocols for laser application are still very variable. Thus, the purpose of this study was to evaluate the efficiency of diode laser, which presented wavelength at the infra-red spectrum ($\lambda=780$ nm, power output of 20 mW, with energy density 5 J/cm², 0,2 J of energy per point, 2 J total energy, submitted to orthodontic retraction, aiming to verify pain reduction during orthodontic movement.

MATERIAL AND METHODS

Material

A total of 12 patients were selected, from the Postgraduation in Orthodontics of the Brazilian Association of Dental Surgeons (ABCD, São Paulo, Brazil), with mean age of 12.66 years. The inclusion criteria were:

- » need of extraction of first premolars, due to double protrusion or dental crowding;
- » presence of permanent dentition;
- » absence of systemic diseases;
- » no use of any medication and no previous orthodontic treatment.

The diode laser (Twin Laser, MMOptics, São Paulo, Brazil) was employed to irradiate maxillary and mandibular canines, submitted to orthodontic retraction, and the painful sensitivity decurrent from this orthodontic movement was evaluated by a visual scale (Visual Analogue Scale – VAS).¹³

This protocol was approved by the Research Ethics Committee at the São Paulo Methodist University, protocol n° 105303/06.

Methods

Orthodontic treatment

Metallic brackets, Andrews prescription, 0.022 x 0.028-in slot (Ormco Corp. Orange, CA, USA), were installed on canines and second premolars, while the first molars were properly banded. Bilaterally, segmented stainless steel 0.016-in archwires were adapted to each side of the dental arch, in conjunction with a closed nickel-titanium spring (12 mm in length, Morelli Ltda, Brazil) for the initial retraction of the canines (right and left). The intensity of the force released by the spring was measured by a dynamometer (Morelli Ltda), delivering force of 150 g.

Laser irradiation and evaluation of pain sensitivity

After the activation of the spring, only one of the canines (left or right) of each patient was

selected at random for application of diode laser Aluminum-Gallium-Arsenide (ArGaAl), low intensity, wavelength in the infra-red spectrum. For the canines on the opposite side, only one simulation was performed for laser application. The irradiated side was considered as laser group (LG) and the non irradiated side, as control group (CG).

The diode laser (Twin Laser, MMOptics, São Carlos, Brazil), with light emission at 780 nm wavelength, power output 20 mW, energy density on the surface tissue at 5 J/cm², was employed for 10 seconds per point, resulting in 0,2 J of energy per point. As 10 points per tooth (5 buccally and 5 lingually) received irradiation (Fig 1), the total energy (TE) surrounding canine roots was 2 J. The irradiations were performed by one operator, per points, employing light beam focused perpendicularly and in contact with the mucosa, which was kept clean and dry, through relative isolation.

Laser irradiation was performed immediately after the closed NiTi coil spring was activated (day 0), 3 and 7 days after the first application, resulting in 6 J/month of energy. The evaluation of the analgesic effect of laser irradiation was performed by the employment of a visual scale (Visual Analogue Scale – VAS)¹³ provided

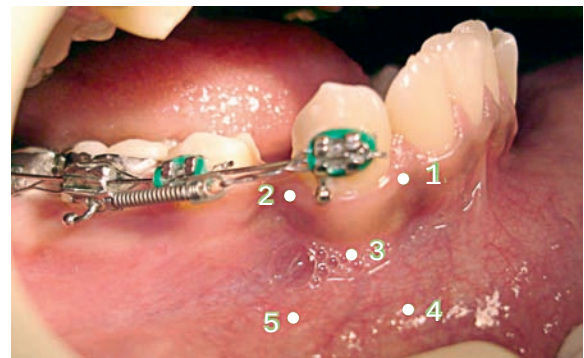


FIGURE 1 - Points for laser application at the buccal surface: 1) mesiobuccal gingival ridge; 2) distobuccal gingival ridge; 3) buccal central point - central in relation to the other points; 4) bottom of oral vestibule, at the same vertical direction of point 1, and at the level of the root apex; 5) Bottom of oral vestibule, at the same vertical direction of point 2, and at the level of the root apex. The same points were selected for lingual application, totaling 10 points.

to each patient (Fig 2). According to this scale, the patient was oriented to mark from 0 to 10, according to the intensity of pain experimented, differentiating the left and right sides, after 12 (T1), 24 (T2), 48 (T3) and 72 (T4) hours of laser irradiation.

After 30 days, the patients were submitted to a new activation of the closed springs, in order to keep the force exertion at 150 g/side, previously established. A new laser irradiation, following the same protocol, was performed on the same tooth which had been already irradiated, and one more time, the sensitivity was evaluated on the four periods described, employing the same scale. The outcomes were computed into an Excel table, for statistical analysis.

Statistical analysis

For comparison between the “irradiated” and “non-irradiated” sides, over several periods of evaluation, the parametric Wilcoxon test was employed ($p < 0.05$).

RESULTS

Tables 1 and 2 show the outcomes obtained on the first and second months, respectively, in the four evaluated moments (T1=12 h, T2=24 h, T3=48 h and T4=72 h) after laser application on the irradiated and non-irradiated sides.

The results presented on the first and on the second months, demonstrated that there is no statistically significant difference between the irradiated and control sides, that is, the irradiation employing infra-red diode laser (780 nm) with the application protocol of 20 mW-10 sec-5J/cm², 0,2 J per point, Et=2 J, was not statistically significant for the reduction of sensitivity to pain, caused by orthodontic movement during the initial retraction of canines.

DISCUSSION

In the literature, it is clear that almost all patients submitted to fixed orthodontic treatment suffer some type of discomfort, considering the separation of teeth for posterior orthodontic banding or during the arch insertion, reaching

EVALUATION OF PAIN AFTER SPRING ACTIVATION One form for each arch- mark X for the level of pain																															
Name: _____																															
Date of irradiation: ____/____/____																															
right side											12 hours after										left side										
0 1 2 3 4 5 6 7 8 9 10											0 1 2 3 4 5 6 7 8 9 10										0 1 2 3 4 5 6 7 8 9 10										
right side											1 day after (24 hours)										left side										
0 1 2 3 4 5 6 7 8 9 10											0 1 2 3 4 5 6 7 8 9 10										0 1 2 3 4 5 6 7 8 9 10										
right side											2 days after (48 hours)										left side										
0 1 2 3 4 5 6 7 8 9 10											0 1 2 3 4 5 6 7 8 9 10										0 1 2 3 4 5 6 7 8 9 10										
right side											3 days after (72 hours)										left side										
0 1 2 3 4 5 6 7 8 9 10											0 1 2 3 4 5 6 7 8 9 10										0 1 2 3 4 5 6 7 8 9 10										

FIGURE 2 - Visual Analogue Scale (VAS).

TABLE 1 - Outcomes obtained on the first month, during the four moments (T1=12 h, T2=24 h, T3=48 h and T4=72 h) after laser application on the irradiated and non-irradiated sides.

Time	Side	mean	median	1 st quartile	3 rd quartile	P
12 h	LG	3.8	3.5	2.0	4.5	0.173
	CG	4.2	4.0	2.5	5.0	ns
24 h	LG	4.0	4.0	1.0	7.0	0.624
	CG	3.9	3.5	1.5	5.5	ns
48 h	LG	1.9	2.0	0.5	3.0	1.000
	CG	1.8	1.0	0.5	3.0	ns
72 h	LG	0.3	0.0	0.0	0.0	1.000
	CG	0.3	0.0	0.0	0.0	ns

ns – not statistically significant.

TABLE 2 - Comparison of the values obtained, referring to pain intensity, between the sides irradiated and control, on the second month of treatment (Wilcoxon test).

Time	Side	mean	median	1 st quartile	3 rd quartile	P
12 h	LG	3.5	3.5	1.0	4.0	0.787
	CG	3.8	3.5	1.0	7.0	ns
24 h	LG	3.2	3.0	1.0	4.0	0.109
	CG	3.6	4.0	1.0	5.0	ns
48 h	LG	1.9	1.5	1.0	3.0	0.789
	CG	1.8	1.0	1.0	2.0	ns
72 h	LG	0.8	0.5	0.0	1.0	1.000
	CG	0.6	0.5	0.0	1.0	ns

ns – not statistically significant.

levels of pain which may also discourage them to continue the treatment, or even giving up at the beginning of the process.^{13,24,25}

The perception of pain varies considerably from patient to patient.²⁰ Thus, pain is a highly subjective sensation and due to this fact, it becomes very difficult to quantify it in scientific researches.^{13,20,24}

The Visual Analogue Scale (VAS) was proposed by Huskisson in 1974 in order to quantify pain.²⁰ It is a 10 cm line which comprehends a scale from 0 to 10 representing the thresholds of pain experimented, so that 0 represents absence of pain and 10 intense pain. For employing it, the patients are oriented to mark on the line the site correspondent to the intensity of pain experimented by them.²⁰

The VAS has been employed by several authors^{13,20} who affirm that this method is reliable, safe and easy to comprehend. Although being a subjective method, it is also employed with five-year-old children, who get used to it very easily.²⁰ Due to this fact, the VAS was adopted to quantify pain in the present study. In order to facilitate the measurement of pain sensitivity, the line was substituted by a scale^{13,20} where the patients should mark an “X” on the score from 0 to 10 according to Figure 2.

The patients were oriented to mark the pain at 12, 24, 48 and 72 hours after the orthodontic activation, either on the right and left sides, and to prevent bias on the outcomes, one laser irradiation was simulated on the contra-lateral side (placebo).

Normally, pain during orthodontic treatment is noticeable, mainly on the first three days, reaching its maximum level in 24 hours, and decreasing after the third day of activation.^{20,22,24} These data are according with the present study, and a higher average of pain can be observed on the periods of 12 and 24 hours after orthodontic activation, decreasing considerably after 48 and 72 hours of orthodontic activation.

Due to discomfort caused by pain during orthodontic treatment, several ways of minimizing it were proposed in the literature. The main way consists on the employment of analgesic and anti-inflammatory medication. However, studies have shown, that, besides the side effects inherent to medicine, dental movement may be inhibited by the administration of non-steroidal anti-inflammatory drugs.^{1,4,13} Thus, laser therapy has been subject of many speculations concerning pain inhibition, because there are few contra indications and no side effects.^{3,10,19}

Researchers and clinicians who employ this

resource during daily practice, confirm that laser therapy inhibits pain, totally or partially.^{5,8,10,13,17,18,20} Nevertheless in the literature the application protocols still generate some controversy, because different dosimetry can be found for the same procedure. In orthodontics, for pain treatment, employing laser Aluminum-Gallium-Arsenide diode laser, Neves et al¹⁹ suggested energy density of 2 J/cm² on the root tip and three points along the axis of the root with energy density of 1 J/cm², applying frequency of application once or twice a week. Genovese⁸ indicated the application of 4 J/cm² on the upper teeth and 5 J/cm² for the lower teeth, in two or three points, following the long axis of the roots.

In order to compare laser application protocols, energy density is not enough, it would be necessary that authors provided other data, such as the application time, power output and point size of the laser equipment employed (in case of application by points and by contact) and the number of irradiated points, so that the energy per point of application may be calculated and outcomes compared.

In the orthodontic literature the recommendation of high doses of laser for pain treatment can be observed after the activation of orthodontic/orthopedic appliances and the infra-red is the most indicated wavelength. For example, Lizzarelli¹⁵ in 2007, suggested a dose of 35 J/cm² or 1,4 J per point (79 mW and 20 seconds) in three points along the axis of the tooth buccally: a cervical point, a point in the center of the root and another at the apex of the root. With this protocol, there would be a total dose of energy of 4,2 J per tooth.¹⁵

However, Lim et al¹³ found effective outcomes, employing infra-red wavelength, power output 30 mW, power density 59,7 mW/cm², in three distinct periods: 15, 30 and 60 seconds, providing energy per point corresponding to 0.45 J, 0.9 J and 1.8 J, respectively. As only one point was irradiated, the total energy per tooth would be equal to the energy per point, that is,

much inferior to the protocol applied by Lizzarelli,¹⁵ 4.2 J per tooth.

Turhani et al²³ observed satisfactory outcomes for analgesy during orthodontic treatment, with higher dosimetry. During the study, they employed 670 nm wavelength, power output 75 mW, power density 14 mW/cm² for 30 seconds. Thus, when energy was calculated per point, value 2.25 J was obtained for each tooth. Since one point was irradiated in the middle third of the root of all the teeth involved in the orthodontic mechanism, there would be a total of energy per dental arch of 27 J. Probably the positive effects towards analgesy obtained from this study were due to the sommatization of the irradiation effects throughout the dental arch innervations.

The present study employed infra-red wavelength, power output 20 mW, energy density 5 J/cm², 0.2 J per point, which are very similar values to the successfully employed by Lim et al¹³ and by Turhani et al.²³ However, the outcomes obtained from the present study, demonstrated that there is no statistically significant difference between the data for irradiated and non-irradiated (placebo) teeth. This is probably due to the differences concerning the amount of applications. In the study of Turhani et al²³ the application was done throughout the dental arch, thus, the total energy accumulated was much higher than the present study. Besides that, in the study of Lim et al¹³ although the energy per point is inferior than that applied in this study, the irradiation was done right after the insertion of the elastic separators, 1 day after and sequentially for three more days, that is, a total of five applications, so the total accumulated energy was higher than in the present study. Probably, these factors have influenced directly on the positive outcomes achieved by these authors, that is, a higher total laser dosimetry. This corroborates with the outcomes of Lizzarelli,¹⁵ who employed successfully higher dosimetry (total energy) when employing laser.

This protocol was selected for the fact observed in the literature, that low intensity laser in accordance with this dosimetry (780 nm / 20 mW / 5 J/cm² / 0.2 J per point / ET=2.0 J) promotes an enhancement on the dental movement speed in patients with fixed orthodontic appliance.^{6,9} Due to this fact, a lower dosimetry was used to evaluate if a dosimetry indicated to get faster orthodontic movement would be able to decrease the pain sensibility. Nonetheless, due to the outcomes obtained, it is possible to suggest that, clinically it will be necessary to choose between a faster treatment applying lower dosimetry, or a treatment not so painful applying laser in higher dosimetry.

It is true that the ideal solution would be the employment of a dose capable of enhancing the speed of dental movement and to reduce pain sensitivity. Additional studies are necessary to achieve the ideal dosimetry for laser application, in order to establish a faster and less painful orthodontic treatment.

CONCLUSION

Based on the outcomes, it was concluded that laser diode irradiation (ArGaAl) 780 nm wavelength, power output 20 mW, energy density 5 J/cm², 0.2 J per point and total energy 2 J per tooth, was not enough to decrease pain, due to orthodontic movement. Thus, additional studies are necessary in order to check the best application protocol.

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Muscle pain intensity of patients with myofascial pain with different additional diagnoses

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Abstract

Objectives: To compare subjective and objective pain intensity and associated characteristics in myofascial pain (MFP) patients with and without migraine. **Methods:** The sample was comprised by 203 consecutive patients, mean age of 40.3 years (89.2% of females), primarily diagnosed with MFP, who presented to the UCLA Orofacial Pain Clinic. Patients with secondary diagnosis of migraine (n=83) were included and comprised group 2. In order to compare group 1 (MFP) with group 2 (MFP + migraine) regarding objective (palpation scores) and subjective pain levels by means of visual analog scales (VAS). Also, comparisons of mood problems, jaw function problems, sleep quality and disability levels using VAS were performed using the Mann-Whitney test. A significance level of 5% was adopted. **Results:** Mann-Whitney test revealed that group 2 presented significantly higher pain levels on palpation of masticatory and cervical muscles in comparison to group 1 ($p<0.05$). Group 2 also presented higher levels of subjective pain, with statistical significance for “pain at the moment” and “highest pain” ($p<0.05$). Additionally, group 2 showed higher levels of mood problems, disability, jaw function impairment and sleep problems than group 1 with statistical significance for the later ($p<0.05$). **Conclusions:** Migraine comorbidity demonstrated a significant impact on pain intensity and life quality of patients with MFP. Clinicians should approach both conditions in order to achieve better treatment outcomes.

Keywords: Temporomandibular disorders. Orofacial pain. Migraine.

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INTRODUCTION

Headaches, facial pain and Temporomandibular Disorders (TMD) comprise a serious contemporary problem, especially when presented simultaneously. Common complaint among TMD patients, headaches, including migraines, present prevalence between 48 and 77%.^{7,9,13,15,19}

However, the actual impact of various types of headache in TMD patients is still subject to much debate and controversy and necessarily involves an understanding of the pathophysiology of each condition. The current literature reports improvement of headache after treatment of the signs and symptoms of TMD, a fact that strengthens the possible interplay between the two entities.^{10,16,19}

Although the triggering mechanism of migraine is still not completely understood, it is well known that its pathophysiology does not primarily involve the masticatory muscle activity. On the other hand, considering that the temporomandibular joint (TMJ) and masticatory muscles receive trigeminal sensory innervation which, in turn, is also responsible for conducting nociceptive input from cranial blood vessels involved in the genesis of migraine, it is obvious the understanding of a possible overlap of nociceptive impulses in cases of comorbidity. Thus, the presence of TMD symptoms seems to cause an excitatory impact on migraine, and vice versa, especially in patients with severe and/or persistent pain, naturally more susceptible to the phenomenon of central sensitization.^{18,19}

Based on the above, the present study aims to compare patients with myofascial pain (MFP) of the masticatory muscles with and without the additional diagnosis of migraine regarding pain intensity and associated characteristics.

METHODS

Initially, 424 consecutive patients who presented with complaint of pain in the facial region

to the Orofacial Pain Clinic of the UCLA School of Dentistry, Los Angeles, were examined. Of these, 203 were included in the final sample, 181 women (89.2%) and 22 men (10.8%), with a mean age of 40.3 years (± 15.44).

In order to be included in the final sample, the patient should receive a primary diagnosis of myofascial pain, presenting one or more trigger points in the masticatory and/or cervical muscles. Considering the difficulty in obtaining single diagnoses of myofascial pain due to the multifactorial nature of TMD, patients with secondary diagnoses of osteoarthritis, capsulitis, tension-type headache (TTH) and migraine were also included in the final sample.

Diagnostic criteria of myofascial pain, capsulitis and osteoarthritis were based on the recommendations of the American Academy of Orofacial Pain,²¹ while the TTH and migraine were diagnosed according to the criteria established by the International Headache Society.²⁹

Patients with the diagnosis of neuropathic pain were excluded. The presence of other diagnostic of primary headaches (cluster or chronic paroxysmal headaches), as well as any secondary headaches, were also exclusion criteria for patients in this study. Finally, patients with systemic conditions such as rheumatoid arthritis or fibromyalgia, among others, as well as those with mental or neurological issues were also excluded.

The 203 patients of the sample were divided into two groups. The first group comprised patients with the exclusive diagnosis of myofascial pain, while the second one included patients with myofascial pain and the additional diagnosis of migraine. The evaluation was performed by four examiners, all residents from the Orofacial Pain Program of the UCLA School of Dentistry, previously submitted to calibration and training by an experienced professional.

The objective muscle pain intensity was re-

corded from conventional digital muscle palpation. The muscles included in the survey were: temporalis (anterior, middle and posterior), masseter (superficial and deep), sternocleidomastoid (SCM), trapezius and splenius capitis.

Five pairs of facial muscles and three pairs of cervical muscles were included, totalizing 16 palpation sites. The exam was performed according to the recommendations of the American Academy of Orofacial Pain,²¹ with palpation pressure according to the findings of Silva et al.²⁵

The palpation score was then recorded in each point, as follows:

- » 0 = no pain;
- » 1 = mild pain or discomfort;
- » 2 = moderate pain;
- » 3 = severe pain, with eyelid reflex or other severe pain signal;
- » 4 = severe pain with referral.

The final score which represented the objective pain intensity (palpation) experienced by each patient was obtained using the arithmetic mean of all sites of muscle palpation.

The intensity of subjective pain, mood state, disability level because of the pain, jaw function problems and quality of sleep/rest were obtained by Visual Analog Scales (VAS).^{4,23,28} This type of scale has proven to be effective in comparison to others, as noted Conti et al⁴ in 2001. As for the subjective pain, four parameters of pain were recorded, through four different VAS. They measured pain levels “at the moment” and “highest”, “lowest” and “average” pain experienced in the last month.

In order to detect differences between groups 1 (MFP) and 2 (MFP + migraine) regarding subjective and objective pain intensity, mood, disability, jaw function problems and sleep quality, Mann-Whitney test was performed with a significance level of 5%.

The present study was submitted for assessment and approved by the Ethics Committee of the University of California, Los Angeles, USA.

RESULTS

Mann-Whitney test showed that group 2 had higher pain levels upon muscle palpation than group 1 ($p < 0.05$), as illustrated in Table 1.

VAS analysis has shown that group 2 presented higher pain levels for all variables, as shown in Figure 1. Statistically significant differences between groups were found with regard to “highest pain” and “pain at the moment” ($p < 0.05$) (Table 2).

Comparisons between groups regarding characteristics associated to the pain such as mood, disability, problems with jaw function and problems with sleep/rest were also performed. For all variables, group 2 showed higher values (Fig 2), however only the variable “problems with sleep/rest” presented statistically significant difference ($p < 0.05$) (Table 3).

DISCUSSION

The possible overlap between headaches, especially migraine and TTH, and TMD has been the subject of numerous studies in the literature. On one side, different pathophysiology theories contradict this hypothesis. On the other, studies of prevalence in populations with different types of headache, migraine, and asymptomatic TMD have detected and

TABLE 1 - Mean, standard deviation and intergroup comparison of the pain levels obtained from muscle palpation.

	Minimum	Maximum	Mean (Standard Deviation)	p (Mann- Whitney)
Group 1	0.25	4	1.56 (0.78)	0.003*
Group 2	0.56	3.75	1.93 (0.80)	

*Statistically significant ($p < 0.05$).

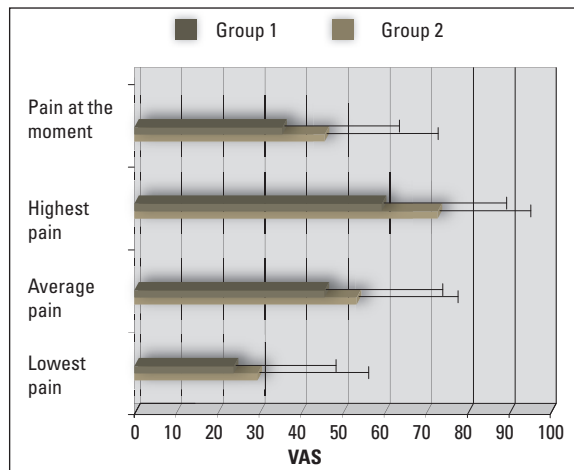


FIGURE 1 - Subjective pain levels intergroup comparison from the VAS.

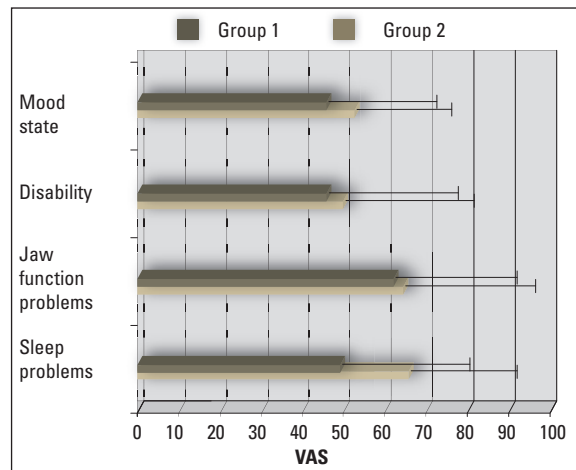


FIGURE 2 - Intergroup comparison of the characteristics associated to the pain measured with VAS.

TABLE 2 - Mean, standard deviation and intergroup comparison of the pain levels obtained from the VAS.

VAS	Group	Mini- mum	Maxi- mum	Mean (Standard Deviation)	p (Mann- Whitney)
Pain at the moment	1	0	98	35.71 (27.98)	0.013*
	2	0	100	45.97 (27.08)	
Highest pain	1	0	100	59.55 (29.92)	0.004*
	2	12	100	72.94 (22.40)	
Average Pain	1	0	100	45.73 (28.28)	0.062
	2	0	100	53.49 (24.35)	
Lowest Pain	1	0	100	24.22 (24.47)	0.221
	2	0	100	29.76 (26.67)	

*Statistically significant (p<0.05).

TABLE 3 - Mean, standard deviation and intergroup comparison of the characteristics associated to the pain measured with VAS.

VAS	Group	Mini- mum	Maxi- mum	Mean (Standard Deviation)	p (Mann- Whitney)
Mood state	1	0	100	45.89 (26.70)	0.098
	2	0	100	52.74 (23.50)	
Disability	1	0	100	45.96 (31.89)	0.369
	2	0	100	50.15 (31.53)	
Jaw function problems	1	0	100	62.14 (29.89)	0.350
	2	0	100	64.62 (32.02)	
Sleep problems	1	0	100	49.21 (31.39)	0.000*
	2	7	100	66.08 (26.04)	

*Statistically significant (p<0.05).

confirmed the overlap of symptoms of both conditions.^{9,10,14,30} When studying a population of patients with chronic headache (migraine and TTH), Glaros et al⁹ found more muscle pain and capsulitis compared to asymptomatic control subjects, confirming the possible association between the two entities. In another

study, Mitirattanakul and Merrill¹⁹ found significantly higher prevalence of headache in the TMD group (72.7%) compared to the asymptomatic control group (31.9%).

Despite displaying different mechanisms, headache symptoms are often found in TMD patients, with prevalence ranging from 48 to 77%.^{5,9,10,19,30}

The pain reported by TMD patients is usually located in the masticatory muscles, preauricular area and/or temporomandibular joint (TMJ). According to Glaros et al,⁹ headache symptoms described by patients with TMD are similar to those reported by patients diagnosed with migraine or TTH.

In general, females are three times more prevalent than males when it comes to the pain subject.^{13,19,22,26,27} Vazquez-Delgado et al,³⁰ in 2004, in a study with a population with chronic daily headache and another with MFP, found a prevalence of 81% of women, value of around the 81.3% found by Mitirattanakul and Merrill¹⁹ and the 81.2% reported by Kim and Kim,¹³ all similar to the number found in this study. Of the 203 patients who comprised the sample, 89.2% were female.

But how can conditions with different pathophysiology in relation to TMD, such as migraine and TTH, cause significant impact on myofascial pain, measured by palpation of the masticatory and cervical muscles?

Theories that explain the phenomenon of headaches, especially migraines, are based on cortical spreading depression phenomena, descending modulatory system dysfunction (serotonergic and noradrenergic), and sensitization of second order neurons.¹³ The phenomena of central sensitization leads to peripheral allodynia and secondary hyperalgesia, felt on the scalp of patients with migraine, or as masticatory and cervical muscle tenderness, both during and after crisis.^{11,19} Some studies have shown increases in muscle pain on palpation during the attack of migraine. Indeed, the nociception caused by muscle pain, commonly found in patients with MFP, as in the patients included in the present study, can induce or increase the phenomena of central sensitization in patients with headache, resulting in the induction or exacerbation of headache in a region previously sensitized (subnucleus caudalis in the trigeminal nucleus).¹⁹

This overlap of stimuli would occur because the structures involved in TMD share the sensory innervation of the trigeminal nerve with the cranial blood vessels, important in the genesis of migraine. Possible noxious stimuli would leave by different routes towards the subnucleus caudalis, where the synapse with a second order neuron takes place. At this point, first order neurons occasionally share the same second order neuron in a phenomena known as the convergence theory.^{17,26}

This fact may explain the findings described in this study, in which the group 2 presented mean pain on palpation significantly higher compared to group 1 ($p < 0.05$). The comparison of subjective pain (VAS) also showed group 2 with higher levels of pain. However, this difference was significant only for "pain at the moment" and "highest pain" ($p < 0.05$). The same results were found by Mitirattanakul and Merrill,¹⁹ in 2006, who showed levels of pain and disability significantly higher in patients with musculoskeletal disorders associated with primary headaches, compared to individuals with exclusive musculoskeletal disorders. Some studies report the presence of muscle tenderness on palpation during the migraine attack and sometimes persisting after the attack,^{14,20,28} depending on the severity and/or frequency of the migraine episode. That fact may contribute to the interpretation of the findings of this study.

If the muscle tenderness is just a result of central sensitization caused by the migraine, it should be resolved with specific abortive migraine medications. There are reports of the veracity of this fact in the literature. Dao et al,⁶ in 1995, analyzing a sample of migraine patients, showed improvement in the symptoms of muscle pain after the administration of dihydroergotamine-45 or a triptan. However, in populations with orofacial pain, especially with MFP, there are reports of the contrary.⁷ In such cases,

the frequency and intensity of the headaches tend to improve after reduction of nociceptive impulses from the masticatory muscles and the TMJ through physical therapy approaches^{9,19} or after myofascial trigger points injections.⁷

Considering that muscle pain caused by the MFP does not improve after administration of specific abortive migraine medications (triptans, for example)¹⁹, one can infer that not only the nociceptive activity of cranial blood vessel can induce neurogenic inflammation, an event that culminates with the migraine attack. Other noxious stimuli coming from other branches of the trigeminal nerve, i.e. the masticatory muscles or the TMJ, can exacerbate or even initiate the headache. According to Davidoff,⁷ muscle pain from trigger points can be severe enough to trigger a migraine attack. Furthermore, the author found that palpation of the trigger point during the migraine attack increases the headache significantly.

Despite disability is one of the most important features of migraine, being part of the diagnostic criteria, significant differences between groups, in this study, were not found. This fact may be explained by the simplicity of the VAS in measuring a variable that involves various aspects of life. A more comprehensive analysis, using more specific and sophisticated tools to measure disability should be performed to clearly elucidate this aspect.

Although reported as common in patients with pain^{24,30}, mood state, in the present study, revealed no significant differences between the groups. The same result was presented by Glaros et al⁹ who found no differences between TMD and headache patients compared to a control group regarding that feature. However, a study published in 2003 by Ruiz de Velasco et al²⁴ reported significant different mood states in patients with migraine, such as sadness, anger, emotional instability and difficulty concentrating. Thus, it appears that mood state is not con-

sistently different among painful conditions in relation to asymptomatic individuals. Likewise, the mood does not seem to be directly affected by the intensity of pain since the group 2 showed significantly higher pain levels than group 1. The mood state results of this study should, however, be considered with caution because it was measured using a VAS and not through a specific test.

Problems with jaw function also lacked significant differences between groups ($p > 0.05$), despite the mean values revealed to be relatively high in the VAS (62.14 in group 1 and 64.62 in group 2). Apparently, problems with jaw function are symptoms exclusively related to TMD^{21,23} and therefore primary headaches, especially migraine, have no influence on the severity of these problems.

Patients with pain, especially chronic, commonly report sleep disturbances.³⁰ Liljestrom et al,¹⁵ however, found no association between sleep quality and TMD in a sample of children. In the present study, significant differences were detected between the groups in relation to problems with sleep, measured by VAS, with group 2 reporting significantly more problems (66.08) than group 1 (49.21). Once again, migraine seems to exert significant impact on the general scenario of patients with MFP, in this case interfering in the sleep quality. Vazquez-Delgado et al³⁰ found poorer sleep quality in patients with MFP than in patients with capsulitis, chronic daily headache, chronic migraine and chronic TTH. According to Dodick et al,⁸ the patient who complains of sleep problems associated with primary headaches usually has consistent symptoms of depression and anxiety, and a history of analgesics abuse and fibromyalgia, conditions that individually cause problems with sleep.

Based on the findings of this study, the importance of addressing each of the pathologies involved in patients with orofacial pain is reinforced, especially disorders of musculoskeletal origin and primary headaches. Therefore, it

is likely that the unawareness of one or more of these disorders lead to equivocal results in terms of resolution or improvement of the pain.

Still, no definitive conclusions can be obtained from the findings of this study due to the diversity of variables involved, a fact that rein-

forces the need for additional investigation to confirm the trend shown in the present study.

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Biometric study of human teeth*

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Abstract

Objectives: To determine the biometric dimensions of human teeth in the mesiodistal, buccolingual and occlusal/incisal-cervical directions. **Methods:** It was used a sample of dental casts from 57 patients, i.e., 31 females with a mean age of 15 years and 5 months, and 26 males with a mean age of 16 years and 6 months. The sample was previously qualified by adopting the criteria established by Andrews' six keys to normal occlusion, whose values were matched to the variations obtained by Bolton. Two examiners used a digital caliper with original (short) and modified (long) tips. **Results and Conclusions:** After statistical analysis of the data it was concluded that the teeth were shown to be symmetrical in the dental arches of both genders. Tooth dimensions are smaller in females than in males and should therefore be studied separately. Overall mean values were obtained and used to build tables distinguishing such dimensions according to gender. Mean values for the three tooth dimensions, occurrence rates of these dimensions and their standard deviations were also calculated. These values allowed the development of an equation called "C" equation as well as "C" percentile tables. With the aid of both, it became possible to measure only one dimension of a given tooth to find the other two "probable" dimensions of the other teeth in the dental arches.

Keywords: Tooth dimensions. Tooth proportions. Tooth size.

INTRODUCTION

In view of the difficulty to accommodate mesiodistal, buccolingual and occlusal/incisal-cervical volumes of the dental masses in restricted locations available in the jaws, orthodontists are ultimately hard pressed to resort to alternative therapies to change the perimeter of the dental arches, either reducing them through extractions

and stripping, or expanding them by proclining the teeth. Although these alternatives have been uncontroversially established, decision-making can sometimes prove challenging. If on the one hand, extractions, when needed, can assist in adjusting the dental arches and promoting function, on the other hand, retoclined upper central incisors may cause cosmetic damage, with consequent

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prominence of the nose, particularly if lip retraction is excessive.

Given the uncertainty in deciding whether or not to perform tooth extractions or stripping, this study aimed to determine the biometric dimensions of orthodontic patients' teeth properly finished in the mesiodistal, buccolingual and occlusal/incisal-cervical direction in both genders, with a view to providing mathematical support for this decision.

LITERATURE REVIEW

Literature review disclosed that many researchers have sought to address issues that have been accepted but not yet well understood. This constant search stems from the investigative spirit of human beings who, not satisfied with the information currently available, seek out conceptual definitions that can be supported by existing scientific methods.

To this end one sees studies focused on several areas, such as dentistry,¹⁵ endodontics,⁹ orthodontics,^{1,5,12,17,18,22} prosthesis¹⁶ and forensics.^{6,21}

As the first author to publish a table of measurements of human teeth, Black⁴ is credited as having conducted the first and most detailed study of dental morphology and anatomical nomenclature of all times.

One hundred and one years after Black's publication⁴ in 1902, Harris and Burris,¹¹ in 2003, emphasized that the most often cited tooth dimensions in literature were those published by Black.⁴ However, they also argue that these values differ from modern values and should therefore be reassessed. The authors of the present study were motivated by this contention to undertake this research.

MATERIAL AND METHODS

Material

Sample

This study used a sample of orthodontic plaster models of 57 patients distributed between the two genders of the human species, 31 were female

with mean age of 15 years and 5 months, and 26 males with mean age of 16 years and 6 months. No racial, cultural or socio-economic criteria were established. All cases were treated with standard Straight-Wire orthodontic appliances ("A" Company). Cases had no extractions, no pre- and post-treatment interproximal stripping and were all well finished.

Sample qualification (Andrews and Bolton)

The goal consisted in finishing all cases with the six keys to normal occlusion recommended by Andrews.² Results received an "A" qualification, the highest quality grade for this method. Additionally, all cases showed proportionality between the 12 maxillary teeth and the 12 mandibular ones, and between the 6 upper anterior teeth and the 6 lower ones when compared to the values described by Bolton⁵ (Fig 1).

Digital caliper

In seeking to emulate the method adopted by Yamaguto²² and Castro⁷ some modifications were made (Fig 2) to the tips of the original digital caliper. They were replaced by two longer tips to enable measurements in areas of difficult physical access, i.e., to measure exclusively the mesiodistal dimensions (Fig 3) of dental crowns on plaster models and thereby determine whether or not errors occurred in the methods, i.e., original tips vs. modified tips. Original tips were referred to as "short" and the modified tips, "long".

Methods

Methods used to perform measurements in the models

Taking the occlusal plane as reference during measurements the caliper was placed parallel to this plane for mesiodistal measurements and in a perpendicular position for buccolingual measurements as well as for the incisal or occlusal cervical measurements. (Figs 3 and 4).

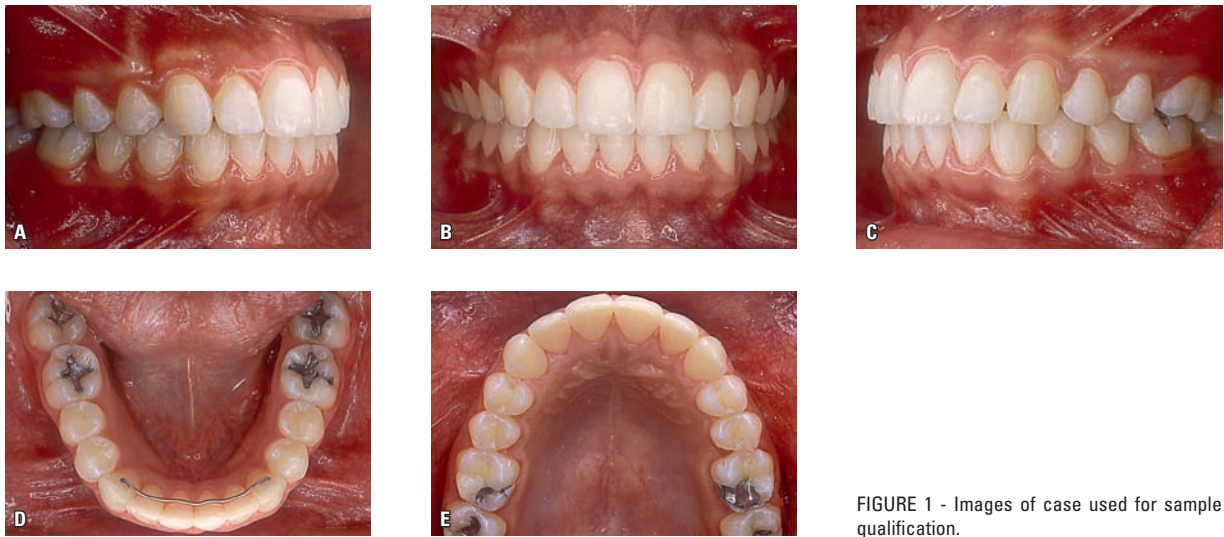


FIGURE 1 - Images of case used for sample qualification.

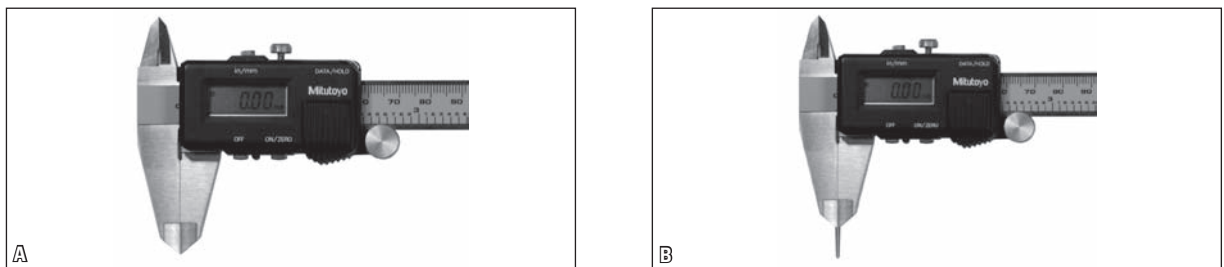


FIGURE 2 - Images showing digital caliper with **A**) its original tips (short) and **B**) the modified tips (long).

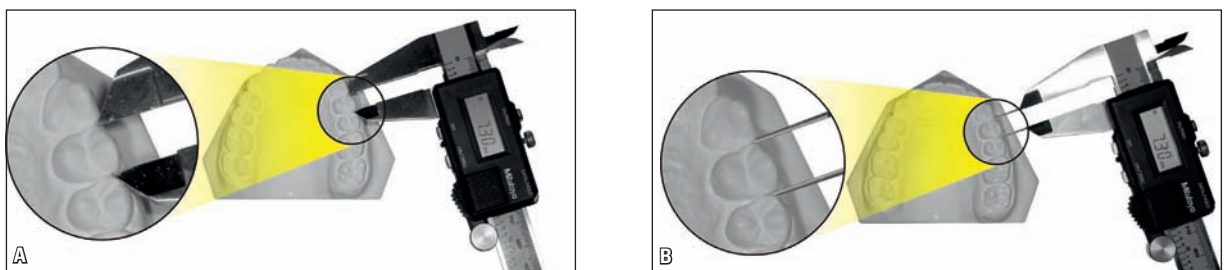


FIGURE 3 - Mesiodistal measurement of a first upper premolar using the digital caliper with **A**) its original tips (short) and **B**) the modified tips (long).

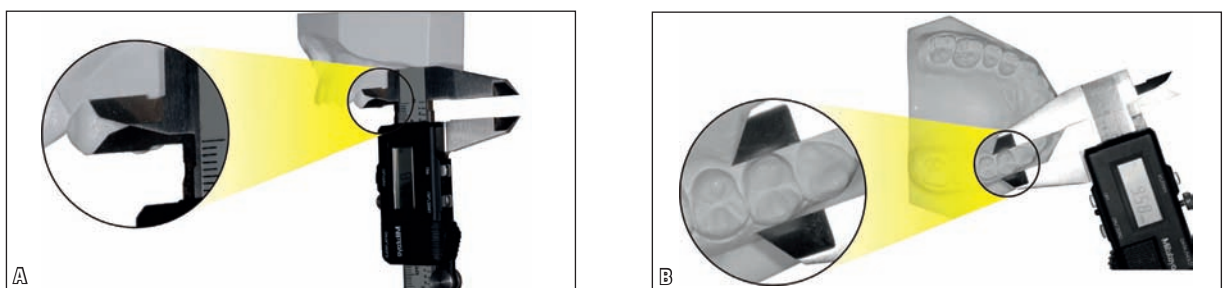


FIGURE 4 - Occlusal-cervical **(A)** and buccal-lingual **(B)** measurements of a first upper premolar using the digital caliper with its original tips (short).

Statistical study

In strict compliance with all scientific protocols, the results and values obtained from tooth size in the sample were subjected to statistical tests. In comparing gender variables Student's t-test was applied whereas to assess the correlations between measurements Pearson's correlation coefficient was employed. Paired t-test was used to identify intra-examiner, inter-examiners and inter-methods systematic errors. Random error was calculated using the method proposed by Dahlberg⁸ as described by Houston.¹³ In all statistical tests a significance level of 5% was adopted.²³

The tests were performed using the software Statistics for Windows v. 5.1 (Statsoft, USA).

RESULTS

This study made use of a sample of 57 patients examining the differences between the genders. It required measuring all teeth in three dimensions, resulting in 6,620 measurements, which resulted in 59 tables, with 19 of these tables being named primary, 22 secondary and 18 tertiary or consequent. It should be underlined that due to the format constraints of this publication only a few tables were made available.

TABLE 1 - Mean values in mm of mesiodistal, buccolingual and occlusal/incisal-cervical dimensions of the upper and lower arches in males and females.

Tooth	Values in millimeters					
	Male			Female		
	M-distal	B-lingual	I-cervical	M-distal	B-lingual	I-cervical
Upper arch						
1	9.18	7.79	10.33	8.93	7.33	9.79
2	7.26	6.98	8.52	7.04	6.55	8.20
3	8.29	8.4	10.05	7.92	7.96	9.53
4	7.28	9.60	7.90	7.06	9.46	7.55
5	7.10	9.82	6.72	6.82	9.58	6.48
6	10.87	11.39	5.65	10.31	11.05	5.45
Σ	49.98			48.08		
Lower arch						
1	5.63	6.42	8.72	5.44	6.15	8.15
2	6.18	6.60	8.60	6.01	6.32	8.04
3	7.34	7.50	9.99	6.91	7.04	9.14
4	7.50	8.20	8.41	7.13	7.76	7.85
5	7.53	8.76	6.97	7.20	8.49	6.79
6	11.31	10.70	5.77	10.95	10.43	5.56
Σ	45.49			43.64		

TABLE 2 - Mean percentage values of mesiodistal, buccolingual and occlusal/incisal-cervical dimensions of the upper and lower arches in males and females.

Tooth	Percentage values					
	Male			Female		
	M-distal	B-lingual	I-cervical	M-distal	B-lingual	I-cervical
Upper arch						
1	18.37	14.40	21.02	18.57	14.09	20.84
2	14.52	12.92	17.32	14.63	12.57	17.42
3	16.58	15.64	20.44	16.48	15.33	20.29
4	14.57	17.78	16.06	14.68	18.23	16.07
5	14.21	18.18	13.69	14.18	18.47	13.79
6	21.74	21.08	11.47	21.46	21.31	11.60
Σ	100%			100%		
Lower arch						
1	12.37	13.33	18.01	12.47	13.31	17.90
2	13.59	13.69	17.75	13.77	13.67	17.67
3	16.13	15.56	20.61	15.83	15.22	20.06
4	16.48	17.02	17.38	16.33	16.81	17.24
5	16.56	18.19	14.36	16.49	18.40	14.93
6	24.86	22.21	11.89	25.10	22.60	12.19
Σ	100%			100%		

DISCUSSION

Variables under study

Intra-examiner and inter-examiners errors

In the statistical analysis, two examiners were used to prevent potential distortions in the measurement methods:

- » **Intra-examiner error:** Examiner 1 measured the materials (models) twice with a 60-day interval to ensure that the results would not become inductive and eventually allow humor factors to disqualify the outcomes.
- » **Inter-examiners error:** Examiner 2 used the same materials for measuring in order to compare his values with those of examiner 1, since any natural inclination or affinity with the work performed by examiner 1 did not interfere with the outcome.

» **Inter-method error:** With the purpose of ascertaining whether there was error in the methods, the same investigator used calipers with different tips to measure the mesiodistal dimensions of the teeth. One had the original tips, and was called "Short" and one had modified tips and was named "Long". Ten cases were measured, 5 male and 5 female.

In checking intra-examiner and inter-examiners systematic and random errors results revealed that only two of the 42 measures showed statistically significant differences. However, in checking the means it was found that these differences lay below the random error, i.e., tenths of a millimeter, and therefore should be ignored as operational values.

Inter-methods systematic and random inter-examiners errors

In examining systematic and random inter-method errors when using a digital caliper in two different manners, i.e., with original tips (short) and modified tips (long), no statistically significant difference was found between these two techniques.

OUTCOME ANALYSIS

Sexual dimorphism between genders

This investigation revealed that 27 of the 42 measurements taken between the genders displayed statistically significant differences, with women's measurements showing lower values than men's. Therefore, in absolute terms

it is suggested that men and women be studied separately. These results agree with most authors,^{10,14,19,20,22} with the sole exception of Baum and Cohen,³ who, in attempting to assess the occurrence of dimorphism, found striking similarities between patients of both genders.

Symmetry

Ghose and Baghdady¹⁰ identified statistically non-significant variations between the mesio-distal diameters of teeth after comparing the right and left sides. In the present study, the results showed that only 3 of 42 measures yielded statistically significant differences. It cannot therefore be implied that there is any difference between the sides (Tables 3, 4 and 5).

TABLE 3 - Comparison between mesiodistal measurements in the left and right sides.

Tooth	Left		Right		Diff.	t	p
	Mean	sd	Mean	sd			
Upper arch							
1	9.04	0.54	9.05	0.53	-0.01	-0.200	0.842 ns
2	7.09	0.41	7.18	0.44	-0.09	-3.022	0.004 *
3	8.06	0.51	8.12	0.48	-0.06	-1.742	0.087 ns
4	7.18	0.41	7.14	0.37	0.04	1.526	0.133 ns
5	6.93	0.46	6.96	0.48	-0.03	-0.990	0.327 ns
6	10.57	0.64	10.56	0.70	0.01	0.212	0.833 ns
7	10.00	0.60	9.89	0.49	0.11	2.112	0.042 *
Lower arch							
1	5.52	0.36	5.54	0.39	-0.02	-1.013	0.316 ns
2	6.08	0.39	6.10	0.38	-0.02	-0.710	0.481 ns
3	7.11	0.44	7.11	0.47	0.00	-0.010	0.992 ns
4	7.28	0.42	7.31	0.40	-0.03	-1.342	0.185 ns
5	7.35	0.41	7.35	0.44	0.00	0.014	0.989 ns
6	11.12	0.54	11.11	0.53	0.01	0.609	0.545 ns
7	10.52	0.57	10.47	0.56	0.05	0.950	0.349 ns

ns = no statistically significant difference.

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

TABLE 4 - Comparison between buccolingual measurements in the left and right sides.

Tooth	Left		Right		Diff.	t	p
	Mean	sd	Mean	sd			
Upper arch							
1	7.52	0.67	7.55	0.65	-0.03	-1.083	0.283 ns
2	6.72	0.80	6.78	0.83	-0.06	-0.896	0.374 ns
3	8.18	0.59	7.19	0.58	-0.02	-0.371	0.712 ns
4	9.52	0.44	9.53	0.45	-0.01	-0.479	0.634 ns
5	9.69	0.47	9.69	0.49	0.00	0.025	0.980 ns
6	11.20	0.54	11.21	0.56	-0.02	-0.545	0.588 ns
7	11.15	0.63	11.19	0.66	-0.04	-0.169	0.249 ns
Lower arch							
1	6.29	0.48	6.26	0.51	0.04	1.411	0.164 ns
2	6.46	0.49	6.43	0.49	0.02	0.869	0.389 ns
3	7.26	0.54	7.28	0.56	-0.02	-0.684	0.497 ns
4	7.91	0.51	8.02	0.63	-0.11	-1.839	0.071 ns
5	8.60	0.51	8.63	0.48	-0.03	-0.749	0.457 ns
6	10.56	0.63	10.55	0.64	0.01	0.384	0.702 ns
7	10.26	0.63	10.15	0.69	0.11	1.480	0.146 ns

ns = no statistically significant difference.

* Statistically significant difference (p<0.05)

TABLE 5 - Comparison between occlusal/incisal-cervical measurements in the left and right sides.

Tooth	Left		Right		Diff.	t	p
	Mean	sd	Mean	sd			
Upper arch							
1	10.06	0.90	10.02	0.87	0.04	1.195	0.237 ns
2	8.36	0.87	8.33	0.90	0.02	0.387	0.700 ns
3	9.73	0.91	9.80	0.96	-0.06	-0.820	0.416 ns
4	7.69	0.76	7.73	0.73	-0.03	-0.852	0.398 ns
5	6.60	0.69	6.58	0.70	0.01	0.213	0.832 ns
6	5.48	0.68	5.62	0.77	-0.14	-2.523	0.015 *
7	5.43	0.78	5.38	0.78	0.05	0.625	0.535 ns
Lower arch							
1	8.42	0.78	8.40	0.75	0.02	0.666	0.508 ns
2	9.56	0.70	8.30	0.82	-0.01	-0.275	0.784 ns
3	9.56	1.00	9.50	1.07	0.06	0.915	0.364 ns
4	8.12	0.66	8.09	0.76	0.03	0.622	0.536 ns
5	6.87	0.64	6.88	0.71	-0.01	-0.240	0.812 ns
6	5.60	0.70	5.71	0.81	-0.11	-1.874	0.066 ns
7	5.09	0.77	5.21	0.77	-0.12	-1.587	0.119 ns

ns = non statistically significant difference.

* Statistically significant difference (p<0.05).

DEVELOPMENT OF "C" FORMULA

In view of the fact that the dimensional reference tables (Tables 1 and 2) depict the mean values as well as the percentages of mesiodistal, buccolingual and occlusal/incisal-cervical dimensions in both genders, the following equation — named the "C" Formula — was developed based on the dimensions of only one tooth so that allows one to calculate the likely dimensions of the other teeth on the same quadrant:

$$W_x = \frac{W_k \times P_x}{P_k} = R$$

W_x = Width of unknown tooth

W_k = Width of known tooth

P_x = Percentage of space that unknown tooth occupies in the arch

P_k = Percentage of space that known tooth occupies in the arch

R = Resultant

"C" PERCENTILE TABLES

To facilitate searching and reading the reference values that correspond to the three tooth dimensions in each gender, 6 (six) Tables (6, 7, 8, 9, 10 and 11) were developed from the "C" formula. These show respectively the minimum values, percentiles 10, 20, 30, 40, means, 60, 70, 80 and 90, and maximum values (in mm) and Σ mesiodistal values (1-6) of each quadrant in both genders.

Tables 6, 7 and 8 depict respectively female percentile values for mesiodistal, buccolingual and occlusal/incisal-cervical measurements.

Tables 9, 10 and 11 depict respectively the male percentile values for mesiodistal, buccolingual and occlusal/incisal-cervical measurements.

TABLE 6 - Percentile values of mesiodistal measurements / Female.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	31	8.0	8.2	8.4	8.6	8.8	8.9	9.3	9.3	9.4	9.5	10.0
	2	31	6.1	6.4	6.7	6.8	7.0	7.0	7.2	7.3	7.4	7.5	7.8
	3	31	7.3	7.5	7.7	7.7	7.8	7.9	8.1	8.1	8.1	8.4	8.5
	4	31	6.2	6.6	6.8	6.9	7.0	7.1	7.2	7.2	7.4	7.5	7.8
	5	31	5.6	6.2	6.5	6.6	6.7	6.8	7.0	7.1	7.1	7.3	7.8
	6	31	9.3	9.8	9.9	10.1	10.2	10.3	10.4	10.5	10.7	10.9	11.3
	1 - 6	31	44.6	45.5	45.9	47.0	47.9	48.1	48.9	49.2	49.4	50.5	51.4
Lower	1	31	4.7	5.0	5.2	5.3	5.4	5.4	5.5	5.5	5.7	5.8	6.1
	2	31	5.4	5.5	5.8	5.9	5.9	6.0	6.1	6.2	6.3	6.6	6.8
	3	31	6.2	6.4	6.5	6.8	6.8	6.9	7.1	7.1	7.3	7.4	7.5
	4	31	6.4	6.7	6.8	6.9	7.0	7.1	7.2	7.2	7.5	7.6	7.9
	5	31	6.3	6.7	6.9	7.0	7.1	7.2	7.3	7.4	7.6	7.7	8.1
	6	31	9.7	10.4	10.7	10.7	10.8	11.0	11.1	11.2	11.4	11.6	11.8
	1 - 6	31	39.9	41.6	42.1	42.7	43.2	43.6	44.1	44.2	45.4	46.0	47.7

TABLE 7 - Percentile values of buccolingual measurements / Female.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	31	5.9	6.6	6.8	7.0	7.1	7.3	7.4	7.6	7.9	8.3	8.5
	2	31	4.2	5.3	5.9	6.2	6.6	6.5	7.0	7.2	7.3	7.4	7.7
	3	31	6.5	7.6	7.7	7.7	7.9	8.0	8.0	8.1	8.4	8.5	9.4
	4	31	8.4	9.1	9.2	9.2	9.3	9.5	9.6	9.7	9.9	9.9	10.4
	5	31	8.7	8.8	9.3	9.4	9.5	9.6	9.8	9.9	10.0	10.1	10.4
	6	31	10.3	10.5	10.6	10.8	10.9	11.1	11.2	11.4	11.4	11.5	12.0
Lower	1	31	4.9	5.6	5.7	5.8	6.1	6.2	6.4	6.5	6.6	6.7	6.8
	2	31	5.3	5.6	6.0	6.1	6.3	6.3	6.5	6.7	6.7	6.8	7.1
	3	31	5.8	6.2	6.5	6.9	7.0	7.0	7.3	7.3	7.5	7.7	7.8
	4	31	6.3	7.2	7.4	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.7
	5	31	7.5	7.8	8.1	8.3	8.4	8.5	8.7	8.8	8.8	9.0	9.1
	6	31	9.3	9.9	10.2	10.3	10.4	10.4	10.5	10.6	10.8	10.9	11.2

TABLE 8 - Percentile values of occlusal/incisal-cervical measurements / Female.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	31	8.4	8.9	9.1	9.2	9.4	9.8	10.0	10.2	10.6	10.8	11.4
	2	31	6.8	7.2	7.5	7.6	8.0	8.2	8.5	8.6	8.9	9.2	10.2
	3	31	7.7	8.6	8.8	8.9	9.3	9.5	9.8	10.0	10.1	10.6	11.3
	4	31	6.5	6.7	7.0	7.2	7.3	7.5	7.7	7.8	7.9	8.4	9.2
	5	31	5.4	5.9	6.1	6.2	6.3	6.5	6.5	6.6	6.8	7.2	8.1
	6	31	4.4	4.7	5.1	5.1	5.3	5.5	5.5	5.8	5.9	6.2	6.9
Lower	1	31	6.7	7.4	7.8	7.9	8.0	8.1	8.4	8.5	8.7	8.8	9.2
	2	31	6.7	7.4	7.5	7.7	8.1	8.0	8.3	8.4	8.5	8.8	9.1
	3	31	7.6	7.8	8.7	9.0	9.0	9.1	9.2	9.6	9.8	10.1	10.7
	4	31	6.7	7.1	7.4	7.5	7.7	7.9	8.0	8.2	8.3	8.6	9.2
	5	31	5.8	6.2	6.5	6.6	6.7	6.8	7.0	7.1	7.1	7.2	8.0
	6	31	4.2	4.9	5.0	5.3	5.4	5.6	5.7	5.9	6.0	6.6	6.8

TABLE 9 - Percentile values of mesiodistal measurements / Male.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	26	8.0	8.5	8.7	8.8	9.2	9.2	9.3	9.5	9.6	9.7	10.0
	2	26	6.5	6.7	6.9	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.9
	3	26	7.1	7.6	7.8	8.0	8.3	8.3	8.5	8.6	8.7	9.0	9.3
	4	26	6.4	6.8	7.1	7.1	7.2	7.3	7.5	7.6	7.6	7.6	7.8
	5	26	6.1	6.6	6.9	7.0	7.0	7.1	7.2	7.4	7.5	7.6	7.7
	6	26	9.5	9.9	10.3	10.4	10.7	10.9	11.1	11.3	11.5	11.7	12.4
	1 - 6	26	46.2	46.4	46.9	49.1	49.5	50.0	50.8	51.5	52.0	52.6	54.3
Lower	1	26	4.7	5.2	5.4	5.5	5.5	5.6	5.8	5.9	5.9	6.1	6.3
	2	26	5.5	5.7	5.9	6.0	6.0	6.2	6.3	6.4	6.5	6.5	7.2
	3	26	6.5	6.8	7.1	7.2	7.2	7.3	7.4	7.6	7.6	8.0	8.1
	4	26	6.6	7.0	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.8	8.0
	5	26	6.8	7.2	7.3	7.4	7.4	7.5	7.6	7.7	7.7	8.0	8.3
	6	26	10.5	10.6	10.8	11.1	11.3	11.3	11.5	11.7	11.7	11.8	12.3
	1 - 6	26	41.7	42.7	43.4	45.5	45.6	45.5	46.2	46.4	46.8	47.3	48.7

TABLE 10 - Percentile values of buccolingual measurements / Male.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	26	6.8	7.3	7.4	7.5	7.6	7.8	7.9	8.1	8.3	8.3	8.9
	2	26	5.9	6.3	6.5	6.6	7.0	7.0	7.1	7.3	7.4	7.6	8.1
	3	26	7.6	7.9	8.1	8.1	8.4	8.4	8.6	8.7	8.9	9.0	9.3
	4	26	8.7	9.1	9.3	9.5	9.5	9.6	9.7	9.8	9.9	10.2	10.5
	5	26	9.1	9.4	9.4	9.5	9.6	9.8	9.9	10.1	10.2	10.4	10.8
	6	26	9.6	10.9	11.0	11.1	11.2	11.4	11.5	11.7	11.8	12.2	12.4
Lower	1	26	5.6	5.9	6.1	6.2	6.4	6.4	6.5	6.6	6.7	7.0	7.2
	2	26	5.6	6.1	6.3	6.5	6.6	6.6	6.7	6.7	6.8	7.2	7.3
	3	26	6.6	6.9	7.1	7.3	7.3	7.5	7.5	7.9	8.0	8.1	8.3
	4	26	7.3	7.6	7.7	7.9	8.1	8.2	8.2	8.5	8.7	8.9	9.1
	5	26	7.6	8.0	8.4	8.7	8.7	8.8	8.9	9.0	9.2	9.4	9.5
	6	26	7.8	10.1	10.4	10.5	10.8	10.7	11.1	11.1	11.1	11.3	11.7

TABLE 11 - Percentile values of occlusal/incisal-cervical measurements / Male.

Arch	Tooth	n	min.	P10	P20	P30	P40	Mean	P60	P70	P80	P90	max.
Upper	1	26	8.2	9.4	9.5	9.9	10.1	10.3	10.7	10.8	11.0	11.5	11.7
	2	26	7.3	7.6	7.7	8.0	8.2	8.5	8.6	8.7	9.0	9.9	10.3
	3	26	7.8	9.2	9.4	9.8	9.9	10.0	10.2	10.6	10.7	11.1	11.8
	4	26	6.0	7.1	7.4	7.6	7.7	7.9	8.1	8.2	8.4	8.5	10.3
	5	26	5.5	6.0	6.3	6.3	6.4	6.7	6.9	7.0	7.2	7.3	8.7
	6	26	4.2	5.0	5.2	5.2	5.4	5.7	5.7	5.8	6.3	6.4	7.9
Lower	1	26	7.5	7.7	8.0	8.2	8.6	8.7	8.9	9.3	9.4	9.6	10.0
	2	26	7.2	7.7	8.0	8.2	8.2	8.6	8.8	8.9	9.2	9.6	10.3
	3	26	8.1	8.9	9.2	9.5	9.7	10.0	10.1	10.4	10.8	11.3	12.1
	4	26	7.0	7.6	8.1	8.2	8.3	8.4	8.5	8.7	8.8	9.1	10.2
	5	26	4.7	6.1	6.6	6.9	6.9	7.0	7.2	7.3	7.5	7.6	8.7
	6	26	3.8	5.0	5.3	5.4	5.5	5.8	6.0	6.1	6.2	6.7	7.6

Example of application and use of "C" percentile tables

Assuming a patient with the following characteristics: Female, with missing first premolars. Planning involved prosthetic reconstruction of the first upper premolars with implant support. What should the mesiodistal dimension of the first maxillary premolars be?

First step: Measure the dimensions of any one of the teeth either in the casts or clinically in the patient. Assuming that the mesiodistal size of one of the upper central incisors was measured and found to be 9.5 mm, the value that corresponds to this dimension is then checked in Table 6 in the "C" percentile table for females. Since the value of 9.5 mm is in column P90, the probable value of the first upper premolars is 7.5 mm.

Additionally, the following conclusions can be drawn. The mesiodistal, buccolingual and occlusal/incisal-cervical dimensions shown in the P90 columns in the Tables 6, 7 and 8 are the probable dental dimensions of the remaining teeth whenever the female upper incisors show a mesiodistal distance of 9.5 mm.

Note also that the sum of the upper and lower quadrants is shown in the respective columns. One could also measure the distances from incisors to canines, and from incisors to second premolars, adding to the respective values.

CLINICAL CONSIDERATIONS

"C" percentile tables may be applied along with other preexisting methods to determine tooth size and thus assist in various areas of dentistry, such as in morphological, esthetic and functional reconstructions. In orthodontics, they could be used to determine individual, collective and inter-arch discrepancies. They can also contribute as an auxiliary method in forensic investigations.

The feasibility of the clinical applications and hypotheses suggested in this study can only be confirmed, denied or amended by

means of longitudinal applications and assessments of the outcomes. However, one should note that often human dental arches exhibit morphological variations and disproportionate tooth dimensions. As a result of these events it is suggested that given the size variations a more conservative alternative should be tried first rather than hastily propose a reduction in dental materials.

CONCLUSIONS

Based on the materials and methods used and the results obtained in this study, the following could be established:

- » The biometric mesiodistal, buccolingual and occlusal/incisal-cervical dimensions of human teeth are distinguishable between genders in terms of the mean, minimum and maximum coefficients, standard deviations, variation coefficients and percentages of each tooth in their respective dimension.
- » Tooth dimensions are smaller in females than in males and should therefore be studied separately.
- » The teeth in their mesiodistal, buccolingual and occlusal/incisal-cervical dimensions proved to be symmetrical in both genders.

Through the overall values obtained, it was possible to build tables to distinguish these dimensions according to gender.

The mean values of mesiodistal, buccolingual and occlusal/incisal-cervical tooth dimension were provide along with the percentage of occurrence between these dimensions and their standard deviations.

By using the mean values of tooth size and the percentages of occurrence it was possible to develop the "C" equation and "C" percentile tables. Thus, with the aid of the "C" equation and/or "C" percentile tables one can measure one single dimension of a given tooth and find the three probable dimensions of other teeth.

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Prevalence of malocclusion in children aged 7 to 12 years

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Abstract

Objectives: To determine the prevalence of malocclusion in a group of 3,466 children aged 7 to 12 years enrolled in public schools in the cities of Lins and Promissão, in the state of São Paulo, Brazil. **Methods:** The sagittal relationships between dental arches, the transverse relationship between arches, and the vertical and horizontal relations of incisors were analyzed. The prevalence of diastemas, crowding and tooth losses were evaluated. **Results:** Among the types of malocclusion, 55.25% of the children had a Class I molar relationship, 38%, Class II, and 6.75%, Class III. The analysis of incisor relationships revealed 17.65% of open bite, followed by 13.28% of deep bite and 5.05% of anterior crossbite; 13.3% of the children had a posterior crossbite. The analysis of relationships between arches showed that 31.88% of the children had diastemas, 31.59%, crowding, and 4.65%, tooth losses.

Keywords: Malocclusion. Angle classification. Normal occlusion. Epidemiology.

INTRODUCTION

Studying normal occlusion, as well as the characteristics that are part of this state is extremely important for the orthodontists.¹ Normal occlusion is not difficult to detect. At least three basic criteria should be met: (1) Total inclusion of the mandibular arch into the maxillary arch; (2) correct sagittal relationships between posterior teeth, that is, a Class I relationship; and (3) incisor relationships with positive horizontal and vertical overlap.

In fact, the desire to define these characteristics is over one hundred years old. Edward Hartley Angle,⁶ in the end of the 19th century, was the first to describe the sagittal relationships between dental arches using the molar relationship as reference, and named as “Class” the type of relationship that these teeth might have. The correct sagittal relationship between molars was called Class I. The mesiobuccal cusp of the maxillary permanent first molar should occlude with the buccal groove of

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the mandibular permanent first molar. Angle⁶ also described two other Classes to define the sagittal relationships between molars: Class II and Class III. In Class II, the mandibular arch has a distal relationship with the maxillary arch, whereas in Class III, the mandibular first permanent molar is positioned mesially to the maxillary first permanent molar.

Malocclusion is definitely more prevalent than normal occlusion in all populations, regardless of the stage of occlusal development.^{2,4,7,8,9,11,14-17,20,21,22} The predominance of malocclusion is explained by its multifactorial etiology,^{4,5,10,13,19} genetic factors²³ and several environmental factors^{3,6,16,18,23,24} that, together, contribute to the occurrence of the different types of malocclusion. Epidemiological studies have demonstrated that Class I malocclusion, together with different types of transverse and vertical occlusal disorders, is the most frequent, followed by Class II and, at a lower frequency, Class III.^{2,7,8,9,11,14-17,20,21,22}

Therefore, based on these informations, this study had the purpose to determine the prevalence of malocclusion considering the three spatial planes and of crowding, diastemas and tooth loss in children aged 7 to 12 years enrolled in public schools in the cities of Lins and Promissão, in the state of São Paulo, Brazil.

MATERIAL AND METHODS

A total of 3,466 boys and girls aged 7 to 12 years enrolled in public schools in the cities of Lins and Promissão, Brazil, were included in the study. Sex, ethnicity and occlusal development were not recorded; whether dentition was deciduous, mixed or permanent was not evaluated because mixed dentition is prevalent in this age group. The incidence of deleterious oral habits was also not determined in this study.

Oral examinations were performed by undergraduate students in the 7th and 8th semesters of the School of Dentistry and graduate students in the Specialization Course in Orthodontics in

the School of Dentistry in Lins (FOL-UNIMEP) wearing adequate outfits (uniform, gloves, cap, goggles) and under the guidance of a professor of the orthodontics course.

Disposable spatulas, rulers, lead pencils, pens, and the form enclosed in Figure 1 were used to perform examinations and record data of the school children. Examiners had practical and theoretical support to ensure that the survey was successful.

For the clinical examination, children were comfortably seated facing a source of abundant light. All the exams began by asking the child to open their mouth, and the examiner recorded the data previously defined. After that, the children were asked to occlude in the habitual position for maximal intercuspation to collect specific data. Some children had difficulties to occlude in the habitual position and, in these cases, they were asked to place the tip of the tongue at the most posterior position against the palate, and to occlude comfortably.

The analysis of occlusal data followed the Angle⁶ classification, which divides malocclusion into different classes: (A) Class I: All cases of malocclusion in which the anteroposterior relation of the maxillary and mandibular first molars is normal. This means that the mandible and mandibular teeth are in correct mesiodistal relationship with the maxilla and the other facial bones. The mesiobuccal cusp of the maxillary first molar rests on the central sulcus of the mandibular first molar. Malocclusion is usually limited to the anterior teeth. (B) Class II: The mandibular arch is positioned distally in relation to the maxillary arch. The mesiobuccal cusp of the maxillary first molar rests on the space between the buccal cusp of the mandibular first molar and the distal surface of the buccal cusp of the mandibular second premolar. It has two divisions: (b.1) Class II, division 1: The maxillary incisors are protrusive and inclined buccally. The shape of the arch is similar to a "V", and this type of malocclusion is usually associated

with abnormal muscle functions, mouth breathing and finger, tongue or pacifier sucking. (b.2) Class II, division 2: Its main characteristic is the vertical or lingual axial inclination of maxillary incisors. The maxilla is usually flattened anteriorly due to the excessive lingual inclination of maxillary central incisors. There is deep overbite and the mandible often has an exaggerated curve of Spee. Muscle function and breathing are normal. (b.3) Subdivision: When the molars in one side are classified as Class I and the opposite side, as Class II. It is called as right or left subdivision according to whether Class II malocclusion is in the right or left side. (C) Class III: The mandibular first molar is mesially positioned in relation to the maxillary first molar. The mesiobuccal cusp of the maxillary first molar rests on the space between the distal cusp of the mandibular first molar and the mesiobuccal cusp of the mandibular second premolar. In this case, a subdivision is also used when one of the sides keeps the occlusal relationship. Incisors may or may not form crossbite with the buccal faces of the maxillary incisors in contact with the lingual surfaces of the mandibular incisors. Mandibular incisors and canines are excessively inclined linguallly. The maxillary arch is often atretic.

The criteria for the classification of deep bite was a positive vertical overlap greater than 4 mm, and of anterior open bite, a negative vertical overlap of at least 1 mm, according to Silva Filho et al.¹⁷

Before the beginning of the study, school principals and teachers were contacted to explain the purpose of the study, which was to conduct an epidemiological study to describe malocclusions. There was 100% cooperation from study participants. An informed consent form was signed by the parents of the participating children.

RESULTS AND DISCUSSION

The purpose of this study was to conduct an epidemiological survey to characterize malocclusions among elementary school children in the area

**PREVALENCE OF MALOCCLUSION IN THE CITIES OF
LINS AND PROMISSÃO, BRAZIL**

NAME: _____
 AGE: _____
 ETHNICITY: _____
 SEX: _____

MOLAR RELATION

CLASS I ☐ CLASS II ☐ CLASS III ☐

DIVISION ☐ SUBDIVISION ☐

1 ☐ 2 ☐ R ☐ L ☐

VERTICAL RELATION

OPEN BITE ☐ DEEP BITE ☐

TRANSVERSE RELATION

CROSSBITE ☐ ANTERIOR ☐ POSTERIOR ☐

UNILATERAL ☐ BILATERAL ☐ TOTAL ☐

R ☐ L ☐

DIASTEMAS

PRESENT ☐ ABSENT ☐

UPPER ☐ LOWER ☐

CROWDING

PRESENT ☐ ABSENT ☐

UPPER ☐ LOWER ☐

TOOTH LOSS

DECIDUOUS ☐ PERMANENT ☐

FIGURE 1 - Questionnaire used in the study.

of the cities of Lins and Promissão in the State of São Paulo, Brazil. Malocclusion is found in considerable percentages in all communities, regardless of ethnicity, race, sex or age.^{2,7,8,9,11,14-17,20,21,22} In fact, malocclusion is the third public health problem according to the World Health Organization. Epidemiological surveys conducted in Brazilian cities and in other countries revealed an important incidence of malocclusion. These findings have been reported for all age groups, even for those that have a deciduous dentition.^{7,8,9,11,14,15,20,21,22}

In the city of Bauru, Brazil, two epidemiological surveys were conducted by orthodontists to evaluate children.^{15,17} The first, published in 1990, included 2,416 children in the mixed dentition and found malocclusion in 88.53% of the sample.¹⁷ The second epidemiological survey, conducted at a more recent date, complemented the first and defined the characteristics of occlusion in deciduous dentition. The incidence of malocclusion was about 73%.¹⁵ Therefore, the prevalence of malocclusion in the mixed dentition, 73%, was higher than that found for children with deciduous dentition, 88%. This cross-sectional comparison showed the early onset of morphological abnormalities, at a time when the dentition is still deciduous, and the absence of self-correction of poor occlusion already established, at least as it progresses from deciduous to mixed dentition.

When these data are compared with those reported in a previous survey conducted in the 1970s also in Bauru but with individuals with permanent dentition, malocclusion was about 90%, which confirms that malocclusion does not self-correct from deciduous to mixed dentition, nor from mixed to permanent dentition. According to cross-sectional epidemiological data, malocclusion is predominant in the three stages of occlusal development with no epidemiological changes along time. Therefore, the prevalence of malocclusion among children in the city of Bauru is 73%, 88% and 90% in deciduous, mixed and permanent dentition (Fig 2). These data indicate that most of the populations under study had some type of occlusal abnormality. The severity of malocclusion, which might define the actual need for orthodontic treatment, was not assessed. All morphological abnormalities, regardless of their magnitude, were classified as malocclusion, which, therefore, justifies the high incidence of malocclusion. The second reason for a high incidence of malocclusion was the fact that orthodontists use very detailed methods of examination.

The general distribution of malocclusion in the cities of Lins and Promissão, in decreasing order, was: Class I, 55.25%; Class II, 38%; and Class III, 6.75% (Table 1 and Fig 3).

Data found in the literature confirm this distribution of malocclusion according to the sagittal relationships between dental arches. According to Silva Filho et al^{15,17} and their surveys conducted in Bauru in 1990 and 2002, the results among the population with deciduous dentition were 50% Class I, 45.0% Class II, and 4% Class III.

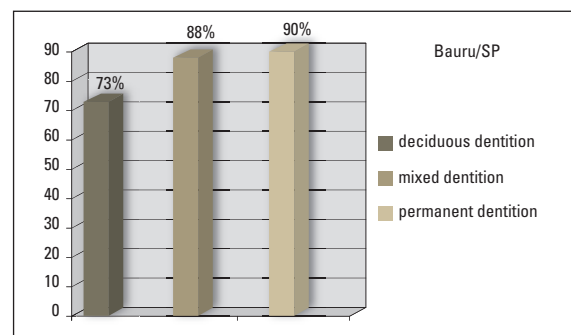


FIGURE 2 - Percentage of malocclusion found in the different occlusal development stages (deciduous, mixed and permanent dentitions) in the city of Bauru, Brazil (Silva Filho et al.^{15,17}).

TABLE 1 - Molar relationship in malocclusions.

Malocclusion	n	%
Class I	1,915	55.25
Class II	1,317	38
Class III	234	6.75
Total	3,466	100

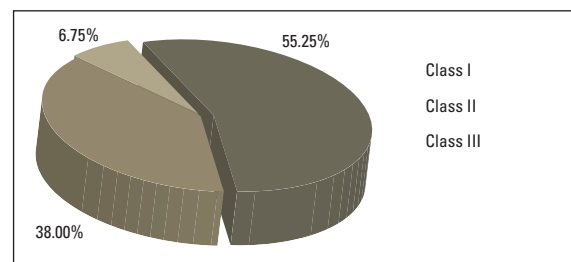


FIGURE 3 - Molar relationship in malocclusions.

For mixed dentition, the distribution of malocclusion was similar, with 55% Class I, 42% Class II and 3% Class III (Table 2). Although the study population was smaller than in previous surveys, results were very similar. The greatest variation was found for the incidence of Class II malocclusion in the population of Lins and Promissão. Some difference in methods should be discussed. In the present survey, the sagittal relationship was defined according to the molar relationship, whereas in the two surveys conducted in Bauru it was based on the deciduous canine or premolar relationship and depended on the presence of the premolar in occlusion.

Open bite was found in 17.65% of the children evaluated in Lins and Promissão (Fig. 4). Anterior open bite is usually associated with sucking habits and atypical lingual pressures.^{3,4,18,24} As sucking habits are more prevalent in childhood, the incidence of anterior open bite tends to be greater in this age group. The incidence of anterior open bite in the group of children with deciduous dentition in the Bauru study was 27.97%. This incidence decreased to 23% in the mixed dentition, close to the prevalence of anterior open bite found for children in the present survey. As the survey in mixed dentition excluded complete permanent dentition, children were younger than the ones evaluated in the present survey. This may have affected statistical results. Therefore, the incidence of anterior open bite in Bauru, Lins and Promissão may be expressed as 28% in deciduous

dentition, 23% in mixed dentition in Bauru and about 17% in the population of children aged 7 to 12 years in Lins and Promissão. These findings seem to reflect the spontaneous sucking behaviors in childhood as suggested in Figures 5 and 6 which show the incidence of sucking habits along time for groups with deciduous dentition. Sucking tends to decrease as deciduous dentition changes into permanent.¹⁰ It is advisable to approach such habits therapeutically at the end of the deciduous dentition to prepare muscles and the alveolar environment for the eruption of permanent incisors, that is, to create favorable morphological conditions for a correct incisor relationship during the eruption of permanent incisors.

Deep bite, or overbite, was found in 13.28% of the study sample (Fig. 4). The analysis of transverse and horizontal crossbite showed that the position of 5.04% was anterior and of 13.7%, posterior in Lins and Promissão (Table 4, Fig 7). The analysis of anterior crossbite revealed that its incidence

TABLE 2 - Distribution of molar relationship in epidemiological surveys conducted in the city of Bauru (Silva Filho et al.^{15,17}) for deciduous and mixed dentitions and in the survey conducted in Lins and Promissão.

Malocclusion	Deciduous dentition in Bauru	Mixed dentition in Bauru	6-12 years of age in Lins and Promissão
Class I	50.0%	55.0%	55.25%
Class II	46.0%	42.0%	38.00%
Class III	4.0%	3.0%	6.75%

TABLE 3 - Vertical relation of occlusion.

Type	n	%
Open bite	612	17.65
Deep bite	460	13.28
Normal	2,394	69.07
Total	3,466	100

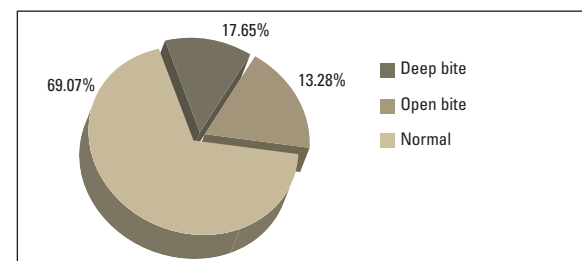


FIGURE 4 - Vertical relation of occlusion.

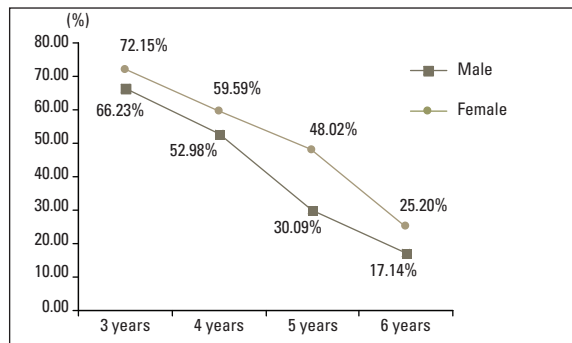


FIGURE 5 - Cross-sectional study of sucking habits in 2,016 children evaluated during the deciduous dentition stage at 3 to 6 years of age according to sex (percentages). (Silva Filho et al¹⁵).

$\chi^2_{(girls)} = 80.94, p < 0.001^*$; $\chi^2_{(boys)} = 124.59, p < 0.001^*$

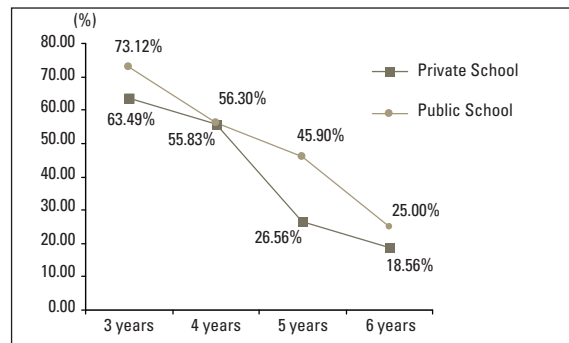


FIGURE 6 - Cross-sectional study of sucking habits in 2,016 children evaluated during the deciduous dentition stage at 3 to 6 years of age according to socioeconomic status (percentages). (Silva Filho et al¹⁵).

$\chi^2_{(public\ school)} = 85.69, p < 0.001^*$; $\chi^2_{(private\ school)} = 113.69, p < 0.001^*$

was greater than that found for the groups with deciduous dentition,¹⁵ which was 3.57%, and lower than the 7.6% found for the group with mixed dentition in Bauru.¹⁷ The incidence of posterior crossbite in Lins and Promissão was a value between the ones found for the deciduous and mixed dentition samples in Bauru, which were 11.65% and 18.2%.

Diastemas were found in 31.88% of the participants (Table 5, Fig 8). A diastema may be defined as the absence of contact between two or more consecutive teeth. It is classified as abnormal and esthetically undesirable in the permanent dentition, but has very little deleterious effect on masticatory efficiency.

Dental crowding results from the difference between the dental arch perimeter and tooth size, either due to environmental or genetic factors. In deciduous dentition, its prevalence is very small, and affects about 10% of the children. However, at the beginning of the mixed dentition, it gains epidemiological significance because its incidence increases considerably. From a therapeutic perspective, it is at this stage of occlusal development that treatment should be initiated. The percentage of children with crowding was 31.59% in the present survey (Table 6, Fig 9). This number is much lower than that found in

TABLE 4 - Horizontal and transversal relation of crossbite.

Crossbite	n	%
Anterior	175	5.05
Posterior	461	13.3
Normal	2,830	81.65
Total	3,466	100

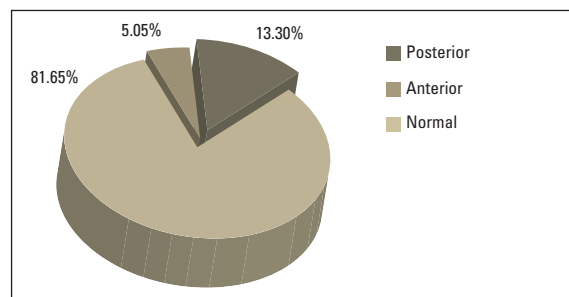


FIGURE 7 - Horizontal and transversal relation of crossbite.

the 1990 mixed dentition survey, which found about 50%.¹⁷ This may be partially explained by the fact that some crowding may have spontaneously resolved in the children of Lins and Promissão because some of them already had permanent dentition. Mixed dentition crowding, known as temporary primary crowding, may resolve spontaneously during the stage of mixed dentition.¹⁰

TABLE 5 - Diastemas.

Diastemas	n	%
Yes	1,105	31.88
No	2,361	68.12
Total	3,466	100

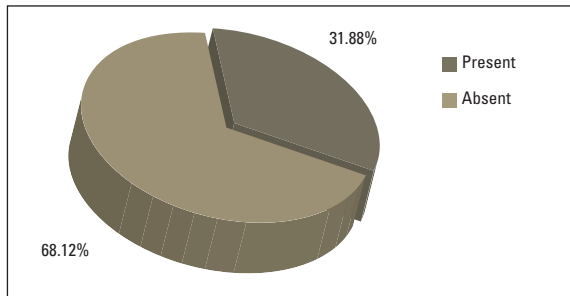


FIGURE 8 - Diastemas.

Tooth losses were seen in 4.65% of the 3,466 school children included in the study in the present survey (Table 7, Fig 10). Early tooth losses are primarily associated with caries and oral habits, and are a public health problem¹² that has been fought by means of prevention and the participation of dental healthcare workers in schools and healthcare systems, as well as by the action of schools of dentistry that conduct preventive studies and social dentistry actions in their communities. Data obtained in the present survey are encouraging when we consider that tooth losses are now less frequent than in the last decade (1990s),¹⁷ which suggests that the prevention systems have been efficient.

Moreover, data in this study seem to corroborate the results found by Almeida et al² in the analysis of a decrease in the incidence of malocclusion in cities where fluoride is added to the water supplied by the public system. This decrease is not associated with genetic factors that affect growth and are responsible for facial patterns, but directly associated with a decrease in tooth losses and a reduction in the areas of interdental contacts resulting from extensive interproximal carious lesions.

TABLE 6 - Crowding.

Crowding	n	%
Yes	1,095	31.59
No	2,371	68.41
Total	3,466	100

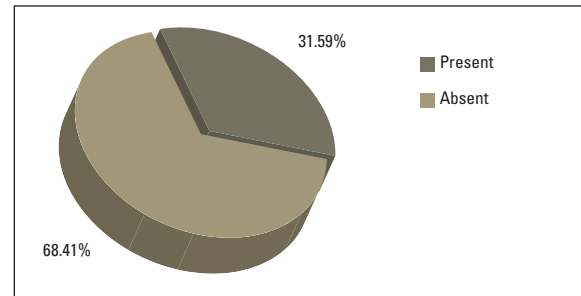


FIGURE 9 - Crowding.

TABLE 7 - Tooth losses in relation to total number of participants.

Description	n	%
Tooth loss	161	4.65
Preserved dentition	3305	95.35
Total	3466	100

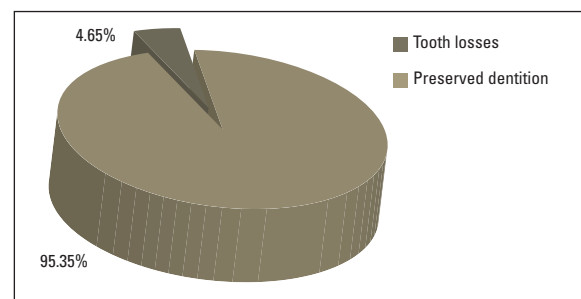


FIGURE 10 - Tooth losses.

Malocclusion has a multifactorial etiology, and tooth loss and the reduction of interdental contacts are only one of the environmental etiological factors responsible for malocclusion.

CONCLUSION

This epidemiological survey defined the morphological characteristics of malocclusion in children in

the cities of Lins and Promissão in the state of São Paulo, Brazil. A total of 3,466 children aged 7 to 12 years were enrolled. Our findings suggest that:

- » The analysis of the sagittal relationship of malocclusion revealed a prevalence of 55.25% for Class I, followed by 38% for Class II, and 6.75% for Class III.
- » The analysis of the vertical dimension revealed that 17.28% of the children had an open bite, whereas 13.28% had a deep bite.
- » Posterior crossbite was found in 13.3% of the total study sample.
- » Anterior crossbite was found in 5.05% of the total study sample.

» Diastemas were found in 31.88%, and crowding, in 31.59% of the children.

» Tooth losses were seen in 4.65% of the study sample.

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Distalization of impacted mandibular second molar using miniplates for skeletal anchorage: Case report

Belini Freire-Maia*, Tarcísio Junqueira Pereira**, Marina Parreira Ribeiro***

Abstract

This study describes a case with an impacted right mandibular second molar which was distalized using miniplates for skeletal anchorage. Uprighting impacted mandibular second molars has been a great challenge for orthodontists and oral surgeons because of the scarcity of anchorage options. Skeletal anchorage was first used in clinical orthodontics in the middle of the 1980s. Since then, several devices have been developed for that purpose, such as mini-screws, tooth implants and, lately, miniplates, which have been tested and showed encouraging results. This topic is relevant for orthodontists and oral surgeons because the use of miniplates may significantly change the treatment of impacted mandibular molars.

Keywords: Skeletal anchorage. Tooth impaction. Molar distalization.

INTRODUCTION

Impacted mandibular second molars are a rather uncommon problem with an incidence of 3 in 1,000 and often pose a challenge for orthodontists and oral surgeons.^{4,8,10} Unilateral impaction is a more common problem and more frequently affects the right side of the mandible of male patients.¹⁰

The possible causes of second molar impaction are the late eruption of second premolars, premature extractions or ankylosis of first molars, dentigerous cysts or odontomas and, finally,

the competition for space by the third molar.⁸ Iatrogenic factors, such as bands and orthodontic loops fixed to the mandibular first molar, may also lead to impactions.¹²

Treatment options depend on tooth inclination, the position of third molars, and the type of movement desired, which may be performed surgically or orthodontically.¹² The best age for treatment is between 11-14 years, when the development of the root of the permanent second molar is still incomplete. Several options have been adopted to treat mandibular molar impaction, and

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one of them is skeletal anchorage, successfully used in orthodontics.

Skeletal anchorage is not a recent procedure. It was first used by Creekmore and Eklund in 1983, who placed screws below the anterior nasal spine for incisor intrusion.⁹

After skeletal anchorage became a regular procedure in orthodontics, several fixation methods and rigid devices have been used for tooth movement,⁵ such as tooth implants,^{3,11,13,17} mini-screws^{2,3,6,7,11,13} and titanium miniplates.^{1,2,3,6,7,11,13}

Miniplates are made of commercially pure titanium, which is biocompatible and adapts to bones.^{1,2,6} Miniplates have been used to treat facial fractures for many years¹ and have recently achieved a prominent place among orthodontic anchorage methods due to its high stability.

Kuroda et al⁶ reported that miniplates provide rigid anchorage for several types of tooth movement, but require patient cooperation after implantation, particularly for oral hygiene. Although infections are rare, they occur in 10% of the cases and are only controlled by strict oral hygiene and, in more severe cases, the use of antibiotics.¹⁵ In addition to infections, other complications such as plate fracture and loosening of screws may occur.

CASE REPORT

A 16-year-old boy sought dental care at an oral surgery service with partial impaction of tooth 47.

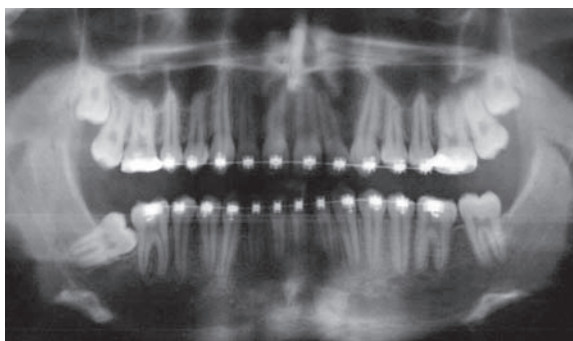


FIGURE 1 - Initial panoramic radiograph shows impacted tooth 47.

A panoramic radiograph confirmed mesial impaction of tooth 47, unerupted maxillary third molars and absence of mandibular third molars (Fig 1). Clinical examination revealed that the crown of the tooth under evaluation was partially exposed in the oral cavity.

The suggestion for treatment was skeletal anchorage using a rigid device placed in the region of the retromolar trigone/mandibular ramus to move the impacted tooth 47 and achieve good occlusion and intercuspation. A 1.0 mm thick straight miniplate with four holes (MDT System 2.0 Ø, MDT®, Rio Claro, Brazil) and two 2.0 mm Ø and 5.0 mm and 7.0 mm long screws.

Surgery for miniplate fixation was performed after the extraction of the maxillary third molars under local anesthesia. A flap was raised by making an incision in the right retromolar region which extended buccally and along the gingival crevice of teeth 47, 46 and 45 to expose the cortical bone (Fig 2).

The selected straight miniplate was previously molded to adapt better to the retromolar region/mandibular ramus, and the screws were fixed after a 1.5-mm bur was used to make the holes in the cortical bone (Fig 3).

The end of the miniplate to be used for orthodontic anchorage was exposed in the oral cavity. Immediately after the surgery, an orthodontic device was placed on the distal face of tooth 47 and



FIGURE 2 - Surgical exposure of the retromolar region/mandibular ramus for miniplate fixation.

traction with an elastic band was initiated.

The incision was closed with 4.0-silk suture, which was removed seven days after the surgery. After the miniplate was fixed, another radiograph was obtained (Fig 4).

For two months, tooth 47 underwent gradual distalization and uprighting produced by the

orthodontic force applied. Three months later, when the tooth had already reached the ideal position (Fig 6), a surgical flap similar to the one used in the first intervention was raised, also under local anesthesia (Fig 7), to remove the miniplate. Total treatment time was three months (Fig 8).

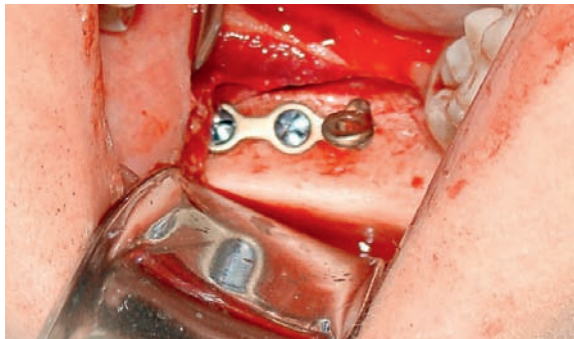


FIGURE 3 - Fixation of miniplate and screws in retromolar region/mandibular ramus.



FIGURE 4 - Radiograph obtained immediately after miniplate fixation and before orthodontic movement was initiated.



FIGURE 5 - Elastic chain for traction placed from the end of the miniplate to two orthodontic devices bonded to tooth 47.



FIGURE 6 - Tooth 47 in upright position after 3 months of treatment.



FIGURE 7 - Miniplate and screws surgically removed after 3-months treatment.



FIGURE 8 - Panoramic radiograph shows tooth 47 in correct position after 3-months treatment.

DISCUSSION

According to Miyahira et al,¹⁰ mandibular second molar impaction is statistically more frequent in the right side of male patients, which was confirmed in the case reported in the present article.

The treatment for second molar impaction, no matter what technique is chosen, should be initiated immediately after the diagnosis because this abnormality may cause caries and periodontal problems, as well as root resorption of the adjacent tooth.

Different treatment options have been discussed in the literature when orthodontic treatment is contraindicated, such as surgical repositioning of the impacted tooth, an option that poses greater risks of complications, such as pulp necrosis, ankylosis and root resorption.¹²

Skeletal anchorage has been evaluated in numerous recent studies and discussions. It provides absolute anchorage, facilitates tooth movement, and is a valuable alternative to orthodontic treatment. Mini-screws,^{2,3,6,11,13} tooth implants^{3,11,13,17} and miniplates^{1,2,3,6,7,11,13} have been used for that purpose.

Mini-screws used in orthodontic anchorage have the advantage of fewer adverse effects and lower operational costs than tooth implants,¹¹ which, according to Miyahira et al,¹⁰ require a longer time for osseointegration, have a higher cost and are difficult to remove.

Mini-screws, however, are not free of complications. Substantially high fracture rates, including fractures that result from their placement, have been reported.²

Choi et al¹ investigated complications after the placement of miniplates for orthodontic anchorage and found high postoperative infection rates. Of the 69 miniplates used in mandibles and maxilla, five led to infection and had to be removed.

Other reasons may also explain miniplate failure, such as the surgical techniques used for insertion, the amount of force, the patient oral hygiene habits and the thickness of the cortical bone, which may contribute to the loss of implanted material.

Sugawara et al¹⁴ showed that skeletal anchorage using miniplates was successful for molar intrusion, distalization and protrusion, which are hardly achieved when using conventional mechanical techniques. Sugawara and Nishimura¹⁵ used the same technique as in our case and achieved success in about 85% of their cases, with plate loosening in only 1% of the cases.

In a recent study, miniplates had a success rate of 96.4% because they resisted reciprocal forces of several traction movements.⁶ Miyawaki et al¹¹ found similar success rates when fixing miniplates with screws longer than 5.0 mm and with a diameter greater than 2.0 mm, a screw size that ensured stability. Similar results have been reported by several authors, who found that miniplates were stable after fixation.^{7,10,13}

CONCLUSION

Miniplates, due to their high stability, may be used for the uprighting of impacted, partially impacted or mesially positioned molars.

In the case reported here, orthodontic treatment was successfully completed after 3 months, and the clinical result was excellent. Based on this experience, we believe that the use of miniplates is a precise, safe and simple method of skeletal anchorage.

Although miniplates are extremely effective, they have some disadvantages, such as the need for surgeries, difficult oral hygiene around the appliance, relatively high cost and the risk of infection and discomfort in the first days after fixation.

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Angle Class I malocclusion and agenesis of lateral incisors*

Fernanda Catharino Menezes Franco**

Abstract

Orthodontic planning for patients with agenesis of lateral incisors should include extremely relevant esthetic and functional considerations so that a satisfactory clinical result is achieved. Both space closure and space opening or maintenance have advantages and disadvantages that should be evaluated according to the patient's individual characteristics. Some of the important factors that affect planning are the skeletal pattern, the type of malocclusion and the color and shape of canines. This study reports on the treatment of a patient with Class I malocclusion and agenesis of lateral incisors, decreased overjet and overbite, and a tendency to open bite and crossbite. The clinical approach included palatal expansion followed by space closure using extraoral anchorage. This case was presented to the Committee of the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) in the Free Case category as part of the requisites to obtain the BBO Diploma.

Keywords: Angle Class I. Tooth agenesis. Corrective orthodontics.

INTRODUCTION

A Caucasian girl aged 10 years and 4 months complained about her teeth esthetics because of the diastemas in the maxillary incisor region, according to herself and her parents. She reported good health except for occasional episodes of allergic rhinitis. The examination of family history showed cases of mandibular prognathism, and the family expressed their concern about the possible genetic transmission of this facial dysplasia.

DIAGNOSIS

Facial examination showed a mesocephalic pattern, no evident asymmetries, a straight profile, increased nasolabial angle and discrete upper lip retrusion. Analysis of the smile showed broad buccal corridors, a result of transverse deficiency in the maxilla, as well as a low smile line with reduced exposure of anterior teeth, a greatly relevant aspect in orthodontic treatment considering the patient's age. Intraoral examination showed low risk of caries and healthy periodontal tissues.

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* Case Report, category 5, approved by the Brazilian Board of Orthodontics and Dentofacial Orthopedics. (BBO).

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The patient presented Class I molar and canine occlusion, missing maxillary lateral incisors, reduced overbite and overjet, which indicated a tendency to open bite and crossbite in the anterior region. Additionally, the upper arch was triangular and atresic and there were spaces between the anterior teeth. The lower arch was also narrow and followed the shape of the upper arch, with marked lingual inclination and crowding in the anterior region (Figs 1 and 2).

The examination of periapical and panoramic radiographs confirmed agenesis of maxillary lateral incisors and showed that the roots of second molars were in an advanced stage of formation and that third molar germs were missing (Fig 3). Cephalometric analysis (Fig 4, Table 1) revealed a Class I ($ANB = 2^\circ$) skeletal pattern, predominance of vertical growth ($SN-GoGn = 40^\circ$) and lingual inclination of mandibular incisors ($IMPA = 88^\circ$).



FIGURE 1 - Initial facial and intraoral photographs.

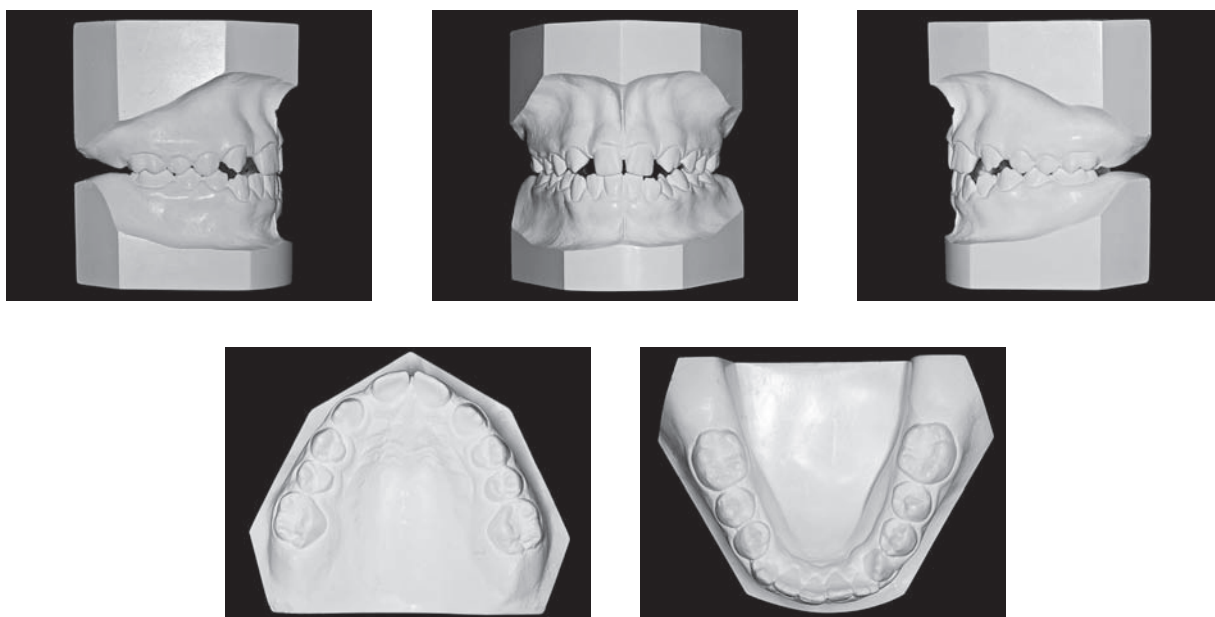


FIGURE 2 - Initial casts.

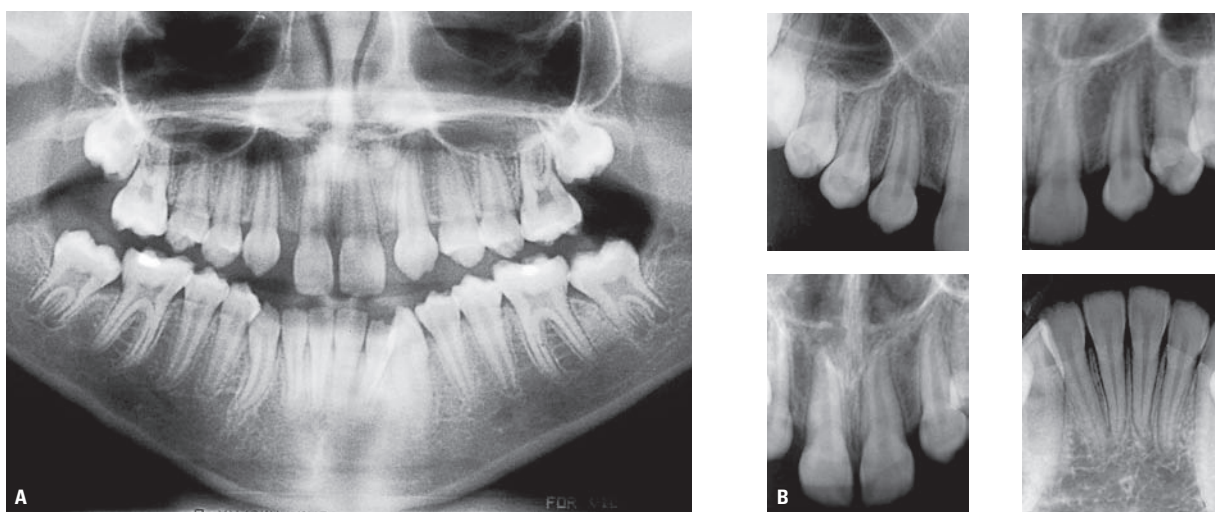


FIGURE 3 - Panoramic (A) and periapical (B) radiographs.

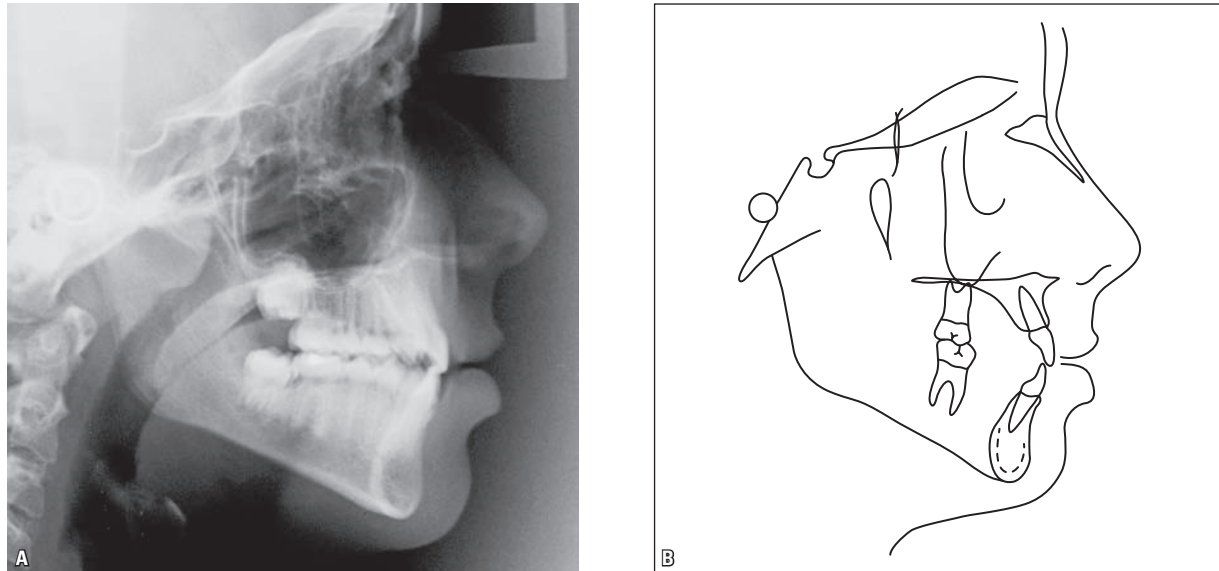


FIGURE 4 - Initial lateral cephalometric radiograph (A) and cephalometric tracing (B).

TREATMENT OBJECTIVES

Considering that the deficiency in the anterior region of the maxilla was one of the aspects that most affected the patient's smile esthetics, the main objective of the treatment was to improve arch shape. In addition to the esthetic benefits, palatal expansion would favor the axial adjustment of mandibular teeth and improve crowding in that region. We decided to close the spaces that corresponded to the missing maxillary lateral incisors by moving the canines and posterior teeth mesially. Another treatment objective was to restore the correct levels of overbite and overjet to achieve a better anterior positioning of the maxilla, control the tendency towards mandibular prognathism and, therefore, establish the harmony of facial and smile esthetics.

TREATMENT PLAN

A comprehensive treatment was planned and included fixed orthodontic appliances in the maxillary and mandibular arches after palatal expansion

using a Hyrax expander associated with maxillary protraction using a facial mask. The purpose of the planned treatment was to increase the transverse dimension and to move the maxilla anteriorly to manage the tendency to crossbite and to define proper overjet.

First, the palatal appliance would be installed. On the second week of activation, the extraoral reverse traction (ERT) appliance would be placed. After expansion, during the six-month retention for the maxillary arch, the ERT would be kept in use, the fixed orthodontic appliance for the mandibular arch would be placed and mandibular alignment and leveling would begin. After the expander was removed, the maxillary fixed orthodontic appliance would be installed. To avoid the tendency towards anterior crossbite, space closure in the maxillary arch would use extraoral anchorage.

After space closure, occlusion would be improved using 0.019x0.026-in rectangular stainless steel archwires with individualized bends

and torques according to esthetic and functional needs in cases of agenesis of lateral incisors. A removable wraparound retainer would be prescribed for the maxillary arch, and for the mandibular arch, a fixed retainer with a 0.028-in stainless steel intercanine wire.

TREATMENT PROGRESSION

The Hyrax palatal expander was placed, and directions were given for two daily activations (1/4 of a turn of the screw every 12 hours) for three weeks. The patient experienced intense pain five days later, and instructions were given to reduce activations to once a day. The ERT appliance was placed on the second week; the initial force was 350 g on each side and progressively increased up to 500 g, which was kept after expansion. Traction direction was adjusted according to the center of resistance of the maxillary bone to avoid unwanted maxillary rotations. Instructions were given to wear the ERT appliance for at least 14 hours per day. Because of the reduction in the number of activations, expansion lasted four weeks; significant opening of the interincisal diastema was achieved, and overjet increased 3 mm.

After active expansion, a fixed orthodontic appliance with a 0.022x0.028-in slot was placed in the mandibular arch for its alignment and leveling. Palatal expansion allowed uprighting of the mandibular teeth, which had a lingual inclination in the beginning of the treatment. This movement promoted a gain in arch perimeter and resolved crowding in the anterior region.

The fixed orthodontic appliance was placed in the maxillary arch six months after retention and when radiographs confirmed suture ossification. After incisor alignment and leveling, the anterior spaces were closed as a result of the mesial movement of canines, which occupied the space corresponding to the missing lateral incisors. To avoid occlusal interferences, canines were reshaped, their torques were individualized, and

their anatomic shape was that of the missing lateral incisors. The remaining spaces were closed by moving the posterior teeth mesially by using the ERT appliance as anchorage. This movement began with the first molar and followed, subsequently, up to the second molar. During finishing, the gingival margins of anterior teeth were adjusted to meet esthetic requirements in this area. The archwires for the final stage were made to have individualized torques for the canines in the sites of the missing teeth and for the premolars that replaced the canines. Posterior teeth were positioned to promote posterior guidance by mandibular excursion. Results were maintained by using an upper arch wraparound removable retainer and a fixed intercanine retainer for the lower arch.

RESULTS

The main objectives established in the beginning of the treatment were achieved, and esthetic and functional results were reasonably satisfactory. Palatal expansion resulted in a favorable increase in the transverse dimension of the maxilla, a more parabolic shape of the arches and proper buccal corridors, which contributed to satisfactory esthetic results (Fig 5). Palatal expansion also changed the shape of the mandibular arch. The shape coordination between arches allowed for uprighting the mandibular teeth that were lingually inclined at the beginning of the treatment and resulted in an increase in arch perimeter and resolution of crowding (Figs 5 and 6). Radiographs confirmed good parallel relationships between dental roots and a discrete apical rounding of maxillary incisors, compatible with orthodontic movement (Fig 7). An important radiographic finding in the final examination was internal root resorption at an initial stage in the maxillary right first molar. Referral to endodontic treatment in this phase ensured that the tooth was preserved.



FIGURE 5 - Facial and intraoral final photographs.

The trend towards anterior crossbite was controlled by the action of the ERT appliance. Even during space closure by movement of the posterior teeth mesially, there was no direct application of force on the anterior teeth, which preserved their position and avoided unwanted effects on occlusion and profile. The effects of reverse traction mechanics were confirmed by cephalometry, which showed the maintenance of the maxillary position both in absolute values (initial and final

SNA equal to 76°) and in total superimposition (Figs 8 and 9).

Final occlusion had a good relationship between arches and a Class II molar relationship, and normal occlusion of mandibular canines and maxillary first premolars, as well as normal overbite and overjet. These results ensure functional balance and mandibular excursion without interferences, as well as healthy periodontal tissues.

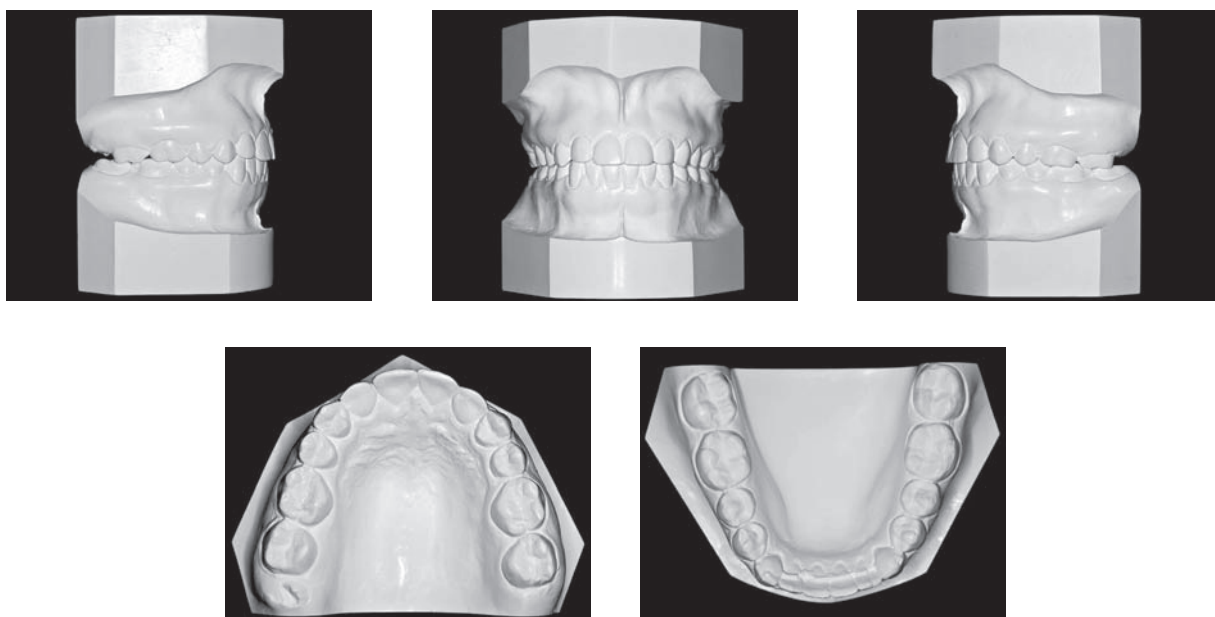


FIGURE 6 - Final casts.

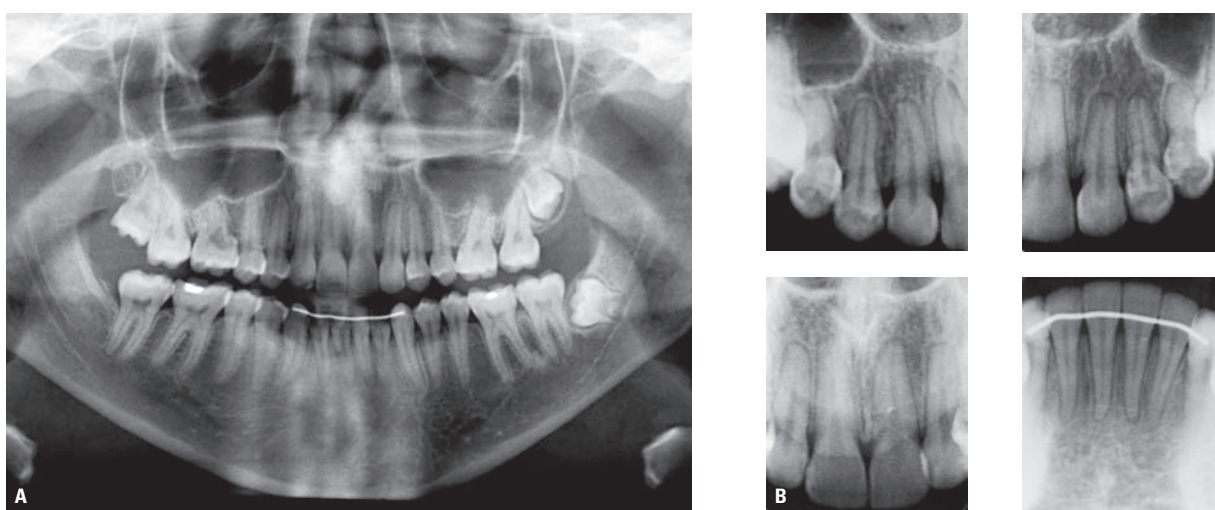


FIGURE 7 - Final panoramic (A) and periapical (B) radiographs.

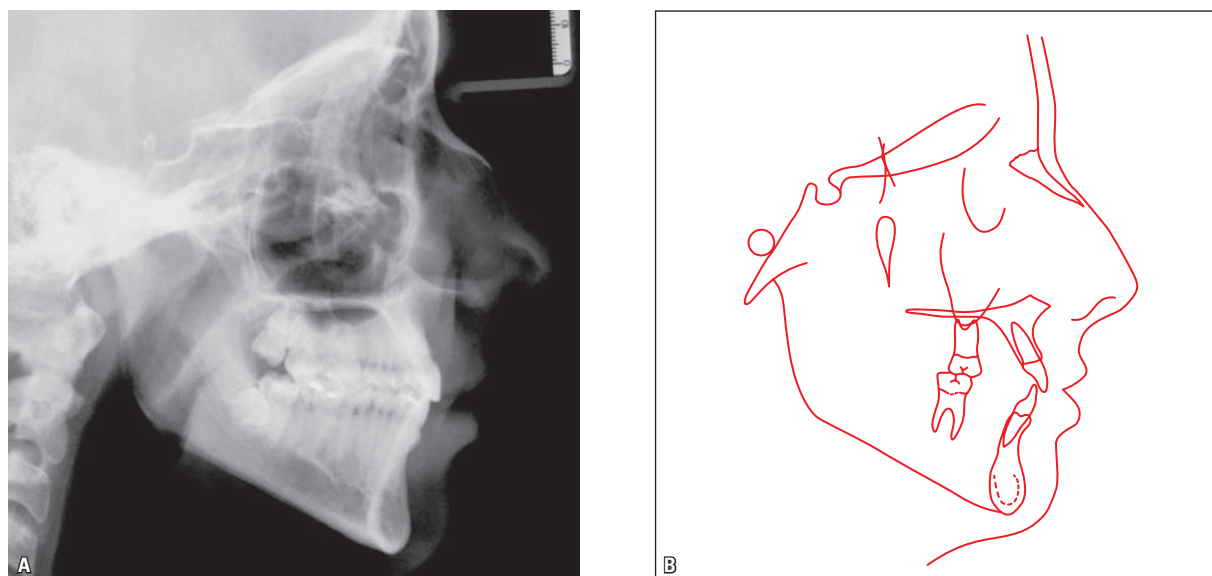


FIGURE 8 - Final lateral cephalometric radiograph (A) and cephalometric tracing (B).

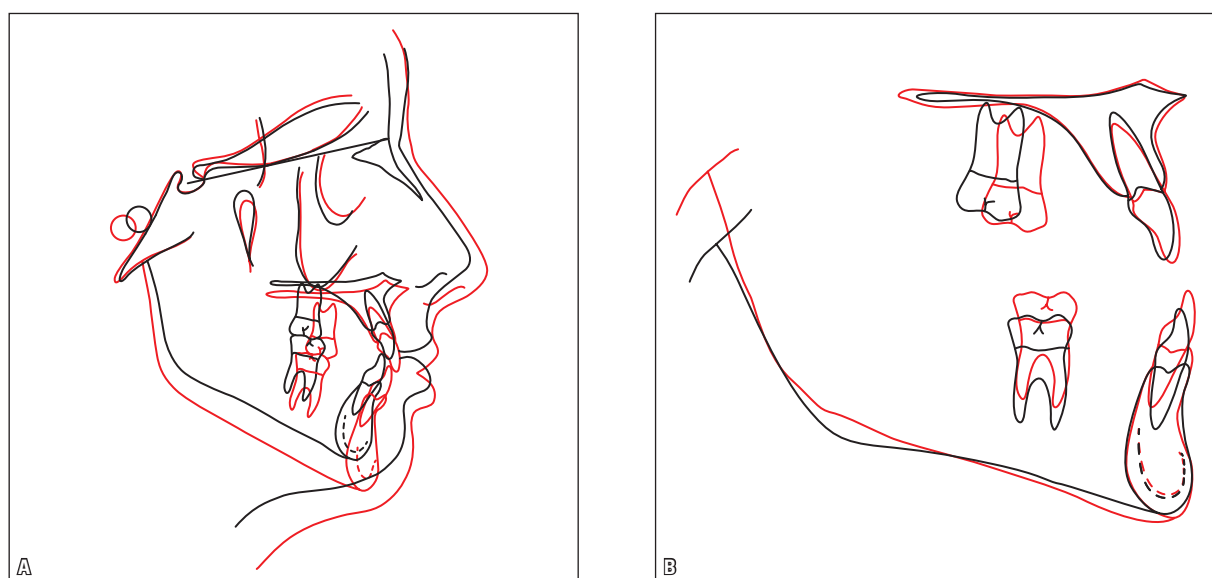


FIGURE 9 - Total (A) and partial (B) superimpositions of initial (black) and final (red) cephalometric tracings.

TABLE 1 - Summary of cephalometric measurements.

MEASUREMENTS		Normal	A	B	A/B DIFFERENCE
Skeletal Pattern	SNA (Steiner)	82°	76°	76°	0
	SNB (Steiner)	80°	74°	74°	0
	ANB (Steiner)	2°	2°	2°	0
	Convexity angle (Downs)	0°	3°	1°	2
	Y axis (Downs)	59°	52°	60°	8
	Facial angle (Downs)	87°	90°	87°	3
	SN-GoGn (Steiner)	32°	40°	39°	1
	FMA (Tweed)	25°	22°	24°	2
Dental Pattern	IMPA (Tweed)	90°	88°	90°	2
	$\underline{1}$ – NA (degrees) (Steiner)	22°	29°	27°	2
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	4 mm	6 mm	2
	$\bar{1}$ – NB (degrees) (Steiner)	25°	22°	24°	2
	$\bar{1}$ – NB (mm) (Steiner)	4 mm	4 mm	4 mm	0
	$\frac{1}{1}$ – Interincisal angle (Downs)	130°	135°	132°	3
	$\bar{1}$ – APo (mm) (Ricketts)	1 mm	3 mm	3 mm	0
Profile	Upper lip – S line (Steiner)	0 mm	0.5 mm	-0.5 mm	1
	Lower lip – S line (Steiner)	0 mm	4 mm	2 mm	2

FINAL CONSIDERATIONS

Orthodontic treatment of lateral incisors agenesis has been widely discussed and documented in the literature. The main treatment options are space closure or the maintenance of that space for future implant placement.^{1,5,7,9,10} In planning and treatment, orthodontic space closure may be either indicated or contraindicated depending on the

original type of malocclusion. Important factors are the degree of crowding, the size and shape of teeth and the state of the occlusion.^{1,3,8} Both treatment options were presented to our patient and her guardians, and the advantages and disadvantages of each were made clear. Despite the normal initial molar relationship and the trend towards anterior crossbite, the decision to close the space was

primarily based on the fact that teeth change positions as the individual grows. That growth is not followed by osseointegrated implants, which, moreover, have effects that are similar to that of ankylosed teeth.^{4,6,8} In addition to that, in middle- and long-term studies about the position of implants in the anterior region of the maxilla, there was progressive loss of marginal bone support in the buccal surface, gingival retractions and exposure of the implant margin.^{2,7,11,12} The patient and her guardians also received explanations about the implications of the increase of treatment time and the greater need for collaboration. Another factor that played a role in treatment choice was the anatomy of the patient's maxillary canines, which were light colored and not very large. These factors favor reshaping and the positioning of these teeth as lateral incisors. To change the shape of the canines, a combination of abrasion and composite resin restoration was used. The palatal surface was also adjusted to avoid premature contacts with maxillary lateral incisors, which ensured the correct axial

positioning of the teeth and the establishment of occlusion without interference.⁴ Moreover, in treatment finishing, canine torque was corrected to be similar to lateral incisor torque, and ideal torques for the first and second premolars were included.^{4,10} The esthetic result might have been better if the first premolar had been intruded to obtain a greater gingival margin height and to ensure a longer premolar crown, whose shape resembled that of the canines more closely.⁴ However, the restorations of the first premolars were rejected by the patient and her guardians after the evaluation of cost and benefits and long-term restoration results.

The choice of an ideal orthodontic treatment for young patients with missing permanent teeth should be based on a careful evaluation of all factors involved in diagnosis, as well as on the characteristics of each patient.¹² In this clinical case report, we considered individual characteristics and needs and chose a multidisciplinary approach to ensure that the wanted esthetic and functional objectives were achieved.

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Brazilian Board of Orthodontics and Facial Orthopedics: Certifying excellence

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Abstract

The Brazilian Board of Orthodontics and Facial Orthopedics (BBO) is the institution that certifies the standards of clinical excellence in the practice of this specialty. This article describes the history of BBO's creation and the examination structure and phases to obtain the BBO Certification. It also presents a detailed report of the first exam applied in Brazil. Its purpose is to expand the knowledge, among professionals in the area, about the importance of BBO Certification as assurance of the highest level of quality in orthodontic treatments.

Keywords: Examination. Certification. Orthodontics.

The advances in medical sciences in the beginning of the 20th century positively affected the practice of specialties. Although such advances promoted improvements in service quality, there was no system to ensure, for the patient, that the professional that advertised as a specialist was actually qualified. Therefore, in 1908, Derrick T. Vail, then President of the American Academy of Ophthalmology and Otolaryngology, came up with the concept of a Board for specialties in health care.¹ Essentially, a Board evaluates the knowledge and clinical skills of professionals in a certain specialty. In May 1916, the pioneering American Board of Ophthalmic Examination was founded.

Since then, this new concept extended to other specialties. In dentistry, orthodontics was the first to establish its Board. In July 1929, during the 28th Conference of the American Society of Orthodontics in the USA, the American Board of Orthodontics (ABO) was founded.² In 1950, the Council on Dental Education of the American Dental Association (ADA) recognized the ABO as the official certifying agency for excellence in orthodontics.³

In Brazil, the idea of creating a Board was also born from the need to promote the achievement of clinical excellence standards in the practice of orthodontics. In 1998, the Brazilian Association of Orthodontics and Facial Orthopedics (ABOR),

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presided by Eros Petrelli, established a Special Committee, whose members were Kurt Faltin Jr., Roberto Mario Amaral Lima Filho and Airton O. Arruda. In 1999, during the 2nd ABOR Meeting, a project to create the Brazilian Board was discussed and evaluated during the ABOR Council Meeting, and its principles were approved by all council members.

In May 2000, members of the ABOR Special Committee participated in a meeting of the ABO in Chicago, USA, to learn about the operations of the American Board. The event was directed to countries interested in the implementation of a certification system. The essential resources to operate a Board were available and provided by the ABO Directors. The Brazilian Committee established contacts to learn about the mechanisms necessary to establish the Brazilian Board and received full support and promises of effective assistance. The material resulting from this meeting was presented in an extraordinary meeting of the ABOR during the Orto Rio Premium Conference in Rio de Janeiro in July 2000.

The professionals appointed to participate in the first Brazilian Board were: Roberto Mário Amaral Lima Filho, Carlos Jorge Vogel, Francisco Damico, Estélio Zen, Anna Leticia Lima, Ana Maria Bolognese, José Nelson Mucha and Telma Martins de Araújo. The legitimacy to hold those positions was obtained in examinations applied during the 101st Meeting of the American Association of Orthodontics (AAO) held in Toronto, Canada, on May 7, 2001. On that occasion, the members of the group were examined by Dr. Jack Dale and Dr. Eldon Bills, former ABO presidents.

The Brazilian Board of Orthodontics and Facial Orthopedics (BBO) was founded on September 2, 2002, in São Paulo. The founding members were Roberto Mário Amaral Lima Filho, Carlos Jorge Vogel, Estélio Zen, Ana Maria Bolognese, José Nelson Mucha and Telma Martins de Araújo, who also participated on the first Board of Directors.

Similarly to what occurred in the United States, the BBO had a pioneering role in health care in Brazil and acted as an exemplary model for other specialties in dentistry and medicine.

The BBO Board of Directors has eight members: President; President-elect; Secretary; Treasurer; 1st Director; 2nd Director; 3rd Director; and 4th Director. The Directors serve one-year terms. After that, the President leaves his position, becomes a member of the group of former presidents and retains membership. The President-elect then becomes President and, sequentially, the other members are appointed to the immediately higher position. The 4th Director position becomes vacant and, on the same date, a new member for that position is elected by the General Assembly. This model gives the members the chance to become familiar with all the institutional structures and prepares and motivates the Directors acting in the different positions.

The candidates to obtain the certification as "Diplomate of the Brazilian Board of Orthodontics and Facial Orthopedics" are evaluated in the areas of diagnosis, treatment planning and knowledge about different aspects of orthodontic treatments. The examinations provide a unique opportunity for candidates to review their practices, reflect about the importance of carefully maintaining quality records, of mechanical control in performing the treatment and of the attention to the final treatment phase.

To ensure the continuous professional qualification and recycle his or her clinical skills and scientific knowledge, the BBO diplomate must undergo periodic revalidation of the Certificate of Excellence.

Another relevant aspect of the certification is professional ethics. The professionals that decide to seek certification are moved by an ideal and dedication to their profession. Being granted is indicative of determination and merit. However, the certificate issued by the

Board does not grant any professional license or academic degree. It is a certificate of excellence and, therefore, does not confer any privileges in the practice of orthodontics. The best definition of the feelings of professionals that seek certifications came from the American orthodontist George Ewans: "The title conferred by the Board will not make you better than others, but it will definitely make you better than before."

Symbols

The BBO logo was developed using a classical lettering style, which conferred a traditional character to this symbol, compatible with the status of an agency that certifies professional excellence. The figure that accompanies the lettering suggests smoothness and stands for the concept of non-traumatic correction: a plant shoot being guided to grow up. As an analogy, this image refers to the aim of our profession (orthodontic correction), to the professional practice per se and the educational guidelines in the area. The colors are references to the Brazilian flag. The seal has the traditional shape of a stamp, and keeps the logo in an outstanding position. This logo is also printed on the lapel pin that all Diplomates receive when certification is granted (Fig 1).

Examination

The BBO certification examination has two phases. Phase 1 is the evaluation of the diagnosis and planning of cases presented by the BBO; phase 2, the presentation of ten cases treated by the candidate.⁴ The cases presented in phase 2 should meet the following criteria: 1) Angle Class II or III malocclusion treated without extractions and with growth control; 2) Angle Class I malocclusion treated with extractions of permanent teeth; 3) Angle Class II malocclusion treated with extractions of permanent teeth; 4) Malocclusion with marked anteroposterior discrepancy: Angle Class III relationship and ANB angle equal to or smaller than -2 degrees; Angle Class II relationship and ANB angle equal to or greater than 5 degrees; 5) Malocclusion with transverse discrepancy and at least one quadrant with crossbite; 6) Malocclusion and marked overbite; 7 to 10) free choice.

Orthodontic records

Good quality orthodontic records are essential for an accurate diagnosis, which is, in turn, key to the success of orthodontic treatment. Records should be identified using letters and colors: A – beginning of the treatment (black); A1, A2 – intermediate (blue); B – end of treatment (red); and C – post treatment (green). The records for



FIGURE 1 - BBO symbols: A) Logo; B) Seal and C) Lapel pin.

the end of treatment (B) may be obtained up to one year after the appliance is removed.

To ensure that evaluations are uniform and balanced, records should be standardized. The cases submitted should include dental casts, radiographs and photographs. The requisites for dental cast trimming and the cephalometric evaluation (tracing, angles, linear measures and superimpositions) follow international norms for case presentations and are available in the BBO website.

Dental casts

Casts should accurately reproduce dental arches and the buccal area to serve as accurate models of the malocclusion. The casts should be trimmed to maximum intercuspation, as shown in Figure 2.⁵

Adjustments or trimming in the anatomic portion (teeth and buccal area) of the casts should

be limited to removing bubbles and small flaws. Changes in tooth anatomy are considered adulterations, which will lead to the automatic rejection of the case. Dental casts must be polished so that all anatomic details are preserved (Fig 3). When preparing casts for cases in which it is not possible to use the recommended heights and angles, symmetry, proportion and esthetics should be taken into consideration.

Radiographs

Panoramic, periapical and supplemental radiographs should be of good quality. The films should be accurately oriented, and the right and left sides should be marked. Panoramic radiographs without a satisfactory definition in the incisor areas (maxillary and mandibular) should be accompanied by periapical radiographs of these areas (Fig 4).

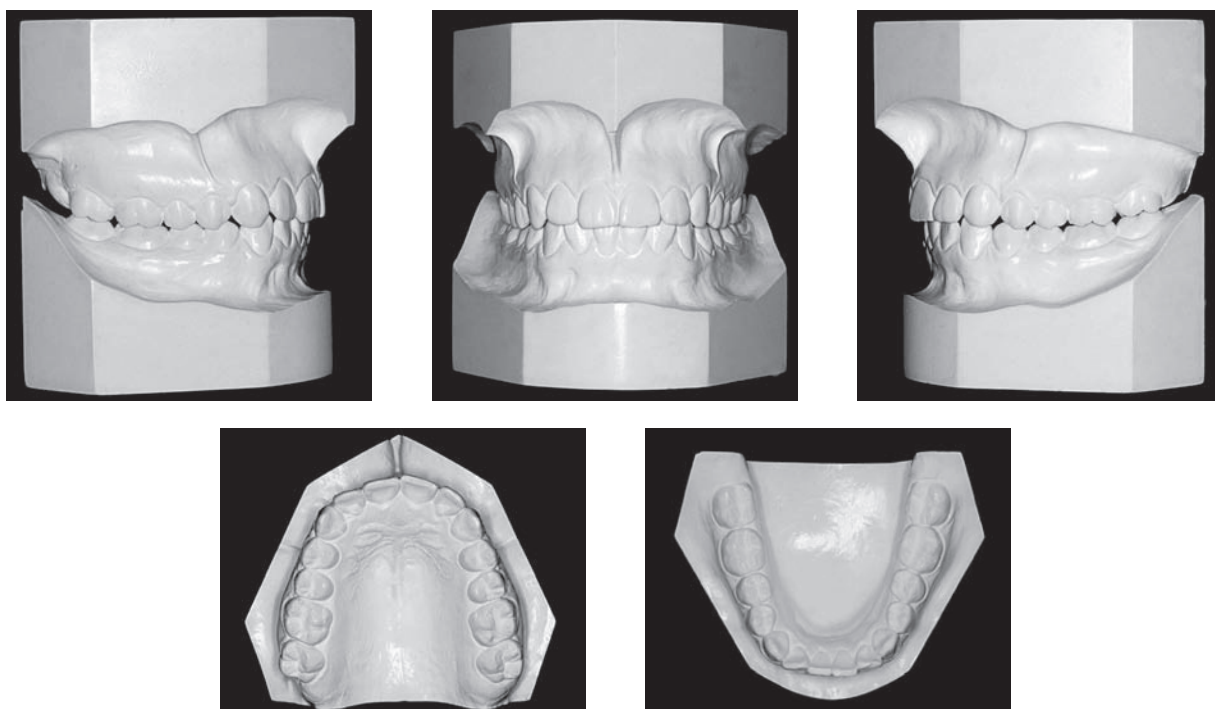


FIGURE 2 - Initial dental casts of Class II malocclusion case, accurately trimmed.⁵

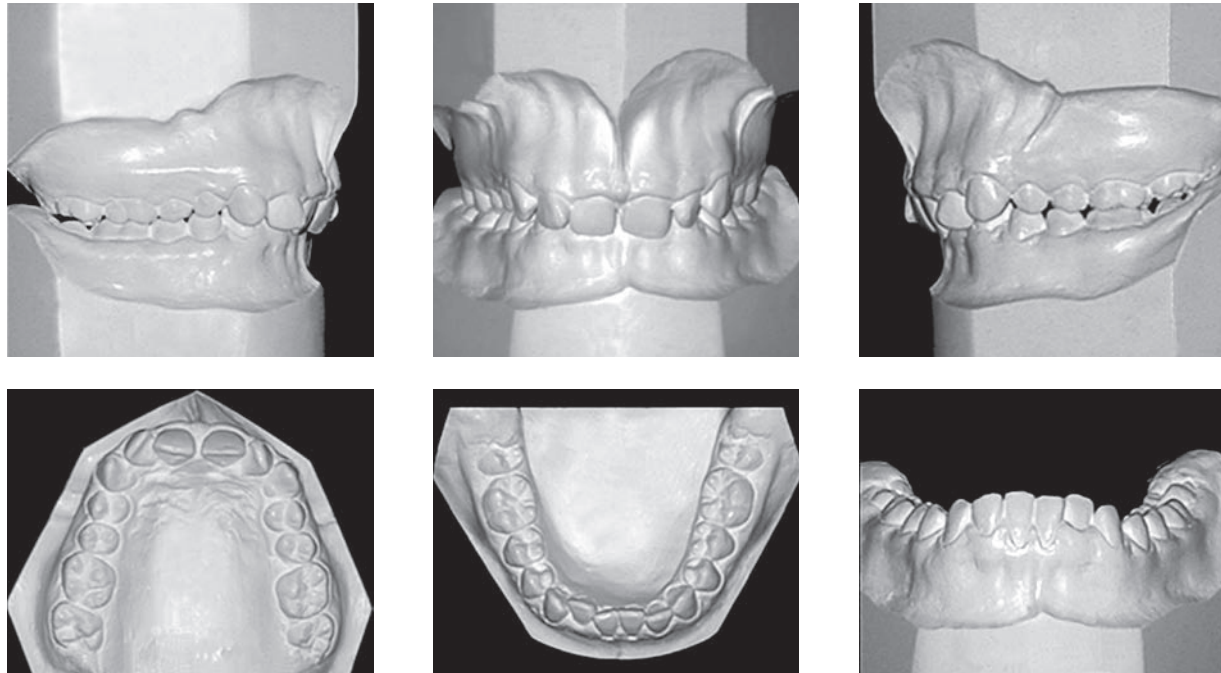


FIGURE 3 - Polished casts with preserved details and accurate reproduction of malocclusion.



FIGURE 4 - Panoramic radiograph (A) and periapical radiograph of maxillary and mandibular incisors (B).

Lateral cephalometric radiographs should be properly standardized, and bone and soft tissue profiles should be clearly visible. In cases of evident facial asymmetry posteroanterior cephalograms should be properly examined and submitted in addition to profile cephalograms (Fig 5). To preserve anonymity, the names of the radiology service and of the dentist should be blacked out.

The patient's name and the radiograph date should be visible.

Cephalograms should be carefully hand-traced by the examinee on tracing acetate using a 0.5-mm diameter pen or pencil. They should contain only the anatomic details of interest for clinical analysis and cephalometric superimpositions (Fig 6). Computer-generated tracings are

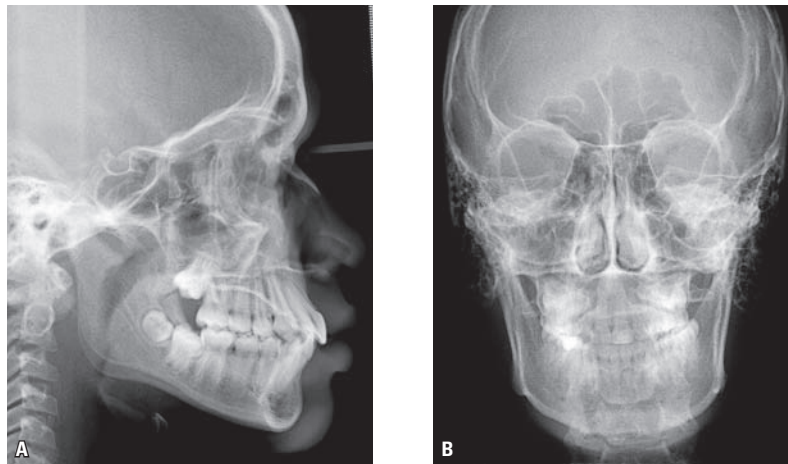


FIGURE 5 - Lateral (A) and posteroanterior (B) cephalometric radiographs.

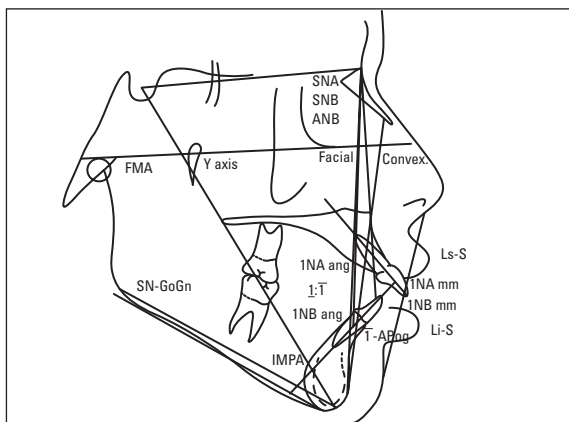


FIGURE 6 - Cephalometric tracing with reference lines and indication of places where measurements should be included.

not accepted. Templates may be used to trace tooth outlines. Cephalometric landmarks should be carefully identified to ensure reliability of the reference lines drawn.

The examinee should be familiar with all aspects of cephalograms, tracings and measurements, as well as their meanings. Tracings should be separated from the lateral radiographs and placed in the plastic envelopes found in the folders.

At least three tracing superimpositions are required: Total or craniofacial, to evaluate general changes during growth and/or treatment; and partial, maxillary and mandibular, to demonstrate dental changes in the maxilla and mandible and their

respective supporting bones. Total superimpositions may be prepared using one of two methods (Fig. 7): (a) Plane of the sphenoid bone and ethmoid cribriform plate, registered on the midpoint between the wings of the sphenoid bone; and (b) the sella-nasion plane, registered on sella. Partial superimpositions should be prepared as follows (Fig 8): Maxilla – best fit of the maxillary bony complex, registered on the palatal curve; mandible – best superimposition in the lower limit of the cortical bone of the mandibular body, registered on the internal cortical outline of the symphysis.

The three superimpositions should be hand-traced by the examinee using pen or pencil. In cases of treatments with intermediate tracings, superimpositions should be presented as follows: A-A1 (beginning–intermediate), A1-B (intermediate–final) and A-B (beginning–final). Cases with post-treatment records should include A-B-C (beginning–final–post-treatment). Superimpositions should be arranged on white paper, but not fixed to it, and placed into separate envelopes. In cases treated with orthognathic surgery, presurgical intermediate tracings should be included.

Photographs

Patient records should include the following face photographs: (a) Frontal; (b) Right lateral profile;

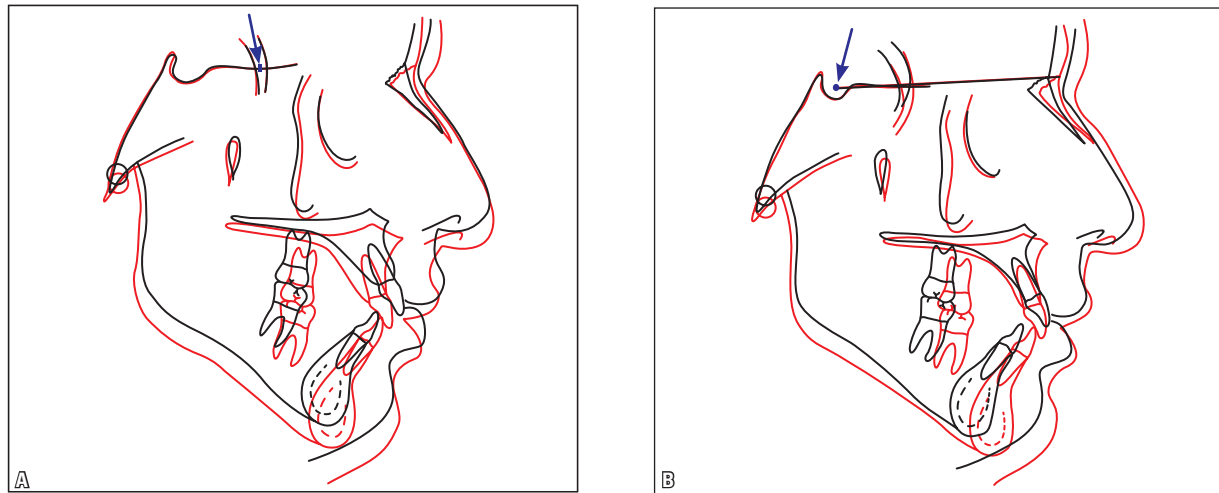


FIGURE 7 - Total superimpositions: **A)** Plane of the sphenoid bone and ethmoid cribriform plate, registered on the midpoint between the wings of the sphenoid bone; **B)** the Sella-Nasion line, registered on Sella.

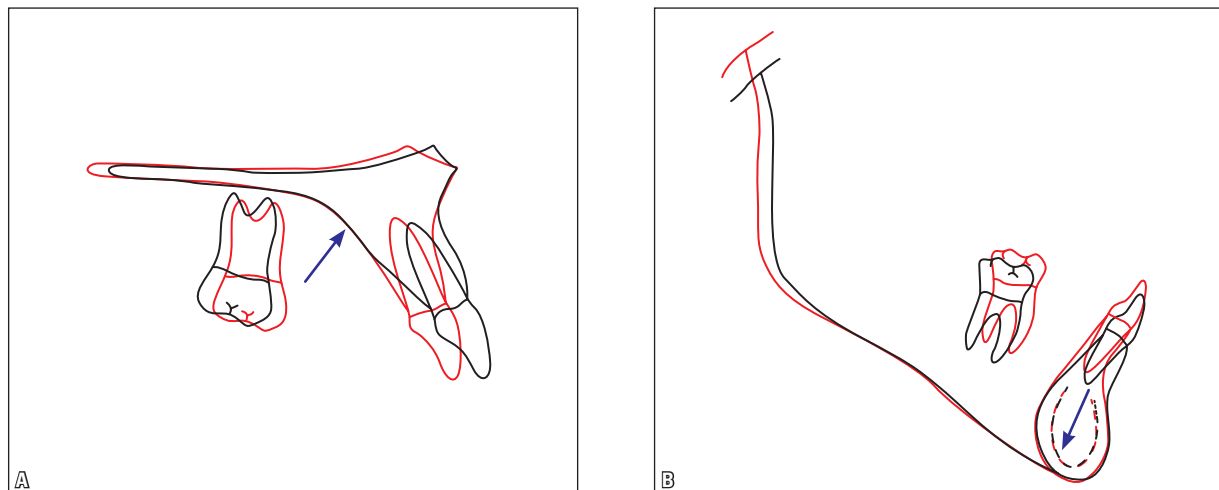


FIGURE 8 - Partial superimpositions: **A)** Maxilla – best fit of the maxillary bony complex, registered on the palatal curve; **B)** Mandible – best superimposition in the lower limit of the cortical bone of the mandibular body, registered on the internal cortical outline of the symphysis.

and (c) whenever possible, a frontal smile photograph. These photographs should be oriented to Frankfort horizontal, and the line between the pupils should be parallel to the ground. They should be taken with relaxed lips and depict the patient's actual labial relationship.

The background should be neutral, preferably white; good-quality lighting should reveal facial contours without shadows; the ears should be visible for

purposes of orientation; the eyes should be open and looking straight ahead; glasses and other accessories should be removed.

In addition to facial photographs, each case should include at least three intraoral records: a frontal view, a right lateral view, and a left lateral view, all with teeth in maximum intercuspation. These photographs should be oriented to the occlusal plane. Optional photographs may be included,

such as occlusal views of the maxillary and mandibular dental arches. Photographs should be as close as possible to a 1:1 ratio with the patient's teeth. If mirror images are used, they should be printed vertically flipped. Attention should be paid to a few other aspects: clean teeth, free of bacterial biofilm, bleeding or saliva; cheek retractors; adequate lighting to show anatomic contours, completely free of shadows; standardized colors; no visual distractions (cheek retractors, labels, fingers).

If the facial and intraoral images are computer generated, their resolution should be high, and

they should accurately demonstrate soft and hard tissues. Photographs may be printed in color to achieve the best possible framing, using the landscape layout and printing them on glossy photo paper. The examinees should keep in mind that records are legal documents and must not be altered. For malocclusions with marked skeletal discrepancies and indication of orthodontic treatment associated with orthognathic surgery, immediate preoperative records must be submitted. Below an example of a photo mount with three facial and five intraoral photographs (Fig 9).

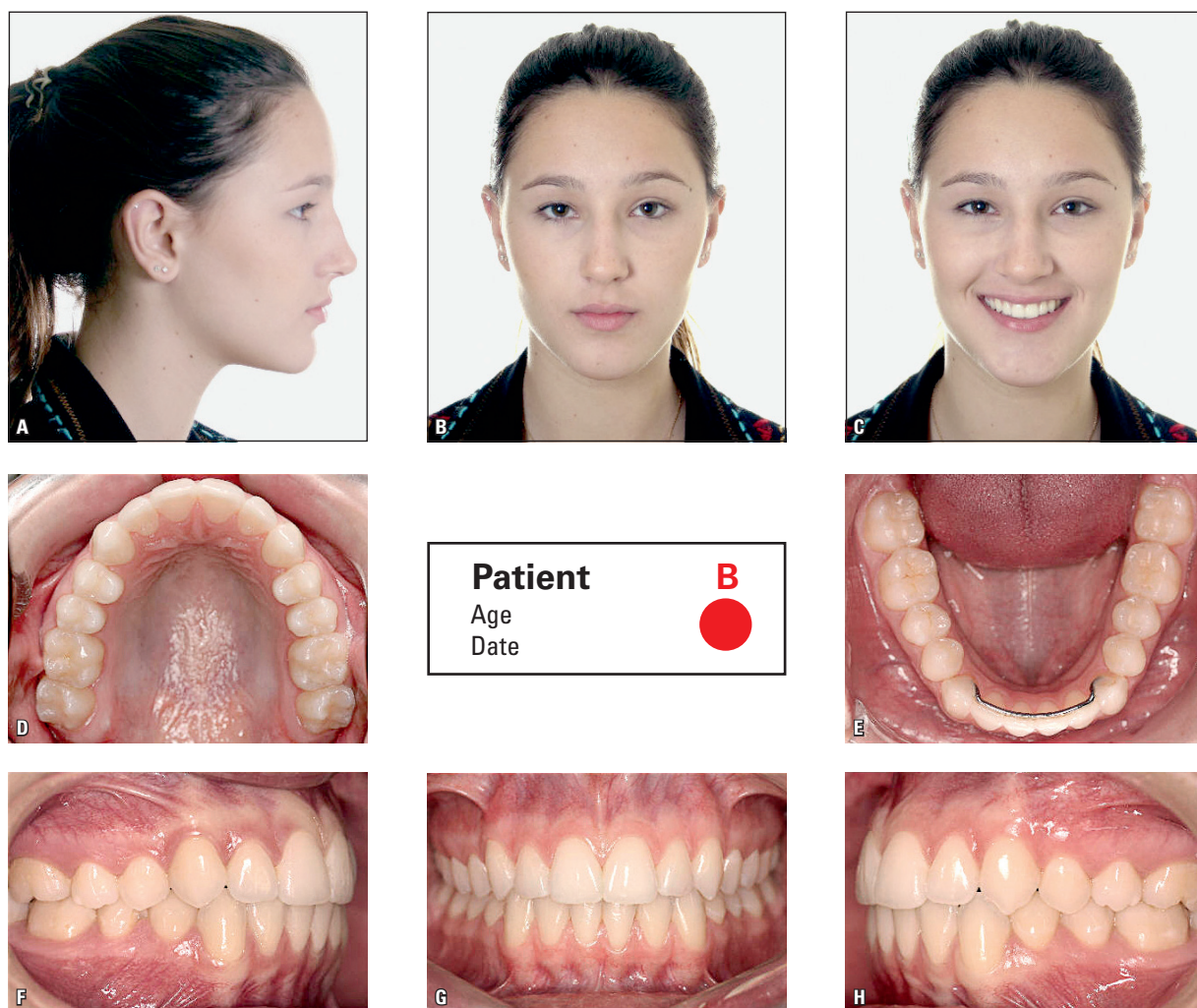


FIGURE 9 - Photograph layout: **A, B, C**) facial - right-side profile, frontal and frontal smiling photographs; **D, E, F, G, H**) intraoral - upper occlusal, lower occlusal, right lateral, frontal and left lateral photographs.

First examination

BBO conducted its first examination from March 19 to 21 in 2004, in the city of São Paulo, Brazil. Interestingly, in that same year, the American Board celebrated its 75th anniversary. The examination had the special participation of Jack Dale, renowned Canadian orthodontist, former ABO president and Professor Emeritus of the University of Toronto. In May of the same year, during the 104th AAO Annual Session in Orlando, Florida, Jack Dale was honored for his services to the American Board. At that time, he mentioned the work of the BBO Board of Directors and highlighted the effort and hard work that were landmarks of the beginning of the journey into BBO's mission.⁶ In special reference to it, he delivered a speech, freely reproduced below, which translated his view of the integrity of the Board efforts in Brazil:

The California redwoods, as magnificent as they are, do not grow alone; they need each other. They grow strong together by intertwining and entangling their roots, thus supporting one another. Without this mutual support they could not be nearly as robust and magnificent. With mutual support, we can remain strong and effective in our service to society. Maintaining our standard of care is a vital part of our strength... all over the world.

It was my honor and privilege to be invited as an external consultant for the first BBO examination. I found the treatment to be superb and the organization by the board of directors outstanding. There were problems, but that was expected. I am sure that these problems will be dealt with and solved in the future, because I am aware of the integrity, dedication, competence and concern of the BBO Directors. The American Board of Orthodontics has also had to solve problems along its 75 years of existence. In the future, these problems will certainly remain challenges.

In Brazil, records were standardized, uniform and beautifully done. You could examine any of the case reports on display and find that the

presentation was identical to the others. How I wish that this standard of excellence existed all over the world.

The exam was divided into two parts: (a) a written exam about case reports presented by the BBO; and (b) case report displays by each examinee.

a) Written examination: examinees from eight Brazilian states had four hours to examine two cases presented by BBO. For that, they were allowed to make cephalometric tracings and carry out any procedures that they used in their practices. I sat in the room for the four hours allotted for the examination, and observed men and women working hard at their tasks. The more I observed them, the more my admiration and respect grew.

B) Case report displays: the ten cases submitted by each examinee included six with specific malocclusions and four optional. The cases were on display in the room to be examined for two days. After that, there was a round table with the participation of all the examinees. The discussion was most valuable and constructive for the BBO.

The motto on the Brazilian flag means "Order and Progress". BBO exemplified this motto to perfection. They certainly achieved progress and did it step by step in an orderly way.

FINAL CONSIDERATIONS

The awareness of the relevance of professional qualification should be developed and expanded, as it occurs in the USA, where this movement has been constant in the different specialties. BBO is synonymous of qualification and adequate training to perform a successful treatment. Its credentials confirm professional competence and assure that the patient will receive a safe and efficacious treatment. Therefore, it should be used as motivation for other professionals to seek excellence in Orthodontics and Facial Orthopedics.

As Jack Dale said, the motto on the Brazilian flag was put into practice by BBO. According to that prominent professional, the level of excellence was achieved in the organization of the examination structure, which makes Brazil stand out as a model for the countries aspiring to become members of the World Board of Orthodontics (14 countries already have a Board of Orthodontics). Brazilian professionals should

believe in such effort so that the seed sown by the words of the Canadian professor germinates and bears good fruit as more specialists apply for excellence certification by the Brazilian Board of Orthodontics and Facial Orthopedics. The BBO certification system has been constantly updating. Therefore, orthodontists interested in taking the Certification Examination should regularly check the website www.bbo.org.br.

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- Preference is given to structured abstracts with 250 words or less.
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- The text must be organized in the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, References and Figure legends.
- Texts must contain no more than 4,000 words, including captions, abstract and references.
- Figures and tables must be submitted in separate files (see below).
- Insert the Figure legends also in the text document to help with the article layout.

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- Digital images must be in JPG or TIF, CMYK or grayscale, at least 7 cm wide and 300 dpi resolution.
- Images must be submitted in separate files.
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- The author(s) must ascertain that all figures are cited in the text.

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- 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.

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- Tables must be self-explanatory and should supplement, not duplicate the text.
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- All articles cited in the text must appear in the reference list.
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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).
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Articles with one to six authors

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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.

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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.

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Kuhn RJ. Force values and rate of distal movement of the mandibular first permanent molar. [Thesis]. Indianapolis: Indiana University; 1959.

Digital format

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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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Decodify® System: Cephalometrics as a risk manager applicative and administrative tool for the orthodontic clinic

Marinho Del Santo Jr*, Luciano Del Santo**

Abstract

Introduction: Cephalometrics may have limited use in orthodontics because of its subjective interpretation. An Artificial Intelligence (AI) system, the Decodify® System, was developed to allow the customized quantitative assessment of contextualized cephalometric data. In this article, the system is tested as an administrative tool in orthodontic offices. **Methods:** The development of algorithms includes the norms and standard deviations modeling of Brazilians' cephalometric data, measured in lateral radiographs. In order to test the system, initial cephalograms of 60 orthodontic patients of two different orthodontic offices (30 cases each) were processed and re-processed by three different technicians. The intra-observer and inter-observer reproducibility and reliability indices were checked by paired comparisons. The risk in each orthodontic case, assessed by the electronic analysis, was compared by covariance matrices and agreement coefficients. **Results:** Levels of paired agreement inter-observers (versus golden-pattern) for 23 pairs of variables ranged from 0.68 (S-Go distance) to 0.98 (Na-Me distance) in an orthodontic clinic (JU) and from 0.66 (L1.APg angle) to 0.98 (S-Go distance) in the other (SP). All the correlations were significant at the $p < 0.001$ level. The average of the agreement coefficients was 0.78 for one clinic (JU) and 0.75 for the other (SP). The agreement coefficients were significant at the $p < 0.001$ level. **Conclusions:** The results of such research support that the analyses provided by the Decodify® System are reproducible and reliable. Therefore, the system can be applied in order to contextualize conventional cephalometric measurements and to generate individualized risk indices. The system may be used by orthodontists as an administrative tool in the daily professional evaluations.

Keywords: Orthodontics. Diagnosis. Artificial Intelligence.

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» The authors declare to be developers of Decodify® System.

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LITERATURE REVIEW

Although cephalometrics presents known limitations, it is an important diagnostic tool for the orthodontist.¹⁻⁴ One of its limitations is the dependence of personal opinion, since each specialist “interprets” cephalometric data according to the biases built up by his/her academic education, clinical experience and type of clinical service. Technically, cephalometrics presents a limited internal validity due to the identification of cephalometric landmarks^{5,6,7} and other methodological⁸⁻¹¹ or geometrical problems.¹² Naturally, new solutions in orthodontic diagnosis has been presented.¹³⁻¹⁸

An important update in cephalometrics would be the customization of cephalometric values measured in each case, what each orthodontist already subjectively makes in daily assessments. Such kind of improvement would not eliminate the need of different sources of information, as cast models and photos. However, in regard to cephalometrics, would be close to the ideal.

Up to date, cephalometric values were not considered in a contextualized model, that means, in the particular scenario of each patient. However, such constraint is more mathematical than biological. Such contextualization would be possible if an artificial intelligence system could provide decisions, imitating what the human being thinking already provides. Such software would need to take into account the degree of uncertainty and inconsistency associated to each cephalometric number, increasing or decreasing the importance of its contribution for the “final degree” of skeletal and dental compromise which each case of malocclusion presents.

Mathematicians and computer engineers have worked in diverse models of “intelligent” algorithms, based upon different types of logic and applied in diverse fields of science as logistics, robotics, defense, economics and medicine.^{19,20}

When artificial intelligence systems make decisions in the medical field, they are called specialist

systems, programmed to support physicians and other professional personnel of the health area, which; however, provide the final diagnosis or the hypotheses of diagnosis, at their own.

The model of logic applied in this project²¹⁻²⁴ allowed that diverse cephalometric variables were contextualized in each specific craniofacial scenario.

The fuzzy logic has been applied in medicine^{25,26,27} and orthodontics^{28,29} in order to prevent inadequate rigid allocations in pre-defined categories. However, fuzzy logic considers only certainty and it is not a sufficient mathematical tool in decision making processes. In other hand, paraconsistent logic^{22,24} also works with the uncertainty, inconsistency and insufficiency of data, common features in cephalometric data bases, and because of that, was applied in the decision making processes here described.

In another article,³⁰ the Decodify® System was tested against the opinions of three specialists in orthodontics and, showing an expected variance, behaved as a specialist system.

In the current paper, the results of the Decodify® System were obtained by two trained technicians and, in a paired matter, were compared with the results of an experienced technician in the processing, source called “golden-pattern”. Therefore, the article has two main goals: 1) To test the reproducibility and reliability of the results obtained by the Decodify® System and; 2) If the Decodify® System is reproducible and reliable to be introduced to the orthodontic community as an administrative tool used by the orthodontist to measure the degree of risk involved in each proposed orthodontic treatment.

Implementation

The Decodify® System was written in Delphi 11.0 language and filed in Oracle databases, between 2000 and 2004. The algorithms allow that independent cephalometric variables were

integrated, considering the uncertainty, inconsistency and insufficiency carried by each variable. The inferences of the system are based upon the degrees of evidence of abnormality (DEA) in specific units: Skeletal (anteroposterior and vertical) and dental (upper and lower teeth).

The components of the Decodify® System (softwares Decodify® e DecodeCAD®) are registered in Brasil in the INPI (Instituto Nacional da Propriedade Industrial) under the licences 00070981 and 00075342. In the USA, the softwares are registered in the Copyright Office – Library of Congress/USA under the protocols TXu1-326-513 (7/31/06) and TXu1-326-514 (7/31/06).

MATERIAL AND METHODS

Samples

The samples, retrospectively collected, included 60 initial cephalograms, from patients of both genders, who seek for orthodontic treatment in two clinics, in Jundiaí (JU) and São Paulo (SP). In Jundiaí, 13 male and 17 female individuals, from 12 to 29 years-old, were included in the sample. In São Paulo, 10 male individuals and 20 female individuals, from ages of 19 to 55 years-old, were included in the sample. Patients who presented compromised lateral cephalograms or craniofacial deformities were not included in the sample. There was not discriminate rule in regard to the malocclusion initially presented by the patient, neither in regard to its severity.

Data collection

Eighteen cephalometric landmarks (Fig 1) were identified, traced, re-identified and re-traced in acetate paper, with mechanical pencil 0.3 mm, by three trained technicians (golden-pattern, Jundiaí clinic and São Paulo clinic). All the tracing were digitalized in the tablet Trust TB 7.300 Wide Screen Design Table (PO Box 8043, 3301 CA Dordrecht, The Netherlands) and the data analyzed by the Excel software (Windows 7, Redmond, Washington, USA).

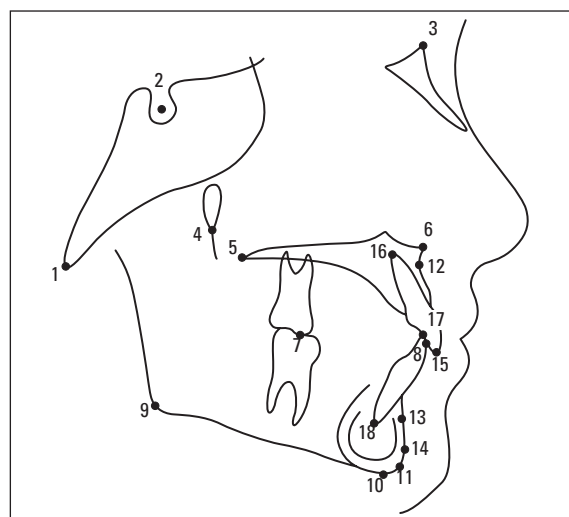


FIGURE 1 - Selected cephalometric landmarks.

Landmarks and cephalometric measurements

The following landmarks and cephalometric measurements were identified and digitalized (Fig 1):

- 1) Basion (Ba): The most postero-inferior point on the posterior margin of the foramen magnum.
- 2) Sella (S): The center of the pituitary fossa of the sphenoid bone.
- 3) Nasion (N): The junction of the frontal and nasal bones, at the fronto-nasal suture.
- 4) Pterygo-maxillary fissure (PtgI): the most inferior point of the pterygo-maxillary fissure.
- 5) Posterior nasal spine (PNS): The most posterior point on the bony hard palate.
- 6) Anterior nasal spine (ANS): The tip of the median anterior bony process of the maxilla.
- 7) Upper molar: The most inferior point of the mesial cuspid tip of the first upper molar, posterior reference for the occlusal plane.
- 8) Anterior reference of the occlusal plane: Established by bisecting the overbite or open bite of the incisors, considering the incisal edges of the upper and lower incisors.
- 9) Gonion (Go): The most postero-inferior point of the angle of the mandible.

- 10) Menton (Me): The most antero-inferior point on the mandibular symphysis.
- 11) Gnathion (Gn): The most antero-inferior point on the contour of the symphysis. Determined by bisecting the angle formed by the mandibular plane (Go-Me) and the Nasion-Pogonion line.
- 12) A Point: The most posterior point on the anterior curvature of the maxilla.
- 13) B Point: The most posterior point on the anterior curvature of the mandibular symphysis.
- 14) Pogonion (Pg): The most anterior point on the contour of the bony chin.
- 15) Upper incisor edge: The incisal tip of the maxillary central incisor.
- 16) Upper incisor apex: The root tip of the maxillary central incisor.
- 17) Lower incisor edge: The incisal tip of the mandibular central incisor.
- 18) Lower incisor apex: The root tip of the mandibular central incisor.

The following cephalometric measurements were considered (Fig 2):

- 1) S-N: Plane that represents the anterior cranial base.
- 2) Palatine plane: Angle between the anterior cranial base (S-N) and the palatine plane, considering the landmarks ANS and PNS.
- 3) Occlusal plane: Angle between the anterior cranial base (S-N) and the occlusal plane, considering the landmarks molar and incisor.
- 4) Mandibular plane: Angle between the anterior cranial base (S-N) and the mandibular plane (Go-Me).
- 5) Ba-Na: Plane that represents the cranial base.
- 6) Y Axis: Smaller angle between the cranial base (Ba-N) and the facial axis (Ptg-Gn).
- 7) S-Go: Distance between Sella and Gonion, representing the posterior facial height.
- 8) N-ENA: Distance between Nasion and ANS, representing the upper part of the anterior facial height.

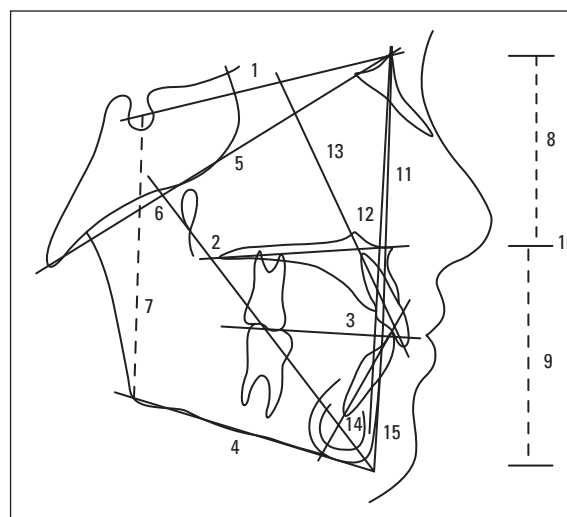


FIGURE 2 - Selected cephalometric measurements.

- 9) ANS-Me: Distance between the ANS and Menton, representing the lower part of the anterior facial height.
- 10) N-Me: distance (mm) between Nasion and Menton, representing the antero-posterior facial height.
- 11) SNA: angle between the anterior cranial base (S-N) and the A Point, representing the antero-posterior positioning of the maxilla.
- 12) SNB: angle between the antero-posterior cranial base (S-N) and the B Point, representing the antero-posterior positioning of the mandible.
- 13) Long axis of the upper incisor.
- 14) Long axis of the lower incisor.
- 15) A Point-Pg plane: Plane representing the maxilla-mandible skeletal profile.

Wits: distance between the perpendicular projections of the A and B Points in the occlusal plane, representing the antero-posterior relationship between the maxilla and the mandible.

Research model and statistical method

The system was developed in 3 units: 1) Antero-posterior, 2) Vertical and 3) Dental. The central tendency measurements (average and standard deviation) for each age (6 to 18 years-old) from both genders were obtained for the Craniofacial Growth Atlas from Bauru.³¹

The chosen golden-pattern was the digitalization and processing operated by the a technician (BioLogique S/S Ltda Company, São Paulo-SP, Brazil) and hosted in the central server Hostlocation (HostLocation S/C Ltda. Company, R. Maestro Cardim 7081, 01323-001, São Paulo-SP). Each one of the two offices provided 30 lateral radiographs and a technician (examiner) to digitalize and process the data.

After the golden-pattern was established, the intra-examiners reproducibility was tested for each one of the examiners. The results of each examiner were independently compared with the golden-pattern (it was called inter-examiner comparison). The results of each sub-sample of 30 cases were also self-compared (re-digitalized 4 weeks after the first trial). The intra-examiners correlations targeted to measure the systematic error and the inter-examiner correlations targeted to measure the method error. Epistemologically, the null hypothesis of no difference intra-examiners and the null hypothesis of no difference inter-examiner (examiner against the golden pattern) were tested.

Coefficients of correlation compared similar cephalometric variables in a paired manner, isolating as dependent variable the examiner. The risk involved in each case, result of the electronic processing by the Decodify® System and presented as a quantitative ranking, was measured in an ordinal mode. The risks were matched by matrices of covariance and such comparisons were expressed by agreement indices, again testing the null hypotheses of no difference intra-examiners and the null hypotheses of no difference inter-examiner (examiner against the golden pattern).

Logic of the artificial intelligence system

Decodify® is an artificial intelligence system that can calculate the degrees of cephalometric severity, skeletal and/or dental, after the mathematical contextualization of the selected variables. The “neural” network is build with paraconsistent logic,^{22,24} capable of making non-trivial decisions, based in its sensibility to uncertainty, inconsistency and insufficiency of the treated data.

RESULTS

The results of reproducibility and reliability of the selected cephalometric variables are described

TABLE 1 - Matched correlation, golden-pattern intra-examiners (IRA) and inter-examiners (IER). Significance level: [p< 0.001].

Variable	Golden-pattern IRA	IER-JU	IER-SP
SNA	0.91	0.74	0.96
SNB	0.94	0.91	0.95
ANB	0.93	0.81	0.97
Wits	0.87	0.86	0.88
M-U1	0.89	0.85	0.77
M-L1	0.84	0.79	0.70
S-Go	0.97	0.68	0.98
Na-Me	0.98	0.98	0.96
Na-ENA	0.90	0.82	0.90
ENA-Me	0.94	0.93	0.97
SN/PP	0.79	0.82	0.82
SN/PO	0.90	0.89	0.89
SN/PM	0.95	0.90	0.97
Y Axis	0.97	0.86	0.97
U1.SN	0.94	0.92	0.95
U1.PP	0.92	0.89	0.95
U1.Na	0.93	0.88	0.96
L1.GoMe	0.90	0.94	0.83
L1.NB	0.79	0.93	0.74
L1-NB	0.93	0.93	0.93
L1.APg	0.84	0.88	0.66
L1-APg	0.81	0.77	0.84
U1.L1	0.90	0.91	0.90

IRA: intra-examiners evaluation.

IER: inter-examiner evaluation.

TABLE 2 - Matched correlation, between intra-examiner and golden-pattern. Significance level ($p < 0.001$).

Variable	IER-JU	IER-SP
SNA	0.86	0.73
SNB	0.94	0.64
ANB	0.69	0.85
Wits	0.81	0.92
M-U1	0.88	0.60
M-L1	0.83	0.56
S-Go	0.98	0.83
Na-Me	0.98	0.62
Na-ENA	0.86	0.77
ENA-Me	0.96	0.69
SN/PP	0.83	0.73
SN/PO	0.90	0.67
SN/PM	0.97	0.75
Y Axis	0.94	0.61
U1.SN	0.86	0.62
U1.PP	0.85	0.61
U1.Na	0.81	0.55
L1.GoMe	0.91	0.81
L1.NB	0.78	0.73
L1-NB	0.91	0.77
L1.APg	0.52	0.62
L1-APg	0.67	0.83
U1.L1	0.75	0.69

IRA: intra-examiners evaluation.
IER: inter-examiner evaluation.

TABLE 3 - Definition of ranking of risk. Ordinal classification of the quantitative results.

Risk: Decodify® result	Clinical significance	Extension of the treatment*	Cost of the Treatment*
Risk I	Dental compromise only	12 months	\$
Risk II	Light skeletal compromise	18 months	\$\$
Risk III	Moderate skeletal compromise	24 months	\$\$\$
Risk IV	Severe skeletal compromise	30 months	\$\$\$\$

*As a reference, up to each clinician.

TABLE 4 - Degrees of agreement measured by matrices of covariance, comparing the measured risk by the two examiners against the golden-pattern. Significance level: [$p < 0.0001$].

Risk-Result	JU	SP
Minor Correlation	0.54	0.47
Major Correlation	0.90	0.88
Average Correlation	0.78	0.75
Degree of Agreement	0.78	0.75

in the Tables 1 and 2. Table 3 describes the ranking of assessed risk and the Table 4 shows the agreement indices between the risks presented in the two examiners assessments compared with the pre-defined golden-pattern.

DISCUSSION

Cephalometrics is a worldwide accepted orthodontic diagnostic tool and considered essential information to offer a reliable treatment plan to the patient. It is based upon measurements on head lateral radiographs and it describes skeletal and dental discrepancies with considerable precision. An experienced clinician can well interpret, although subjectively, cephalometric numbers and apply such information in his/her daily practice. Because only numbers cannot be directly applied in the clinic, such subjectivity has been referred as a drawback in the potential value of cephalometrics for routinely use.

The point to be discussed is not if cephalometrics should be or should not be used, but how cephalometric numbers might be interpreted before its application, since that interpretation holds significant variance. This occurs because of two main reasons: first, because the degree of clinical abnormality is not quantitatively measured and; second, because there is no way to establish a golden-pattern. Golden-pattern is the pattern reference established in order to have other references compared to it and, according to this comparison, become acceptable or not.

In our research project, we established a golden-pattern (Table 1), contextualizing cephalometric measurements of wide application. The result of such contextualization is called risk. It is important to highlight that such risk was based upon expected norms for each one of the elected measurements, individualized by gender and age, measured in the same population of the evaluated cases (Brazilians, Caucasians, with average degree of ethnic miscegenation). The contextualization (or risk) can be defined as: "What we should expect as the degree of severity of malocclusion, skeletal or dental, in that particular patient."

From our results, it was observed that the inter-examiners comparison (against the golden-pattern) varies according to the cephalometric measurement. Such result is what we expected from the human evaluation of cephalometric landmarks with different degrees of identification and reproduction. Notice that such degree of variation involves the degree of accuracy of the examiner and of the golden-pattern as well. As examples of landmarks vulnerability in regard to the identification and reproduction the point A (due to the thickness of the maxillary bone), the inclination of the lower incisor (due to the lower incisors images superimposition) and the geometric location of the Gonion point (constructed bisect).

Such variations also account the intra-examiner variation, isolated in the Table 2. The variation in reproducibility of the technicians implies in the fact that there are examiners with better knowledge and/or expertise to trace a cephalogram, what is reasonably expected.

The quantitative results provided by the Decodify® System as risk are presented in an ordinal ranking in the Table 3. Then, parameters that we consider useful for the daily orthodontic practice are suggested. For instance, the greater the skeletal compromise of a case, greater its risk and consequently greater the treatment time

required and the cost involved.

The contribution of our work is evident when the degrees of agreement are presented. When we have a calibrated system which presents degrees of severity, throughout algorithms that contextualize individual cephalometric variables, we have the level of risk in each evaluated case. The degrees of agreement show that such level of risk is reproducible and trustworthy and, therefore, evaluations are minimally based in personal opinions. The "cephalometric guessing" is exchanged by the "evidence" of the cephalometric risk. In few words, the Decodify® System works as a "ruler", to measure the degree of difficulty to treat a specific orthodontic case.

With such instrument, therefore, the orthodontist can measure, with high level of precision, how much "energy" the office must dedicate to that particular case. And the practical consequences of such measurement are many: The orthodontist might estimate the extension of the treatment, the approximated number of appointments, and the need of his/her attention as the chief clinician (and consequently the possibility to delegate less important functions to his /her assistants), the potential problems, the fee to be charged etc.

Metaphorically, in a near future if not today, orthodontic treatment will be offered to the patients as a "well defined flight script", with an estimated time to take off, estimated time to last and estimated time to land, well defined destination and well forecasted flight conditions. Who does not have scientific premises to base on, will still "take off its orthodontic airplane" with no information about the airport to be addressed, what is the estimated flight duration and what are the expected weather conditions ahead. Such professionals will be naturally avoided by their potential patients, who will look after better services. And it is impossible to be different: nowadays everybody expect to receive quality services, reliably delivered with trust and comfort, in estimated time and by acceptable fees.

CONCLUSION

Our results support that the risk measured by the presented system is reproducible and reliable. Therefore, we accept the null hypotheses of no difference intra-examiner and inter-examiners evaluations, in all the matched comparisons performed.

As a direct consequence of the acceptance of these null hypotheses, we suggest that the Decodify® System is an important cephalometric tool for the orthodontist to establish clear parameters about the service that will be provided to his/her clients. Then, the patient can have a reliable estimation on the degree of severity

of his malocclusion, the difficulties to treat it and the necessary time to accomplish such goal. Consequently, the patient will pay the fair fee for the contracted service, according to the market in which it is inserted.

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Influence of the cross-section of orthodontic wires on the surface friction of self-ligating brackets

Roberta Buzzoni*, Carlos N. Elias**, Daniel J. Fernandes***, José Augusto M. Miguel****

Abstract

Objectives: The purpose of this study was to assess the surface friction produced between self-ligating stainless steel brackets equipped with a resilient closure system and round and rectangular orthodontic wires made from the same material. **Methods:** Thirty maxillary canine brackets were divided into six groups comprising Smartclip and In-Ovation R self-ligating brackets, and conventional Gemini brackets tied with elastomeric ligatures. This investigation tested the hypothesis that self-ligating brackets are susceptible to increases in friction that are commensurate with increases and changes in the cross-section of orthodontic wires. Traction tests were performed with the aid of thirty segments of 0.020-in and 0.019 x 0.025-in stainless steel wires in an EMIC DL 10000 testing machine with a 2N load cell. Each set of bracket/wire generated four samples, totaling 120 readings. Comparisons between means were performed using analysis of variance (one way ANOVA) corrected with the Bonferroni coefficient. **Results and Conclusion:** The self-ligating brackets exhibited lower friction than conventional brackets tied with elastomeric ligatures. The Smartclip group was the most effective in controlling friction ($p < 0.01$). The hypothesis under test was confirmed to the extent that the traction performed with rectangular 0.019 x 0.025-in cross-section wires resulted in higher friction forces than those observed in the 0.020-in round wire groups ($p < 0.01$). The Smartclip system was more effective even when the traction produced by rectangular wires was compared with the In-Ovation R brackets combined with round wires ($p < 0.01$).

Keywords: Brackets. Orthodontic wires. Stainless steel. Friction.

INTRODUCTION

The increasingly frequent use of sliding mechanics underscores the importance of controlling friction when performing orthodontic movement.¹⁰ Friction can be defined as a force

that opposes or slows down the movement of two bodies in contact.^{5,8,10} Before orthodontic movement can be produced it is necessary that the force delivered exceed the frictional resultant present in the bracket/wire interface.

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However, when high friction rates are observed in this situation, force can be reduced to as low as 60%¹¹ of its original intensity, which may clinically cause a delay in biological response.^{8,10}

A wide range of variables can modulate the amount of friction generated, among which are type of material, size and shape of brackets^{4,10} and orthodontic wires,^{1,4,10} and types of ligation used at the bracket/wire interface.^{1,15} Wire thickness has a direct relationship with friction forces while rectangular archwires feature higher friction than their round counterparts.⁹ Regarding ligation type, self-ligating brackets are reported in the literature as appliances that allow friction control of the orthodontic archwires engaged in their slots¹⁵ (Fig 1).

Self-ligating systems are divided into two categories according to how the mechanical ligation method operates. Action can be either active or passive.^{4,15} Passive systems have a sliding clip that entraps the archwire inside the bracket slot without applying any pressure.¹⁵ Active models exert a continuous pressure on

the archwire,⁴ enabling faster alignment with greater speed and torque control.¹⁵ In some models, pressure becomes more intense as archwire size is increased,⁹ which may also result in the incorporation of higher frictional forces. This investigation tested the hypothesis that self-ligating brackets are susceptible to increases in friction that are commensurate with increases and changes in the cross-section of orthodontic wires used in traction. The aim of this study was to assess the surface friction produced by self-ligating stainless steel brackets equipped with a resilient closure system and compare the friction generated during traction of round and rectangular orthodontic wires made from the same material using round and rectangular cross-section wires.

MATERIAL AND METHODS

For this study, 30 maxillary canine brackets were divided into six distinct groups each with five brackets. The groups were composed of SmartClip (3M/Unitek, CA, USA) and In-Ovation R (GAC, NY, USA)

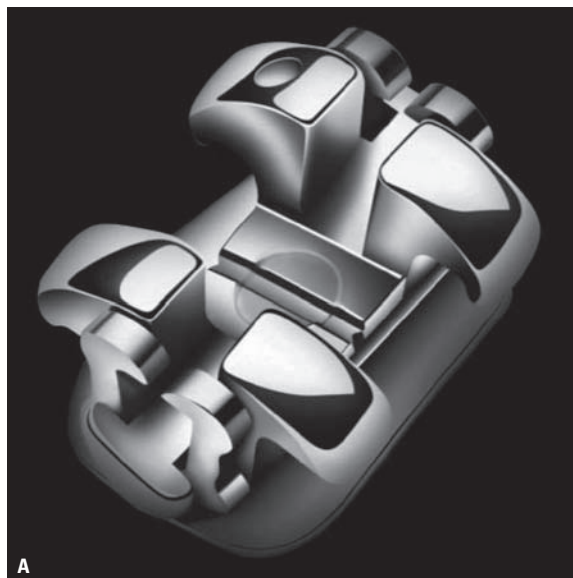


FIGURE 1 - Self-ligating brackets with resilient self-ligating system. **A)** Front view of SmartClip system (3M/Unitek) with anterior clip. **B)** Side view of the In-Ovation R brackets (GAC), with anterior resilient cap. Note round wire entrapped inside bracket slot.

self-ligating brackets, and conventional Gemini (3M/Unitek, CA, USA) brackets tied with gray elastomeric ligatures (TP Orthodontics, IN, USA) (Table 1). Five segments of round 0.020-in orthodontic wires and five segments of rectangular 0.019 x 0.025-in (TP Orthodontics, IN, USA) wires measuring 8.0 cm were used in each of the three types of brackets evaluated (Table 1). The surface friction generated by traction of the steel wires inside the bracket slots was evaluated according to four consecutive readings of each bracket/orthodontic wire pair. Twenty readings were conducted of each group in a total of 120 readings.

The bracket/wire models were tested for surface friction in an EMIC DL 10000 (EMIC, PR, Brazil) testing machine with a load cell of 2.0 kilograms (kg) of force (Fig 2). To perform the tests and compensation of different angulations (tips) built into the pre-adjusted brackets, metal cylinders were especially developed with compensatory tips so that all the wires were placed in parallel relationship with the bracket slots. These stainless steel cylinders were connected to the testing machine and the brackets bonded with the aid of Super Bonder instant adhesive (Loccrite, SP, Brazil). The bracket bases were first filled with Transbond XT (3M/Unitek, CA, USA)

TABLE 1 - Description of groups, number of brackets, pre-angulations and pre-torques relating to prescriptions, and angulations used in the bracket traction tests.

Groups	Brackets	Number of brackets	Pre-angulations	Pre-torques	Cross-section
1	SmartClip	5	+8°	0°	0.020-in
2	In-Ovation R	5	-2°	13°	0.020-in
3	Gemini	5	+8°	0°	0.020-in
4	SmartClip	5	+8°	0°	0.019 x 0.025-in
5	In-Ovation R	5	-2°	13°	0.019 x 0.025-in
6	Gemini	5	+8°	0°	0.019 x 0.025-in

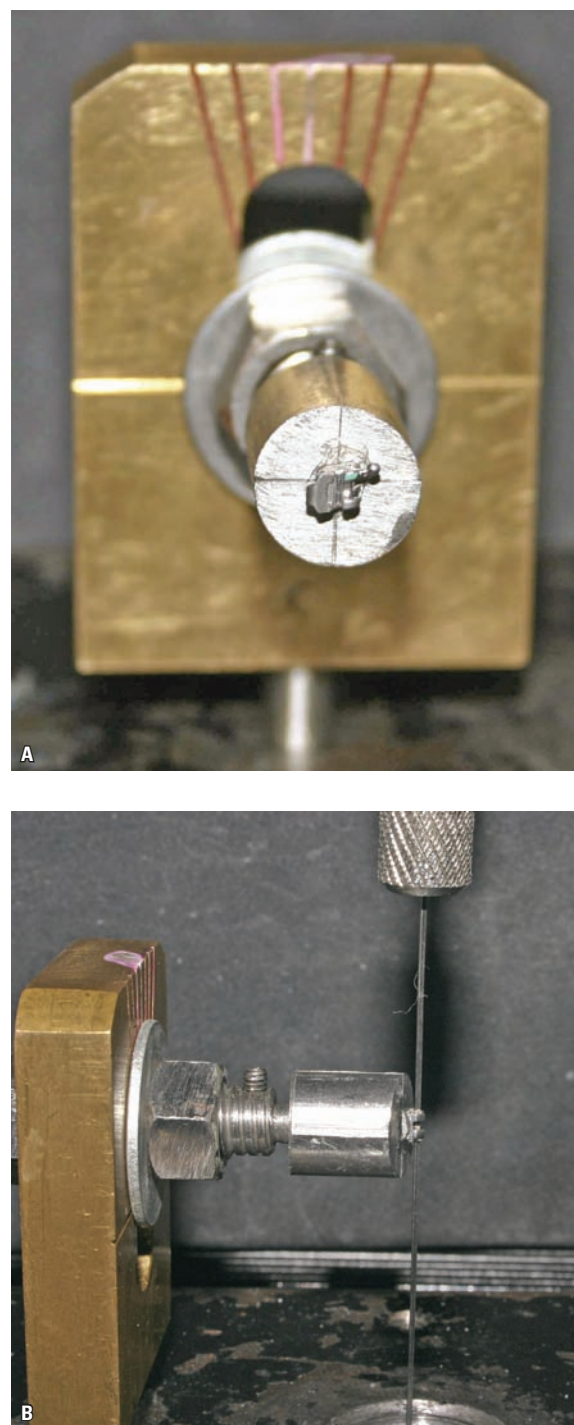


FIGURE 2 - **A)** Front view of self-ligating bracket bonded to metal cylinder with compensatory angulation to ensure traction is performed with no pre-angulation or torque. Total absence of angulation (tip) can be confirmed by the vertical alignment of the markings on the metal cylinder and copper colored part seen in the background. **B)** Side view of the same bracket described during traction of stainless steel 0.019 x 0.025-in cross-section wire.

light cure resin in order to determine the area for bonding (Fig 3).

Ligation of orthodontic wires to the Gemini brackets was performed using elastomeric ligatures (TP Orthodontics, IN, USA), which were replaced at each trial. The orthodontic wires were pulled at a speed of 5 mm/min at a distance of 3.5 mm (Fig 2). Maximum force (gF) values were recorded by computer program Tesc, version 3.04 (EMIC, PR, Brazil).

The results were summarized as means and standard deviations. Comparisons between means were performed using analysis of variance (one way ANOVA) corrected with the Bonferroni coefficient.

RESULTS

Comparison between surface friction force means in grams-force (gF) under traction with 0.020-in and 0.019 x 0.025-in stainless steel wire is shown in Table 2. The values found show lower mean friction in the self-ligating groups compared with conventional brackets tied with elastomeric ligatures. The most effective friction control was afforded by the groups with SmartClip self-ligating brackets, regardless of the wire

cross-section under traction ($p < 0.01$). Increases and changes in the cross-section of wires, from round to rectangular, caused friction to increase in all groups tested ($p < 0.01$).

Distribution of values was analyzed using the Shapiro-Wilk normality test ($p < 0.05$) and presented in a box-plot graph (Fig 4). The resulting pattern showed normal distribution for all groups except for SmartClip brackets combined with 0.020-in archwires.

Analysis of variance (ANOVA) values revealed associations between frictional forces and self-ligating systems. The p value ($p < 0.01$) found with the Bonferroni multiple comparisons test indicated statistical differences between groups (Table 2).

DISCUSSION

In this study, twenty specimens from each group were obtained through surface tensile tests. Each bracket provided four consecutive friction readings representative of the traction of each archwire type in the slot, totaling twenty measurements for each group. This methodology was employed with the purpose of simulating the clinical conditions involved in



FIGURE 3 - Gemini bracket bases filled with resin for subsequent bonding to surface of metal cylinders. Observe the flattening of the bases accomplished with Transbond XT light cure resin. This procedure was used prior to bonding all brackets under test.

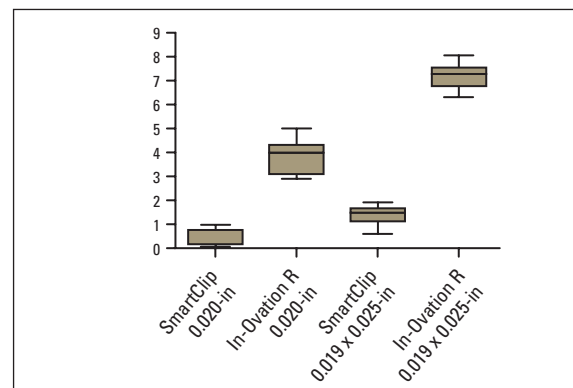


FIGURE 4 - Distribution of friction values in gram-force (gF) for self-ligating brackets and stainless steel wires of 0.020-in and 0.019 x 0.025-in cross-sections.

TABLE 2 - Surface friction in Gram-force (gF) produced by self-ligating brackets using stainless steel wire with 0.020-in and 0.019 x 0.025-in cross-sections.

Self-ligating Group	Cross-section	Mean (gF)	Standard Deviation	Sample (n)
SmartClip	0.020-in	0.470 ^a	0.3525	20
In-Ovation R	0.020-in	3.864 ^b	0.6952	20
SmartClip	0.019 x 0.025-in	1.467 ^c	0.3468	20
In-Ovation R	0.019 x 0.025-in	7.182 ^d	0.5290	20

Note: Conventional Gemini brackets combined with 0.020-in wires. Mean (gF) = 114.4 conventional Gemini brackets combined with 0.019 x 0.025-in wires. Mean (gF) = 147.48. ANOVA ($p < 0.01$) - different letters imply different means by the Bonferroni multiple comparisons test ($p < 0.01$).

sliding repeatedly — be it the bracket sliding on the wire or vice versa — according to the time period established in the treatment goals. The results showed reduced standard deviations, which would make redundant repetitions with the same brackets. Although some authors argue that the bracket/wire surface is susceptible to wear,^{6,7} the authors believe that, in this test, wear occurs significantly only in materials with a high coefficient of friction such as crystalline matrix or polycarbonate. This methodology is similar to research conducted by Voudouris¹⁵ in which only eight brackets in each group were subjected to sliding, totaling twenty four samples for each type of bracket.

Only maxillary canine brackets were evaluated. This choice is justified by the fact that, clinically, canine teeth are often involved in sliding mechanics, especially in cases that require premolar extraction. The same brackets were selected in studies conducted by Berger² and Brown et al.³ However, the bases of these brackets were found to be too concave, hindering the bonding procedure. To ensure proper bonding, the bracket bases had to be filled flush with light cure resin. Voudouris¹⁵ also used the same resin filling technique in his study and noted no variation in friction values.

Each manufacturer developed their own self-ligating model with individual angulations and torques. It has been argued that there is a direct relationship between angulation (tip), active torques and increased surface friction.⁹ Metal cylinders were fabricated with the purpose of standardizing the various prescriptions in bonding the brackets subjected to traction. A compensatory angulation was pre-adjusted in the bonding surface so as to neutralize the original bracket tip, ensuring parallelism between slot and wire. This standardization system is consistent with the methodology developed by Sims et al,¹¹ who also used a piece of metal support for compensatory bonding. Some authors have used different methods to standardize the pre-existing angulations.^{3,15}

An important factor influencing the magnitude of friction is how the bracket and orthodontic wire are ligated.¹¹ The conventional brackets were ligated with the aid of elastomeric ligatures in order to standardize the force delivered to entrap the orthodontic wire inside the bracket slot. Voudouris¹⁵ reported that the loss of elasticity experienced by the material is subjective and directly proportional to the length of time it remains stretched, and such loss could exert significant influence on the surface friction. For this reason, the ligatures were replaced at each test.

Piozzoni, Ravnholt and Melsen⁹ argued that thicker wires produce higher friction values and, in general, rectangular archwires generate more friction than round archwires due to a broader contact area with the brackets under traction. Others believe that the most important variable is the extent to which bracket slots are filled by the archwires.^{3,11} In this research, after comparing different stainless alloy wires, it was found that increases in friction are directly proportional to increases in the cross-section of the archwires, regardless of the bracket model evaluated. This was shown to have a statistically significant correlation.

Self-ligating brackets with a resilient closure system feature a self-closing anterior cap that entraps — by pressure — the orthodontic wires inside the bracket slots.⁹ It is believed that the permanent contact between the self-ligating cap and the wire contribute to increasing the friction generated in sliding.¹⁴ This interaction was evidenced in this study, where the friction generated by rectangular wires was found to be higher than that of round wires. A possible explanation could be that rectangular wires contact the self-closing cap on its 0.025-in face, while round wires contact only the 0.020-in face. As the bracket slot is filled by the wire, the resilient cap exerts more pressure on the wires, consequently increasing the friction resultant on the brackets that experience traction.

The results of this study showed that In-Ovation R brackets yielded friction means above those observed in the SmartClip appliance when 0.020-in and 0.019 x 0.025-in cross-section wires were used. The group comprising SmartClip brackets was statistically more effective in controlling friction even when the traction of rectangular wires was compared with the test involving In-Ovation R brackets in combination with round wires.

The mean friction values produced by conventional Gemini brackets indicate that the self-ligating groups were more effective in controlling surface friction. This finding is in agreement with several previous studies.^{1,2,10,11} The aim of this study was to assess the behavior of self-ligating brackets with resilient ligation systems in combination with orthodontic wires of different cross-sections. The mean values found for the conventional Gemini system served only as reference and were therefore not treated statistically.

CONCLUSIONS

The SmartClip self-ligating bracket system allowed better control of friction forces regardless of the type of orthodontic wire used for traction. Rectangular 0.019 x 0.025-in wires produced a greater amount of friction than round 0.020-in wires made from the same stainless alloy. This finding supports the hypothesis of this investigation as regards the self-ligating brackets tested. The group comprised of SmartClip brackets was more effective even when the traction of rectangular wires was compared with the test involving In-Ovation R brackets in combination with round wires.

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Orthodontists' and laypersons' perception of mandibular asymmetries

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Abstract

Objective: To analyze orthodontists' and laypersons' perceptions of facial asymmetries caused by mandibular changes. **Methods:** The faces of two patients, a man and a woman, were photographed in natural head position, and additional photographs were produced with progressive mandibular shifts of 2, 4 and 6 mm from maximum habitual intercuspation (MHI). Intraclass correlation coefficients (ICC) and weighted kappa coefficients were used to test method reproducibility. The differences in scores for mandibular positions between orthodontists and lay persons were examined using Friedman analysis. All statistical analyses were performed at 95% confidence interval. **Results:** Orthodontists only perceived shifts greater than 4 mm from MHI position ($p < 0.05$), and laypersons had similar results when analyzing the woman's photographs. However, when examining the man's photographs, laypersons did not perceive any change in relation to MHI. ($p > 0.05$). Although median scores assigned by orthodontists were, in general, lower than those of laypersons, this difference was only significant for the 6-mm shift in both patients. **Conclusions:** Orthodontists and laypersons evaluated mandibular asymmetries differently. Orthodontists tended to be more critical when asymmetries were more severe. The evaluation of facial asymmetries also varied according to what patient was being examined, particularly among lay examiners.

Keywords: Facial asymmetries. Mandible. Perception. Orthodontics.

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INTRODUCTION

Current orthodontics has been closely associated with esthetics. Because of the subjective character of esthetic parameters, orthodontists and patients should reach a consensus to establish common treatment goals. Therefore, cephalometric data are no longer the most important element of treatment planning because patients' main demand is to be recognized as beautiful, or at least normal, by themselves and by society and to eliminate unpleasant characteristics of their smiles and faces.¹⁵

However, it is difficult to define esthetics; beauty may change according to several factors and, therefore, no single facial characteristic can be defined as the feature responsible for beauty.¹⁵ A study that used standardized digital photographs found a high level of agreement in facial diagnosis between specialists, although results were not unanimous.⁸ Previous studies showed that, when mandibular anteroposterior changes are added to photographs, either using image manipulation software,^{9,11,16} or producing changes directly on the faces,^{1,2,12} orthodontists and laypersons evaluate facial harmony differently.

Vertical and anteroposterior facial changes are associated and have been extensively studied.^{9,16} However, few studies have investigated changes in facial symmetry. Facial asymmetry is a consequence of the disorderly growth of craniofacial structures, and may be triggered by genetic factors, congenital malformations, environmental factors such as habits or trauma, and functional disorders that may affect mandibular growth.^{3,7} Symmetry and balance, when applied to facial morphology, describe a harmonious distribution of features. Size, shape and organization of the anatomic characteristics are balanced between opposite sides divided by a reference midplane.^{13,14} However, subtle facial asymmetries may be normal and natural and, depending on their severity, may often go unnoticed by the patients or those around them.^{3,5,6}

The evaluation of pairs of photographs that had been manipulated to make them perfectly symmetrical revealed that examiners were able to identify asymmetries even in faces that had been previously classified as very pleasant.¹⁷ Moreover, clinically symmetrical and balanced faces in the studied sample had subclinical asymmetry indices detected when posteroanterior cephalograms were used.¹³

At more severe degrees, mandibular asymmetry may affect function as well as esthetics. Tooth asymmetries and several functional disorders may be treated using orthodontics. However, significant structural facial asymmetries are not easily camouflaged by orthodontic treatment, and may require controlled orthopedic correction during growth or orthognathic surgery in adulthood.³

The limit between "acceptable" and "unacceptable" facial asymmetries does not seem to be clear, nor easy to be established. However, it is often defined according to a clinical sense of balance and the patient's perception of imbalance.^{3,17} Also, it is unclear whether this perception threshold is similar for orthodontists and laypersons. Therefore, this study evaluated whether orthodontists and laypersons perceived facial asymmetries and measured at what point asymmetry became perceptible for these two groups of examiners.

MATERIAL AND METHODS

The sample comprised a set of photographs of two patients with normal occlusion, a man (19 year old) and a woman (26 year old). Four photographs of each were produced, one in maximum habitual intercuspation (MHI) and the others with mandibular shifts of 2 mm, 4 mm and 6 mm.

The patients were photographed with their heads in natural position and the mandible in MHI using a Canon Rebel Xti camera (Canon, Osaka, Japan). After the photographs were obtained, they were manipulated to change occlusion at

progressive 2-mm shifts from the original position up to 6 mm. To guide the mandibular shifts, checkbite records were made using #7 wafer wax, and three new lateral positions were recorded at 2 mm, 4 mm and 6 mm parallel to the original position using a millimeter ruler (Fig 1). The shifts were to the right side of the patient (Figs 2 and 3).

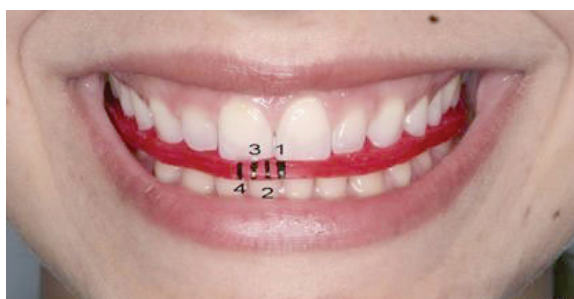


FIGURE 1 - Markings in the wafer wax record: #1 (MHI), #2 (2 mm), #3 (4 mm) and #4 (6 mm).

Posteroanterior radiographs of both patients were obtained to investigate pre-existing skeletal asymmetries (Figs 4 and 5).

Photographs were printed in photographic paper measuring 20 x 30 cm. Two photographs of each patient, MHI and 4 mm for the man and 2 mm and 6 mm for the woman, were chosen for replication and mixed with the others to test reproducibility of the method.

Images were examined by 30 orthodontists (11 men) registered on the Regional Board of Dentistry and with experience of, at mean, 6.3 years (1-23 years) and by 30 college-educated laypersons (13 men) with degrees in different areas but not dentistry and who had graduated a mean 10.4 years (1-32 years) before. Photographs were evaluated randomly, and the examiners were previously told to assign scores from 0 to 10 according to their perception of facial harmony considering 6 as the

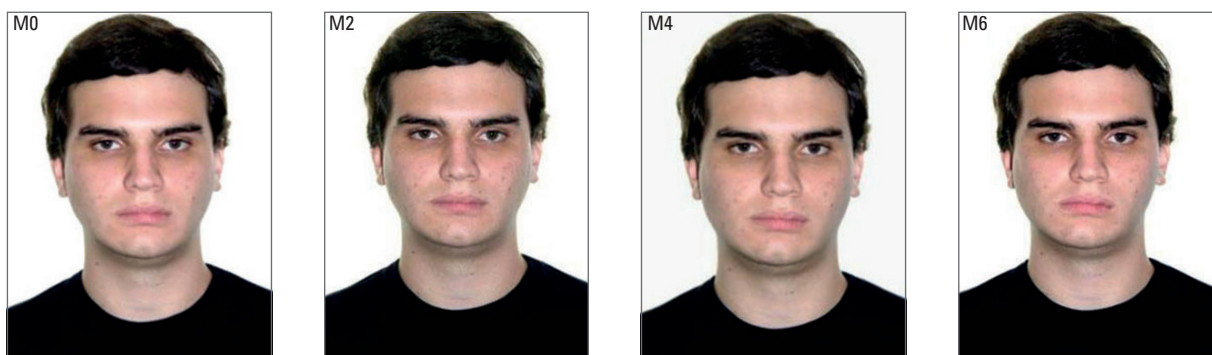


FIGURE 2 - Man's photographs in MHI (M0) and with shifts of 2 mm (M2), 4 mm (M4) and 6 mm (M6).

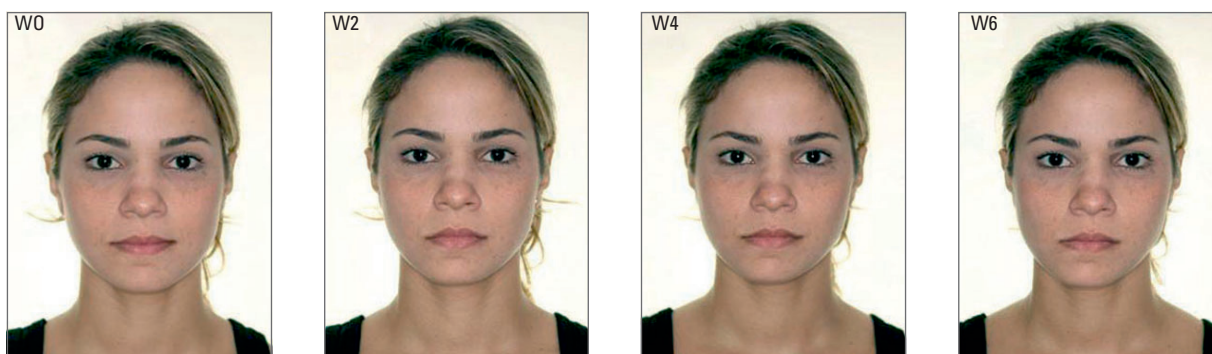


FIGURE 3 - Woman's photographs in MHI (W0) and with shifts of 2 mm (W2), 4 mm (W4) and 6 mm (W6).

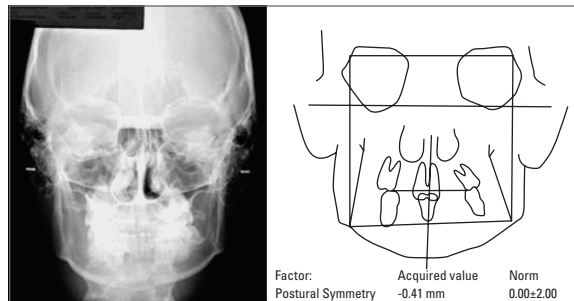


FIGURE 4 - Man's posteroanterior radiograph and cephalometric tracing.

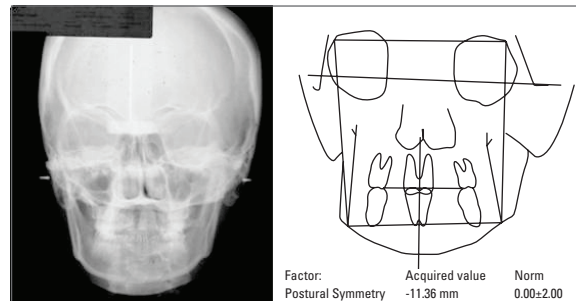


FIGURE 5 - Woman's posteroanterior radiograph and cephalometric tracing.

minimum acceptable. Each photograph was observed for up to 60 seconds, and examiners were not allowed to see the photographs again. Examiners received no other instructions or information.

To collect data about self-evaluation, the patients were asked to evaluate their own photographs after receiving the same instructions as the other examiners.

Statistical analysis

Intraclass correlation coefficients (ICC) and weighted Kappa were used to test the reproducibility of the method. The differences between orthodontists and lay examiners were compared using the Mann-Whitney test, whereas Friedman analysis was used for the differences in scores for mandibular positions (MHI, 2 mm, 4 mm and 6 mm). All statistical analyses were reported at a 95% confidence interval.

RESULTS

Method reproducibility using weighted Kappa coefficients was good to moderate for the pairs of photographs analyzed by both orthodontists and laypersons ($p < 0.01$). ICC ranged from good to excellent ($p < 0.01$). These results showed that the face photographs with progressive mandibular shifts had a good reproducibility, which confirmed the reliability of the method (Table 1).

The main purpose of this study was to evaluate orthodontists' and laypersons' perception of facial asymmetries. Results showed that, when

TABLE 1 - Weighted Kappa coefficients and intraclass correlation coefficients (ICC) of the scores assigned by examiners in the analysis of photograph reproducibility when the two evaluations were compared.

	Orthodontist			Layperson		
	Kappa	ICC	p value	Kappa	ICC	p value
M0A x M0B	0.58 (Mod)	0.73 (Good)	$p < 0.01$	0.64 (Good)	0.85 (Exc)	$p < 0.01$
M4A x M4B	0.63 (Good)	0.82 (Exc)	$p < 0.01$	0.67 (Good)	0.82 (Exc)	$p < 0.01$
W2A x W2B	0.54 (Mod)	0.74 (Good)	$p < 0.01$	0.56 (Mod)	0.74 (Good)	$p < 0.01$
W6A x W6B	0.53 (Mod)	0.67 (Good)	$p < 0.01$	0.59 (Mod)	0.77 (Good)	$p < 0.01$

M0 = Man, maximum habitual intercuspation; M4 = Man, 4 mm; W2 = Woman, 2 mm; W6 = Woman, 6 mm.

Mod = Moderate; Exc = Excellent.

evaluating the woman's face, median values assigned by both orthodontists and laypersons were higher than in MHI and decreased as the face became more asymmetrical (Figs 6 and 7). The same, however, was not seen for the evaluation of the man's photographs, in which case the scores assigned by both groups were similar for the photographs in MHI and with 2-mm shifts, but decreased progressively as the mandibular shifts increased (4 mm and 6 mm) when evaluated by orthodontists, and were not statistically different when evaluated by laypersons ($p > 0.05$). Statistical analyses revealed that the orthodontists were more capable than laypersons to perceive mandibular shifts, and the only differences that they did not perceive were between the MHI position and the 2-mm shift ($p > 0.05$) and between the 4-mm and 6-mm shifts ($p > 0.05$) for both patients (Figs 6 and 7).

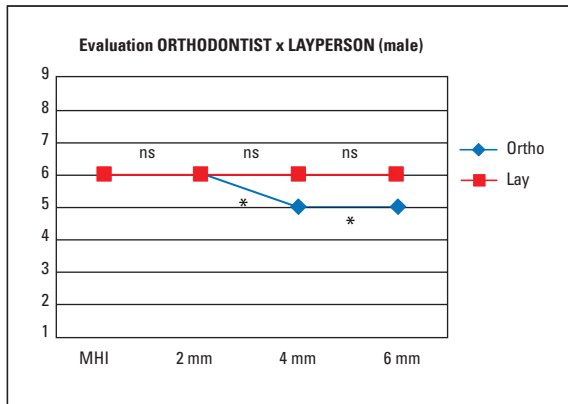


FIGURE 6 - Comparative analysis of median scores for man's evaluations by two examiner groups (Friedman analysis).

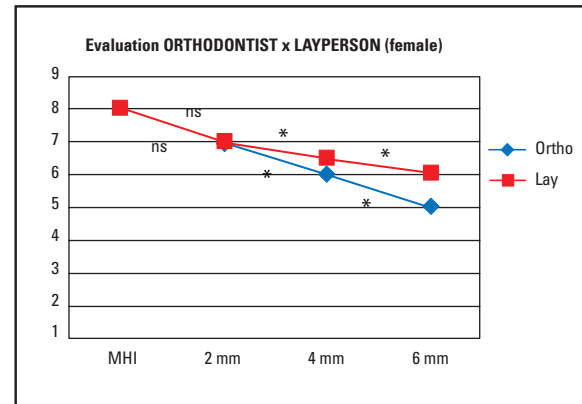


FIGURE 7 - Comparative analysis of median scores for woman's evaluation by two examiner groups (Friedman analysis).

Laypersons did not notice differences in any of the shifts for the man, and for the woman, the differences between the MHI position were only noticed when compared with 4-mm ($p < 0.05$) and 6-mm ($p < 0.05$) shifts.

There were no statistically significant differences in scores between the evaluation by the two groups of examiners for MHI, 2 mm and 4 mm. However, the scores for the 6-mm shift assigned by orthodontists were significantly lower than those assigned by laypersons (Table 2).

When the photographs were examined by the patients themselves, both assigned scores above the minimum acceptable (6) for all photographs, except for the photograph with the greatest degree of asymmetry (6 mm) (Fig 8).

DISCUSSION

The evaluation of facial esthetic perception has fundamental importance in establishing treatment plans for orthodontic patients with skeletal discrepancies. Studies in the literature, however, have focused attention on sagittal changes of the face. Previous studies^{2,9,12,16} correlated the effects of anteroposterior changes on facial esthetics and found that mandibular advances of 2-3 mm or more are perceptible by the orthodontist, but advances should be greater for the patient to perceive changes in facial esthetics.

TABLE 2 - Median (Md) and interquartile difference (IQD) of the values assigned in the evaluation of the man's and woman's photographs by the two examiner groups and the p value obtained in the comparative analysis between orthodontists and laypersons (Mann-Whitney test).

	Man			Woman		
	Ortho Md (IQD)	Lay Md (IQD)	p value Ortho x lay	Ortho Md (IQD)	Lay Md (IQD)	p value Ortho x lay
MHI	6 (1)	6 (2)	0.93 (ns)	8 (1.75)	8 (1.75)	0.94 (ns)
2 mm	6 (2)	6 (2)	0.42 (ns)	7 (2)	7 (2)	0.79 (ns)
4 mm	5 (2)	6 (1)	0.24 (ns)	6 (2)	6.5 (2.75)	0.09 (ns)
6 mm	5 (1.75)	6 (1)	0.05*	5 (1.75)	6 (2)	0.03*

Ns = non-significant; * $p \leq 0.05$.

There are no data in the literature about the perception of facial symmetry changes. This study measured 2- to 6-mm mandibular shifts using a method described on other studies.^{1,2} Some studies found that the results of changes produced in the face by image manipulation software have only a reasonable degree of quality prediction.^{10,11} Therefore, changes made directly on the patient's face may be more reliable than the ones obtained using computer software. In addition, the use of mandibular shifts is also justifiable because of the greater prevalence of facial asymmetries that affect the mandible rather than the maxilla.⁷

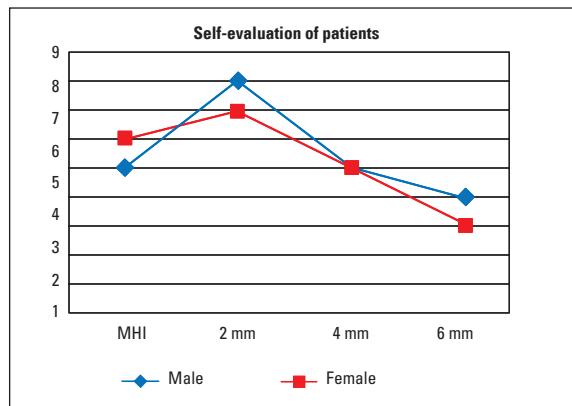


FIGURE 8 - Scores assigned by both patients to their own photographs.

Our results showed that the degree of perception of facial asymmetry was different between orthodontists and laypersons and between the patients under examination. Moreover, orthodontists and laypersons tend to have similar opinions when analyzing a face that is close to normal, and tend to have different evaluations when the severity of mandibular asymmetry that affects the face increases. In this study, laypersons were more sensitive to changes in the woman's photograph than in the man's photograph with the same change. This greater capacity to perceive changes preferentially in women has also been found in other studies that evaluated the perception of changes in profiles simulated using image manipulation software.^{4,16}

In their self-evaluation, the woman assigned decreasing scores as the face became more asymmetrical, except for the photograph with a 2-mm shift when compared with the MHI photograph. The man assigned the highest score to the photograph with a 2-mm shift (score = 9), did not see differences between the MHI photograph and the photograph with a 4-mm shift (score = 6), and assigned the lowest score to the 6-mm photograph (score = 5). Although score variations were not uniform, all were classified as acceptable in the patients' self-evaluation, except the photographs with a 6-mm shift, which received scores below the acceptable level from both patients.

Asymmetry is an anomaly that may compromise the different facial planes. Therefore, a facial examination using a three-dimensional method may yield more realistic results. However, in orthodontics, three-dimensional methods have not become widely available yet, which justifies the use of two-dimensional face photographs, which are basic elements of orthodontic documentation.

Another complementary exam used to aid in the diagnosis of asymmetries is the posteroanterior radiograph. Cephalograms of both patients evaluated in this study showed a slight shift of the mandibular midline to the left, more marked in the woman. This finding confirms a study that used radiographs to evaluate 52 patients included in the sample because their faces were symmetrical and balanced. Results showed asymmetries in at least one of the variables under analysis, and the authors concluded that even in clinically symmetrical faces there is often some degree of subclinical asymmetry.¹³

Although far from unanimity, the degree of agreement between orthodontists was very high for facial diagnoses, particularly when asymmetry was analyzed. Specialists tend to make similar diagnoses of facial asymmetries.⁸ In contrast, studies showed that, in some cases, orthodontists and laypersons do not agree, which confirms the results of the present study.^{1,2}

Therefore, considering the risks associated with orthognathic surgery, its indication should be carefully evaluated when the objective is the correction of facial asymmetry, particularly when this is not the patient's main complaint. Based on the results of the man's photographs, this study results suggest that laypersons, often the patients themselves or their families, are not capable of perceiving shifts as large as 6 mm from the normal face, which may justify the use of limited orthodontic treatment.

This study describes an analysis of the face using statistical analyses, which may lead to certain biased conclusions. Asymmetry may, in

some cases, be more perceptible in an analysis of the individual during functional activities, such as speaking or smiling, and a dynamic analysis may be a more complete evaluation method, but, although available to the specialist in clinical practice, may be difficult to use in scientific studies.

One of the limitations of this study was the fact that it evaluated mandibular asymmetry alone, although asymmetries, even those that have a mandibular origin, do not present as isolated characteristics because asymmetrical mandibular growth compromises the muscles in the region. However, this type of facial change would be impossible to reproduce on the patients' faces.

Complementary studies should be conducted with a larger patient sample because what is per-

ceived in an individual with certain traits and characteristics may be overlooked by the same examiner in another individual with different features. The analysis of a large patient sample, however, may demand the evaluation of more photographs, which might make it tiring for the examiner and might affect the final results of the study.

CONCLUSION

The results of this study showed that:

» Orthodontists and laypersons evaluated mandibular asymmetries differently, and orthodontists tended to be more critical when asymmetries were more severe.

» The evaluation of facial asymmetries also varies according to what patient is under examination, either man or woman, particularly among laypersons.

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Friction force on brackets generated by stainless steel wire and superelastic wires with and without IonGuard

Luiz Carlos Campos Braga*, Mario Vedovello Filho**, Mayury Kuramae***, Heloísa Cristina Valdrighi***, Sílvia Amélia Scudeler Vedovello***, Américo Bortolazzo Correr****

Abstract

Objective: The aim of this study was to evaluate the friction forces on brackets (Roth, Composite, 10.17.005, 3.2 mm, width 0.022x0.030-in, torque -2° and angulation $+13^\circ$, Morelli®, Brazil), with stainless steel orthodontic rectangular wire (Morelli®, Brazil) and nickel-titanium superelastic Bioforce wires with and without IonGuard (Bioforce, GAC®, USA). **Methods:** Twenty-four brackets/segment of wire combinations were used, distributed into 3 groups according to the orthodontic wire. Each bracket/segment of wire combination was tested 3 times. The tests were performed in a universal testing machine EMIC DL2000®. The data was submitted to ANOVA one way followed by Tukey's post hoc test ($p < 0.05$). **Results:** The rectangular orthodontic Bioforce wire with IonGuard presented significantly lower resistance to sliding than Bioforce without IonGuard. There was no statistical difference among the other groups. However, the coefficient of variation of Bioforce with and without IonGuard was lower than that of the stainless steel wire. **Conclusion:** The rectangular orthodontic Bioforce wire with IonGuard presented lower resistance to sliding than Bioforce without IonGuard, with no difference to the stainless steel wire.

Keywords: Orthodontic appliance design. Friction. Orthodontic wires.

INTRODUCTION AND LITERATURE REVIEW

The sliding mechanics is one of the most common methods of tooth movement and consists of controlled movement of teeth obtained by conducting the brackets along an arch. During this procedure, the bracket comes into contact with the wire, promoting friction

between their surfaces. The friction between the bracket and orthodontic wire may reduce in half the force used to move the tooth.⁵ As a result, the desired tooth movement is retarded or even inhibited. Therefore, it is desirable for orthodontic wires and brackets to have the lowest possible coefficient of friction.

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Among the various wires used in orthodontics, stainless steel wires have proven to be efficient and are used up until today. Nevertheless, new materials are being introduced, among them heat-activated and nickel-titanium (NiTi) wires. Heat-activated wires are characterized by the light and physiological distribution of forces and are indicated for various stages of active mechanotherapy. NiTi wires, due to their superelastic properties, enable the force to be more uniform due to the diminishment in deflection during tooth movement. Therefore, light and continuous forces are produced, allowing more physiological and effective tooth movement.^{1,4,10} This wire is indicated, mainly for torque leveling and control, but the detailing and finalization must be done with stainless steel wires with the appropriate shape and size.^{1,10}

The great disadvantage of wires made of beta-titanium or titanium-molybdenum alloy, known as TMA, is high friction, up to eight times higher than that of stainless steel,⁶ and it is also higher than that of NiTi.⁸ The wires made of titanium-niobium alloy have properties similar to those of TMA, with the advantage of resilience associated with moderate formability, but are not recommended for the retraction mechanics or closing spaces by sliding, due to the higher coefficient of friction.⁶

With the aim of reducing the friction between the bracket and NiTi wires, alternative surface treatments on these alloys have been recommended, such as ion implantation, a technique in which the metal substrate is hardened by the implantation of high energy ions in a very thin surface layer.⁵

Orthodontic wires are components that will determine the quantity of force distributed and the level of stress generated in the supporting structures of teeth throughout the active stage of orthodontic therapy. Due to the importance of the selection of metal wires on the success and speed of orthodontic treatment, the purpose of this study was to evaluate the force of friction between metal brackets and stainless steel wires, and Bioforce with and without IonGuard.

MATERIAL AND METHODS

For this study the materials listed in Table 1 were used. With the objective of simulating the sliding mechanics of a fixed orthodontic appliance, a device was constructed to demonstrate the distal movement of a canine in a previously established area, based on the methodology described by Secco¹³ and Kuramae.⁷

Test specimen preparation

In order to perform the tests, an acrylic plate was made with the following measurements: 4.0 cm wide x 14.0 cm long x 0.5 cm thick. Next, a groove measuring 1 cm x 1.2 cm was made 2 cm from one of the ends. Four brackets were placed on the acrylic plate, bonded at a distance of 2 mm from the groove, with a 14mm a distance between them, and 2 other brackets were bonded onto the opposite side of the groove. The distance between the 2 sets of brackets was 14 mm (Fig 1). For bracket fixation the light polymerizable adhesive Adper Single Bond 2 (3M/ESPE Dental Products, St Paul, MN, USA) and resin composite Filtek Z100™ (3M/ESPE Dental Products, St Paul, MN, USA) were used. Before polymerization was performed, a 0.021 x 0.025-in wire was fit into the

Material	Composition	Prescription	Manufacturer
Canine bracket	Stainless steel	Roth: 3.2 mm wide, slot 0.022 x 0.030-in, Torque -2° and angulation +13°	Morelli (Sorocaba/SP, Brazil)
Maxillary central incisor bracket	Stainless steel	Edgewise: slot 0.022 x 0.030-in	Morelli (Sorocaba/SP, Brazil)
Rectangular wire 0.019 x 0.025-in	Stainless steel	-	Morelli (Sorocaba/SP, Brazil)
Rectangular wire 0.019 x 0.025-in	nickel-titanium - without IonGuard - Bioforce	-	GAC (Central Islip, New York, USA)
Rectangular wire 0.019 x 0.025-in	nickel-titanium - with IonGuard - Bioforce	-	GAC (Central Islip, New York, USA)

TABLE 1 - Materials used in the study.

bracket slots, guaranteeing their alignment. Right after polymerization with light activation appliance Light Cure Unit Cl-K50 Kondortech (São Carlos, SP, Brazil), this wire was removed. Elastic ligatures were used to fix the wire segments onto the acrylic plate.

Test bracket model

A 14 mm long and 1 mm thick wire, representing the root of a canine tooth was bonded to each of 24 metal brackets (Morelli®), at the center of the base and perpendicular to the bracket slot. On this wire, 10 mm from the center of the bracket slot, a small groove was made using a carborundum disk at low speed, which marked and represented the center of resistance of the root, on which a load of 50 g was applied to create the normal force between the bracket slot and orthodontic wire, to generate friction during the tests.

The test bracket was placed on the wire, and a 50 g counterweight was inserted on a previously made groove, with the objective of creating a force and generating friction during

the tests. The fixation of the test brackets on the wires was performed with a firmly adjusted metal tie, which was loosened until the bracket slid on the wire under its own weight when the acrylic plate was placed perpendicular to the ground on the testing machine grip (Fig 2).

Test to determine the sliding and friction force

For the sliding and friction tests, the samples were divided into 3 groups, according to the wire used. Each group consisted of 8 bracket/wire segment sets, and each set was tested 3 times to obtain a mean value. The ends of the wires were tightly bent against the brackets so that the wires would not slide through the bracket slots.

For the friction test the acrylic plate mounted with the wire segment was vertically fixed to the grip at the base of the EMIC DL2000® machine (EMIC, equipamentos e sistemas de ensaio LTDA, São José dos Pinhais, PR, Brazil) so that the wire that passed through the bracket slot would be aligned with the center of the load cell at the top part of the machine.

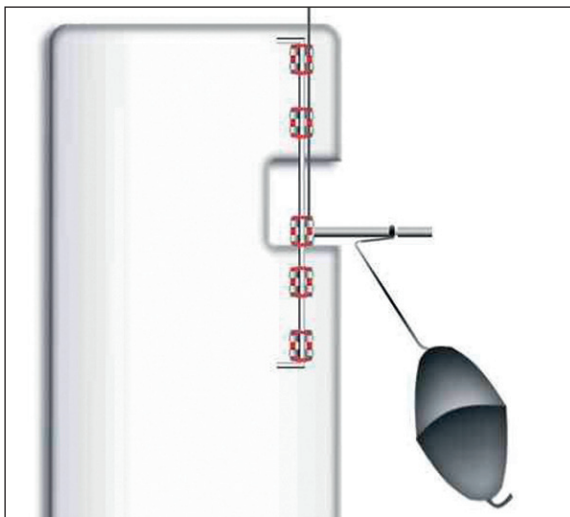


FIGURE 1 - Plate with wire segment and the test bracket that simulated the canine tooth in sliding mechanics, placed vertically to adjust the tie of the test bracket, on the Universal Testing Machine EMIC DL2000®.



FIGURA 2 - Acrylic plate perpendicularly positioned to the ground on the grip of the testing machine.

A 0.025-in stainless steel wire bent into a “U” shape, with the ends measuring 14 cm and the base 0.5 cm, was placed with its base supported on the mesial surface of the test bracket and its two ends fixed onto the load cell.

The readout of the sliding force and friction between the brackets and the different types of wires was performed in a universal testing machine EMIC DL2000® at a speed of 5 mm/min, for a distance of 8 mm. The force necessary to conduct the bracket through the wire was recorded in the form of a force x time graph.

The data was submitted to the Analysis of Variance and the Tukey test at a level of significance of 5%.

RESULTS

The means and standard deviation of the friction force for the different bracket/wire segment sets are shown in Table 2. The results showed that the Bioforce wire without IonGuard presented the highest friction force (1.597 ± 0.147), significantly higher than the Bioforce wire with IonGuard (1.377 ± 0.086), which presented the lowest friction force values. There was no significant difference among the other groups ($P > 0.05$).

DISCUSSION

Friction, defined as the force that is resistant or opposed to movement, in which one

surface slides over another, has a multifactorial nature. Friction can be static or dynamic and both types represent resistance to movement when orthodontic force is applied. There are various factors that influence the magnitude of friction between the bracket and wire, among them: The material of the wire and bracket, shape and caliber of the wire, ligature material, size of the bracket slot, bracket width and angulation, the point of force application in relation to the center of resistance, surface roughness, force applied and lubrication by saliva.³ To determine the influence of the wire and the parameters involved in diminishing the force, the variation factor in this study was only the type of wire used, as the other factors were kept constant. Consequently, the differences found in the friction force are due to the wire characteristics.

The results obtained in this study indicated that the Bioforce wire without IonGuard presented higher friction force (1.597 ± 0.147), significantly higher than that of Bioforce with IonGuard (1.377 ± 0.086).

There was no significant difference between the stainless steel wire and the other groups ($p > 0.05$). These results corroborate the reports of Viazis,¹⁵ who verified that the second generation of square or rectangular Bioforce wires is versatile as initial arches because they allow alignment, leveling and closing spaces simultaneously. Studies that compared stainless steel, NiTi and beta titanium wires, have shown that beta titanium wire produced higher friction forces than NiTi,^{3,8} but no significant difference was observed between NiTi and stainless steel wire, in agreement with the results of this study.⁸

Because NiTi wires presented better elasticity and resistance to corrosion, it began to be used in orthodontic therapy at the end of the 1960s.² The use of wires made of nickel-titanium has advantages such as: 1) Reduced chair time; 2) Application of light and continuous force;

TABLE 2 - Friction force values (N) of Bioforce wires with IonGuard, Bioforce without IonGuard and stainless steel wire.

	Bioforce with IonGuard	Bioforce without IonGuard	Stainless steel wire
Mean	1.377 ^b	1.597 ^a	1.573 ^{ab}
Standard Deviation	0.086	0.147	0.214
Minimum Force	1.240	1.420	1.200
Maximum force	1.480	1.800	1.820
Coefficient of Variation (%)	10.62	10.94	22.41

Distinct letters represent statistically significant difference with a level of significance of 95%.

3) reduced time required for tooth alignment and leveling, which can frequently be performed with a single arch and; 4) working within acceptable biological limits.⁹ The main advantage of using friction mechanics is the fact that in general, there is no need for complicated configurations on the wire, and less time is consumed to perform the initial wire placement. However, one cannot overlook its greater efficiency when compared with mechanics without friction, since the presence of friction diminishes the movement of the tooth along the wire.¹⁴

With the objective of reducing friction between wires and orthodontic brackets, the process of ion implantation, frequently used in the engineering field, was introduced. In this process, a substrate is refined by ionized atoms that adhere to radicals positively charged with high energy by means of a negative charge. The radicals penetrate into the substrate surface and unite with it. Therefore, is it not a coating, but a permanent modification produced in the surface composition. This process alters the composition of the wire surface, diminishing the friction forces produced during tooth movement.¹² A 3 µm layer of nitrogen, achieved with ion bombardment on the wire surface, allows the force of friction to be reduced, increases the fracture resistance and diminishes the release of nickel in the mouth, which is responsible for allergic processes in some patients.¹⁵

The most important characteristic of superelastic nickel titanium in the orthodontic clinic is the release of more constant forces for larger deflections.¹⁷ The association of lighter and constant forces with a lower coefficient of friction of the Bioforce IonGuard wires is extremely important in facilitating and accelerating orthodontic treatment, allowing longer intervals between appointments and producing physiologic forces for tooth movement.

Therefore, it can be suggested that rectangular Bioforce IonGuard wires have an excel-

lent clinical application, especially in the initial stages of orthodontic treatment; that is, in alignment and leveling, and can replace all the round wires, as well as some rectangular stainless steel wires.^{1,10,11} These new alloys used in orthodontic wires present characteristics capable of filling the gaps left by orthodontic treatment performed with sequential stainless steel wires, which vary the force by the growing change in the cross-sectional caliber of the wires.⁹ However, Wichelhaus et al¹⁶ verified that after 4 weeks of clinical use there was a significant increase in the friction of the wires with ion implantation, concluding that the advantages of these materials occur in the initial periods of their use.

Based on this data, the particular properties of these wires allow their application in the various stages of treatment, largely replacing the use of classical stainless steel wires.⁶ Therefore, in the sliding mechanics, the Bioforce IonGuard wire could generate less resistance due to friction than the Bioforce wire without IonGuard, allowing tooth movement with lower forces. Nevertheless, the detailing and conclusion of orthodontic treatment must be performed with stainless steel wires of appropriate shape and size.¹

CONCLUSION

Based on the methodology used, test conditions, and according to the results obtained in this study, it was concluded that the type of wire has an influence on the result of friction force. The highest friction values were presented by the Bioforce wires without IonGuard and the lowest friction force by the Bioforce wire with IonGuard, this being a good alternative to the Bioforce wire without IonGuard, when more sliding is required in tooth movement. The stainless steel wire presented intermediate friction force in comparison with the other wires.

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Comparison of periodontal parameters after the use of orthodontic multi-stranded wire retainers and modified retainers

Marlice Azoia Lukiantchuki*, Roberto Massayuki Hayacibara**, Adilson Luiz Ramos***

Abstract

Objective: The objective of the present study was to compare two types of fixed orthodontic retainers (a multi-stranded wire retainer and a modified retainer) in relation to established periodontal parameters. The multi-stranded wire retainer is commonly used, and the modified retainer has bends to enable free access of dental floss to interproximal areas.

Methods: For this crossover study, 12 volunteers were selected and used the following retainers for six months: (A) a multi-stranded wire retainer and (B) a modified retainer. Both retainers were fixed to all anterior lower teeth. After this experimental period, the following evaluations were made: Dental Plaque Index, Gingival Index, Dental Calculus Index and Retainer Wire Calculus Index. The volunteers also responded to a questionnaire about the use, comfort and hygiene of the retainers. **Results:** It was observed that the plaque index and the gingival index were higher on the lingual surface ($p < 0.05$) for the modified retainer. Furthermore, the calculus index was statistically higher ($p < 0.05$) for the lingual and proximal surfaces when using the modified retainer. The retainer wire calculus index values were also significantly higher ($p < 0.05$) for the modified retainer. In the questionnaire, 58% of the volunteers considered the modified retainer to be less comfortable and 54% of them preferred the multi-stranded wire retainer. **Conclusion:** From the results obtained, it could be concluded that the multi-stranded wire retainer showed better results than the modified retainer according to the periodontal parameters evaluated, as well as providing greater comfort and being the retainer preferred by the volunteers.

Keywords: Orthodontic retainers. Gingival index. Plaque index. Calculus index.

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INTRODUCTION

Fixed retainers are frequently used on the lingual side of the anterior lower teeth to stabilize the results of orthodontic treatment.^{3,9,22,24} Such retainers are prescribed to avoid the relapse and crowding of mandibular incisors.³ The greatest disadvantage of using fixed orthodontic retainers is the tendency for plaque and calculus to accumulate along the retainer wire^{3,12}, which after prolonged periods tend to cause the loss of hard and soft tissues adjacent to the wire.³ The presence of a fixed retainer makes oral hygiene difficult, as the retaining wire leads to areas that are more difficult to keep clean; this favors plaque formation around the teeth, which in turn can favor calculus formation and induce gingival inflammation and periodontal disease.¹

Conventionally, plain fixed retainers are rectilinear wires fixed only to the canines,²⁴ however their use could not avoid lower incisor minor relapse. A variation of this retainer, known as the modified retainer,^{7,8,9,17} has folds below the papillae of the incisors and canines to enable free access of dental floss, with the aim of facilitating oral hygiene. However, it is fixed to all the anterior mandibular teeth.⁸ In a recent study, Shirasu et al²¹, compared the two models of fixed retainers and showed that with the modified retainers, there was greater plaque and calculus accumulation both on the wire and at the gingival margin, and consequently, this produced greater gingival inflammation. This result was attributed to the greater length of the orthodontic wire, its greater contact with dental surfaces and the fact that it was fixed to all the teeth in the anterior segment. However, the other retainer evaluated in this study was the conventional plain 3x3, which only needs to be fixed at its extremities, which is a relevant factor for smaller plaque and calculus accumulation on both the wire and at the gingival margin.

The use of a multi-stranded wire retainer attached to all the teeth in the anterior segment is prescribed in cases of severe crowding, thus avoiding the risk of relapse.^{10,25} However, to date, there are no studies in orthodontic literature that compare these two types of retainers when they are fixed to all the teeth. In the light of this, the objective of the present study was to evaluate the plaque and calculus accumulation on the wire and at the gingival margin, as well as the gingival conditions caused by the use of the modified and multi-stranded wire retainers, when they are fixed to all of the anterior teeth.

MATERIALS AND METHODS

Selection of volunteers

Twelve volunteers were selected to participate in this study, all of whom underwent an anamnesis and a clinical oral examination. The inclusion criteria were that the volunteers: were not using another orthodontic appliance during the research period, had good alignment of the mandibular anterior teeth and had no periodontal disease.

The volunteers signed free and informed terms of consent which were in accordance with the Regulatory Rules and Directives of the National Health Council (Resolution No. 196/96) and the study began after approval by the Human Research Ethics Committee of the State University of Maringá.

Experimental design

A crossover study was carried out, containing two treatment phases:

- » A – use of a multi-stranded wire retainer,
- » B – use of a modified retainer.

The experimental period was 6 months, with a 15-day interval between the two phases. Before each phase, the volunteers had the roots of their mandibular anterior teeth scaled and polished, and they received oral hygiene guidance. Clinical evaluations were carried out after the end of each phase. All the evaluations were carried out by the same examiner.

Manufacture of the retainers

The retainers were made by the same orthodontist, from special plaster models obtained from each volunteer.

Multi-stranded wire retainer

The retainer was made from multi-stranded 0.020-in orthodontic wire (Morelli, Sorocaba, Brazil) (Fig 1) and fixed 4 mm from incisal edges of mandibular anterior teeth, avoiding incisor rotation, changes in the intercanine distances and not disrupting esthetics. The height was standardized by using a dental floss which was folded and passed in the interproximal regions of lateral and central incisors on both sides (Fig. 2). In this manner, the retainer was held in position by the dental floss and a knot was tied to the buccal surface of the teeth enabling the retainer to be kept in exactly the same position it was in on the plaster model while it was being cemented to the canines. The retainer was then bonded to all of the anterior teeth.

Modified retainer

The modified retainers (Fig 4) were made from 0.6 mm / 0.024-in round wire (Morelli, Sorocaba, Brazil) and fixed so that the upper bends were 4.5 mm from the most cervical point of the incisors (Fig 3), leaving a distance of approximately 0.5 mm from the lingual papilla.^{14,26} The upper part of the retainer, located in the center of the lingual face of each tooth was left in passive contact with it so it could be a point of fixation. The bonding process was carried out using a silicon device and a resin composite, 3M Concise (3M-Glendora, CA, USA). In the cervical region, the end of the resin was kept at zero degrees in order to avoid creating a mechanical bacterial plaque retention area.^{7,8}

Clinical evaluations

After each phase, periodontal evaluations of the mandibular anterior teeth were carried out in two proximal and one lingual area by using



FIGURE 1 - Multi-stranded wire retainer cemented at ends and pre-stabilized with dental floss.



FIGURE 2 - Multi-stranded wire retainer after being fixed to all the teeth.



FIGURE 3 - Modified retainer fixed to the plaster model with pink wax.



FIGURE 4 - Silicone guide used in the bonding procedure.



FIGURE 5 - Modified retainer after being bonded to the teeth.

the: Dental Plaque Index,²¹ Gingival Index¹⁸ and Dental Calculus Index.¹⁹ The amount of calculus on the retainer wire was also measured.³

Questionnaires

All of the volunteers responded to a questionnaire after the end of each phase of the study, through which the two retainers were analyzed in terms of comfort, easiness to clean and their approval by the volunteers.

Statistical analysis

The means obtained for the plaque, gingival and calculus index variables were compared by the Tukey's Studentized Range test (HSD), using a 5% level of significance.

RESULTS

Plaque index

In Figure 6, the mean bacterial plaque indices for lingual, proximal and total faces are shown for the periods when multi-stranded wire and modified retainers were used. Greater plaque accumulation was observed for the modified retainer, with the difference being statistically significant for the lingual and total faces compared with values for the multi-stranded wire retainer.

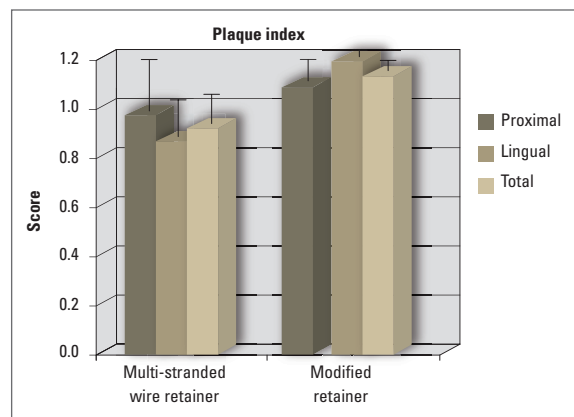


FIGURE 6 - Means and standard deviations for plaque index on the proximal, lingual and total surfaces for multi-stranded wire and modified retainers.

Gingival index

In Figure 7, the mean gingival indices for lingual, proximal and total faces are shown for the periods when the multi-stranded wire and modified retainers were used. There was a statistically significant difference in the results only for the lingual face, with the modified retainer showing the higher index.

Calculus index

The mean dental calculus indices are shown in Figure 8. There was a statistically significant difference in the results only for the total faces, when the multi-stranded wire and modified retainers were compared, with the modified retainer showing the higher index.

Retainer wire calculus index

The results for the retainer wire calculus indices are presented in Figure 9. There was greater calculus accumulation on the modified retainer wire, with this difference being statistically significant.

Questionnaire

The results for the questionnaire are presented in Table 1.

With regard to the comfort of the retainers, 58% of the volunteers thought the modified retainer was less comfortable. Fifty-four percent

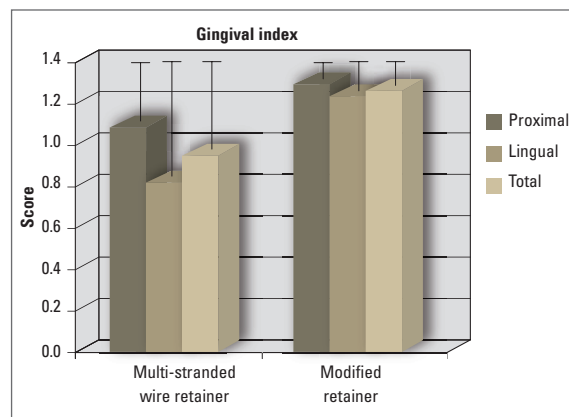


FIGURE 7 - Means and standard deviations for gingival index on the proximal, lingual and total surfaces for multi-stranded wire and modified retainers.

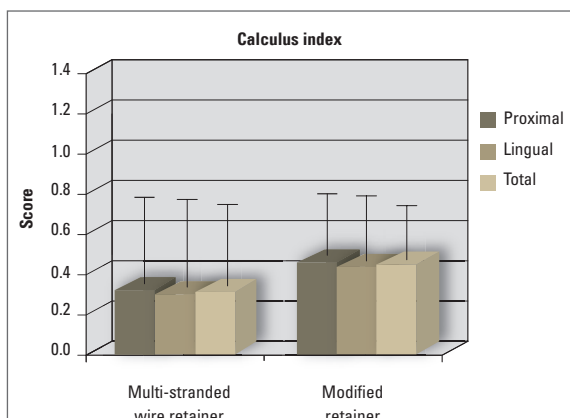


FIGURE 8 - Means and standard deviations for dental calculus index on the proximal, lingual and total surfaces for multi-stranded wire and modified retainers.

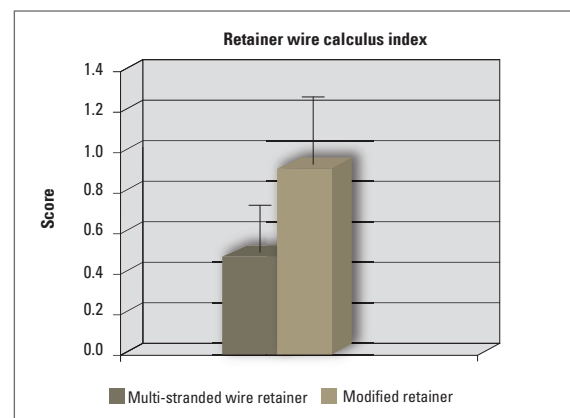


FIGURE 9 - Means and standard deviations of the scores obtained for the retainer wire calculus index for multi-stranded wire and modified retainers.

reported that they were able to achieve better hygiene with the conventional multi-stranded wire retainer. Seventy-nine percent confirmed the need to use a floss threader when using the conventional multi-stranded wire retainer, while 21% confirmed this need when using the modified retainer. Fifty-four percent of the volunteers reported that the conventional multi-stranded wire retainer was better, while 46% preferred the modified retainer.

DISCUSSION

Orthodontic retainers are important resources in orthodontic treatment for the purpose of post-movement stabilization of teeth.^{3,22,23} However, the greatest problem caused by their use is the difficulty of maintaining oral hygiene, leading to plaque and calculus accumulation on the retainer wire and in adjacent areas.^{3,12} Modified retainers were created in an attempt to improve access to the interproximal regions to enable the use of dental floss.^{7,8,9,17}

The present study has shown that a greater plaque accumulation occurs on lingual and total surfaces when using the modified retainer, when compared with the multi-stranded wire retainer (Fig 6). These results corroborate those found by Shirasu,²¹ although the difference between the two types of re-

TABLE 1 - Results of the questionnaire administered to the volunteers.

	Multi-stranded wire retainer	Modified retainer
Comfort in use	58%	42%
Better hygiene	54%	46%
Need to use a floss threader	79%	21%
Preferred type of retainer	54%	46%

tainers was quantitatively smaller in the present study than that found in 2007. This can be explained by the fact that the multi-stranded-wire retainer in the present study was cemented onto all six anterior teeth, which favors the accumulation of plaque in these regions. The continuous presence of retainer wires creates areas that are difficult to clean.⁴ Furthermore, the difficulty in maintaining hygiene leads to worse consequences for the periodontal areas in patients that use retainers fixed to all the teeth.⁴ There was no statistically significant difference in plaque accumulation on the proximal surfaces, demonstrating that the modified retainer, in spite of offering free access for dental floss, does not offer any advantages with regard to the plaque index in the proximal region, since the volunteers managed to clean interproximal faces to a similar extent with both retainers.

The gingival index was higher for the modified retainer on the lingual surfaces (Fig 7), this being in agreement with the results found for the plaque index, as the greater the quantity of bacterial plaque, the greater the gingival inflammation.¹³ This can be explained by the modified retainer design that has U-shaped bends on the lingual surface,⁸ which lead to greater plaque accumulation, and consequently, to a greater degree of gingival inflammation. There was no statistically significant difference on the proximal surfaces, this being in agreement with the results found for the plaque index.

The calculus index for the total surfaces was higher for the modified retainer than the multi-stranded wire retainer. Although the proximal and lingual faces both had higher means for the modified retainer, they were not statistically different (Fig 8). This result can be attributed to the small sample of volunteers, the short evaluation time, the volunteers' manual care and good oral hygiene standards, as they were dental students.

Evaluation of the retainer wire calculus index demonstrated that the modified retainer had greater calculus accumulation (Fig 9). This can be attributed to the larger surface area of the modified retainer wire and to it being in greater contact with the dental surfaces; in agreement with a previous study.²⁶

In the questionnaire applied to all of the volunteers, 58% chose the modified retainer as being the

least comfortable, complaining about the tongue sensitivity it caused. This could be attributed to this retainer being made with a longer piece of orthodontic wire.²⁶ With regard to cleaning the interproximal areas, 79% confirmed that it was necessary to use a floss threader with the multi-stranded wire retainer, and 21% confirmed this for the modified retainer. From these 21% all stated that they were unable to floss down to the gingival sulcus. This can be attributed to all the volunteers being dental students, who understood the need for flossing down to the gingival sulcus. For this reason, 54% of them stated that they could achieve better hygiene using the multi-stranded wire retainer, because although it required more time to clean the interproximal areas, they were able to do so more thoroughly. Fifty-four percent of the volunteers stated that they preferred the multi-stranded-wire retainer, and considered it to be better than the modified retainer, because they were able to perform interproximal cleaning more thoroughly, flossing down to the gingival sulcus, and also because they accumulated less food when eating.

CONCLUSION

The findings demonstrated that the multi-stranded wire retainer offered better results than the modified retainer according to the periodontal parameters evaluated, as well as providing greater comfort and being the option preferred by the volunteers.

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