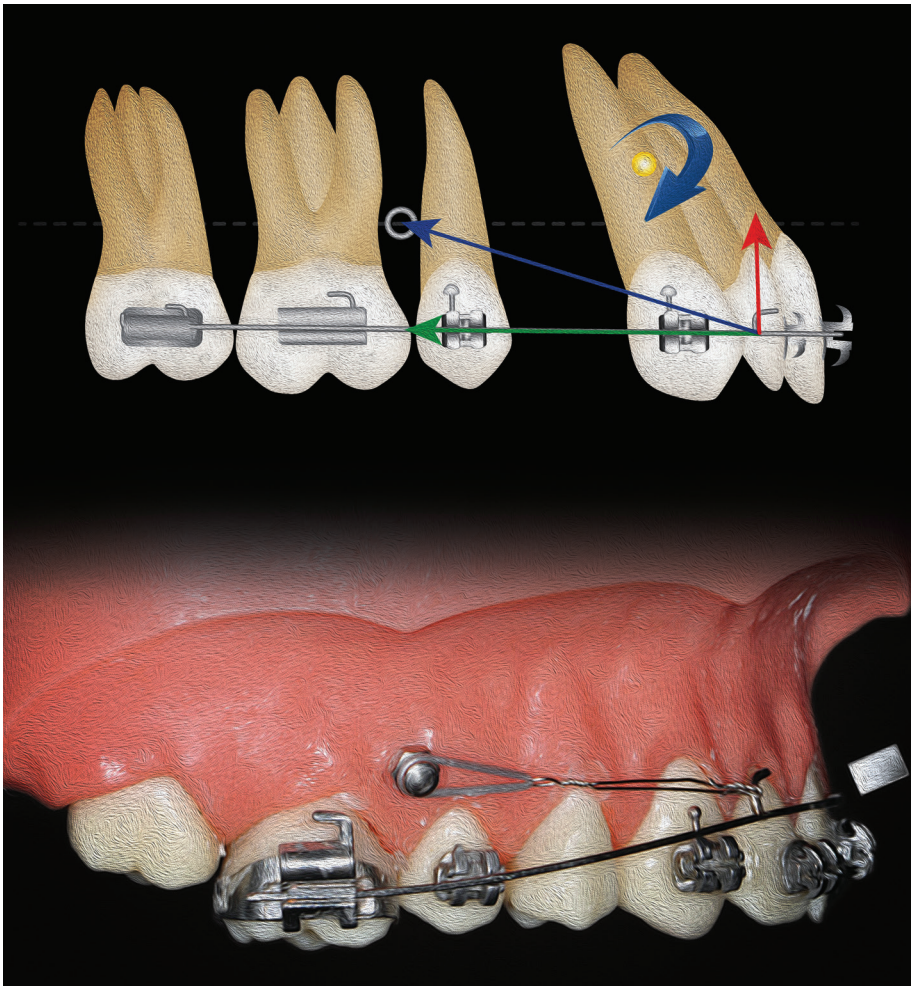
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Dental Press Journal of ORTHODONTICS

Volume 19, Number 3, May / June 2014



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Dental Press J Orthod. 2014 May/June;19(3):1-160

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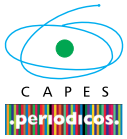
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v. 1, n. 1 (set./out. 1996) - . -- Maringá : Dental Press International,
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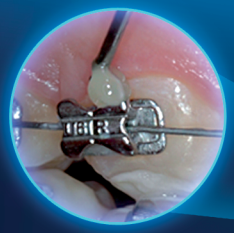
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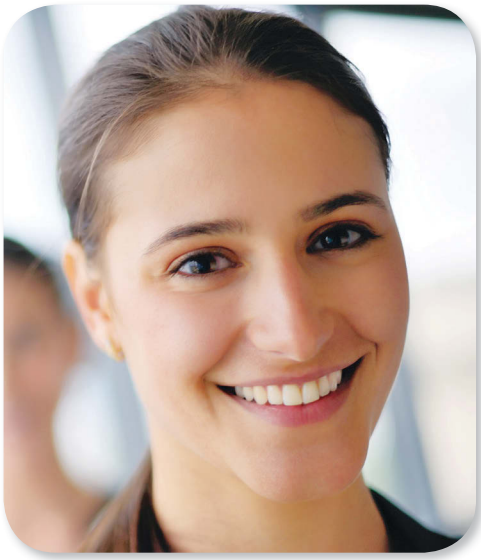






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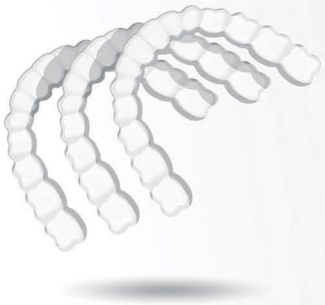
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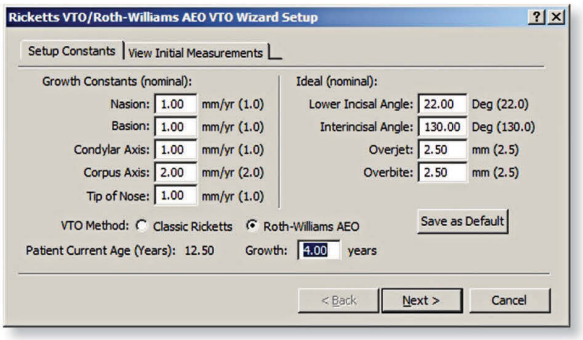


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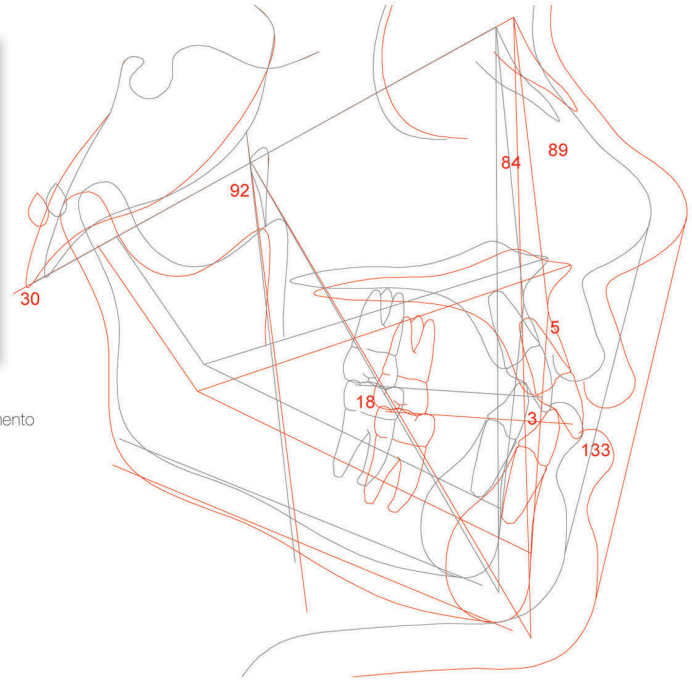
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Dental malocclusion at the navel of the Xingu river

"And whatever is now disclosed to the people,
Will surprise everyone not for being exotic,
but for having remained concealed
Until it was perceived as obvious."
Caetano Veloso, song: "An indian"

The feeling of coexisting with and treating a highly prevalent disease of which origin is unknown is unsettling. It reminds us of when heavy drugs were used to treat cancer of which association with Genetics was still unknown — in fact, nothing was known about the fact that the origin of cancer was right there, in the nucleus of the cell, in the DNA. And this logically resulted in a waste of time and lives. However, when the time came for oncologists and geneticists — cloistered in their laboratories, traveling into the nucleus of the cell — to meet, science made a gold-medal jump and Oncogenetics, the new science, sat on the front chairs of Oncology conferences.

Although millions of people undergo orthodontic treatment, the causes of malocclusion have not yet been clearly determined. That certainly is a paradox for a contemporary world that strives to offer evidence of facts. What is even worse is to know that discussions on malocclusion, held in orthodontic events, raise significantly less interest than presentations about new material and new treatment techniques. Would we be walking towards the same abyss Medicine, a science that does not admit delays, has fallen into?

It all began with Begg[2] who, in 1954, studied the skulls of Australian aborigines. He established that malocclusion is "a disease of modern civilization" caused by tooth wear. Understanding Begg's findings means perceiving the brilliant history that influenced the origins of Orthodontics and provided the road that enabled extraction of permanent teeth for space opening in the dental arch so as to counterbalance the absence of interproximal wear. Nevertheless, Begg's concepts went beyond technicality, which bothers a lot of people, as Omar Gabriel would say. A macro analysis reveals the remarkable influence of his theory over the hypothesis that malocclusion, especially dental crowding, is mainly of environmental etiology.

Begg's theory is still controversial and has been discussed under four models of investigation: 1) experiments with animal models; 2) analysis of ancestors' skulls gleaned by means of excavations, and epidemiological studies conducted with primitive/isolated populations; 4) studies conducted with human twins. Overall, the findings have given support to the hypothesis that malocclusion is basically of environmental etiology.

Nevertheless, the issue is not as simple as it may seem and, for this reason, must be brought to light. One should assume that a given malocclusion probably has different etiological factors in comparison to other occlusal alterations. The fact that the obvious may be concealed intrigues a whole generation of uneasy orthodontists who believe that if we repeat the same mistakes made by Oncology — restrain the micro look taken at the nucleus of the cell and the DNA — we may pay a high price for a torpid progress.

Following Begg's line of reasoning, I decided to provoke the monolith of orthodontic architecture by trying to reproduce his finding under a micro look: the DNA. I chose to study the indigenous people from the Brazilian Amazon[3,4] following the pattern established by Begg. I sailed down the profuse Xingu river, carrying Genetics in my saddlebag.

Initially, it is worth noting that it is common for the amerindian (American indigenous) to establish new settlements, whether by means of fission (division) or fusion (union). Thus, it is easy to understand that miscigenation contributes to increasing genetic variation among indigenous people, which counterbalances with low intratribal variation.[5] Therefore, unlike what it is commonly believed, indigenous groups are genetically different from each other, even though the individuals comprising the same village are similar in appearance.

Would that be the perfect opportunity for me to answer my questions regarding the theme? I put on my indigenist boots and my researcher saddlebag and, just like Begg who is now disguised in the brazilianity of a Villas-Bôas, I steered my horse towards the Xingu river where I remained between 2009 and 2010. The area has several settlements consisted of indigenous people of nine different ethnic groups. It is, therefore, one of the most ethnically diverse human community in the world.

Normando D. Malocclusion at the navel of the Xingu river. Dental Press J Orthod. 2014 May-June;19(3):15-6. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.015-016.edt

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During our first trip, we established contact with two Arara villages. Thus, two genetically different settlements.

An anthropological study about the Arara people[6] revealed that the individuals comprising the Arara of Iriri village come from the same family who descend from a couple who, according to historical reports, was expeled from the Arara of Laranjal village. The separation process supposedly occurred between 1925 and 1926 when the indigenous people lived isolated.

The expelled couple had seven children and the initial expansion of the Arara of Iriri village occurred through the mating of closely related people characterized as incestuous (brother-sister, father-daughter, mother-son). Afterwards, it was established as a result of marriage between close relatives (aunt-nephew, uncle-niece, first cousins).[5] Inbreeding, however, was rare in the ancestral tribe.

A genetic study[5] comparing Arara villages revealed the presence of one single haplotype DNAY and mitochondrial DNA, which corroborates the historical reports on the descendant group.The study also revealed a drastic case of linear fission (involving relatives) within an ancestral tribe.Furthermore, it revealed that the genetic distance and the molecular variance between the two Arara villages were so great that despite having the same origin, their populations significantly differ in terms of genotype.

These indigenous people keep the same traditional eating habits, which was proved by similar tooth wear (a direct evidence of what an individual ate in the past) found between different villages. Therefore, both populations have the same origin and live in similar environments, but they are significantly different in terms of genetics.That was an open door for answering my initial question, but now, with a genetic support.

In the study design, we obtained an epidemiological assessment of malocclusion prevalence, which revealed marked differences in the dentofacial characteristics of the tribes. Malocclusion was twice as prevalent in the descendent village (Arara of Iriri). Most individuals comprising the original villages had a normal occlusal relationship, whereas those comprising the descendent group often had Class III malocclusion. The condition affected one third of the population. Another spasmodic result was the absence of dental crowding in the descendent village, while the original group had one fourth of its population affected by this type of malocclusion. These results mitigate the influence of tooth wear on dentofacial development and highlight the predominance of heredity in the etiology of abnormal variation in dental occlusion .We went on the opposite direction of the river rapids imported by Begg's findings.[2]

After my journey on the land of the Arara, I decided to steer my canoe even further. That was when we decided to visit the Assurini people in the Xingu river, and two Xicrin-Kaiapó villages in the Bacajá river. The results yielded by our investigation confirmed the marked difference in the occlusal pattern of these groups. We reached the same conclusion. No great news for Dr. Cléber Bidegain Pereira, a Brazilian orthodontist from Uruguaiana who visited the Yanomamis in the 70s. The Yanomamis lived in complete isolation from civilization. Notwithstanding this fact, the results yielded by Dr. Pereira revealed that 71% of the sample had some feature of malocclusion, similarly to what is found for the Brazilian urban population. Crowding was observed in 48% of the sample, even though the indigenous population kept their traditional eating habits. Adults had completely worn cusps. Our true Villas-Bôas of Orthodontics concluded that malocclusion is genetically determined and follows the morphological human evolution. Thus, it does not rely on an individual's masticatory activity. We reached the same village half a century later.

Every science must accept the potential errors arising from its conclusions: that is a fact. Science must also establish a reasonable amount of self-contemplation, often examining its exposed navel — a common habit among indigenous people. There is a chance that we are mistaken. But black swans are real in the scientific community as well as in non-fiction works, as it is the case of the movie directed by Cao Hamburger — a moviemaker generated by scientists. Xingu: a confluence of water, people, science and conscience.

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Matheus Melo Pithon*

PROTRACTION OF THE MAXILLA MAY BE ACHIEVED WITH FACE MASK WITHOUT PREVIOUS PALATAL EXPANSION

Class III malocclusion treatment is a daunting challenge for Orthodontics. In growing patients, the treatment procedure chosen for this malocclusion is maxillary expansion followed by reverse traction performed by means of a face mask. According to the literature, the ideal age range for patients undergoing this type of treatment is between 7 and 8 years old. At this age, it is possible to achieve better orthopedic results in comparison to dental effects. Nevertheless, patient's age may vary. Therefore, what is the ideal treatment approach for adult patients? Would it include maxillary expansion and protraction, as in younger patients, or protraction with face mask, only? According to Halicioglu et al,[1] no study has been conducted to assess these treatment methods having adult patients as target. Thus, the authors conducted a study in which they assess the effects of protraction of the maxilla (alone and associated with palatal expansion) on treatment of young adults with maxillary retrognathism (Fig 1). Their results reveal that palatal expansion before maxillary protraction by means of a face mask does not enhances the effects of the former in young adult patients. Such outcomes are important, since they suggest that the use of face mask could start earlier without the need for previous maxillary expansion, thus taking advantage of the last months of maxillomandibular growth.

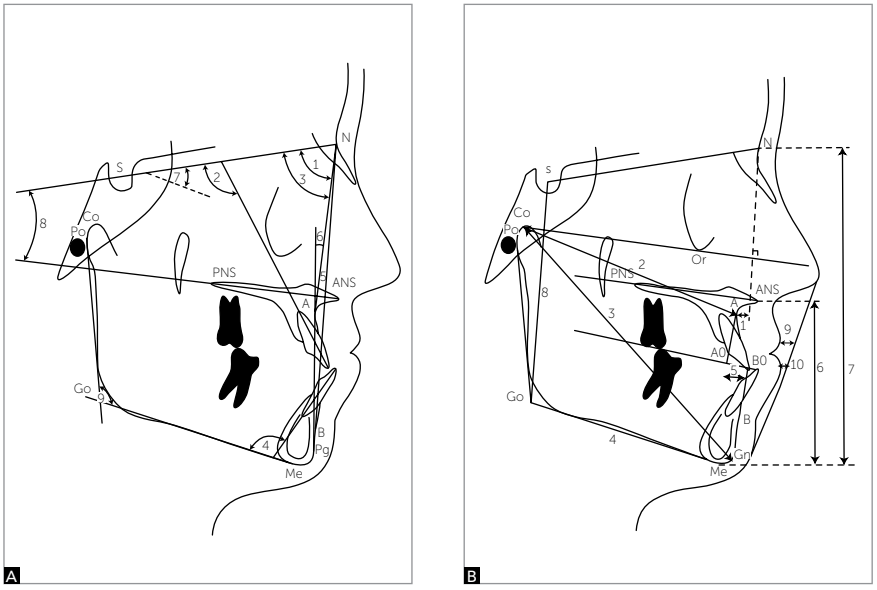


Figure 1 - Measurements used: **A**) angular and **B**) linear. (Source: Halicioglu et al,[1] 2014)

Submitted: March 3, 2014 - **Revised and accepted**: April 10, 2014

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How to cite this article: Pithon MM. Orthodontics highlights. Dental Press J Orthod. 2014 May-June;19(3):17-9.

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CONVENTIONAL AND SELF-LIGATING BRACKETS HAVE SIMILAR TOOTH MOVEMENT, ANCHORAGE LOSS AND TOOTH TIPPING RATES

Undoubtedly, the issue of self-ligating brackets is what currently arouses the interest of most orthodontists. These devices have several benefits, namely: better orthodontic movement, decreased chair time and stronger possibility of greater intervals between appointments. Although these advantages are widely known, further scientific evidence is required to support theory. In the attempt to answer these questions, Brazilian researchers conducted a clinical trial[2] with Class I malocclusion patients in need for tooth extraction. Their aim was to assess the following rates: tooth movement, molar anchorage loss, and canine as well as molar tipping during canine retraction. Their results revealed that no differences are found regarding canine movement, molar anchorage loss and canine as well as molar tipping in comparing both types of brackets. It is worth noting that further studies are warranted to assess the other benefits offered by the aforementioned devices.

PREMATURITY AND LOW BIRTH WEIGHT DO NOT AFFECT POTENTIAL MALOCCLUSIONS

It is widely known that several etiological factors contribute to develop and worsen malocclusion. For this reason, Orthodontics is a unique specialty that deals with cases that seem similar, but in fact are caused by completely different etiological factors. Many studies have to be conducted to understand the occlusal characteristics associated with certain etiological factors. Prematurity and low birth weight are associated with several changes in physical development, including the orofacial structures. In this context, what are the functional and morphological characteristics of malocclusion in patients with deciduous dentition? In the attempt to answer this question, Slovene researchers[3] conducted a study to clinically assess premature, underweight children by means of questionnaires answered by the children's guardians. Their results revealed that the prevalence of malocclusion among premature children was not significantly different from the control group (children born from the 37th week of pregnancy on). The authors also found that premature birth is not considered an indication of risk of any functional or morphological characteristic of malocclusion.

VERTICAL PATIENTS HAVE THINNER CORTICAL BONE

Since their beginning, in the mid-90s, mini-implants have been constantly renewed. Initially, they required previous perforation. However, as time went by, mini-implants became self-drilling and, nowadays, have different

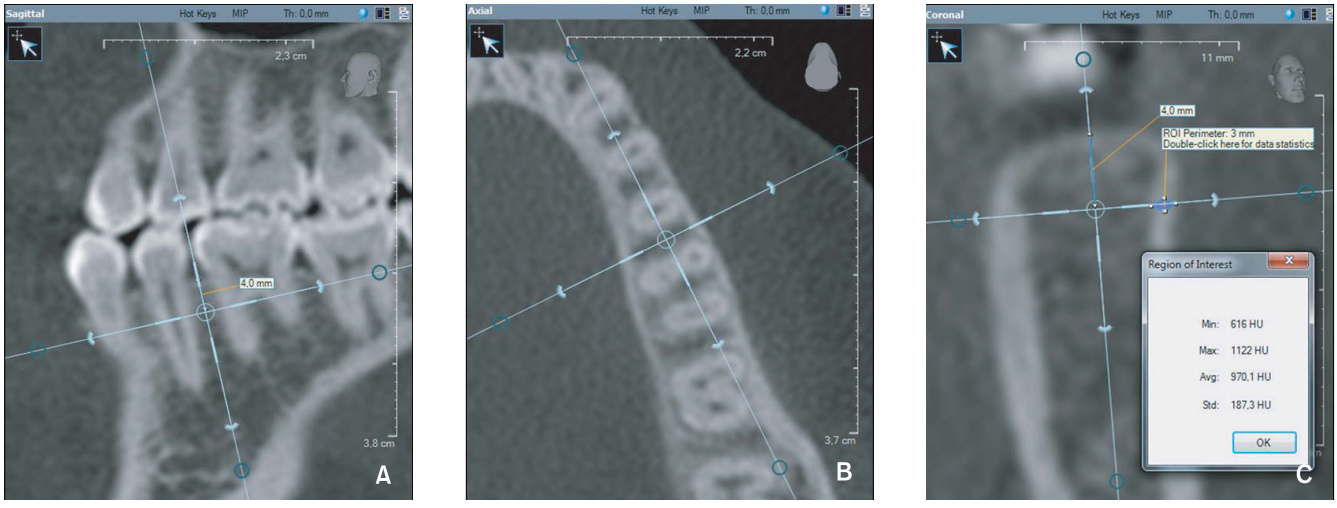


Figure 2 - Measuring cortical bone density. A) In sagittal view, the vertical reference line cuts the interdental area and is parallel to root long axis. B) In axial view the vertical reference cuts the interdental area. C) In coronal view, the cortical bone density is measured (in Hounsfield units or HU) between the points (one on the outer surface and the other on the border of the cortical-cancellous bone) on a line perpendicular to the bone surface and 4 mm apically to the alveolar crest. (Source: Ozdemir et al,[4] 2014).

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types of threads. All the modifications mini-implants went through happened for one reason: To increase stability and provide greater practicality during placement. Nevertheless, it is known that implant stability is associated with different factors, among which alveolar bone density is one of the most important. In this context, how can we measure an individual's alveolar bone density without using tomography? Is it possible to estimate it based on the individual's facial type? With a view to establishing an association between facial type and bone density, Turkish authors[4] assessed the tomographic images (Fig 2) of patients with good growth vector, whether horizontal or vertical. Their results revealed that vertical patients tend to have lower bone density in comparison to other patients. They also found that women tend to have thicker palatal cortical bone in the alveolar process in comparison to men.

TOOTH GEL WITH *MELALEUCA ALTERNIFOLIA* PROVES EFFECTIVE IN CONTROLLING CARIOUS BIOFILM IN ORTHODONTIC PATIENTS

Controlling carious biofilm in orthodontic patients is one of the most challenging tasks orthodontists have to face daily. Which orthodontist never bothered seeing white lesions when debonding brackets? Every day, new products are launched on the market with a view to reducing the amount of carious microorganisms and, as a consequence, the amount of white lesions. Different substances have been added to dental pastes, mouthwashes and dental varnish with a view to reducing carious biofilm. Several medicinal plants with antimicrobial active ingredients have been added, among which *Melaleuca alternifolia* is the most frequent. In this context, the following question arouses: Is the active ingredient of *Melaleuca alternifolia* effective in reducing carious biofilm in orthodontic patients? In the attempt to answer this question, Brazilian researchers conducted a clinical study[5] to compare tooth gel with *Melaleuca* with conventional tooth gel (Colgate Total®). In addition to assessing the microbiological activity of both gels, the participants were invited to conduct a sensorial analysis of the products (aspect, color, smell, brightness, viscosity and first taste sensation). They yielded satisfactory results, given that tooth gel with *Melaleuca* proved more efficient in controlling carious biofilm than conventional gel. Nevertheless, conventional tooth gel had better taste.

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Mini-implants and miniplates generate sub-absolute and absolute anchorage

Alberto Consolaro[1]

DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.020-023.oin*

The functional demand imposed on bone promotes changes in the spatial properties of osteocytes as well as in their extensions uniformly distributed throughout the mineralized surface. Once spatial deformation is established, osteocytes create the need for structural adaptations that result in bone formation and resorption that happen to meet the functional demands. The endosteum and the periosteum are the effectors responsible for stimulating adaptive osteocytes in the inner and outer surfaces. Changes in shape, volume and position of the jaws as a result of skeletal correction of the maxilla and mandible require anchorage to allow bone remodeling to redefine morphology, esthetics and function as a result of spatial deformation conducted by orthodontic appliances. Examining the degree of changes in shape, volume and structural relationship of areas where mini-implants and miniplates are placed allows us to classify mini-implants as devices of subabsolute anchorage and miniplates as devices of absolute anchorage.

Keywords: Miniplates. Mini-implants. Osteocytes. Mechanotransduction. Periosteum. Orthopedics.

The protein cytoskeleton of cells is responsible for maintaining normal tridimensional cell shape, as well as cell movement and migration. Cytoskeletal proteins are classified according to their molecular weight and spatial structure as: microtubules, microfilaments and intermediate filaments.

In all body systems, the balance provided by the intrinsic annulation of all forces results in a force equals to zero known as tensegrity. All cells tend to be similar in shape as a result of balance established between inner and outer forces that, in turn, result from a mutual annulation between them. This state of balance or stability is also known as cellular tensegrity.

Whenever tensegrity is lost by compression of the cytoskeleton, the latter tends to go back to its natural state similarly to other natural systems, but by stimulating a set of events so as to meet that purpose. Chemical mediators are released to induce cell and tissue phenomena, which is part of the process established by the cells with a view to restoring tensegrity. Tensegrity is responsible for determining stability of shape and standard morphology of an object or system, particularly cells.

Breaking tensegrity affects the permeability of cell membrane and results in activation of intracellular metabolic pathways with release of substances

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» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

How to cite this article: Consolaro A. Mini-implants and miniplates generate sub-absolute and absolute anchorage. Dental Press J Orthod. 2014 May-June;19(3):20-3. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.020-023.oin

Submitted: April 10, 2014 - **Revised and accepted:** May 07, 2014

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that act as mediators capable of inducing cellular, tissue and/or vascular phenomena.These substances are the cytokines, growth factors and products of arachidonic acid. This mechanism transforms a physical event, such as force, into biological and biochemical events. This transformations is also known as mechanotransduction.

Osteocytes are mechanotransductors!

Osteocytes have between 40 and 50 extensions and, for this reason, have a dendritic shape.[11] They comprise 90 to 95% of adult bone cells[15] and are included in mineralized bone matrix inside the lacunae also known as osteoplasts (Figs 1, 2). Osteocyte extensions allow osteocytes to communicate with each other and with bone surface cells. The extensions are distributed in 100 to 300-nm thick canaliculi[3,4,5] that, three-dimensionally, form a network that resembles the neural network of the central nervous system. The canaliculi are filled with a tissue fluid that carries nutrients as well as mediators and connects the osteocytes, not only with the cells of the cortical and trabecular surfaces, but also with bone marrow cells.[10]

This network captures potential bone deformations resulting from compression and traction deflection. The osteocyte network acts as an excellent mechanotransductor. Additionally, it also plays a major role in bone metabolism by releasing mediators that reach the bone surface.[16,17]

Periosteum and endosteum act!

The surface of bone trabeculae has a thin layer of connective tissue that consists of osteoblasts and undifferentiated cells and functions as bone modeling units and its clasts: the endosteum. It has a superior osteogenic and resorptive capacity that meets the increasing demand for bone remodeling.

Similarly, the outer surface of cortical bone is lined by the periosteum, a thicker membrane of fibrous connective tissue that covers outer bone surface. The outer periosteum layer is fibrous; whereas its inner layer, which touches the cortex, is highly cellularized and vascularized with young as well as pre and undifferentiated cells. These characteristics provide the periosteum with a high osteogenic reactional capacity.

The osteocytes network form a very sensitive 3D system that uptakes bone deformities. Any change in bone form during skeleton function can be captured by this sensitive network/web of osteocytes and extensions or mechanotransduction detection system. Exercise can increase bone structure by initially mechanical stimuli on this strain capturing network.

In other words: alterations in bone volume and shape are captured by the tridimensional osteocyte network that releases mediators and stimuli that allow osteoblasts and clasts to form or resorb bone according to the need for adaptation established by functional demand. Functional demand refers to alterations in shape and volume induced by tension and

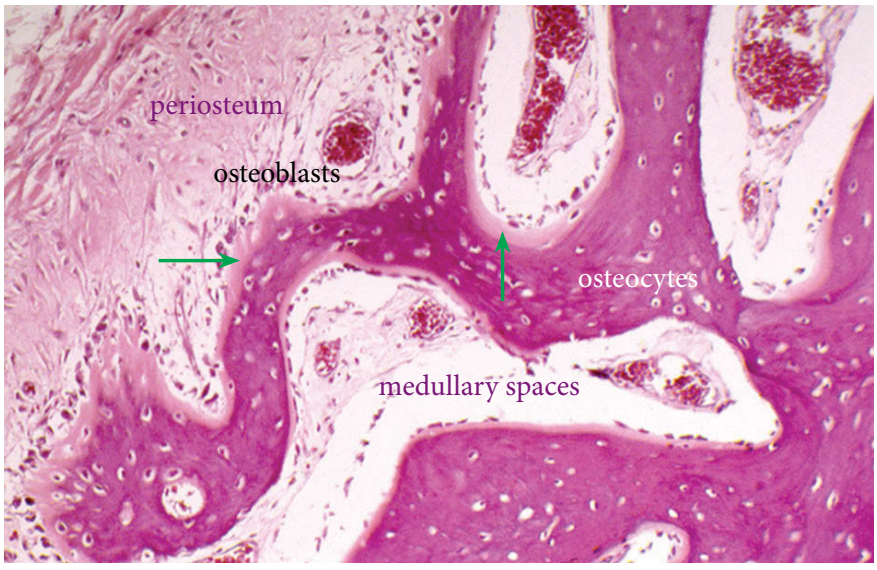


Figure 1 - Osteocytes are the most numerous cells of the skeleton. Acting as mechanotransductors, they are able to pick up signs of minor structural deformations. Polyhedron-shaped osteoblasts are arranged in palisade in the surface of trabecular and cortical bone. The arrows indicate the osteoid which represents the last recently-deposited, non-mineralized bone layer. (HE, 40X).

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compression exerted by the action of orthodontic and orthopedic appliances, similarly to what occurs with natural body movements.

Osteocytes as mechanotransductors: more details

Osteocytes individually pick up signals by mechanical deformation of their cytoskeleton. At the same time, the network in which each osteocyte participates, distributed throughout the bone structure, picks up deformations, overloads, deflections and limitations of nutrients. Deformation of the cytoskeleton as well as restriction of oxygen and nutrients stress the osteocytes. As a result, osteocytes release mediators to communicate with each other, as well as with osteoblasts and clasts on the bone surface, inducing them to reactive or adaptive phenomena.

During orthodontic movement, osteocytes undergo mechanical stress, which increases the production of mediators that circulate through the fluid in the canaliculi. Mediators reach the respective periodontal and bone surfaces and stimulate or inhibit bone formation and/or bone resorption in the "distant" cortical bone surface. In the bone marrow inside the bone, these mediators can influence higher or lower production of clastic cells and osteoclastogenesis.

Therefore, osteocytes strongly influence the function of bone to adapt its shape according to the determination of functional demands, thereby changing mechanical stimuli into biochemical events, a phenomenon also known as mechanotransduction.[2,7,13] Osteocytes also play a major role in regulating mineral metabolism,[9] in addition to inducing changes in the properties of bone matrix around it.[12] However, these functions were already well known.

The skeleton is able to continuously adapt to mechanical loads by adding new bone so as to increase the ability to resist or remove bone in response to a lighter load or lack of use.[6,8] Osteocytes have high interconnectivity and are considered as bone mechanotransductors. Osteocytes increase glucose-6-dehydrogenase phosphatase after a few minutes of load.[19] This enzyme is a marker of increased metabolism which occurs in cells associated with bone surface. Seconds after load is applied on the osteocytes; nitric oxide, prostaglandins and other molecules, such as ATP, increase.[1]

Therefore, when facing induced loads, osteocytes have the ability to release mediators that stimulate the precursors of clasts or osteoclastogenesis to differentiate into new clasts, increasing the rate of resorption. Among these mediators, the M-CSF, or stimulating factor of colonies for macrophages, and the RANKL are the most significant ones.[14] It can be argued that osteocytes can command the activities of the clasts on bone surfaces according to functional demand. The set of osteocytes or the lacunocanalicular osteocyte system can be considered as a real endocrine body.[4]

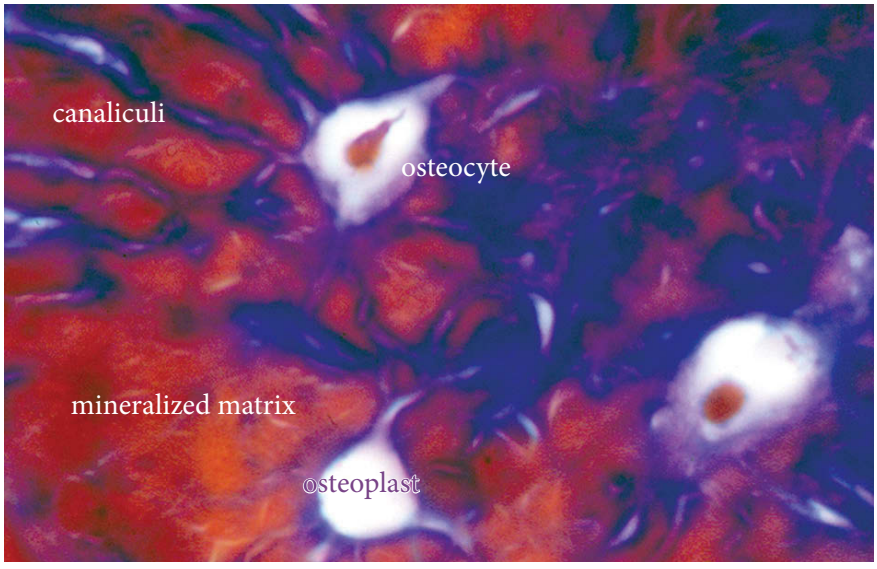


Figure 2 - In the mineralized bone matrix, osteocytes have many cytoplasmic extensions that interconnect with other 40 to 50 cells and, three-dimensionally, capture minor structural deformations. They fill the lacunae known as osteoplasts and their extensions are distributed in canaliculi filled with a tissue fluid that carries mediators (Mallory, 100X).

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Correction of maxillary and skeletal alterations; miniplates and mini-implants

Tooth movement associated with changes in bone position, volume and shape continuously changes, for weeks or months, the tridimensional shape of maxillary bone. Absolute anchorage is required for these deformations to be efficient.

The use of miniplates[18] provides enough anchorage to change the osteocyte network, causing it to release mediators that induce osteoblasts and clasts to directly reshape and restore bone volume and structure. Bone shape responds to functional demand and is able to correct major skeletal alterations, which not long ago was only possible through surgery.

The use of mini-implants with a view to causing major changes in shape, volume and dentoskeletal relationship is limited. Mini-implants are usually placed in the alveolar process of the maxilla and/or mandible or near them. Mini-implant anchorage may result in deflection in its placement sites, which decreases the "absolute" anchorage mini-implants provide within a limited system of force.

If mini-implants require greater force for correction of skeletal alterations, we can say that they offer subabsolute anchorage. As for miniplates, they offer real absolute anchorage as a result of being fixed in upper areas such as thicker cortical bone and denser trabeculae. Proper anchorage and thicker bone structure hardly allow deflection and deformation of the osteocyte network, thus providing absolute anchorage.

Final Considerations

This Insight recommends some studies that can be used to examine the degree of changes in shape, volume and structure in the areas where mini-implants and miniplates are placed for anchorage necessary for tooth movement and associated skeletal correction. Such studies allow us to classify mini-implants as devices of subabsolute anchorage and miniplates as devices of absolute anchorage.

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DOI: http://dx.doi.org/10.1590/2176-9451.19.3.024-025.ebo

Controlling false positive rates in research and its clinical implications

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Statistical analysis is, in fact, an error analysis. A statistical test does not guarantee reliable results, it only quantifies the probability of error of a given conclusion.[1] While reading the articles of this journal, you will find a p-value. For instance, the article by Garib et al[2] describes the p-values for a given variable at two different moments: this p-value, also known as false-positive rate,[1] demonstrates the probability of error when asserting that there is a difference before and after expansion.

Every research is subjected to some degree of error, given that we are not investigating an entire population, but only a fraction, a sample. For this reason, when we compare two samples undergoing different treatment procedures with a view to identifying the most efficient therapy, we will always have the chance of having reached a wrong conclusion. Therefore, the lower the p-value is, the smaller the chance of error and, as a result, the more certain we are to assure that treatment "A" is more efficient than "B".

But, how can we control a false-positive error? Initially, we have to decide on the significance level (α) we expect to establish. In Dentistry, we usually set a significance level not greater than 5% (α = 5%). Nevertheless, should we increase the number of comparisons of a given study, we increase the chances of yielding outcomes that are due just to chance and, as a consequence, finding a false-positive result. The lottery is a good example. The chances of winning are little, less than 5%. However, the more we bet, the higher our chances of winning.

In statistical tests, there is a dramatic increase in false-positive rates, in which the number of comparisons is directly proportional to the number of false-positive results, as shown in Table 1.

Thus, when we make several comparisons using a simple statistical test, we significantly increase the chances of yielding a false-positive result. Table 1 demonstrates that the chances of yielding a false-positive result are of 40% for a study involving 10 comparisons. In these cases, some adjustments are necessary to keep the significance level set at 5%. One of the procedures employed to correct false-positive rates is the Bonferroni correction. It consists of dividing the significance level by the number of comparisons made in a given study.[3] Suppose we carried out a comparative analysis of five cephalometric variables between two groups using an independent t-test. By dividing the significance level initially set at 0.05 or 5% by 5, the new level of error will be adjusted to 0.01 or 1%. Thus, differences will be considered significant for a p-value lower than or equal to 0.01. Nevertheless, Bonferroni correction

Table 1. Number of comparisons (tests) and increase in false-positive rates.

# tests	α value	FW α
1	0.05	0.05
3	0.05	0.14
6	0.05	0.26
10	0.05	0.4
15	0.05	0.54

$\alpha_{fw} = 1 - (1 - \alpha_{pc})^c$
C = # of comparisons, α_{pc} stands for error type I (0.05).

How to cite this article: Simas R, Maestri F, Normando D. Controlling false positive rates in research and its clinical implications. Dental Press J Orthod. 2014 May-June;19(3):24-5. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.024-025.ebo

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Submitted: Mach 05, 2014 - **Revised and accepted**: March 20, 2014

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results in a much more inflexible significance level than necessary, thus increasing the chances of yielding a false-negative rate.[4]

In 1995, Benjamini and Hochberg[5] (BH) suggested another method to counteract false-positive rates when multiple comparisons with univariate statistical analysis are carried out. In this procedure, the researcher has to accept a minor false-positive rate and set this rate before the procedure. Suppose we compared 10 cephalometric measures between two populations A and B. After the number of comparisons is established, we determine the p-value for each analysis and organize these values in ascending order. The value of i = 1 (0.01) will be lower than the p-value, with i = 10 being the highest value. Table 2 shows the p-values in ascending order. After values are properly ranked, we apply the Benjamini-Hochberg formula: (i/m).Q (Q = false-positive acceptance rate; m = total number of comparisons). This formula allows us to correct the p-value and eliminate potential false-positive rates. With a view to obtaining the Q value, we divide the number of comparisons with $P < 0.05$ by the number of comparisons with $P > 0.05$. Table 3 shows that after finding the Q value and applying the Benjamini-Hocheberg formula, we find the corrected p-value for each comparison (i = 1, i = 2, etc.). Subsequently, we arrange the data in a table similar to Table 3, including the initial p-value and the p-value corrected by means of the formula. This method allows us to determine which comparisons are significant, in which case only those with a p-value lower than [(i/m).Q] are significant.[6] Table 3 shows that comparisons 1 and 2 are the only ones with p-value lower than [(i/m).Q].

In this same example, should we use Bonferroni correction to counteract error type I, comparisons 1 and 2 would probably not be significant, since $\alpha = 5\%$ divided by the number of comparisons (ten) would result in $0.05/10 = 0.005$. This value would be lower than comparisons 1 and 2 corrected by the BH technique, which demonstrates how strict Bonferroni's procedure is.

Choosing the wrong statistical test may lead clinicians to jump to conclusions. For instance, a given treatment may be considered the best one as a result of statistical analysis. Thus, statistical analysis is the key to reach more reliable clinical results. Employing more simple statistical procedures, such as the t-test, to carry out multiple comparisons, creates the need to counteract type I error (false-positive). Therefore, it is reasonable to conclude that multiple comparisons require one to carefully choose the test as well as the corrections to be employed.

Table 2.

Comparisons	P-value
i = 1	0.01
i = 2	0.017
i = 3	0.2
i = 4	0.22
i = 5	0.23
i = 6	0.3
i = 7	0.35
i = 8	0.4
i = 9	0.45
i = 10	0.5

Table 3.

Comparisons	P-value	(i/m). Q
i = 1	**0.01**	0.025
i = 2	**0.017**	0.05
i = 3	0.2	0.075
i = 4	0.22	0.1
i = 5	0.23	0.125
i = 6	0.3	0.15
i = 7	0.35	0.175
i = 8	0.4	0.2
i = 9	0.45	0.225
i = 10	0.5	0.25

Q= 2/8 = 0.25.

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An interview with

Mark G. Hans



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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.026-035.int*

It is a great honor to conduct an interview with Professor Mark G. Hans, after following his outstanding work ahead of the Bolton-Brush Growth Study Center and the Department of Orthodontics at the prestigious Case Western Reserve School of Dental Medicine(CWRU) in Cleveland, Ohio. Born in Berea, Ohio, Professor Mark Hans attended Yale University in New Haven, CT, and earned his Bachelor of Science Degree in Chemistry. Upon graduation, Dr. Hans received his DDS and Masters Degree of Science in Dentistry with specialty certification in Orthodontics at Case Western Reserve University. During his education, Dr. Hans' Master's Thesis won the Harry Sicher Award for Best Research by an Orthodontic Student and being granted a Presidential Teaching Fellowship. As one of the youngest doctors ever certified by the American Board of Orthodontics, Dr. Hans continues to maintain his board certification. He has worked through academics on a variety of research interests, that includes the demographics of orthodontic practice, digital radiographic data, dental and craniofacial genetics, as obstructive sleep apnea syndrome, with selected publications in these fields. One of his noteworthy contributions to the orthodontic literature came along with Dr. Donald Enlow on the pages of "Essentials of Facial Growth", being reference on the study of craniofacial growth and development. Dr. Mark Hans's academic career is linked to CWRU, recognized as the renowned birthplace of research on craniofacial growth and development, where the classic Bolton-Brush Growth Study was historically set. Today, Dr. Hans is the Director of The Bolton-Brush Growth Study Center, performing, with great skill and dedication, the handling of the larger longitudinal sample of bone growth study. He is Associate Dean for Graduate Studies, Professor and Chairman of the Department of Orthodontics, working in clinical and theoretical activities with students of the Undergraduate Course from the School of Dental Medicine and residents in the Department of Orthodontics at CWRU. Part of his clinical practice at the university is devoted to the treatment of craniofacial anomalies and to special needs patients. Prof. Mark Hans has been wisely conducting the Joint Cephalometric Experts Group (JCEG) since 2008, held at the School of Dental Medicine (CWRU). He coordinates a team composed of American, Asian, Brazilian and European researchers and clinicians, working on the transition from 2D cephalometrics to 3D cone beam imaging as well as 3D models for diagnosis, treatment planning and assessment of orthodontic outcomes. Dr. Hans travels to different countries to give lectures on his fields of interest. Besides, he still maintains a clinical orthodontic practice at his private office. In every respect, Dr. Hans coordinates all activities with particular skill and performance. Married to Susan, they have two sons, Thomas and Jack and one daughter, Sarah and he enjoys playing jazz guitar for family and friends.

Matilde da Cunha Gonçalves Nojima

How to cite this interview: Hans MG. An interview with Mark G. Hans. Dental Press J Orthod. 2014 May-June;19(3):26-35. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.026-035.int - **Submitted:** February 05, 2014 - **Revised and accepted:** February 27, 2014

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1. As Director of the Bolton-Brush Growth Study Center, could you tell us some points about this renowned research center?

(Lincoln Nojima)

Located on third floor of the Bolton Dental Building, the Bolton-Brush Growth Study Center houses the world's largest longitudinal radiographic collections of cranial and post cranial skeleton. The Bolton Study was started in 1930 by the inventor of the cephalostat, B. Holly Broadbent, with the goal of increasing our understanding of the normal growth of the human face. A total of 4,309 subjects were enrolled. Lateral and frontal cephalograms as well as hand wrist radiographs and dental study casts were taken yearly on these children, usually on or around their birthday. Under the direction of T. Wingate Todd, the Brush Study began at the same time with the goal of radiographically documenting the normal growth and development of the appendicular skeleton. All of Bolton subjects were also enrolled in the Brush Study. The Brush Study ended in 1950 and the Bolton study ended in 2001. To be part of the Bolton-Brush subject population, individuals had to be in excellent health and free from any major illness or infirmity. Often, these children were enrolled because they had won "Healthy Child" contests at their schools. Landmark publications resulted from these legendary studies. Some examples are the Greulich and Pyle Hand Wrist Atlas used by pediatricians around the world to assess skeletal development in growing children, the Bolton Standards for Dentofacial Growth and Development used by craniofacial practitioners to assess facial proportions and skeletal balance, as well as the classic work by Rolf Behrents on Adult Craniofacial Growth and Development.

Although we stopped enrolling new subjects in these studies, the collections are still used by researchers from around the globe to answer important questions pertaining to human health. One of the main activities for center staff is to convert the fragile radiographs to digital format. A small portion of the Bolton Collection is available online by visiting the American Association of Orthodontist Legacy Collection website: http://www.aaoflegacycollection.org/aaof_collection.html?id=CASEBolton

Many more radiographs are available in digital format and can be accessed at the center or by ordering digital copies of the radiographs. A complete index to the radiographs in the Bolton and Brush collections is available by sending an email to mark.hans@case.edu with the subject line "Bolton-Brush Index". The index is in Filemaker Pro format and a demo version of the Filemaker Pro program can be downloaded for free from the Filemaker Pro website.

2. In your opinion, which theories of Facial Growth should be taught in an orthodontic program?

(Juan Martin Palomo)

In my opinion, we do not understand the switches that turn bone growth on and off. However, the morphologic changes that occur as a result of the growth process have been well described (Fig 1). Therefore, orthodontic education should focus on giving students a thorough understanding of morphologic changes that occur as well as the biological processes that result in

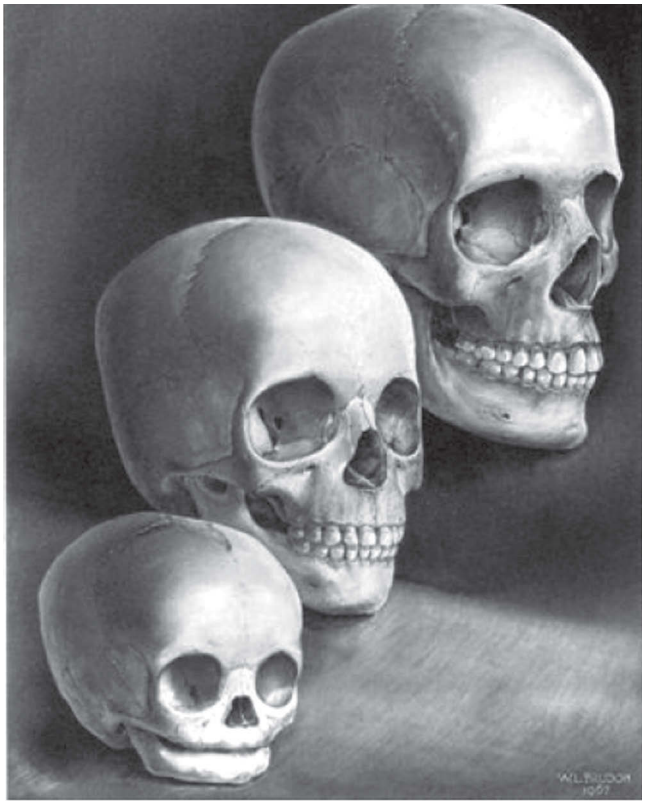


Figura 1 - Morphologic changes of the face. The infant and young child are characterized by a wide-appearing face but vertically short. During later childhood and into adolescence, vertical nasal enlargement keeps pace with growing body and lung size, dental and other oral components have approached adult sizes and configuration. Overall, the early wide face has become altered in proportion by the later vertical changes. (In Enlow, D. H. and Hans, M. G.: Essentials of Facial Growth. 2nd ed. Ann Arbor: Needham Press, 2008. Courtesy of William L. Brudon. From Enlow, D. H.: The Human Face. New York, Harper & Row, 1968, with permission.)

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those changes. For example, orthodontic programs must teach students about bone remodeling and displacement. Remodeling activity includes the deposition of new bone on both periosteal and endosteal surfaces by osteoblasts concomitant with the resorption of bone on these surfaces mediated by osteoclasts. The areas of bone deposition and resorption were mapped for the human face as part of the life work of Donald H. Enlow, PhD. Dr. Enlow was my predecessor as department chair at CWRU and I was very fortunate when he asked me to coauthor the textbook Essentials of Facial Growth in 1996. Now, in its second edition, Essentials describes in detail, the remodeling process. As second equally important concept is that of bony displacement. Displacement is the movement in space of an entire bone en masse. All morphologic changes we see in the bony skeleton are the result of these two basic processes. And since all orthodontic and orthopedic treatments must affect changes in one or both of these processes, they must be taught in all orthodontic training programs.

In terms of theories of facial growth, I think it is important for students to know something about Moss' Functional Matrix hypothesis as well as Scott's Nasal Septum Theory. Each of these theories adds something of value to students understanding of facial growth. In the case of the functional matrix hypothesis, it leads the student to think about the relationship between hard and soft tissues of the head and neck. The theory is particularly strong when applied to the growth of the neurocranium. In this area, growth of brain tissue clearly paces enlargement of the flat bones of the skull. As you move into the area of the cranial base, Scott's cartilage theory becomes attractive because of the ability of cartilage to grow interstitially and the histologic similarity between synchondrosis and epiphyseal growth plates. As we approach areas closer to the occlusal plane, things get more confusing. For example, what is the most logical theory regarding the tissue separating force that drives midfacial growth? The nasal septal cartilage sits in the midline and the septopremaxillary ligament attaches to the anterior nasal spine of the maxilla allowing expansile growth of the cartilaginous septum to pull the maxilla downward and forward. This is consistent with the observed displacement of the maxilla downward and forward. The functional matrix theory holds that it is respiration and in particular nasal respiration that drives growth of the midface downward and forward. It is most likely that both of these processes (i.e. septal growth and respiration) influence maxillary development, and further, that a deficiency in one driving force is likely compensated by an excess in the other. That there exists a certain amount of redundancy in critical growth systems seems plausible. However, the complexity of human maxillary growth will likely not allow the relative contributions of the functional matrix compared to the nasal septum to be tested by hypothesis driven research methods. Finally, neither theory provides a compelling rationale for mandibular growth. Clearly, the mandibular condyle does not function as a locus of control. Rather, the most important role for this cartilage is in establishing and maintaining the integrity of the temporomandibular joint. It is also difficult to comprehend how mastication and/or deglutition influence mandibular growth. I would say that both theories fail to provide a compelling argument for the driving force behind the downward and forward displacement of the mandible.

3. How do you focus on the importance of knowledge on Craniofacial Biology for orthodontic treatment planning and achievement of better treatment outcomes? (Matilde Nojima)

The goal of orthodontic treatment should be to transform one stable system (malocclusion) into another stable system (normal occlusion) using a combination of growth modification and dental movement in the growing patient and a combination of orthognathic surgery and dental movement in non-growing patients. So, in my mind, better treatment outcomes mean more stable outcomes. How can we best achieve this goal? I think we need to consider several factors. First, where the cause of the malocclusion can be identified, we need to treat the cause first. The best example of this strategy is with a child that sucks his thumb. We need to stop the habit first, then if the malocclusion does not spontaneously improve, we need to intervene to treat the effect of the thumb habit. Stability will be achieved since the cause of the malocclusion has been addressed. Unfortunately, in most malocclusions the cause is less obvious. Most of us would agree that malocclusions are the result of both intrinsic (i.e. genetic) and extrinsic (i.e. environment) factors. I don't think anyone is considering gene therapy for malocclusion so that leaves us with modifying extrinsic factors and treating the net effect of the genetic factors rather than the genetic cause.

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Orthodontists need to be very effective at moving teeth in all three dimensions (vertical, lateral, and horizontal) within the alveolar process. We need to pay attention to tooth movements and control the movements. To do this effectively, we should know the normal way teeth move during growth and development. We are all familiar with the term eruption of teeth. I want to clarify an important difference between eruption of teeth and drift of teeth. Eruption is a biologic process whereby the tooth moves towards the occlusal plane until it contacts its opposing tooth and is said to be "in occlusion". Once a tooth is in occlusion, it is finished with the eruption process. However, the face continues to grow downward and forward and to maintain this occlusion of the teeth, they must drift towards the occlusal plane. This means maxillary teeth drift inferiorly and mandibular teeth drift superiorly. In addition to the vertical drift of teeth, the teeth drift mesially with normal growth and development. Thus, drift of teeth naturally occurs toward the occlusal plane and mesially. So, what does this mean for the average orthodontist and their patients? We all know it is easier to move teeth in the direction they naturally want to go. So, if you do not pay any attention to your treatment mechanics, you will naturally accelerate the movement of teeth toward the occlusal plane and mesially. This means that when you are finished with your treatment, the face will be longer (vertical dimension will be increased), and the teeth will be more forward in the face (i.e. more bimaxillary protrusive). If these movements are outside of the physiologic boundaries of stability, then you will have created an unstable result. Not what we are looking for. So, to achieve better treatment outcomes, you need to pay attention to your mechanics if you do not want a longer face or a more protrusive denture. The skilled orthodontist can control the teeth in all three dimensions so it is critical that we do so.

4. In order to better understand growth and development of the face, do you believe that establishing VTOs on growing patients can be helpful? If so, which method do you recommend us to use?
(Kunihiko Miyashita)

To be an excellent orthodontist, you need to have two goals in mind. First, the alignment of the teeth and second the placement of the teeth within the face. The alignment of teeth is almost always dictated by the contact points of adjacent teeth. This results in little disagreement among dentists as to the ideal position of the teeth relative to each other. Likewise, there is general agreement among dentists about the proper occlusion of the teeth, that is, axial loading of posterior teeth with anterior guidance provided by the cuspids and incisors. However, there is not universal agreement as to the ideal place for the teeth within the face. It is in this area that I believe a VTO is helpful. A VTO gives the orthodontist a target to shoot for and he or she should aim for the bull's eye. Without a target you cannot measure the accuracy of treatment plan for the position of teeth within the face.

So, I believe you should have a goal for the position of the dentition within the face. I prefer to start my VTO by asking the question, "Where should the upper central incisor be located in this patient's face?" There are several ways to determine this position. I prefer to use the Bolton Standards as a guide for upper incisor location. In addition, I confirm the use of the Bolton Standard position by using a Nasion Vertical and placing the maxillary central incisor 5 mm in front of the line and vertically about 2-3 mm below the inferior border of the upper lip in the relaxed state. Once I have established the position of the upper incisor, I then decide on how best to establish anterior guidance and an acceptable interincisal angle. In terms of growth prediction, I prefer to use a mean change expansion as described by Johnston et. al.[1] In general, this method assumes that the maxilla will grow 1 mm forward at A Point per year and 1 mm vertically at ANS per year. Mandibular growth will exceed maxillary growth by 1 mm per year in both vertical and horizontal directions.

5. What are the biological indicators that should be observed in order to predict the amount of future growth in a specific bone of the face?
(Ana Maria Bolognese)

In general I think that the Greulich and Pyle Hand Wrist Atlas is useful to estimate skeletal age and predict standing height. However, it has been well documented that facial growth cannot be predicted using skeletal maturity as an indicator. So, the best assumption for growth of the facial bones — i.e. the maxilla and mandible — is to assume that in the absence of treatment, mandibular growth will exceed maxillary growth by about 1 mm per year. In terms of estimating

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the amount of growth, one can use chronologic age, hormonal indicators of maturity (acne, onset of menstruation in girls, facial hair in boys) to help estimate the amount of growth potential remaining. However, I still believe that the only way to determine when facial growth has slowed is to use serial cephalometric radiographs taken a minimum of 6 months apart. When the two films shows less than 0.5 mm of change over a six month period prior, then the clinician can safely assume adolescent facial growth has been completed.

6. What are your thoughts on the best timing to treat skeletal disharmonies as Class III malocclusions? (Matilde Nojima)

I am glad you asked this question because although there are three treatment options for Class III correction: orthopedic modification of facial growth, orthodontic camouflage, and orthognathic surgery; the age of the patient often dictates the best treatment strategy. The orthodontic literature clearly indicates that full orthodontic treatment increases mandibular growth. I call this non-specific stimulation of mandibular growth the "fertilizer effect". By this, I mean that no matter what we do with our mechanics, we tend to increase the amount of mandibular growth a patient has during treatment. For treatment of Class II malocclusion, the fertilizer effect is beneficial, but in Class III treatment it is not helpful. The fertilizer effect is greatest during periods of rapid facial growth. So, my first rule for treating Class III is to try to start treatment either before or after pubertal growth spurt. This is fairly easy to achieve for our orthopedic procedures. In terms of orthopedic intervention for Class III, I think data on the success of face mask protraction to stimulate maxillary growth is much stronger than data on successful restraint of mandibular growth using a chin cup. Therefore, I recommend the use of protraction facemask therapy for developing Class III malocclusions. It is my opinion that this type of therapy can be done at any time before fusion of the maxillary suture system. However, I think the optimal time for treatment is after eruption of the maxillary and mandibular central incisors. I prefer to wait until this time for two reasons. First, treatment can still be completed well before the onset of puberty, and second, you can establish normal overbite and overjet of the permanent incisors so we do not need to have any sort of retention appliance used after the anterior crossbite is corrected. If you correct Class III any sooner, you have the problem of retaining correction during the transition of the incisor dentition. It is important to me that there be contact of natural dentition during the post treatment period. I think proprioceptive feedback during function is an important factor in the success of early Class III treatment. Ideally, if I treat a patient early for Class III, I like to wait to begin full fixed orthodontic treatment until after the pubertal growth spurt is complete.

If you miss the orthopedic treatment window, then I think it is best to wait to begin full fixed treatment until after the pubertal growth spurt. I think this is best because at this point you have only two options remaining, camouflage or surgery. And, in one case (camouflage) you will be adding dental compensations to establish the best possible occlusion while in the other (surgery) you will be removing dental compensations to allow correction for skeletal disharmony. It is impossible for the orthodontist to do both at the same time. So, you are forced to choose. And delaying the choice as long as possible gives you the best chance to make the correct decision between these two options.

7. What are your views on growth modification through the use of functional appliances? (Juan Martin Palomo)

I believe the data on modification of maxillary growth both forward using a protraction facemask or backward using cervical pull headgear is compelling and I recommend these treatment options to my younger patients who would benefit from such therapy. I recommend that these orthopedic devices be worn only at night because we know that humans only grow at night and that teeth only erupt at night. There seem to be two major factors that predict treatment success. The first is patient compliance. To see any effect with the headgear, it must be worn almost every night. Since orthopedic treatment seeks to influence facial growth, we have to allow time for growth to occur. This means that a minimum of 6 months of compliant wear must be achieved before you can assess the second factor that influences treatment success. That second factor is the genetic susceptibility of the patient to growth modification, i.e. is the patient a "responder" or a "non-responder" to orthopedic therapy? I think most orthodontists

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tend to think all non-responders are non-compliant, but I disagree. I think you can get most patients to comply with treatment for a few months. The ones that see results are encouraged and continue to wear their device at night, the ones that do not respond get discouraged and stop wearing the device. I never blame the patient for not responding, in most cases it is not their fault. As my friend Gerry Samson says: "You can't ask them to take another dip in the gene pool". It would be great if we could find a way to determine responders from non-responders without having to wait 3-6 months, but I do not see that as an option in the near future.

8. Since you are a great expert on craniofacial growth, what is your opinion on the historical debate between functional appliances and headgear traction for the correction of ClassII malocclusions? (Lincoln Nojima)

I take an approach to the use of headgear traction in the correction of Class II that is very similar to Dr. Robert Ricketts. I like to use a cervical pull facebow in combination with a lower utility arch. The headgear is effective in correcting maxillary skeletal prognathism and maxillary dental protrusion, and the utility arch uncouples the upper and lower anterior teeth by intrusion of lower incisors. Ricketts's theory, and I agree, was that by uncoupling the anterior teeth you allow the mandible to be displaced downward and forward. Since the effect of orthodontic treatment on mandibular growth is non-specific and highly variable, I do not find a big difference in mandibular growth response between functional appliances that advance the mandible and headgear/utility arch mechanics. And, since headgear is a fixed device, it is much more effective at addressing maxillary protrusions that often accompany Class II malocclusions.

By the way, I use the cervical pull headgear exclusively for facebow type headgear traction. I find the posterior high pull headgear not as effective as an anterior J-Hook headgear in controlling vertical. Plus, you need to add the TransPalatal Arch to the Posterior high pull to negate the buccal rolling of molars. I used to apply straight pull facebows but found that patient compliance was much better with the simpler cervical pull. And, since I do not use facebow headgear in high angle cases, the small difference between the angle of pull for straight pull and cervical was not clinically significant.

9.Do you think that using temporary anchorage devices (TAD) can help us control craniofacial growth patterns? (Kunihiko Miyashita)

I think that TADs can help control vertical dental drift in growing patients. As mentioned earlier, vertical drift of dentition occurs towards the occlusal plane. So, controlling this natural movement could be helpful in patients with increased lower vertical facial height. Of course, to achieve this goal it would be necessary to control both the inferior drift of the maxillary buccal segments, as well as the superior drift of the mandibular buccal segments. In addition, because we are trying to limit vertical facial development by modifying the dentition and alveolus, these mechanics would likely need to be continued until vertical facial growth was completed. This type of growth modification will face the same challenges as we faced when we used chin cups to limit mandibular growth, i.e. achieving long-term stability will require a long-term retention strategy. I have used miniplates to intrude posterior segments in several patients including one that we published in the Journal of Plastic Surgery. TADs are an exciting addition to our mechanical systems and their effective use will require orthodontists to apply bone biology in their TAD placement planning. For example, long-term placement of a TAD in an area of bone that is undergoing bone resorption as part of remodeling process will likely fail. Whereas, placement of a TAD in an area of natural bone deposition has a higher chance of success based on biology. Applying this concept to vertical control of dental drift would mean that maxillary TADs should be placed in the palate, and not on the buccal surface. In the mandible, TADs could be placed on the buccal cortices adjacent to the molars. TADs placed in alveolar bone are likely to fail sooner than those placed in cortical bone. Since you need long-term TAD success to modify craniofacial growth, the resorptive and depository remodelling patterns are important to understand.

10. Is there any different clinical response in the sutural tissues of growing patients using miniplates or headgear traction considering growth and displacement of facial bones? (Ana Maria Bolognese)

Absolutely!!! This is one of the biggest areas of confusion regarding the use of miniplates compared to using headgear. The goal of applying orthopedic forces to

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the growing craniofacial complex is to change the displacement and remodelling of the bones. For example, cervical pull headgear can be used in a variety of ways to change facial growth depending on how the force is applied. Dr. Andy Haas, Robert Ricketts and others have documented the effects of cervical pull headgear applied solely to maxillary first molars. When the headgear is attached only to maxillary first molars you are using the teeth via the periodontal ligament (PDL) as a transducer to send mechanical signals to the periosteum and sutural systems. The sutural system can be influenced by this mechanical system including the intermaxillary suture, the circummaxillary suture system, and, to a lesser extent, the circumfacial sutures. Cervical headgear applied to maxillary first molars combined with a lower utility arch to intrude the lower incisors can also influence mandibular growth. The most logical explanation of the effect of cervical headgear on mandibular growth is that by disengaging the dentition with the intrusion arch, the mandible outgrows the nasomaxillary complex. In contrast to the biological impact of orthopedic force application, miniplates are just devices that can be rigidly attached to bone. There is no biologic rationale to think that miniplates are anything like headgear.

11. Considering the important concepts included in your classic "Essentials of Facial Growth", how do you feel about research on craniofacial growth and airway? And how such information can be correlated to clinical intervention? (Matilde Nojima)

Probable, one of the most classic experiments that demonstrated the impact of forced oral respiration on facial growth was conducted by Egil Harvold when he plugged the noses of growing rhesus monkeys. What everyone remembers about this experiment is that Harvold was able to cause open bite malocclusions in these monkeys. And these open bite malocclusions were characterized by increased lower vertical facial height, maxillary transverse deficiency and dental crowding. What most people forget is that not all of Harvold's monkeys developed malocclusions. This variability in response to airway obstruction has not been talked about very much in our literature. In my opinion, if we have such variability in a genetically homogeneous population of experimental animals I would expect even greater variation in human populations. And, this is in fact what we have found with any large study on the impact of airway on facial growth. It is impossible to show a simple cause and effect relationship between mouth breathing and malocclusion. It makes sense that there should be some influence since the roof of the mouth and the floor of the nose are the same bone, but I do not think we will ever be able to prove such a relationship. In terms of clinical intervention, I think we do know that rapid palatal expansion reduces nasal airway resistance. And, we know that moving the mandible forward with functional appliances increases the oral pharyngeal airway. These are anatomic facts. Therefore, if you have a patient that has nasal obstruction and is a mouth breather you could consider palatal expansion as one mode of treatment. If the pediatrician asks whether removal of adenoid tissue would be beneficial for facial growth I would answer the following way: If the child needs to have adenoid tissue removed for medical reasons (i.e. recurrent infection), then I would support the operation and indicate that there could be a positive effect on facial development. In contrast, if a pediatrician asks me if I would recommend removal of adenoid tissue for improving facial growth I would say that the evidence is not strong enough to support such a recommendation from the orthodontist.

12. What changes can be achieved, after growth, to correct the morphology of the nasomaxillary complex in cases of open bite and mouth breathers ? (Ana Maria Bolognese)

After the pubertal growth spurt and adolescent growth has completed, I think that the only changes in the morphology of the nasomaxillary complex that can be reliably achieved involve remodeling of the alveolar processes that accompanies tooth movement. However, these changes can be significant, especially when permanent teeth are removed. We published several interesting studies on the influence of extraction of permanent teeth on vertical facial growth. We found that after growth, the extrusive effects of orthodontic treatment are minimal. This really helps in the correction of anterior openbite. The clinician does not have to worry as much about molar extrusion in non-growing patients. We were able to show that correction of openbite was achieved primarily by uprighting upper and lower incisors. This was true for extraction of first bicuspids as well for extraction of permanent first molars. I think the tendency for treating without

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extraction of permanent teeth has severely limited what we can achieve for our patients after growth. For the non-growing patient, the need for extraction of permanent teeth must be carefully evaluated.

13. How do you address the relationship between Craniofacial Growth and stability of orthodontic treatment outcomes? (Lincoln Nojima)

This is an interesting question, especially as it pertains to craniofacial growth that occurs after orthodontic treatment. During treatment, the orthodontist is constantly monitoring craniofacial growth, treatment response, and the progress towards completion of therapy. Treatment decision can be made on a monthly basis to compensate or decompensate the dentition in response to craniofacial growth. Once the treatment goals of dental alignment, anterior guidance, axial loading of posterior teeth, proper smile arch, pleasing smile, etc., have been achieved and braces are removed, the game changes. Now, the patient no longer has the skilled orthodontist to help maintain equilibrium among all of components of the craniofacial complex that are involved in maintaining the dental occlusion. Although there are no easy answers to this dilemma, I can offer one suggestion. Do not try to finish all of your cases with centric relation (the ligamentous position of the mandibular condyle in the glenoid fossa) coincident with the position of the condyle in the glenoid fossa dictated by the maximum intercuspation of the teeth. Allow at least 1-2 mm of difference between these two condylar positions. That way, if you get a couple millimeters of late mandibular growth, a change in CR-MIC relationship can occur and compensate for this growth, thereby keeping teeth in proper occlusion.

14. In a constantly changing craniofacial complex, what are your views on the changes that occur during adulthood, the appearance of late dental misalignment and the concept of retainers for life? (Juan Martin Palomo)

The publications from the University of Washington group on long-term stability of treated malocclusions in the mid 1980's coupled with the natural bias of doctors and patients against extraction of teeth, caused a monumental paradigm shift in Orthodontics. Prior to these publications, orthodontists considered stability of orthodontic correction to be one of the main goals of treatment. And to achieve this goal, the removal of permanent teeth was often prescribed so that expansion of dental arches in the anterior and lateral dimensions could be avoided. After these publications, lifetime retention was de rigueur for all patients. I think that this change in our approach to stability is very dangerous to our profession. The main reason for my thinking is that if we give up on stability as a treatment goal, we run the risk of diminishing the specialty to the level of a cosmetic rather than a functional service. This, in turn, will make it much easier for the public to view orthodontic treatment as a commodity. When the public purchases a commodity, they focus on value. If stability is not part of the value equation, we are left with price and treatment time. Patients will assume that quality of treatment results is equal among providers. Our specialty is much more than aligning teeth. Fit and function as well as lifetime dental health should be important goals of treatment. Making beautiful smiles is fine, but we cannot do so at the expense of dental health.

My main concern about lifetime retention is that there is a real possibility that significant changes in the supporting periodontium could result if teeth retained for a lifetime in an unstable position. We know from our studies of bone biology that under pressure bone resorbs. So, if an orthodontist moves teeth beyond their physiologic boundary, pathology will ensue. The critical question is "What are those boundaries?" Identifying these boundaries should be the focus of orthodontic research for the coming decade. Until we have a better idea of the limits of treatment, we should be wary of lifetime retention. I think a more biologic approach would be to tell our patients that we can produce an orthodontic treatment result as good as someone who was born with straight teeth. However, we know from the Bolton Brush Studies, that naturally straight teeth do not stay that way for a lifetime. The idea that a single orthodontic intervention will lead to a lifetime of perfectly straight teeth is not realistic. We should inform patients that additional treatment may be needed in the future due to naturally occurring growth of the adult craniofacial skeleton.

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15. Which bone is your favorite? And why?
(Kunihiko Miyashita)

Without question, the mandible is my favorite bone in the craniofacial regions. My attraction to the study of the mandible is based on three factors. First, the historic orthodontic controversies involving this bone. These begin with the myth of the condylar cartilage as a growth center that magically determined the size and shape of this complex bone. This was followed by the functional appliance craze in the United States with the outrageous claims of mandibular protrusive devices being capable of stimulating mandibular corpus growth in the six to seven millimeter range. Then, came the false claims that malocclusions caused temporomandibular joint disease. And finally, the most recent controversy over the role of the size and shape of the mandible in Obstructive Sleep Apnea Syndrome. The second reason I am fond of the mandible is its anatomic complexity (Fig 2). When I teach students about the mandible I like to divide the bone into five areas based on function. Area one, the condyle with the primary function of articulation. Area two, the coronoid process, primary function, attachment of the temporalis muscle. Area three, the corpus, primary function to connect the right and left halves for the mandible as a rigid strut. Area four, the alveolus, primary function to support the dentition. Area five, the ramus, primary functiont to provide compensations in both the vertical and horizontal dimensions to insure occlusion of molar teeth within 6 mm among the entire human race. Finally, I like the mandible because we have much to learn about the control processes involved in its growth. Right now, I like to say to my students that all orthodontic/orthopedic treatments of growing patients increase mandibular growth a little bit, I refer to this non-specific stimulation of mandibular growth as the "fertilizer effect".

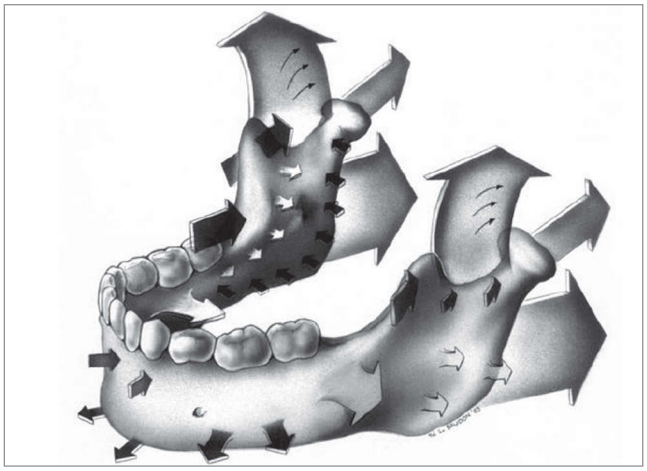


Figure 2 - Summary diagram of the growth of the mandible. Growth directions involving periosteal resorption are indicated by arrows pointing into the bone surface, and growth directions involving periosteal deposition are represented by arrows pointing out of the bone surface. (In Enlow, D. H. and Hans, M. G.: Essentials of Facial Growth. 2nded. Ann Arbor: Needham Press, 2008. From Enlow, D. H. and D. B. Harris: A study of the postnatal growth of the human mandible. Am. J. Orthod. 50 (25), 1964, with permission.)

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Immediate periodontal bone plate changes induced by rapid maxillary expansion in the early mixed dentition: CT findings

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.036-043.oar*

Objective: This study aimed at evaluating buccal and lingual bone plate changes caused by rapid maxillary expansion (RME) in the mixed dentition by means of computed tomography (CT).

Methods: The sample comprised spiral CT exams taken from 22 mixed dentition patients from 6 to 9 years of age (mean age of 8.1 years) presenting constricted maxillary arch treated with Haas-type expanders. Patients were submitted to spiral CT scan before expansion and after the screw activation period with a 30-day interval between T1 and T2. Multiplanar reconstruction was used to measure buccal and lingual bone plate thickness and buccal bone crest level of maxillary posterior deciduous and permanent teeth. Changes induced by expansion were evaluated using paired t test ($p < 0.05$).

Results: Thickness of buccal and lingual bone plates of posterior teeth remained unchanged during the expansion period, except for deciduous second molars which showed a slight reduction in bone thickness at the distal region of its buccal aspect. Buccal bone dehiscences were not observed in the supporting teeth after expansion.

Conclusion: RME performed in mixed dentition did not produce immediate undesirable effects on periodontal bone tissues.

Keywords: Palatal expansion technique. Periodontium. Spiral computed tomography.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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How to cite this article: Garib DG, Menezes MHO, Silva Filho OG, Santos PBD. Immediate periodontal bone plate changes induced by rapid maxillary expansion in the early mixed dentition: CT findings. Dental Press J Orthod. 2014 May-June;19(3):36-43. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.036-043.oar

Submitted: April 10, 2012 - **Revised and accepted**: August 30, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

During rapid maxillary expansion, orthopedic effect is produced by midpalatal suture splitting. Additionally, a dental effect characterized by buccal movement of supporting teeth is also produced.[19-22,27,33] As a result, maxillary posterior teeth are buccally displaced by an association of inclination and translation. The literature evinces that buccal tooth movement is associated with the occurrence of bone dehiscences. Engelking and Zachrisson,[15] Steiner et al,[28] Thilander et al[29] and Wennström et al[32] conducted animal investigations and demonstrated that buccal tooth movement with mild forces increases the distance between the cementoenamel junction and the buccal alveolar crest. Wehrbein et al[31] reached a similar conclusion when conducting a cadaver study. Buccolingual tooth movement seems to occur through the alveolar bone and not along the bone. It leads to bone dehiscences in the short-term[15,28,29,31,32] and to gingival recession in the long-term.[1-4]

Recent studies conducted with CT have shown apical migration of buccal alveolar crest of posterior teeth after RME is performed in permanent dentition patients.[18,25] By means of CT methodology, Garib et al[18] assessed a sample of eight female adolescents before RME and after the removal of the expander following a 3-month retention period. The authors concluded that RME induced bone dehiscences on the buccal aspect of supporting teeth (first premolars and first molars), especially in subjects who initially presented thinner buccal bone plate. Rungcharassaeng et al[25] found similar results in a sample of thirty consecutive RME patients with a mean age of 13.8 years. Their findings included buccal bone loss in both horizontal and vertical dimensions for all posterior teeth after expansion, and displayed a significant correlation with age, amount of expansion and initial buccal bone thickness. Ballanti et al[8] observed, at the end of the active expansion phase, a significant decrease of buccal bone plate thickness of permanent maxillary first molars in a sample of 17 prepubertal patients with a mean age of 11.2 years. However, a tendency for partial recovery was found six months after expansion.

Buccal bone changes produced by rapid maxillary expansion in the permanent dentition raise the question about the periodontal effects of RME performed in the early phases of mixed dentition. During deciduous and early mixed dentitions, RME produces greater orthopedic effects[14,23] and transfers anchorage to deciduous molars and canines. A classic implant study showed that, in adolescents, skeletal effects corresponded to 35% of expansion, whereas dental effects accounted for 65%.[23] On the other hand, in young children, the proportion between skeletal and dental effects was 1:1. Baccetti et al[5] also observed that RME performed before the peak of skeletal maturation produced more skeletal effects than RME performed after the peak. Thus, the periodontal changes related to the orthodontic effect of RME in the early phases of mixed dentition deserve to be differentiated from those observed in late mixed dentition or even in permanent dentition. Therefore, the aim of this study was to investigate, by means of spiral CT, the periodontal bone changes of RME in early mixed dentition using deciduous teeth as anchorage.

MATERIAL AND METHODS

This study was approved by the School of Dentistry — University of São Paulo/Bauru Institutional Review Board. The sample comprised spiral CT exams taken from 22 orthodontic patients (10 males and 12 females) with mean initial age of 8.1 years (ranging from 6 to 9 years). The exams had been taken for a previous study,[13] in 2002, before CBCT was introduced in Brazil. In selecting the sample, the following inclusion criteria were applied: patients in early mixed dentition, and the presence of constricted maxillary arch with or without posterior crossbites. In the examined sample, all subjects were in the early transitional phase, as described by Van der Linden,[30] and either at stage CS1 or CS2 at the time of treatment.[6] In other words, patients were treated before or at the beginning of the pubertal growth spurt.

Maxillary expansion was performed with Haas-type expanders anchored exclusively on deciduous teeth (Fig 1). For all patients, maxillary deciduous second molars functioned as supporting teeth and received bands, whereas maxillary deciduous canines were bonded to a "C" shape anterior extension wire (Fig 1). The expansion screw was activated at two-quarter turns in the morning and two-quarter turns in the evening for approximately 8 days, reaching a mean opening of 7 mm.

All patients were submitted to computed tomography imaging before expansion and after the active expansion phase, with a mean interval of 30 days in between. A spiral computed tomography machine model Xvision EX (Toshiba Corporation Medical Systems Company,

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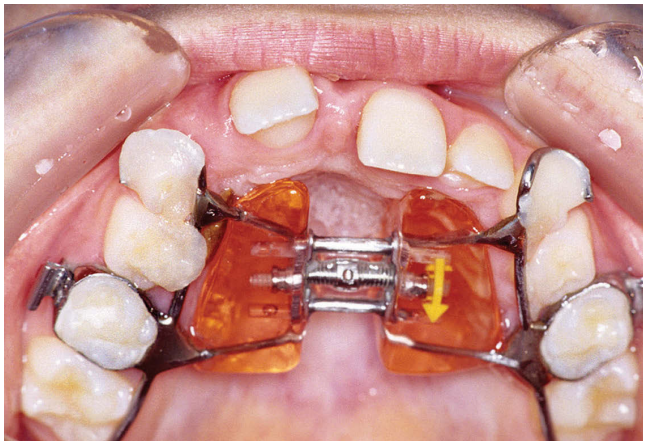


Figure 1 - Haas-type expander used in this study.

Otawara-Shi, Japan) was used at 120 kV and 100 mA, with a scanning time of one second per section. A FC 30 scanning filter, field of view (FOV) of 12.6 x 12.6 cm and matrix of 512 x 512 pixels was used. Window width was 2400 HU with a center of 1300 HU.

For standardization of head positioning in all three planes, the perpendicular light beam resource provided by the machine was used; thereby, allowing comparison of images obtained before and after expansion.[18, 19] For that purpose, patients were positioned with Camper's plane perpendicular to the ground, while the longitudinal light beam passed through the center of the glabella and the filtrum, and the transverse light beam passed through the lateral eye canthus. Teeth were kept apart in order to avoid imaging the mandibular dental arch. One-millimeter thick axial sections were performed parallel to the palatal plane, including the dentoalveolar and basal areas of the maxilla, up to the lower third of the nasal cavity. The imaged area encompassed 36 to 40 mm, totalizing 36 to 40 sections. This protocol results in images with a spacial resolution that ranges from 0.2 to 0.5 mm.[17]

Data were transferred to a network computer workstation (Silicon Graphics, Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan), using Alatoview software (Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan) on which 2D reformatted images were generated and measured by the computerized method. The Allatoview software generates a very small ball size pointer for linear measurements.

Measurement of alveolar bone plate thickness of maxillary posterior teeth at the buccal and lingual aspects was conducted on two axial sections parallel to the palatal plane, one at the level of right maxillary permanent first molar furcation and another at the level of right maxillary deciduous second molar furcation (Figs 2 and 3). Measurements of alveolar bone thickness were performed on magnified images (4x), before and after expansion. Whenever tooth rotations were present, bone plate thickness was measured at the area where the root was closer to the external contour of the alveolar ridge.

Evaluation of the buccal alveolar bone crest level of maxillary posterior teeth was conducted by means

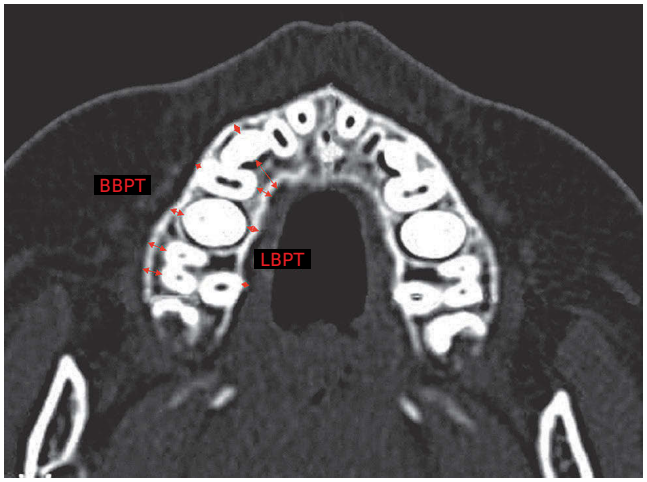


Figure 2 - Measurements of buccal and lingual bone plate thickness (BBPT and LBPT) of permanent erupted and non-erupted posterior teeth were performed in the axial section, parallel to the palatal plane, passing at the level of right maxillary permanent first molar furcation.

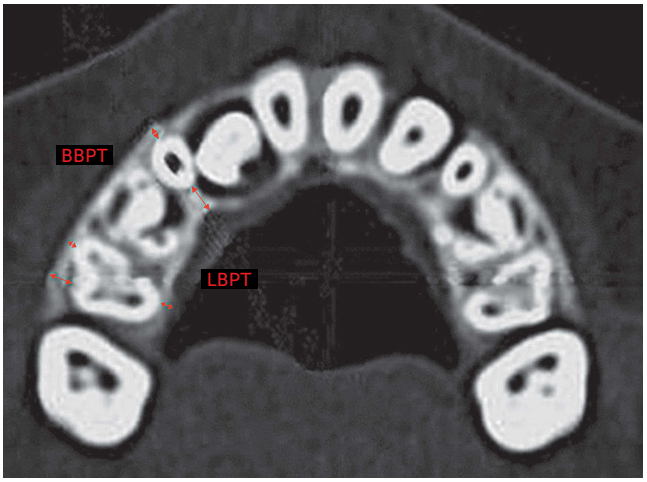


Figure 3 - Measurements of buccal and lingual bone plate thickness (BBPT and LBPT) of deciduous posterior teeth were performed in the axial section, parallel to the palatal plane, passing at the level of right maxillary deciduous second molar furcation.

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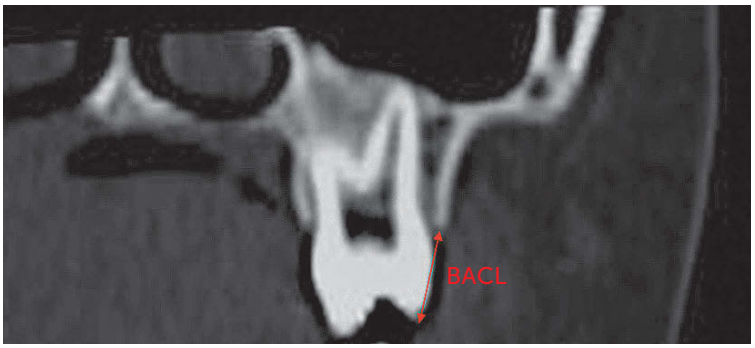


Figura 4 - Measurement of maxillary posterior teeth buccal alveolar crest level. BACL: buccal alveolar crest level measured from the buccal cusp tip to the buccal alveolar crest.

of orthoradially reformatted images perpendicular to the contour of the dental arch (cross sections), passing through the center of the buccal aspect of the deciduous canines, deciduous first molar and through the center, mesial and distal areas of the buccal aspect of deciduous second molars and permanent first molars. Figure 4 illustrates the linear variable obtained on each of these eight images both before and after expansion.

Statistical analyses

All measurements were performed twice within a monthly interval by the same calibrated examiner. Statistical analysis was performed taking into account the mean of these two measurements. Each tooth category corresponded to the mean of right and left side teeth. Mean and standard deviation of each variable were calculated before and after expansion, and so were the changes between these stages. An exploratory test revealed normal distribution of data. Therefore, dependent t-tests were used to compare inter-phase changes. Sample size calculation (with an alfa value of 0.05 and statistical power of 90%) revealed that a sample size of 23 was more than enough. Results were regarded as significant for $p < 0.05$.

Systemic and casual errors

Casual and systematic errors were calculated by comparing the first and second measurements with Dahlberg's formula and dependent t-test respectively, at a significance level of 5%.

RESULTS

The results of the error of the method are shown in Table 1. Two out of 22 variables had a statistically significant systematic error (LBPT of the permanent first molars and BABCL at the center of deciduous second molars — as shown in Figures 2 and 4). Casual errors ranged from 0.11 (BBPT at the distal region of permanent first molars) to 0.52 (BBPT at the mesial region of permanent first molars).

Buccal and lingual bone plate thickness (BBPT and LBPT)

Table 2 shows that buccal bone plate thickness of supporting teeth was not significantly changed by RME. Additionally, no changes were observed in the buccal bone plate thickness of tooth germs and permanent first molars (Table 2). The only exceptions were the buccal bone plate of first premolar germ which showed a statistically significant decrease (mean of 0.18 mm), and the buccal bone plate of deciduous second molar which showed a statistically significant decrease at the distal region (mean of 0.3 mm).

No changes were observed for the lingual bone plate thickness of deciduous and permanent teeth (Table 2).

Buccal alveolar bone crest level (BABCL)

No statistically significant changes were observed in the level of buccal alveolar bone crest of supporting teeth (deciduous canines and deciduous second molars) and permanent first molars (Table 3).

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Table 1 - Systematic and casual errors (dependent t-tests and Dalhberg's formula).

Variables	First Mean ± SD	Second Mean ± SD	t	p	Dalhberg
Buccal bone plate thickness (BBPT)					
Permanent canine germ	1.54 ± 0.60	1.52 ± 0.59	0.260	0.798	0.21
1st premolar germ	0.97 ± 0.46	0.95 ± 0.42	0.356	0.727	0.12
2nd premolar germ	2.10 ± 1.01	2.15 ± 1.17	-0.612	0.549	0.25
Deciduous canine	1.13 ± 0.64	1.15 ± 0.68	0.74	0.463	0.12
Deciduous 2nd molar/mesial	1.11 ± 0.58	1.14 ± 0.59	0.91	0.367	0.12
Deciduous 2nd molar/distal	1.72 ± 0.70	1.75 ± 0.67	0.95	0.349	0.15
Permanent 1st molar/mesial	2.96 ± 1.21	2.77 ± 1.21	1.121	0.277	0.52
Permanent 1st molar/distal	2.92 ± 0.88	2.87 ± 0.90	1.334	0.200	0.11
Lingual bone plate thickness (LBPT)					
Permanent canine germ	5.60 ± 2.03	5.72 ± 2.07	-1.170	0.259	0.30
1st premolar germ	3.09 ± 0.97	3.03 ± 1.05	0.637	0.534	0.29
2nd premolar germ	2.71 ± 1.05	2.74 ± 1.02	-0.421	0.680	0.16
Deciduous canine	4.73 ± 1.58	4.79 ± 1.61	1.955	0.057	0.16
Deciduous 2nd molar	1.16 ± 0.55	1.18 ± 0.55	0.64	0.527	0.11
Permanent 1st molar	1.41 ± 0.57	1.30 ± 0.61	3.082	0.007*	0.13
Buccal alveolar crest level (BACL)					
Deciduous canine	9.14 ± 2.02	9.28 ± 2.12	-0.690	0.512	0.39
Deciduous 1st molar	7.66 ± 1.16	7.67 ± 1.18	-0.031	0.976	0.27
Deciduous 2nd molar/mesial	7.72 ± 1.40	7.72 ± 1.44	-0.026	0.980	0.35
Deciduous 2nd molar/center	7.80 ± 0.45	7.98 ± 0.40	-2.545	0.020 *	0.24
Deciduous 2nd molar/distal	8.10 ± 0.58	8.03 ± 0.62	1.108	0.284	0.18
Permanent 1st molar/mesial	8.39 ± 1.24	8.50 ± 1.08	-1.130	0.275	0.29
Permanent 1st molar/center	7.64 ± 1.02	7.71 ± 1.21	-0.725	0.479	0.27
Permanent 1st molar/distal	7.79 ± 0.88	7.79 ± 0.90	0.000	1.000	0.22

*Statistically significant at P < 0.05

Table 2 - Buccal and lingual bone plate thickness expansion changes (Paired t test).

Variables	n	Pre-expansion Mean ± SD		Postexpansion Mean ± SD		Changes	t	p
Buccal bone plate thickness (BBPT)								
Permanent canine germ	23	1.32	0.55	1.31	0.71	-0.01	0.109	0.914
1st Premolar germ	17	0.92	0.41	1.10	0.37	-0.18	-3.318	0.004*
2nd Premolar Germ								
Canine	20	2.33	1.08	2.28	1.14	-0.05	0.572	0.574
Deciduous canine	20	1.20	0.82	1.03	0.38	-0.17	0.913	0.373
Deciduous 2nd molar/mesial	19	1.14	0.50	1.06	0.63	-0.09	0.785	0.443
Deciduous 2nd molar/distal	19	1.89	0.69	1.59	0.68	-0.30	2.494	0.023 *
Permanent 1st molar/mesial	22	3.21	1.20	2.90	1.32	-0.31	1.478	0.154
Permanent 1st molar/distal	22	3.01	0.75	2.95	0.81	-0.05	0.823	0.420
Lingual bone plate thickness (LBPT)								
Permanent canine germ	19	5.81	2.07	5.47	1.98	-0.34	1.627	0.121
1st premolar germ	17	3.46	1.30	3.36	1.15	-0.10	0.580	0.570
2nd premolar germ	18	2.81	1.14	2.85	1.02	0.04	-0.331	0.744
Deciduous canine	21	4.77	1.72	4.81	1.54	0.04	-0.200	0.844
Deciduous 2nd molar	17	1.26	0.53	1.19	0.55	-0.07	0.714	0.486
Permanent 1st molar	20	1.34	0.59	1.42	0.66	0.08	-1.128	0.273

*Statistically significant at P < 0.05

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Table 3 - Buccal alveolar crest level (BACL) expansion changes (Paired t test).

Variables	n	Pre-expansion Mean ± SD	Postexpansion Mean ± SD	Change	t	p
Deciduous canine	17	9.02 ± 2.67	8.01 ± 3.55	-1.01	0.934	0.364
Deciduous 1st molar	20	7.32 ± 2.06	7.31 ± 2.07	-0.01	0.088	0.931
Deciduous 2nd molar/mesial	18	7.82 ± 0.67	7.60 ± 1.19	-0.22	0.863	0.400
Deciduous 2nd molar/center	22	7.73 ± 0.57	8.03 ± 0.77	0.30	-1.810	0.085
Deciduous 2nd molar/distal	20	7.82 ± 1.25	8.30 ± 0.93	0.48	-1.714	0.103
Permanent 1st molar/mesial	20	8.31 ± 1.19	8.27 ± 0.80	-0.04	0.190	0.851
Permanent 1st molar/center	21	7.68 ± 0.96	7.59 ± 1.10	-0.09	0.474	0.640
Permanent 1st molar/distal	19	7.91 ± 0.92	7.81 ± 0.84	-0.10	0.495	0.627

*Statistically significant at P < 0.05

DISCUSSION

Spiral CT proves valuable in assessing alveolar bone thickness and level . Fuhrmann et al[16] demonstrated that buccal and lingual bone plates can be identified in spiral CT images provided that they are at least 0.5 mm thick. On the other hand, when the periodontal ligament space is apparent, CT identifies even thinner buccal and lingual bone plates (0.2 mm). Measurements taken with spiral CT showed high accuracy and precision.[10,11] While periapical radiographs underestimate horizontal alveolar bone defects in 0.6 to 2.2 mm, spiral CT overestimate them in 0.2 mm.[17] Moreover, previous studies measuring alveolar bone plate thickness and level in spiral CT showed high reproducibility and no-significant errors.[8,18,24]

This study assessed the changes in alveolar bone thickness and level at the region of maxillary posterior teeth after RME was performed during early mixed dentition. The comparison between initial and post expansion CT images was possible due to standardization of head positioning during the exam associated with selection of standardized image sections for measurements. Molar furcation was used as reference to obtain standardized axial sections before and after expansion. This region is relatively stable, since — in reference to the palatal plane — posterior tooth extrusion is very small during RME and may be compensated by tooth buccal tipping.[9]

With regard to changes in buccal bone plate thickness of supporting teeth, deciduous canines, which received a bonded C wire extension, did not reveal reduction in BBPT after expansion (Table 2). Conversely, deciduous second molars, which received bands, showed statistically significant reduction in buccal bone plate thickness at the distal region after expansion, while the mesial aspect of buccal bone plate remained stable (Table 2). The mean decrease in thickness of the distal aspect of buccal bone plate of deciduous second molars was 0.3 mm. Although statistically significant, this reduction was of lesser magnitude than the reduction in BBPT observed for permanent first molars when RME is performed in permanent dentition.[18,25]

RME performed in mixed dentition and anchored exclusively in deciduous teeth produces permanent first molar expansion of one-half the amount of screw expansion, following the orthopedic effect of basal bones.[12] In this study, palatal wire extension was used at permanent first molars and probably produced further orthodontic effect in this region. However, results revealed that buccal bone plate of permanent first molars did not undergo any changes (Table 2). Previous studies assessing changes in buccal bone plate thicknes of posterior teeth after rapid maxillary expansion were performed in permanent dentition[18,25] or in late mixed and permanent dentitions.[8] In these previous studies, only permanent teeth were analyzed.[8] Garib et al[18] reported a significant decrease in buccal bone plate thickness of banded supporting teeth (first premolars and permanent first molars) that ranged from 0.6 to 0.9 mm, three months after expansion. Rungcharassaeng et al[25] corroborated the findings by Garib et al[18] and showed a significant decrease in buccal bone plate thickness of first premolars, second premolars and permanent first molars, with an average of 1.1 mm, 0.8 mm and 1.2 mm, respectively, three months after expansion. Ballanti et al[8] assessed a sample of young patients aged between 8 to 14 years old, and reported a significant decrease in buccal bone plate thickness of supporting maxillary permanent first molars immediately after the active phase of RME. The mean decrease was less than 0.5 mm and tended to recover six months after expansion.

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The effects of RME on mixed dentition are similar to the effects observed in permanent dentition, including an orthopedic effect represented by midpalatal suture split and an orthodontic effect represented by buccal movement of posterior teeth.[13,14] The V shaped maxillary split observed after RME, in both occlusal and frontal planes during permanent dentition, is also observed during mixed dentition.[13,14] However, maxillary halves separation is greater in mixed dentition and corresponds to 50% of screw activation, while in permanent dentition it corresponds to approximately 30% of screw activation.[23] Consequently, the amount of orthodontic effect decreases in mixed dentition in comparison to permanent dentition. Considering that periodontal bone changes are related to tooth movement in the alveolar ridge, it would be expected that RME during the mixed dentition causes less changes in buccal bone plate thickness, as confirmed in this study.

Lingual bone plate thickness (LBPT) of supporting teeth and permanent first molars did not change after RME (Table 2). A previous study performed in permanent dentition reported an increase in lingual bone thickness of posterior teeth after RME, thereby reflecting the buccal movement of these teeth.[18] This increase had a mean value of 0.7 to 1.4 mm, three months after expansion.[18] The absence of changes in lingual bone plate thickness in mixed dentition observed in this study can be explained by the smaller amount of orthodontic effects caused by RME during childhood.[5,23] Furtheremore, the relatively short interval between the first and second CT exam might have influenced the results. A previous study assessing patients in permanent and late mixed dentitions reported that lingual bone plate thickness of permanent first molars did not immediately change after the active phase of expansion; however, an increase was observed 6 months after RME.[8]

All patients comprising the sample had maxillary permanent canines and premolars unerupted when RME was performed. Thus, one of the goals of the present study was to observe the behavior of posterior tooth germs during expansion. Results showed that buccolingual position of posterior tooth germs is not affected by RME. Thickness of buccal and lingual bone plates of posterior tooth germs remained unchanged from T1 to T2 (Table 2). Only the buccal bone plate of first premolars germs demonstrated a small decrease. Such decrease might be related to tooth eruption, although the mean decrease of 0.18 mm is not clinically relevant. It is interesting to note that a favorable side effect of RME in early mixed dentition consists in facilitating eruption of palatally displaced maxillary permanent canines.[7] This aspect can be regarded as a "bonus" of early expansion therapy at the maxillary arch.

The level of buccal alveolar crest of posterior teeth showed a slight reduction in the distal region of deciduous second molars, only; although changes were not statistically significant (Table 3). Results indicated that bone dehiscences did not occurr immediately after RME in the early mixed dentition. In permanent dentition, Garib et al[18] found that banded teeth showed a significant reduction in buccal alveolar crest level, with a mean loss of 7 mm in the first premolar and 3.5 mm at the mesial aspect of first molars. Rungcharassaeng et al[25] observed significant vertical bone losses at the buccal aspect of all supporting teeth after RME in permanent dentition. The mean change in buccal crest level of first premolars, second premolars and first molars was 4.4, 1.3 and 2.9 mm, respectively.[25] Therefore, RME performed in early mixed dentition seems to preserve the integrity of buccal bone plate more than RME performed in permanent dentition.The possible explanation is that the reduced orthodontic effect of RME on mixed dentition in comparison to permanent dentition[5,23] is not enough for moving posterior teeth throughout the alveolar bone.

Evidence provided by current investigation suggests that early mixed dentition proves adequate to accomplish orthopedic expansion. In addition to good stability[26] and greater orthopedic effect,[5,23] RME performed in early mixed dentition may avoid collateral buccal bone changes that predispose gingival recession in the long-term.

CONCLUSION

RME performed in early mixed dentition did not produce immediate undesirable effects on alveolar bone morphology of maxillary posterior teeth, mainly in terms of bone dehiscences and decrease in buccal bone plate thickness.

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Cephalometric effects of the Jones Jig appliance followed by fixed appliances in Class II malocclusion treatment

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.044-051.oar*

Objective: The aim of this study was to cephalometrically assess the skeletal and dentoalveolar effects of Class II malocclusion treatment performed with the Jones Jig appliance followed by fixed appliances.

Methods: The sample comprised 25 patients with Class II malocclusion treated with the Jones Jig appliance followed by fixed appliances, at a mean initial age of 12.90 years old. The mean time of the entire orthodontic treatment was 3.89 years. The distalization phase lasted for 0.85 years, after which the fixed appliance was used for 3.04 years. Cephalograms were used at initial (T1), post-distalization (T2) and final phases of treatment (T3). For intragroup comparison of the three phases evaluated, dependent ANOVA and Tukey tests were used.

Results: Jones Jig appliance did not interfere in the maxillary and mandibular component and did not change maxillomandibular relationship. Jones Jig appliance promoted distalization of first molars with anchorage loss, mesialization and significant extrusion of first and second premolars, as well as a significant increase in anterior face height at the end of treatment. The majority of adverse effects that occur during intraoral distalization are subsequently corrected during corrective mechanics. Buccal inclination and protrusion of mandibular incisors were identified. By the end of treatment, correction of overjet and overbite was observed.

Conclusions: Jones Jig appliance promoted distalization of first molars with anchorage loss represented by significant mesial movement and extrusion of first and second premolars, in addition to a significant increase in anterior face height.

Keywords: Malocclusion. Angle Class II. Corrective Orthodontics. Tooth movement.

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How to cite this article: Patel MP, Henriques JFC, Freitas KMS, Grec RHC. Cephalometric effects of the Jones Jig appliance followed by fixed appliances in Class II malocclusion treatment. Dental Press J Orthod. 2014 May-June;19(3):44-51. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.044-051.oar

Submitted: December 08, 2012 - **Revised and accepted**: May 26, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Class II malocclusion is an anteroposterior discrepancy characterized by dentoalveolar or skeletal change or a combination of both, of which mandibular retrusion is the predominant etiologic factor.[1]

There are several methods used to treat this anteroposterior discrepancy, in which case treatment is certainly diversified by patients' etiologic factor, growth pattern, age, degrees of cooperation and, specially, their chief complaint. They may opt for a treatment with or without extractions, with the use of headgear, intermaxillary elastics, functional or mechanical orthopedics removable appliances, fixed intraoral appliances, and even surgical-orthodontic treatment.

Patient's cooperation is a determinant factor for successful orthodontic treatment, thus, protocols that require minimal collaboration are of great value in orthodontic practice. Intraoral distalizers fulfill this function, i.e., they correct Class II malocclusion without entirely depending on the patient to achieve satisfactory results by the end of treatment.[2-5]

Intraoral distalizers differ in the site of action, either buccal or palatal, and promote different results during distalization.[6] Another important factor is the type of anchorage which can be performed in deciduous molars or pre-molars, supported by two or four teeth.[7] Anchorage reinforcement can be currently accomplished by miniscrews fixed on the palate, thereby promoting skeletal anchorage and reducing adverse effects that are characteristic of intraoral distalizers.[8]

However, intraoral distalization through intraoral fixed appliances is only the first phase of treatment that will be finalized with fixed corrective mechanics. In the literature, there are only a few studies scientifically assessing the results of the two treatment phases;[9-12] most researches only assess the results of distalization.[2,4,7,13-17] Therefore, it is of paramount importance to conduct a study that assesses distalization phase and post-distalization fixed appliance phase, separately.

Thus, the aim of this study was to cephalometrically assess the skeletal and dentoalveolar changes of young subjects with Class II malocclusion treated with the Jones Jig appliance followed by corrective fixed appliances, comparing the changes caused by the distalization phase with the changes of the corrective fixed appliances phase.

MATERIAL AND METHODS

Material

This study was approved by Ingá College Institutional Review Board. The prospective sample comprised 75 lateral cephalograms of 25 subjects treated with the Jones Jig appliance followed by fixed appliances.

The criteria for sample selection were based on the following characteristics: Presence of Class II, division 1 malocclusion; mild to moderate crowding; absence of previous orthodontic treatment; absence of supernumerary teeth or agenesis.

Fourteen out of 25 patients were male, while 11 were female, all presenting Class II, division 1 malocclusion, 4 full-cusp Class II, 3 ¾-cusp Class II, 7 ½-cusp and 11 ¼-cusp Class II.

These patients were part of a prospective sample treated by a single student of Masters in Orthodontics at Ingá College. Class II molar relationship was initially corrected by means of the Jones Jig appliance and maintained as a result of the nightly use of headgear during the entire treatment. Fixed corrective appliances were also installed.

The mean initial age was 13.10 years (SD 1.40; minimum 10.83, maximum 16.24), the mean post-distalization age was 13.95 (SD 1.48; minimum 11.33, maximum 17.23), and the mean final age was 16.99 years (SD 1.87; minimum 15.03, maximum 23.15). The mean time of total orthodontic treatment was 3.89 years (SD 0.99). The distalization phase lasted for 0.85 years (SD 0.30; minimum 0.41, maximum 1.95) whereas the phase of fixed appliance after distalization lasted for 3.04 years (SD 0.97; minimum 1.73, maximum 5.93).

Methods

Orthodontic treatment with Jones Jig appliance

The Jones Jig appliance[5] was manufactured by Morelli®, and consisted of a 0.036-in steel body, a steel distal end of 0.016-in, a steel cursor on the mesial end and a stainless steel open spring which requires sequential activation. However, for this research, in order to dissipate light and continuous force, the steel spring was changed by a nickel-titanium spring of which mean size was 10 mm, GH manufacturer (Greenwood, USA & Canada). Distalizer installation started from the bandage of the maxillary second premolars in order to construct the

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modified Nance button. The compression spring corresponded to a distance of 5 mm, which promoted a dissipation of 120 grams (0.12N) of force, in average.

By the end of distalization and correction of molar relationship, an average overcorrection of 2 mm beyond normal molar relationship was endeavored. After removal of the Jones Jig, a modified Nance button was installed on the distalized molars in association with a headgear with middle-high traction (jeans helmet). This phase was followed by bonding of fixed orthodontic appliances (Morelli, Roth, slot 0.022 x 0.028-in). In the maxillary anterior retraction phase, the Nance button was removed and in addition to the night use of the headgear, (with a force of 250 grams, 0.25 N), 3/16-in Class II elastics were used, releasing an average force of 200 g/side (0.2 N), between 12 and 20 h/day. After the fixed orthodontic appliance was removed, a maxillary Hawley plate and a mandibular 3x3 were installed for retention.

Lateral cephalograms

Three lateral cephalograms of each patient were taken at three different times: T1 (initial), T2 (post-distalization) and T3 (final).

Each radiograph was traced with landmarks set in a darkened room. Through a Numonics A-30TL digitizing table, attached to an AMD K-6 II 500MHz microcomputer, the location of the cephalometric landmarks was transferred to the Dentofacial Planner 7.02 software (Dentofacial Planner Software Inc., Toronto, Ontario, Canada) in which measurements involving planes and lines were processed. Magnification factors were set at 6% and 9.8%.

Error of the method

Intra-examiner error was assessed by retracing and obtaining new measurements of 20 randomly selected cephalometric radiographs. The first and second measurements were performed within a month interval. The formula proposed by Dahlberg[18] ($Se^2 = Sd^2/2n$) was applied to estimate the magnitude of casual errors, while systematic errors were analyzed by paired t-tests.[19]

Statistical analysis

Descriptive statistics was performed to obtain means and standard deviations of age and treatment times.

For intragroup comparisons of the three times evaluated, dependent ANOVA as well as Tukey tests were used whenever necessary.

STATISTICA for Windows (7.0 version, StatSoft. Inc.) software was used for analysis. Significance level was set at 5% ($P < 0.05$).

RESULTS

Two systematic errors were observed (PTVI-A and NAP). Casual error ranged from 0.26 mm of overjet to 1.75 degrees of NAP variable.

There were significant changes in almost all components of the three assessed phases (Table 1). The Jones Jig appliance did not affect the maxillary and mandibular component and did not change maxillomandibular relationship. There was distalization of first molars with loss of anchorage, extrusion and mesial movement of first and second premolars. Anterior face height was increased after treatment. Mandibular incisors were uprighted and protruded. By the end of treatment, overjet and overbite were corrected (Table 1).

DISCUSSION

The use of a control group could have added more data to this research by allowing the differentiation of changes produced by the Jones Jig and the fixed appliances from changes that occur with individuals' normal growth. However, the main objective of this study was to observe, separately, the changes in the period of use of the Jones Jig and in the period of use of fixed appliances, headgear and intermaxillary elastics. With this variation of time, there was no compatible control group that could have been used for comparison. Nevertheless, in no way, the lack of a control group invalidates the results obtained herein.

Maxillary component

Distalization with the Jones Jig followed by corrective fixed appliances did not produce statistically significant changes in the effective length of the maxilla (Fig 1, Table 1). This result was already expected, since intraoral distalizers do not promote skeletal changes, as reported in other studies.[9,14-16]

Nevertheless, there was significant maxillary retrusion.[9] This change is probably related to the use

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Table 1 - Intragroup comparison of the three evaluated phases: Initial (T1), post-distalization (T2) and final (T3) (dependent ANOVA and Tukey tests).

Variables	T_1 Mean ± SD	T_2 Mean ± SD	T_3 Mean ± SD	p
Maxillary component				
SNA (°)	81.91 ± 3.96^{AB}	82.84 ± 4.20^{A}	81.72 ± 4.84^{B}	0.022*
Co-A (mm)	81.85 ± 5.21^{A}	82.97 ± 5.65^{A}	82.58 ± 5.48^{A}	0.216
PTVI-A (mm)	47.85 ± 4.51^{A}	48.06 ± 4.23^{A}	48.77 ± 4.72^{A}	0.148
Mandibular component				
SNB (°)	78.50 ± 3.00^{A}	79.31 ± 3.26^{A}	79.18 ± 4.37^{A}	0.210
Co-Gn (mm)	104.41 ± 5.02^{A}	106.30 ± 6.50^{B}	109.67 ± 6.90^{C}	0.000*
P-NB (mm)	1.40 ± 1.11^{A}	1.47 ± 1.17^{A}	1.66 ± 1.30^{A}	0.284
PTVI-B (mm)	47.28 ± 5.43^{A}	47.00 ± 5.11^{A}	49.36 ± 5.98^{B}	0.000*
Maxillomandibular relationship				
ANB (°)	3.42 ± 2.63^{A}	3.57 ± 2.41^{A}	2.54 ± 2.62^{A}	0.055
NAP (°)	5.44 ± 5.89^{A}	5.69 ± 5.77^{A}	3.34 ± 5.58^{A}	0.051
Vertical component				
FMA (°)	29.84 ± 4.17^{A}	31.99 ± 4.88^{B}	31.76 ± 4.04^{B}	0.005*
SN.PP (°)	6.40 ± 4.07^{A}	5.77 ± 3.70^{A}	6.84 ± 3.34^{A}	0.285
SN.GoGn (°)	31.80 ± 4.11^{A}	31.86 ± 4.98^{A}	32.25 ± 4.59^{A}	0.650
SN.GoMe (°)	34.95 ± 4.18^{A}	35.33 ± 4.46^{A}	35.40 ± 4.63^{A}	0.563
NS.Gn (°)	66.50 ± 3.58^{A}	66.32 ± 3.89^{A}	67.35 ± 4.34^{A}	0.059
SN.Ocl (°)	9.77 ± 4.05^{A}	10.04 ± 4.45^{AB}	11.85 ± 3.40^{B}	0.015*
LAFH (mm)	61.75 ± 5.54^{A}	63.77 ± 5.71^{B}	66.72 ± 6.95^{C}	0.000*
Maxillary dentoalveolar component				
SN.1 (°)	107.26 ± 5.52^{A}	111.77 ± 6.73^{B}	106.16 ± 6.29^{A}	0.000*
PTVI-1 (mm)	55.71 ± 5.23^{A}	56.82 ± 5.06^{A}	57.04 ± 5.35^{A}	0.086
PP-1 (mm)	26.90 ± 2.82^{A}	27.09 ± 2.95^{A}	28.58 ± 3.38^{B}	0.000*
1.NA (°)	25.33 ± 6.19^{AB}	28.73 ± 6.93^{A}	24.45 ± 6.95^{B}	0.015*
1-NA (mm)	5.05 ± 2.72 ^{A}	6.33 ± 2.67^{A}	5.48 ± 3.36^{A}	0.087
SN.4 (°)	82.20 ± 4.57^{A}	94.60 ± 5.55^{B}	80.66 ± 5.61^{A}	0.000*
PTVI-4 (mm)	36.41 ± 3.87^{A}	38.87 ± 3.61^{B}	38.60 ± 4.21^{B}	0.000*
PP-4 (mm)	19.20 ± 2.47^{A}	20.61 ± 2.49^{B}	21.20 ± 2.81^{C}	0.000*
SN.5 (°)	78.24 ± 5.24^{A}	88.78 ± 5.53^{B}	79.80 ± 5.69^{A}	0.000*
PTVI-5 (mm)	29.99 ± 3.76^{A}	32.72 ± 3.73^{B}	32.14 ± 4.33^{B}	0.000*
PP-5 (mm)	18.69 ± 2.50^{A}	20.64 ± 2.44^{B}	20.69 ± 2.86^{B}	0.000*
SN.6 (°)	65.48 ± 4.82^{A}	55.30 ± 6.13^{B}	66.80 ± 5.21^{A}	0.000*
PTVI-6 (mm)	21.83 ± 3.61^{A}	19.66 ± 3.34^{B}	23.58 ± 4.23^{C}	0.000*
PP-6 (mm)	16.90 ± 2.29^{A}	16.46 ± 2.44^{A}	19.15 ± 3.04^{B}	0.000*
SN.7 (°)	50.26 ± 6.44^{A}	48.57 ± 6.08^{A}	55.42 ± 6.82^{B}	0.000*
PTVI-7 (mm)	12.14 ± 3.14^{A}	11.34 ± 3.36^{A}	13.53 ± 3.98^{B}	0.000*
PP-7 (mm)	11.48 ± 3.64^{A}	11.82 ± 3.24^{A}	15.68 ± 3.18^{B}	0.000*
Mandibular dentoalveolar component				
1.NB (°)	25.79 ± 5.70^{A}	24.62 ± 5.75^{A}	28.48 ± 5.17^{B}	0.001*
1-NB (mm)	4.54 ± 2.21^{A}	4.73 ± 2.04^{A}	5.90 ± 1.93^{B}	0.000*
PTVI-6i (mm)	20.86 ± 4.51^{A}	21.04 ± 4.47^{A}	23.25 ± 4.34 ^{B}	0.000*
GoMe-6i (mm)	27.72 ± 2.78^{A}	28.29 ± 2.76^{A}	30.92 ± 3.62 ^{B}	0.000*
Dental relationships				
Molar relationship (mm)	-0.35 ± 1.09^{A}	-4.54 ± 1.07^{B}	-2.76 ± 0.58^{C}	0.000*
Overjet (mm)	4.59 ± 1.59^{A}	5.71 ± 1.98^{B}	2.80 ± 0.57^{C}	0.000*
Overbite (mm)	3.82 ± 1.52^{A}	3.40 ± 1.62^{A}	2.35 ± 0.51^{B}	0.000*

* statistically significant difference ($p < 0.05$)
- different letters mean statistically significant difference.

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of an extraoral headgear, since after distalization performed by means of the Jones Jig the headgear was used as anchorage so as to maintain molars distalized as well as to verticalize their roots.[9,20]

Mandibular component

The effective length of the mandible was gradually and significantly increased, showing changes in the end of the distalization phase and at the end of corrective orthodontic treatment (Fig 1). Assessment of PTVI-B demonstrated statistically significant mandibular increase in the final phase of corrective treatment (Table 1). This change was probably related to craniofacial growth and development, which proves mandibular growth in the long-term.[21]

Maxillomandibular relationship

Maxillomandibular relationship was improved by the end of corrective orthodontic treatment; however, these changes were not statistically significant in all three stages (Table 1). This result was already expected, specially at the end of distalization of maxillary molars, since intraoral distalizers do not significantly interfere in changes of bone bases.[9,14-16]

Vertical component

The variables related to the vertical component showed a slight tendency towards angular increase in the phase of fixed corrective treatment; however, only FMA showed a statistically significant increase during distalization, a change that remained in the final stage. Likewise, the occlusal plane angle showed a statistically significant increase at the end of corrective treatment compared to the initial stage (Table 1). There was also a statistically significant increase in lower anterior face height in the post-distalization stage and at the end of corrective orthodontic treatment (Table 1).

Changes in cephalometric variables related to the vertical component certainly occurred due to clockwise rotation of the mandible probably caused by significant extrusion of first and second premolars during distalization.[9,16]

Changes in the occlusal plane and LAFH were also observed at the end of corrective orthodontic treatment and were related to extrusion of first premolars and first and second molars (Fig 2). However, in this phase, vertical changes occurred to correct overbite, which decreased in 1.47 mm from the initial to the final stage.[9] Moreover, increased LAFH may also be credited to normal vertical facial growth.

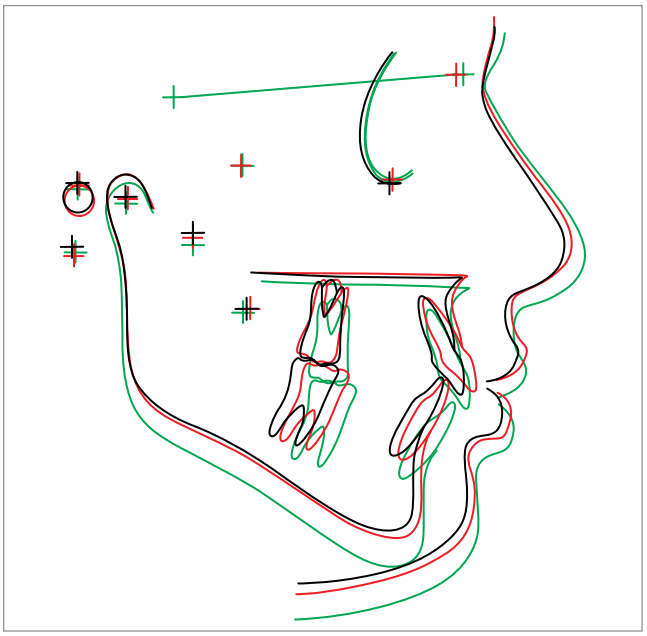


Figure 1 - Mean cephalometric landmarks in the three observation phases: (T_1, black; T_2, red; and T_3, green) (overlap on line SN).

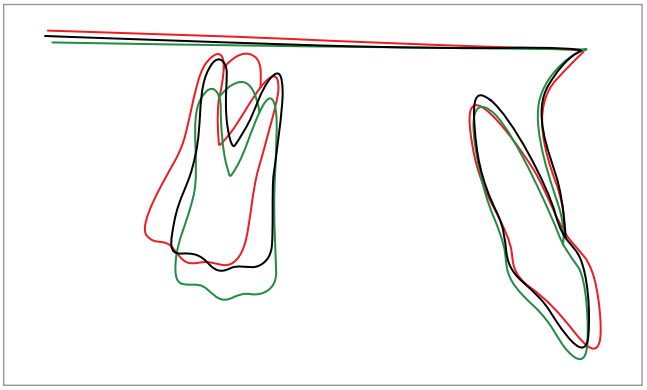


Figure 2 - Maxillary teeth alterations in the three observation phases (T1, black; T2, red; and T3, green) (overlap on palatal plane).

Maxillary dentoalveolar component

Maxillary incisors

Maxillary incisors showed statistically significant buccal inclination in the post-distalization phase. This accentuated inclination is a characteristic of anchorage loss during intraoral distalization.[9,15-17] However, in the final phase of orthodontic treatment, maxillary

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incisors showed significant palatal inclination, thereby reversing anchorage loss. Protrusion of maxillary incisors was not statistically significant (Table 1).

In the final phase of corrective orthodontic treatment, maxillary incisors also showed significant extrusion related to correction of buccal inclination, vertical displacement of the maxilla due to the craniofacial growth[22] and the use of Class II elastics.

First and second maxillary premolars

In the post-distalization phase, first premolars demonstrated effects of anchorage loss related to distal movement through intraoral distalizers.[7,10-13,20] There was significant linear and angular mesial movement associated with extrusion in relation to the palatal plane. Mesial angulation was corrected at the end of orthodontic treatment; however, mesial positioning remained in the final stage (Table 1), probably due to anterior displacement of the maxilla in an attempt to accompany mandibular displacement.[10,20] First premolars showed significant extrusion at the end of distalization and orthodontic treatment.

Previous researches[9,16] also assessed the effects of the Jones Jig appliance, but focused only on second premolars, which are the anchorage teeth selected for placement of the Nance button during intraoral distalization.

Second premolars showed similar behavior to first premolars, also characterizing anchorage loss due to intraoral distalization.[2,4,7,9-13,15-17,20,23,24] There was statistically significant angular and linear mesial movement in the post-distalization phase. Conversely, in the final stage, mesial angulation was corrected, but mesial positioning also remained accompanying the displacement of the maxillary base in relation to the mandible.[10,20]

There was statistically significant extrusion during distalization in comparison to the initial position. This vertical change was related to mesial angulation and mesial movement, i.e., reflecting anchorage loss.[9,16]

Longitudinal observations show that extrusion, mesial angulation of premolars and anterior inclination of maxillary incisors are reversed effects that occur during active treatment with maxillary fixed appliances.[9,15] They may even occur spontaneously in the period of verticalization and stabilization with the Nance button positioned in distalized molars. However, the vertical positioning of second premolars remained at the end of corrective treatment, similarly to the post-distalization phase. In other words, it is probable that the accentuated curve of Spee preserved extrusion of second premolars to correct overbite, which was greater at the beginning of treatment.

First and second maxillary molars

Maxillary first molars demonstrated significant distal angulation, as already anticipated in treatment of Class II with intraoral devices.[2-4,7,9,11-17,20]

Accentuated distal angulation is observed in all researches that assess distalization with the Jones Jig appliance,[5,9,14-17,25] including cases of absolute anchorage.[26] However, this angulation was reversed and, by the end of corrective orthodontic treatment, maxillary first molars showed a verticalized position in relation to the cranial base (Table 1 and Fig 2). This correction was already expected, since patients, by the end of the distalization process, used the extraoral headgear in order to anchor and verticalize distalized molars.[16,20]

Maxillary first molars were significantly distalized in the post-distalization phase; however, after corrective orthodontic treatment, significant angular and linear mesial movement was observed, probably due to correction of accentuated distal angulation and displacement of the maxilla of which goal is to maintain normal maxillomandibular relationship[10] (Fig 2).

By the end of corrective orthodontic treatment, molar extrusion was statistically significant, probably due to correction of overbite (Fig 2). Extrusion of maxillary first molars can also be related to appositional maxillary growth and vertical flotation process.[22] In this group, the use of headgear may not have promoted extrusion of first molars, since the headgear was used with medium-high traction (jeans helmet), thereby preventing tooth extrusion.

Maxillary second molars showed no statistically significant changes in the post-distalization phase; however, at the end of corrective orthodontic treatment, second molars showed mesial angulation in relation to the cranial base, as well as statistically significant mesialization. Statistically significant extrusion was also observed at the end of corrective orthodontic treatment. Changes caused to second molars were not only due to eruption, but also to movement of maxillary first molars in the corrective phase.[9]

In relation to maxillary first molars, second molars showed greater extrusion at the end of corrective treatment. This result can probably be attributed to the different stage of eruption of maxillary first and second molars.[9]

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Mandibular dentoalveolar component

Mandibular incisors

With regard to mandibular incisors, there was statistically significant buccal inclination and protrusion at the end of corrective orthodontic treatment (Table 1 and Fig 3). This change was related to correction of overjet which was greater at the beginning of treatment. Therefore, changes observed in mandibular incisors occurred to decrease overjet and were due to the use of Class II elastics.

In the literature, only the study conducted by Brickman, Sinha and Nanda[9] assessed the effect of Class II treatment with the Jones Jig appliance followed by corrective fixed appliances. Nevertheless, the authors did not report the behavior of mandibular incisors. However, studies that assessed other distalizers observed buccal inclination during orthodontic treatment.[10,11,20] According to Angelieri et al,[20] mandibular incisors are buccally inclined due to anterior mandibular displacement and the use of Class II elastics.

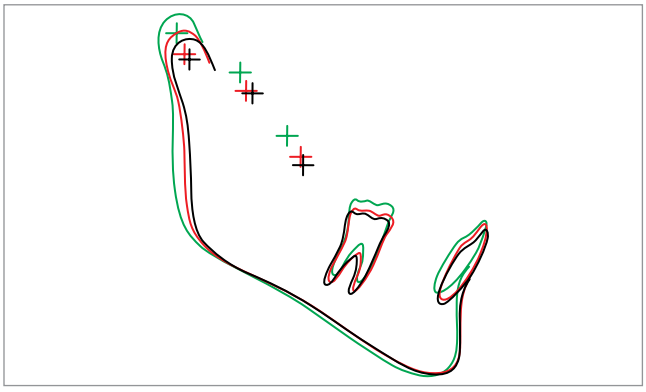


Figure 3 - Manibular teeth alterations in the three observation phases (T1, black; T2, red; and T3, green) (overlap on mandibular plane).

Mandibular first molars

Mandibular molars showed statistically significant mesialization during corrective treatment when initial and post-distalization phases were compared (Table 1). Class II molar relationship was corrected not only by maxillary molars distalization, but also by mesial movement of mandibular molars.[10,20]

As for the vertical component, at the end of corrective treatment, mandibular molars showed significant extrusion when the initial and post-distalization phases were compared (Fig 3). Changes in mandibular molars are not reported by studies assessing distalization with the Jones Jig [5,15-17] followed by fixed appliances;[9] however, extrusion was observed in studies that use the Pendulum appliance.[10,11] Therefore, it is assumed that mandibular molars extrusion may be related to the use of Class II elastics, vertical displacement due to appositional growth of the lower base of the mandible and to vertical floating.[22]

Dental relationships

Molar relationship showed statistically significant changes in the three phases of assessment. In the initial phase, patients showed Class II relationship, whereas in the post-distalization phase, there was overcorrection with molars ending up in a "super" Class I relationship, as suggested by previous studies.[9,11,12] However, as expected, maxillary molars mesially moved during corrective treatment to establish normal molar relationship, (Table 1).

At the beginning of treatment, both overjet and overbite were increased. In the post-distalization phase, there was an increase in overjet due to buccal tipping of maxillary incisors, thereby characterizing anchorage loss related to distalization with the Jones Jig appliance.[16] By the end of corrective orthodontic treatment, both overjet and overbite were reduced, thus demonstrating that orthodontic treatment goals were achieved. Correction of overjet was related to uprighting of maxillary incisors and buccal tipping of mandibular incisors, as described above. Correction of overbite, on the other hand, was probably related to extrusion of first and second premolars and first and second molars, as previously reported.

Brickman, Sinha and Nanda[9] observed an increase of 0.45 mm in overjet and a decrease of 1.28 mm in overbite during distalization of maxillary molars. According to the authors, changes in overjet were related to mesial movement of maxillary premolars and buccal inclination of maxillary incisors, as reported by other studies assessing intraoral distalization.[12,13,16,20]

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CONCLUSION

The Jones Jig appliance did not interfere in maxillary and mandibular components and did not change maxillomandibular relationship. The Jones Jig appliance promoted distalization of first molars with anchorage loss, significant mesialization and extrusion of first and second premolars, and a significant increase in anterior face height at the end of treatment. Most adverse effects occurred during the intraoral distalization phase and were subsequently corrected with corrective mechanics. There was buccal inclination and protrusion of mandibular incisors. At the end of treatment, overjet and overbite correction was observed.

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Mandibular asymmetry: A proposal of radiographic analysis with public domain software

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.052-058.oar*

Objective: This preliminary study aimed to propose a new analysis of digital panoramic radiographs for a differential diagnosis between functional and morphological mandibular asymmetry in children with and without unilateral posterior crossbite.

Methods: Analysis is based on linear and angular measurements taken from nine anatomic points, demarcated in sequence directly on digital images. A specific plugin was developed as part of a larger public domain image processing software (ImageJ) to automate and facilitate measurements. Since panoramic radiographs are typically subject to magnification differences between the right and left sides, horizontal linear measurements were adjusted for greater accuracy in both sides by means of a Distortion Factor (DF). In order to provide a preliminary assessment of proposed analysis and the developed plugin, radiographs of ten patients (5 with unilateral posterior crossbite and 5 with normal occlusion) were analyzed.

Results: Considerable divergence was found between the right and left sides in the measurements of mandibular length and position of condyles in patients with unilateral posterior crossbite in comparison to individuals with normal occlusion.

Conclusion: Although there are more effective and accurate diagnostic methods, panoramic radiography is still widespread, especially in emerging countries. This study presented initial evidence that the proposed analysis can be an important resource for planning early orthodontic intervention and, thus, avoid progression of asymmetries and their consequences.

Keywords: Panoramic radiography. Imaging diagnosis. Mandible.

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How to cite this article: Lemos AD, Katz CRT, Heimer MV, Rosenblatt A. Mandibular asymmetry: A proposal of radiographic analysis with public domain software. Dental Press J Orthod. 2014 May-June;19(3):52-8. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.052-058.oar

Submitted: January 16, 2013 - **Revised and accepted**: June 08, de 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Advances in medical and biological sciences in recent years and the growing importance of determining the relationship between structure and function have made imaging analysis an increasingly important discipline.[1] Healthcare professionals, especially dentists, depend on analyses from radiology centers; however, the software programs designed for this purpose are expensive and restricted to the services of these centers. Thus, the use and disclosure of an easy-to-use public domain program for analysis of digital images is of paramount importance.

ImageJ occupies a unique position as a public domain software (www.rsb.info.nih.gov/ij/) that can run on any operating system (Macintosh, Windows, Linux and even a PDA operating system). This software is easy to use, can perform a full set of imaging manipulations and has a huge and knowledgeable user community.[1] Wayne Rasband is the core author of ImageJ. Its first release (version 0.50) was on September 23rd, 1997 and its most recent version (1.47h) was released on December 23rd, 2012. After developing the Macintosh-based image bank for the National Institutes of Health (NIH) during 10 years, Rasband made the brave decision to start afresh with ImageJ using the Java programming language (the letter J in the name stands for Java), which freed the software from an individual operating system.[2] According to the NIH, the software has been downloaded from its web site tens of thousands of times, with a current rate of about 24,000 downloads per month.

ImageJ incorporates a number of useful tools for digital image processing, including determination of linear and angular measurements, calculation of areas, particle analysis, cell counts, etc. This tool has been employed in Medicine (with more than 200 published researches) as well as in other fields of knowledge, such as Engineering, Physics, Astronomy, Computer Science and Chemistry. However, few studies involving the use of ImageJ in the field of Dentistry have been published.[2,3,4] A search of Pubmed, EBSCO and Scopus databases using the keywords Dentistry and ImageJ revealed 39 studies, only three of which were in the field of Orthodontics.

Studies suggest that patients with unilateral posterior crossbite often exhibit mandibular asymmetry stemming from a functional deviation of the mandible.[5-8] Routine screening procedures for dental and craniofacial disorders and bilateral examinations of the stomatognathic system are needed. Since panoramic radiographs provide this information, such images could be used as a routine tool for diagnosis and treatment planning. Panoramic radiographs have been used to assess right and left height differences in the condyle, ramus and total mandible height for the definition of asymmetries.[9-12]

Radiographic analyses found in the literature are restricted to the diagnosis of morphological asymmetry in the mandible.[7,8,13,14,15] Thus, the aim of the present study was to propose a new analysis of panoramic radiographs for a differential diagnosis between functional and morphological asymmetry in children with and without unilateral posterior crossbite using the ImageJ software.

MATERIAL AND METHODS

The aim of the present preliminary study on differential diagnosis between morphological and functional mandibular asymmetry was to propose a new analysis method involving the use of a public domain software. To this end, digital radiographs from ten patients were analyzed – five with unilateral posterior crossbite and five with normal occlusion. Patients' average age was nine years old. The present study was performed in the city of Campina Grande, in the state of Paraiba, in the northeast of Brazil. It was approved by Paraiba State University Institutional Review board (CAAE: 3201.0.000.133-10).

The criteria for patients with normal occlusion were as follows: Class I canine and molar relationships with minor or no crowding, normal growth and development and well-aligned maxillary and mandibular dental arches; presence of all teeth except for third molars; good facial symmetry (clinically determined); no significant medical history; no functional deviation of the mandible; and no history of trauma or previous orthodontic treatment.

The criteria for patients with posterior crossbite were as follows: unilateral posterior crossbite with at least two posterior teeth in crossbite; mandibular dental midline deviation of at least 1 mm to the crossbite side; functional deviation of the mandible; no systemic disease and no developmental or acquired craniofacial or neuromuscular deformities;

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no remarkable facial or occlusal asymmetry; no history of orthodontic treatment; no missing teeth (excluding third molars); and no extensive carious lesions or pathologic periodontal condition.

Images were taken with a digital Orthophos DS panoramic radiograph machine (Sirona Dental Systems, Germany) previously standardized (62 Kv, 8 mA and 14.1s exposure time). All radiographs were standardized and taken by the same operator. Patients were positioned with the lips in resting position and the head oriented to Frankfurt horizontal plane.[16]

Anatomical points were marked directly on the digital images using ImageJ software. Based on the objectives of the study, the following landmarks were used: 1- right pterygomaxillary fossa (RPF); 2- anterior nasal spine (ANS); 3- left pterygomaxillary fossa (LPF); 4- most cranial point of left condyle (LHC);[14] 5- left gonion (LGo); 6- most cranial point of right condyle (RHC);[14] 7- right gonion (RGo); 8- Pogonion (Pg – midpoint of mandible often seen in panoramic radiographs as a white spot on the midline);[14] 9- inter-incisive point (IP).

A plugin was created to automate and facilitate measurement-taking (download and instructions - http://rsbweb.nih.gov/ij/plugins/lemos-asymmetry-analysis/index.html).

The following linear (mm) and angular (degree) measurements were taken on both sides of each digital panoramic radiograph:

Linear measurements

Morphological variables:

- Ramus height (RH): distance between the most cranial point of the condyle (points 4 and 6, as described by Deleurant et al[14]) and the gonion (points 5 and 7).
- Corpus length (CL): distance between gonion (Go) and pogonion (Pg); the gonion was defined as a random midpoint on the posterior curvature of the mandible (intersection points between corpus and ramus).

Functional variables:

- Pg-MSP: distance between pogonion and median sagittal plane, represented by a horizontal link connecting the Pg to the plane
- IP-MSP: distance between IP and MSP, represented by a horizontal line connecting the IP to the plane
- CHD: difference between the heights of the right and left condyle (beginning with most superior to the most inferior position; represented by a horizontal line automatically drawn from the CH point of the taller condyle, proceeding to the contralateral side for better visualization in relation to the opposing condyle.

Pg-MSP, IP-MSP and CHD variables were considered as functional, once the panoramic images were taken with subjects in protrusion position; in other words, in functional movement.

Angular measurement

- Gonial Angle (GA): formed between RH and CL on both sides; results expressed in degrees.

After marking the points and determining lines and planes, angular and linear measurements were analyzed (Figs 1,2).

Assessment of mandibular asymmetry was performed using the criteria described by Ramirez-Yanes et al,[15] and categorized as follows: non-significant asymmetry (difference of 0 to 2 mm between the sides of the mandible); light asymmetry (difference of 2 to 3 mm); moderate asymmetry (difference of 3 to 5 mm); and severe asymmetry (difference > 5 mm).

RESULTS

Tables 1, 2 and 3 display patients' measurements assessed by means of the proposed analysis method. Figures 1 and 2 show the radiographs with the analyses preformed. Considerable divergence was found between the sides in the crossbite group in relation to the corpus length measurement (CL), and positioning of the condyles (CHD) in patients with posterior crossbite in comparison to patients with normal occlusion (Tables 1, 2, 3).

DISCUSSION

Although it is not considered a public health problem, posterior crossbite stands out as one of the most frequently studied malocclusions in the primary dentition and onset of mixed dentition. Once occuring in the early stages of dental development, self-correction does not generally occur.[18,19] Early diagnosis and orthodontic intervention allow adequate guidance of

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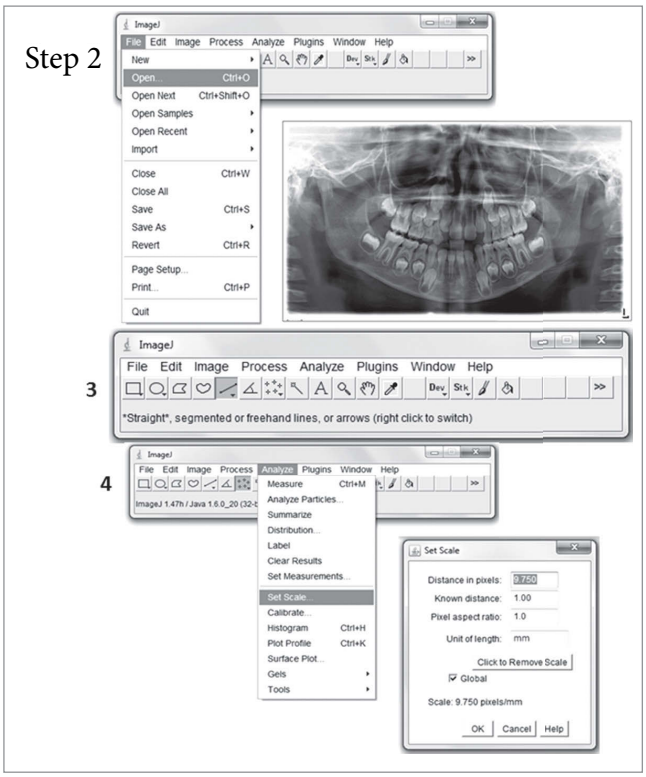


Figure 1 - Lemos asymmetry analysis performed on patient with normal occlusion.

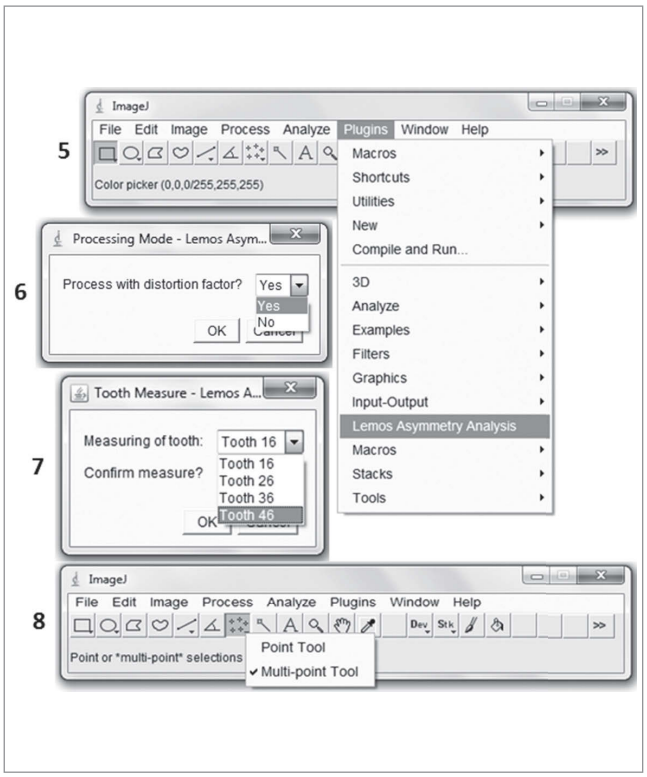


Figure 2 - Lemos asymmetry analysis performed on patient with unilateral (right side) posterior crossbite.

maxillary and mandibular growth as well as establishment of an adequate, stable functional pattern in the entire associated musculature, in addition to harmonious development of occlusion.[6,20] If treatment is not instituted early enough, skeletal remodeling of the temporomandibular joint can occur, thereby leading to permanent deviation from the lower midline and facial asymmetry.[21] Thus, late treatment is normally more complex, expensive and time-consuming and may involve auxiliary surgical procedures.[22,23]

The present study sought to demonstrate the viability of using ImageJ software as a tool to diagnose mandibular asymmetry in patients with posterior crossbite. Moreover, a plugin was created to facilitate analysis. This plugin is a diagnostic tool that can be extended and improved at any time.

Habets et al[9] proposed one of the first analyses for assessment of mandibular asymmetry developed on a sample of patients with temporomandibular joint problems. Other authors adopted this analysis to measure mandibular asymmetry in patients with posterior crossbite.[7,8] Although widely employed due to its ease of use, this analysis is restricted to the assessment of vertical measurements (height of corpus and condyle of the mandible) and does not consider horizontal and angular measurements.

Ramirez-Yanes et al[15] carried out a study to determine the prevalence of mandibular asymmetry, proposing the analysis of digitized panoramic radiographs of 327 children. They found that half of the sample had moderate to severe mandibular asymmetry. The authors used the inter-incisive point as reference to determine the corpus of the mandible. However, prevalence may be overestimated, as a patient may exhibit a dental deviation that alters the point of reference and consequently affects measurement of mandible length.

One difference in the present analysis is the use of points on the maxilla (ANS, RPF and LPF), which is a stable bone and serves as reference for tracing the median sagittal plane. The advantage of this plane is that it corresponds to the true midline, thereby facilitating diagnosis of skeletal (Pg-MSP) and dental (IP-MSP) deviation. With regard to the length of the

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Table 1 - Statistics for the following variables: ramus height + condyle, corpus length and gonial angle according to side and differences in the crossbite group.

Variable	Side	
	Crossed	Non-crossed
	Mean ± SD	Mean ± SD
Ramus height + condyle	51.9 ± 6.6	51.7± 5.2
Corpus length	68.4 ± 6.2	69.9 ± 7.3
Gonial angle	112.6 ± 6.4	112.8 ± 6.3

Table 2 - Statistics for the following variables: ramus height + condyle, corpus length and gonial angle according to side and differences in the normal occlusion group.

Variable	Side	
	Right	Left
	Mean ± SD	Mean ± SD
Ramus height + condyle	50.9 ± 1.9	51.3 ± 1.9
Corpus length	75.5 ± 4.7	75.3 ± 4.1
Gonial angle	109.4 ± 3.1	110.0 ± 2.8

Table 3 - Statistics for the following variables: Pog-MSP, IP-MSP, CHD according to groups.

Variable	Group	
	Experimental	Control
	Mean ± SD	Mean ± SD
Pog-MSP	2.8 ± 2.2	0.8 ± 1.3
IP-MSP	2.0 ± 1.9	0.9 ± 0.9
CHD	3.2 ± 1.7	1.2 ± 0.7

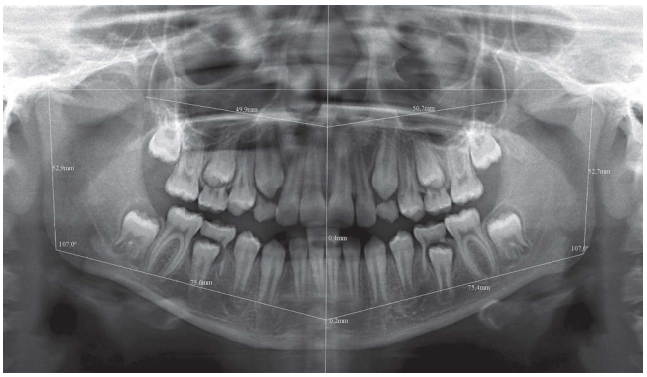


Figure 3 - Lemos asymmetry analysis performed on patient with normal occlusion.



Figure 4 - Lemos asymmetry analysis performed on patient with unilateral (right side) posterior crossbite.

corpus of the mandible on both sides (LCL, RCL), the reference in the present study was an anatomic point on the mandible (Pg), which is the midpoint of the mandible often seen in orthopantomograms as an white spot on the midline.[14] Thus, this analysis can also be applied to patients with missing incisors, regardless of the type of malocclusion.

Comparison of measurements revealed considerable discrepancy in the length of mandibular corpus as well as the positioning of the condyles in the patient with posterior crossbite. According to the criteria proposed by Ramirez-Yanes et al,[15] this suggests significant asymmetry. Analysis of measurements demonstrates that patients (crossbite group) had both skeletal (CL) and positional (CHD) asymmetry. At times, even in cases of obvious mandibular asymmetry, it is not self-evident whether one side has overgrown or the other has undergrown,[24,25] which underscores the applicability of the analysis proposed herein.

Unlike other analyses available in the literature,[7,8,9,14,15] this analysis is also based on the visualization of positional asymmetry of condyles through CHD measurement as well as skeletal asymmetry through measurements of the ramus (LRH and RRH), providing a differential diagnosis and assisting in the choice of adequate treatment. It is worth noting that the mandible adapts to mandibular deviations by modeling the condyle and glenoid fossae,[26] suggesting that asymmetry may be an adaptive response to functional demands.[27] Animal studies as well as studies involving humans with crossbite have shown that functional shift can produce asymmetric

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mandibular growth.[7,22] Children in deciduous and mixed dentition with unilateral posterior crossbite have asymmetrically positioned condyles and asymmetric muscle function. The condyles on the crossbite side are positioned relatively more upwardly and backwardly in the glenoid fossae than the condyles on the non-crossbite side.[29] Therefore, the prevalence of mandibular asymmetries in young growing patients must be further studied, along with the impact these asymmetries may have on facial growth.[15]

The use of panoramic radiographs to diagnose mandibular asymmetries is subject to distortions, especially in horizontal and oblique measurements;[12,13,17] thus, a Distortion Factor (DF) is recommended.[15] It should be calculated for each hemimandible so as to ensure greater accuracy in horizontal measurements (more subject to distortion), and, as a consequence, in diagnosis. This tool (DF) is available in the plugin. Although there are more effective and accurate diagnostic methods, for instance cone-beam computed tomography (CBCT), panoramic radiography is still widespread,[29] especially in emerging countries.

CONCLUSIONS

The analysis proposed herein has the advantage of simultaneously assessing horizontal, vertical and angular mandibular measurements in patients with and without posterior crossbite, thereby allowing differential diagnosis between functional and morphological asymmetry. This easy-to-use public domain tool proves to be an important resource for planning of early orthodontic intervention, in addition to avoiding the progression of asymmetries and their consequences.

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Association between gingivitis and anterior gingival enlargement in subjects undergoing fixed orthodontic treatment

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.059-066.oar*

Objective: The aim of this study was to investigate the association among gingival enlargement (GE), periodontal conditions and socio-demographic characteristics in subjects undergoing fixed orthodontic treatment.

Methods: A sample of 330 patients undergoing fixed orthodontic treatment for at least 6 months were examined by a single calibrated examiner for plaque and gingival indexes, probing pocket depth, clinical attachment loss and gingival enlargement. Socio-economic background, orthodontic treatment duration and use of dental floss were assessed by oral interviews. Associations were assessed by means of unadjusted and adjusted Poisson's regression models.

Results: The presence of gingival bleeding (RR 1.01; 95% CI 1.00-1.01) and excess resin around brackets (RR 1.02; 95% CI 1.02-1.03) were associated with an increase in GE. No associations were found between socio-demographic characteristics and GE.

Conclusion: Proximal anterior gingival bleeding and excess resin around brackets are associated with higher levels of anterior gingival enlargement in subjects under orthodontic treatment.

Keywords: Epidemiology. Orthodontics. Gingivitis. Gingival enlargement.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

How to cite this article: Zanatta FB, Ardenghi TM, Antoniazzi RP, Pinto TMP, Rösing CK. Association between gingivitis and anterior gingival enlargement in subjects undergoing fixed orthodontic treatment. Dental Press J Orthod. 2014 May-June;19(3):59-66. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.059-066.oar

Submitted: September 22, 2012 - **Revised and accepted**: April 08, 2013

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INTRODUCTION

The balance of health-disease processes in Periodontics depends on adequate supra and subgingival plaque control achieved by patient and professional's combined efforts. Accumulation of supragingival plaque results in inflammatory alterations of gingival tissues. However, interindividual differences might explain the different patterns of response and time needed for evident clinical responses. It is possible that these variations may be associated with different plaque growth patterns, local and systemic individual resistance or even a specific microbial challenge.[1,2]

Clinical studies suggest that orthodontic treatment may be associated with a decrease in periodontal health.[3,4,5] One of the adverse periodontal alterations is a hypertrophic form of gingivitis.[5,6,7] The exact mechanism for the development of gingival enlargement (GE) is not yet completely understood, but it probably involves increased production by fibroblasts of amorphous ground substance with a high level of glycosaminoglycans. Increases in mRNA expression of type I collagen and up-regulation of keratinocyte growth factor receptor could play an important role in excessive proliferation of epithelial cells and development of GE.[8] In some studies, poor oral hygiene increased GE.[9,10] Other clinical studies concluded that overall gingival changes during orthodontic treatment are transient with no permanent damage to the periodontal supporting tissues.[11,12]

The presence of orthodontic brackets also increases the skills and effort required to maintain good levels of oral hygiene, especially on the proximal surfaces.[11] Microbiological studies demonstrate that when fixed orthodontic appliances are placed, the potential for quantitative[13,14] and qualitative[15,16] changes in the microbial composition of these areas enhances. Thus, periodontal reaction might be elicited by a change in the microbiological environment.

To the best of our knowledge, there are no studies assessing GE and associated factors in individuals undergoing orthodontic therapy. Thus, this study aimed at assessing the prevalence of GE and associated factors in a group of orthodontic patients.

MATERIAL AND METHODS

This cross-sectional study examined subjects who were undergoing orthodontic treatment in an orthodontic graduate program in Santa Maria, Brazil. Ethical approval was obtained from the Franciscan University Center Institutional Review Board prior to the start of the study (protocol registration number 1246 in the National Ethics Committee). Subjects who agreed to participate signed an informed consent form. Patients diagnosed with oral pathological conditions were advised to seek consultation and treatment.

Eligibility criteria

To be eligible for the study, individuals should have been undergoing fixed orthodontic treatment for at least 6 months. Exclusion criteria comprised presence of diseases and conditions that could pose health risks to the participant or that could interfere in clinical examination, for instance, users of nifedipine, cyclosporine or phenytoin, contraceptive and decompensated diabetics. Individuals who had undergone antibiotic therapy within three months prior to examination were also excluded. Female subjects were excluded if they were pregnant or breastfeeding. Additionally, individuals who required a prophylactic regimen of antibiotics for clinical examination were excluded.

Study sample

The orthodontic dental clinic of Ingá College (UNINGÁ) was treating, during data collection period, an estimated population of seven hundred patients, six hundred of which were regularly under treatment and, therefore, were assessed for eligibility criteria. This process resulted in four hundred eligible individuals, 330 of which were assessed, resulting in a non-response rate of less than 20%. Clinical examinations were performed between September/2009 and July/2010.

Examinations

A single, calibrated examiner performed all clinical examinations with the aid of a dental assistant who took the records. All permanent and fully erupted teeth, except for third molars, were examined by means of a manual periodontal probe (Neumar®, São Paulo,SP, Brazil). Six sites (mesio-buccal, mid-buccal, disto-buccal, disto-lingual, mid-lingual, and mesio-lingual) were assessed for each tooth.

Teeth in each quadrant were washed with air and water spay as well as dried with air spray. Afterwards, Plaque Index (PII),[17] Gingival Index (GI),[18] probing

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depth (PPD), attachment loss (CAL) and bleeding on probing were assessed. Thereafter, gingival enlargement[19] was assessed. The degree of gingival thickening in both labial and lingual aspects was scored as follows: 0 = normal; 1 = thickening up to 2 mm; 2 = thickening greater than 2 mm. The extent of gingival tissues encroachment onto the adjacent crowns was also graded, using 0, 1, 2 and 3 on the labial and lingual surfaces. The sum of both scores (thickening and gingival encroachment) resulted in an enlargement score for each gingival unit. The maximum score obtainable using this method is 5. Additionally, excess resin was dichotomously assessed by inspection with a probe around the bracket on the buccal surfaces of each bonded bracket. For this purpose, the buccal surface was divided into distal, mesial and cervical. Excess resin, located at less than 1 mm from the gingival margin was present.

After clinical examination, socioeconomic and demographic data were collected using a structured written questionnaire. Race was scored as white or non-white. Socioeconomic status was scored by the individual's level of education (≤ 11 years / > 11 years) which, in Brazil, corresponds to those who have completed high school or those educated beyond high school level. Household income information was measured in terms of the Brazilian minimum wage, which corresponded to approximately US$290 (US dollars) during the period of data collection. Income information was measured dichotomously (≤ 5 national minimum wages / > 5 national minimum wages). PII and GI were dichotomized as visible plaque (present / absent) and gingival bleeding[20](present / absent), respectively. The percentages of sites with visible plaque, gingival bleeding and bleeding on probing were calculated individually. The questionnaire also reported the declared frequency dental floss use. Regular interdental hygiene was defined as the use of dental floss at least once a day. Non-users of dental-floss were defined as subjects who did not use interdental oral hygiene devices every day or who did not perform interdental hygiene.

Measurement reproducibility

The examiner was trained and calibrated to perform the clinical measurements before the study started. Assessment of measurement reproducibility was conducted with 15 subjects who were divided into three groups of 5 subjects each. In each one of the groups, replicate measurements were made by the examiner on two occasions, with a two-day interval. At the site level, reproducibility was assessed by means of the weighted Kappa (± 1 mm) and resulted in values of 0.73 for probing pocket depth and of 0.68 for clinical attachment loss. Gingival enlargement reproducibility was assessed by means of Intraclass Correlation coefficient at the site level in 15 subjects, resulting in an ICC of 0.86.

Data analysis

Most participants presented low mean values for PPD and CAL. Thus, these data were not used in the present analysis. For this exploratory analysis, data pattern distribution was analyzed and non-parametric (Mann-Whitney and Kruskal-Wallis) tests were used. After descriptive analysis, the frequencies of gingival enlargement scores (full mouth mean) were compared for differences between demographic characteristics, socioeconomic indicators and clinical status.

Unadjusted Poisson regression analysis with robust variance was performed to correlate the overall mean of the anterior gingival enlargement (AGE) score with each demographic, socioeconomic and clinical indicator. AGE was considered for anterior teeth located in esthetic regions, only. This region was chosen because a recent publication[21] emphasized the impact of AGE in oral health related quality of life (OHRQoL) in subjects undergoing fixed orthodontic treatment. In this analysis, the outcome was considered as continuous. Additionally, rate ratios (RR), which correspond to the quotient between average scores of each comparison group, and 95% confidence intervals (95% CI) were calculated. A multivariate model was then run with the covariates. These covariates were selected using a backward stepwise procedure. Only variables with $p \leq 0.20$ or those that presented a conceptual association with the primary outcome were included in the model. In order to be retained in the final multivariate model, the variables should present $p \leq 0.05$. The statistical software STATA 9.0 (Stata Corp, College Station, USA) was used for all analyses.

RESULTS

All subjects completed both the questionnaire and the clinical examination. The demographic characteristics, socioeconomic indicators and clinical status of the subjects are shown in Table 1. In the present investigation, the

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Table 1 - Research subjects' clinical and socio-demographic characteristics.

Variables	n (%)
Demographic characteristics	
Sex	
Male	159 (48.1%)
Female	171 (51.8%)
Ethnicity	
White	263 (79.7%)
Non-White	67 (20.3%)
Age (years)	
14 - 19	162 (49.0%)
20 - 24	121 (36.6%)
25 - 30	47 (14.2%)
Socioeconomic status	
Household Income	
≤ 5	270 (81.8%)
> 5	60 (18.1%)
Educational level	
> 11 years	159 (48.1%)
≤ 11 years	171 (51.8%)
Clinical status	
TUFOT (Months)	
6 - 12	185 (56.06%)
> 12	145 (43.93%)
Dental floss	
Users	81 (24.5%)
Non-users	249 (75.5%)

TUFOT: Time under fixed orthodontic treatment.

study sample comprised 330 individuals aged between 14 and 30 years old, 171 (51.8%) female and 159 (48.2%) male, 263 (79.7%) white and 67 (20.3%) non-white. As for periodontal diagnosis, based on patient's age and periodontal data explored in another study[22] (2.06 mm ± 0.18 and 1.6 ± 0.11 for mean probing depth and clinical attachment levels in proximal sites, respectively) most patients had periodontal diagnosis of gingivitis, only.

The mean value for anterior gingival enlargement, percentage of whole mouth visible plaque and percentage of whole mouth gingival bleeding were 0.69, 47.38% and 58.72%, respectively. Table 2 shows the unadjusted analysis between demographic, socioeconomic and clinical variables related to different scores of gingival enlargement. Statistically significant differences were observed in each frequency of gingival enlargement for almost all covariates. Level of education was not associated with GE. When considering score 2 of GE, no association was detected with sex and for score 3 of GE, age was not associated.

The unadjusted Poisson regression assessment of associations revealed use of dental floss (RR 1.25; 95% CI 1.08-1.43), percentage of proximal anterior gingival bleeding (RR 1.01; 95% CI 1.0-1.01) and percentage of sites with excess resin around brackets (RR 1.02; 95% CI 1.02-1.03) as the main covariates associated with higher levels of anterior gingival enlargement. In the multivariate regression model, the percentage of proximal anterior gingival bleeding remained associated, in which higher frequencies of anterior gingival bleeding were associated with a 1.01 fold increase in average AGE scores (RR 1.01; 95% CI 1.0-1.01). Additionally, the percentage of sites with excess resin around brackets also remained associated, with higher frequencies of sites with excess resin around brackets being associated with a 1.02 fold increase in average AGE scores (RR 1.02; 95% CI 1.02-1.03).

DISCUSSION

The present study aimed at investigating potential associations among gingival enlargement, sociodemographic and clinical characteristics. When GE was assessed by frequency of scores, statistically significant differences between nearly all independent variables and frequencies of GE were observed. While the clinical relevance of these differences could be dubious for some of these variables, others such as household income, use of dental floss and time with orthodontic appliances presented substantial clinical differences for the prevalence of gingival enlargement score two. After regression analysis had been performed, proximal anterior gingival bleeding and excessive resin around brackets were revealed as independent variables associated with the level of anterior gingival enlargement.

Since hyperplasic gingival response is a common response to plaque accumulation in subjects undergoing fixed orthodontic therapy. this study used two indexes to assess gingival inflammatory status: color alteration and/or swelling and bleeding after marginal probing. Gingival bleeding IS shown by clinical and histological studies to be an earlier and more sensitive sign of gingival inflammation in comparison to cardinal signs such as redness and swelling, which may be rather subjective and not very reliable.[23,24] Furthermore, a single calibrated examiner, unaware of dental floss use habits, assessed all parameters. These methods probably increased the quality of data collection as well as results reliability.

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Table 2 - Univariate analysis between socioeconomic factors and oral clinical conditions related to frequencies of different scores of gingival enlargement index.

Variables	N (%)	GE0 (%)	GE1 (%)	GE2 (%)	GE3 (%)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Demographic characteristics					
Sex		p* = 0.010	p* = 0.010	p* = 0.120	p* < 0.001
Male	159 (48.1%)	58.10 ± 9.24	27.56 ± 4.55	12.52 ± 8.95	1.21 ± 3.43
Female	171 (51.8%)	58.15 ± 9.66	29.05 ± 5.53	10.48 ± 8.20	1.70 ± 2.67
Ethnics (%)		p* < 0.001	p* = 0.016	p* = 0.001	p* = 0.000
White	263 (79.7%)	59.17 ± 10.0	28.05 ± 5.04	11.17 ± 9.35	1.10 ± 3.19
Non-white	67 (20.3%)	54.04 ± 5.01	29.16 ± 5.23	13.0 ± 4.72	2.80 ± 2.21
Age (yrs)		p** = 0.037	p** < 0.001	p** < 0.001	p** = 0.083
14 - 19	162 (49.0%)	56.98 ± 10.15	27.59 ± 4.86	12.89 ± 9.19	1.88 ± 3.74
20 - 24	121 (36.6%)	59.88 ± 9.36	29.52 ± 5.30	8.91 ± 7.66	1.05 ± 2.51
24 - 30	47 (14.2%)	57.57 ± 5.79	27.46 ± 4.82	13.63 ± 7.51	0.95 ± 1.25
Socioeconomic status					
Household income (Wages)		p* < 0.001	p* < 0.001	p* < 0.001	p* < 0.001
≤ 5	270 (81.8%)	56.62 ± 8.72	27.55 ± 4.39	13.35 ± 8.25	1.77 ± 3.33
> 5	60 (18.1%)	64.88 ± 9.61	31.56 ± 6.60	3.36 ± 4.81	0.0 ± 0.0
Subject's education		p* = 0.055	p* < 0.001	p* = 0.011	p* < 0.001
≤ 11 years	159 (48.1%)	57.28 ± 9.91	27.51 ± 4.73	13.03 ± 9.11	1.46 ± 3.63
> 11 years	171 (51.8%)	59.41 ± 8.54	29.45 ± 5.41	9.28 ± 7.35	1.42 ± 2.03
Clinical status					
Dental floss users		p* = 0.018	p* < 0.001	p* < 0.001	p* = 0.031
Yes	81 (24.5%)	61.46 ± 8.28	31.25 ± 5.64	6.44 ± 6.66	0.45 ± 0.90
No	249 (75.5%)	57.04 ± 9.54	27.31 ± 4.51	13.2 ± 8.57	1.77 ± 3.46
TUFOT (Months)		p*<0.001	p*<0.001	p*<0.001	p*=0.016
6 a 12	185 (56.06%)	60.56 ± 6.40	29.26 ± 3.77	8.78 ± 3.66	0.81 ± 1.69
> 12	145 (43.93%)	55.02 ± 11.56	27.02 ± 6.18	15.02 ± 11.46	2.26 ± 4.13

Caption :GE0=Gingival enlargement score 0; GE1=Gingival enlargement score 1; GE2=Gingival enlargement score 2; GE3=Gingival enlargement score 3; TUFOT: Time under fixed orthodontic treatment; p*= Mann Whitney test; p**= Kruskall Wallis test

The use of dental floss was dichotomized into subjects who use it every day and individuals who do not have this habit. This cutoff was made based on evidence that demonstrates reduction in inflammatory parameters associated with gingivitis when flossing is performed every day.[25] The use of dental floss was not an independent predictor for AGE. There is no evidence in population basis evaluating the association between dental floss and GE. However, short-term clinical studies with subjects without orthodontic appliances have demonstrated a significant improvement in the interproximal gingival condition with the correct use of dental floss.[25,26,27] It is important to highlight that some studies conducted with highly motivated individuals who efficiently brush their teeth revealed that the incorporation of flossing in oral hygiene routines does not significantly contribute to improve interproximal gingival conditions.[28] Thus, the lack of association between dental floss and AGE may be due to the possibility of toothbrushing alone resulting in low levels of plaque accumulation in anterior segments. These results should be interpreted with care. Although no statistically significant differences were observed in AGE in users and non-users of dental floss, this habit is also recommended for other purposes, such as preventing attachment loss, halitosis, carious lesions, etc.

The positive correlation found between sites with excess resin around brackets and levels of AGE confirmed the hypothesis that oversight in the bonding of brackets might influence gingival enlargement. The standard of finishing/polishing techniques and surface roughness proved to be important factors for bacterial adhesion with different types of dental materials.[29,30] Thus, our results could hypothesize that excess resin causes greater adhesion of bacterial plaque and subsequent gingivitis formation. Moreover, poor oral hygiene proved to be an important causal factor of gingival enlargement.[9]

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Table 3 - Unadjusted (RR) and Adjusted assessment (RR*) for association between socioeconomic factors and oral clinical conditions related to anterior gingival enlargement average. Robust poisson regression analysis.

Variables	n (%)	AGE Mean ± SD	AGE RR (95%IC)	AGE RR* (95% IC)
Demographic characteristics				
Sex			p = 0,142	**
Male	159 (48.1%)	0.72 ± 0.33	1.08 (0.97-1.20)	
Female	171 (51.8%)	0.66 ± 0.34	1	
Ethnics (%)			0.188	**
White	263 (79.7%)	0.7 ± 0.34	1	
Non-white	67 (20.3%)	0.64 ± 0.32	0.91 (0.79-1.04)	
Age (yrs)			p = 0.123	**
14-19	162 (49.0%)	0.73 ± 0.35	1.11 (0.96-1.29)	
20-24	121 (36.6%)	0.66 ± 0.34	1.00 (0.85-1.17)	
24-30	47 (14.2%)	0.65 ± 0.29	1	
Socioeconomic status				
Household income (Wages)			p = 0.213	**
≤ 5	270 (81.8%)	0.70 ± 0.33	1.10 (0.94-1.28)	
> 5	60 (18.1%)	0.64 ± 0.35	1	
Subject's education			p = 0.14	**
< 11 years	159 (48.1%)	0.73 ± 0.35	1.08 (0.97 – 1.20)	
≥ 11 years	171 (51.8%)	0.63 ± 0.31	1	
Clinical status				
Dental floss users (%)			p = 0.000	p = 0.239
Yes	81 (24.5%)	0.58 ± 0.34	1	1
No	249 (75.5%)	0.73 ± 0.33	1.25 (1.08-1.43)	1.07 (0.95-1.22)
TUFOT (Months)			p = 0.18	**
6 a 12	185 (56.06%)	0.64 ± 0.32	1	
> 12	145 (43.93%)	0.75 ± 0.35	0.91 (0.79-1.04)	
PAGB (%)		-	p = 0.000	p = 0.000
			1.01(1.0 – 1.01)	1.01 (1.00-1.01)
Excessive resin (% of sites)		-	p = 0.000	p = 0.000
			1.02 (1.02-1.03)	1.02 (1.02-1.03)

RR: Ratios rate; AGE: Anterior gingival Enlargement; TUFOT: Time under fixed orthodontic treatment; PAGB: Proximal anterior gingival bleeding. *Adjusted by sex, ethnics, age, Household income, subjects´s education, TUFOT, dental floss, GAE and excessive resin ** Variables not included in the final multiple model after adjustment.

In this study, variables related to socio-demographic characteristics, such as sex, ethnicity, household income and subjects' level of education, were not associated with anterior gingival enlargement. However, it has been established that individuals from different socioeconomic backgrounds are exposed to different risk factors that affect oral health. Individuals with lower socioeconomic status are subjected to material deprivation which could influence their engaging in riskier behaviors, thereby resulting in worse oral health conditions.[31] Furthermore, low educational level may lead to reduced income, unemployment and poor occupational status, all of which could influence oral health.[31] Our contradictory results could be explained by one of the following hypotheses: First, in subjects with orthodontic appliances, socio-demographic characteristics may not influence gingival enlargement levels, differently to subjects without orthodontic appliances; second, the lack of extreme differences related to socioeconomic status in our sample may have influenced the results, i.e., individuals participating in this study were recruited at a private institution, presenting at least six years of education without a great disparity between educational levels.

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Studies assessing the association between levels of anterior gingival enlargement and socioeconomic as well as clinical conditions in orthodontic subjects (using multiple regression analyses controlled for other socio-demographic and clinical variables which may act as confounders) are inexistent. From this perspective, the present study provides new information. In addition, Poisson regression with robust variance was used in order to provide PR estimates which are easier to interpret than odd ratios. In a situation of anterior gingival enlargement, with prevalence higher than 50%, odd ratios would strongly overestimate PRs.[32] It is important to highlight that this study had a cross-sectional design, which hypothesizes relations between the outcome and predictor variables without establishing causal relationships. This is a limitation of this study. However, conclusions from cross-sectional studies are important to identify indicators that may be included in longitudinal or, even, experimental studies. The present study comprised 330 orthodontic patients attending a private orthodontic specialist training program. This sample limited the extent to which these findings can be generalized to a larger population. Nevertheless, analyses were performed with sufficient power and the analytical results strengthen the hypotheses of this study.

Evidence shows that gingival enlargement is associated with esthetic impairment and, in more severe cases, with phonetic alterations and masticatory problems.[7] A recent publication[21] conducted with an orthodontic sample emphasized the impact of anterior gingival enlargement in oral health related quality of life (OHRQoL). Thus, prevention and/or treatment of gingival enlargement may contribute to improve the OHRQoL of orthodontic patients. According to our results, proximal anterior bleeding and excess resin around brackets were associated with higher levels of anterior gingival enlargement. However, further studies are required to understand whethwe it is possible that prevention and treatment of gingivitis and careful bonding of brackets may result in decrease in the prevalence or even the severity of GE in orthodontic subjects.

CONCLUSIONS

Anterior gingival enlargement is associated with gingival inflammation and excess resin around brackets.

Acknowledgements

The authors would like to thank all volunteers participating in the present research, as well as UNINGÁ for allowing us to use its dental clinics.

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Immunolocalization of FGF-2 and VEGF in rat periodontal ligament during experimental tooth movement

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.067-074.oar*

Objective: This article aimed at identifying the expression of fibroblast growth factor-2 (FGF-2) and vascular endothelial growth factor (VEGF) in the tension and pressure areas of rat periodontal ligament, in different periods of experimental orthodontic tooth movement.

Methods: An orthodontic force of 0.5 N was applied to the upper right first molar of 18 male Wistar rats for periods of 3 (group I), 7 (group II) and 14 days (group III). The counter-side first molar was used as a control. The animals were euthanized at the aforementioned time periods, and their maxillary bone was removed and fixed. After demineralization, the specimens were histologically processed and embedded in paraffin. FGF-2 and VEGF expressions were studied through immunohistochemistry and morphological analysis.

Results: The experimental side showed a higher expression of both FGF-2 and VEGF in all groups, when compared with the control side ($P < 0.05$). Statistically significant differences were also found between the tension and pressure areas in the experimental side.

Conclusion: Both FGF-2 and VEGF are expressed in rat periodontal tissue. Additionally, these growth factors are upregulated when orthodontic forces are applied, thereby suggesting that they play an important role in changes that occur in periodontal tissue during orthodontic movement.

Keywords: Periodontal ligament. Orthodontics. Vascular endothelial growth factor A. Fibroblast growth factor 1.

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Submitted: October 01, 2012

Revised and accepted: January 20, 2013

How to cite this article: Salomão MFL, Reis SRA, Vale VLC, Machado CV, Meyer R, Nascimento ILO. Immunolocalization of FGF-2 and VEGF in rat periodontal ligament during experimental tooth movement. Dental Press J Orthod. 2014 May-June;19(3):67-74. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.067-074.oar

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» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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INTRODUCTION

Orthodontic tooth movement is achieved by remodeling the alveolar bone and periodontal ligament (PDL) in response to mechanical loading.[17] It is a highly sophisticated biological process that leads to local inflammation, with vascular, cellular and extracellular matrix (ECM) alterations that allow remodeling events and, ultimately, tooth displacement.[17,37] Orthodontic tooth movement is characterized by the abrupt creation of compression and tension sides in the PDL, with a repeated process of alveolar bone resorption on the pressure side and new bone formation on the tension side.[3,6,35]

Although the exact mechanism of periodontal tissue remodeling is not clearly understood, a milieu of cytokines, growth factors, neurotransmitters, ECM components, colony-stimulating factors and inflammatory mediators have been reported to be synthesized and released in PDL during orthodontic movement.[2,7,17,25,28,36] These molecules interact with various dental and paradental cells and stimulate them to initiate and sustain tissue remodeling, inducing bone deposition and resorption.[6,42]

Continuous orthodontic forces can exert pressure that compromises the integrity of the vascular compartment in PDL. Over-compression results in ischemia, gradual reduction of capillaries, presence of thrombi, interruption of nutrition and cell death[21,29] with almost unavoidable formation of a necrotic or hyaline zone, mainly on the pressure side.[27,38] In contrast, dilated blood vessels were found in the tension side.[33,38]

These vascular alterations can be mediated by different growth factors, such as fibroblast growth factor-2 (FGF-2) and vascular endothelial growth factor (VEGF). FGF-2, also known as basic FGF, is a potent angiogenic factor that shows increased expression in hypoxic conditions and during wound healing.[5,15] This growth factor enhances endothelial cell proliferation and induces endothelial cell sprouting.[3] Likewise, FGF-2 is a component of bone matrix and plays an important role in regulating bone remodeling.[13,19]

VEGF is considered the most important regulator of vasculogenesis and angiogenesis in physiological as well as in pathological conditions.[4,9] *In vivo*, VEGF enhances vascular permeability and induces potent angiogenic responses.[8,10] There is solid evidence for a functional link between vasculogenesis and bone development.[41] Furthermore, VEGF may participate in the regulation of bone metabolism and wound healing during orthodontic tooth movement.[16,23] This growth factor has the ability to induce functional osteoclasts when injected in PDL, thereby increasing the rate of tooth movement in mice.[16]

Thus, this study was designed to assess the expression levels of FGF-2 and VEGF in rat periodontal tissue submitted to mechanical forces in an experimental model of orthodontic tooth movement.

MATERIAL AND METHODS

Animal model and experimental orthodontic tooth movement

All experiments were conducted according to the guidelines of the Ethics Committee on Animal Use from the Federal University of Bahia (Brazil) where this study was submitted and approved.

The study sample comprised 18 male Wistar rats aged between 60 ± 5 days (mean ± SD), with a mean weight of 170 g. The upper right first molar in each animal was mesially moved by means of a closed coil spring (3M Brasil, Sumaré, Brazil) which was fixed to the upper incisor from the same side (Fig 1), as previously described by Heller and Nanda.[11] Grooves were made on the incisors to support the appliance. Forces of 0.5 N were applied for periods of 3 (group I, n = 6), 7 (group II, n = 6) and 14 days (group III, n = 6). The intensity of force was assessed using a dynamometer (Dentaurum Brasil, São Paulo, Brazil) while the spring was being fixed and then every day during the three different experimental periods. The upper left first molar, which was not subjected to any orthodontic movement, served as control. The orthodontic appliance was fixed and activated under anesthesia induced by intraperitoneal injection of ketamine (0.12 ml/100 g) and xylazine (0.06 ml/100 g). The animals had access to food and water *ad libitum*, and were kept on a reversed 12-h light/12-h dark cycle (dark period 08.00–20.00 h).

Tissue processing

At the end of each experimental period, the animals were euthanized under deep anesthesia. The maxillary bone was removed, sagittally sectioned on the midline and fixed in 4% buffered paraformaldehyde for 24 h.

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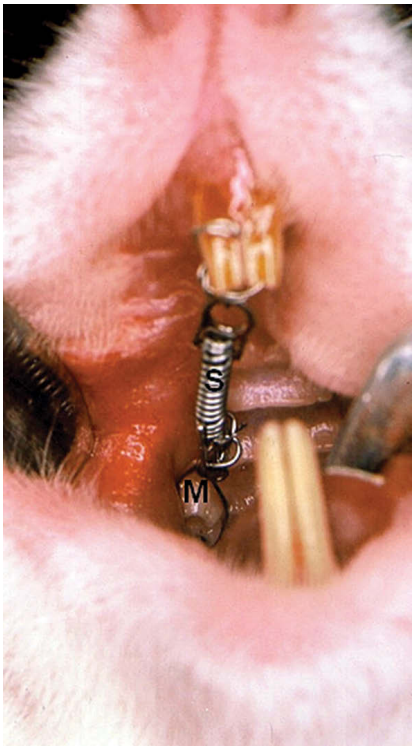


Figure 1 - Occlusal view of orthodontic appliance placed on rat upper right first molar. The closed-coil spring (S) is attached to the molar (M) and incisor.

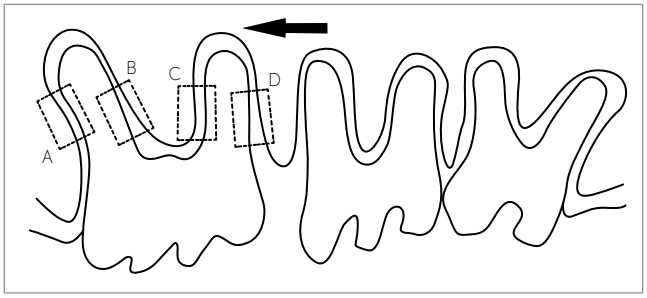


Figure 2 - Diagrammatic representation of the areas chosen for morphological and immunohistochemical analyses. A and C correspond to pressure areas; B and D correspond to tension areas; arrow indicates direction of experimental orthodontic tooth movement.

The specimens were decalcified in 10% EDTA at room temperature (pH 7.2) for 12 weeks, processed histologically and paraffin embedded. Sections of 5 µm, parallel to the long axis of the first upper molar, were obtained and mounted on glass slides.

Morphological and immunohistochemical analysis

For morphological analysis, one section of each sample was stained with hematoxylin and eosin and analyzed by light microscopy. For immunohistochemical assay, a streptavidin-biotin complex (LSAB, Dako Cytomation, Carpinteria, USA) was used. For detection of FGF-2 and VEGF, polyclonal anti-FGF-2 (dilution 1:1000; clone 147; Santa Cruz Biotechnology, Santa Cruz, CA) and monoclonal anti-VEGF (dilution 1:50; clone C-1; Santa Cruz Biotechnology, Santa Cruz, CA) antibodies were respectively used. The sections were dewaxed, rehydrated and washed in distilled water. The antigen retrieval was performed by enzymatic digestion with 1% trypsin (Sigma, Saint Louis, USA) for 20 min at 37°C. Endogenous peroxidase was blocked by treatment with 3% hydrogen peroxide for 10 min at 25°C. The slides were then incubated with the primary antibody in a humid chamber overnight at 4°C. Subsequently, the slides were washed with 1% PBS/BSA and incubated with biotinylated secondary antibodies (link reagent, Dako Cytomation, Carpinteria, USA) for 60 min at room temperature, followed by washing and incubation with the streptavidin-biotin-peroxidase complex. Diaminobenzidine (Dako Cytomation, Carpinteria, USA) was used as chromogen and the slides were counterstained with Harris hematoxylin (Sigma, Saint Louis, USA) for 15 seconds. Negative controls included replacement of primary antibodies with non-immune bovine serum albumin.

Specific areas of the PDL were selected for morphological and immunohistochemical assessment. They corresponded to pressure and tension sides of the upper first molar submitted to orthodontic movement, as shown in Figure 2. The same areas in control teeth were chosen for analysis.

Quantitative analysis of immunohistochemistry was performed by means of a microscope (Axiolab, Zeiss, Germany) with a coupled camera (Axiocam HRP, Zeiss, Germany) linked to the Image J Software. Calibrations for each objective were performed using an image captured from calibration slides provided by the manufacturer. The slides were examined by random selection of two 0.1 mm^2 areas. An experienced observer examined these images and identified DAB cells and excluded unstained tissue. Immunohistochemical staining was quantified by determining the percentage of the stained area. Thereafter, each area was captured under a final magnification of 400 x and saved in TIFF format.

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Statistical analysis

Wilcoxon Signed Ranks test was used to compare differences between the experimental and the control side as well as to compare the tension and the pressure areas within each experimental group. Kruskal-Wallis test and Dunn's post hoc test were used to compare the three experimental groups. Significance level was set at $P < 0.05$. Statistical analysis was performed with SPSS 17.0 for Windows.

RESULTS

Histology

All specimens comprising the control group exhibited a PDL without signs of alteration, as shown in Figure 3. In the groups submitted to orthodontic movement, marked alterations were observed on the PDL, especially in the interradicular space. Hyalinization areas were observed, mainly on the pressure side. Bone resorption was also observed with the presence of numerous osteoclasts. Most blood vessels collapsed and periodontal ligament fibers were rendered disorganized. On the tension side, the fibers were distended and sometimes disrupted. Hyperemic and dilated blood vessels were observed throughout the PDL extension on the tension side. Some areas of bone formation were found.

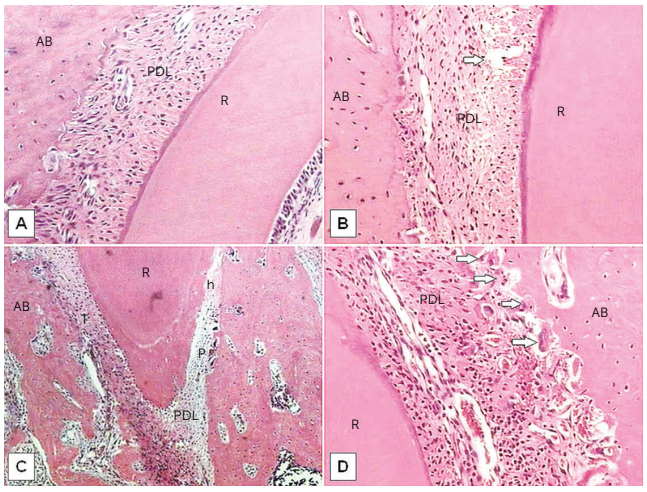


Figure 3 - Histological findings in the control (A) and experimental groups (B-D) after 3 days of orthodontic tooth movement, stained with H&E. **(A)** PDL without signs of alteration (100x). **(B)** Disrupted fibers (arrow) observed on the tension side (100x). **(C)** Hyalinized areas (h) seen on the pressure side (40x). **(D)** Resorption lacunae with osteoclasts (arrows) observed on the pressure side (200x). AB indicates alveolar bone; PDL, periodontal ligament; R, root; T, tension side; P, pressure side.

Immunohistochemistry

FGF-2 and VEGF immunoreactivity was detected in fibroblasts, osteoblasts, osteoclasts and endothelial cells in PDL of both the control and experimental sides (Figs 4 and 5). For FGF-2 expression, statistically significant differences were found between experimental and control groups at 3, 7 and 14 days ($P < 0.05$), as shown in Figure 6. When the pressure and tension sides were compared in the teeth that had undergone orthodontic movement, FGF-2 expression was significantly higher after 3 days of orthodontic movement on the pressure side, but not after 7 or 14 days ($P < 0.05$; Table 1). On the pressure side, all three experimental groups were statistically different for this growth factor, with group I showing the strongest expression ($P < 0.05$). On the tension side, FGF-2 expression was higher after 14 days of treatment, when compared with groups I and II ($P < 0.05$) (Table 1).

There were also significant differences between the experimental and control groups after 3, 7 and 14 days of orthodontic movement for VEGF expression ($P < 0.05$; Fig 6). On the tension side, the expression of VEGF was statistically less in group I, when compared with groups II and III ($P < 0.05$). Conversely, on the pressure side, it was statistically higher on group I, when compared with the other groups ($P < 0.05$). When pressure and tension sides were compared, the expression of VEGF was higher on the pressure side after 3 days of orthodontic movement, but not after 7 and 14 days ($P < 0.05$) (Table 1).

DISCUSSION

Orthodontic tooth movement is produced by mechanical forces that evoke biological responses. Mechanics and biology act together to produce desirable and predictable alterations in the form and function of the dento-alveolar complex.[18] In this study, histological assessment revealed that experimental tooth movement induced periodontal remodeling. The main characteristic of the tension side was alveolar bone formation, whereas on the pressure side it was bone resorption, which is in accordance with other researches.[22] Some hyalinized areas were observed, mainly on the pressure side. Previous studies show the presence of hyalinized areas in the periodontium after orthodontic tooth movement, even

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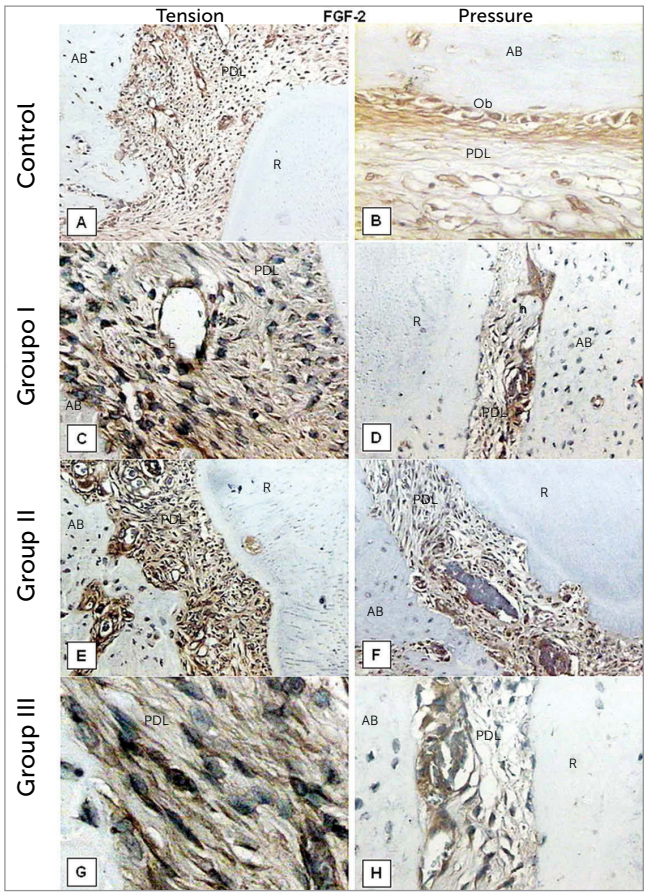


Figure 4 - FGF-2 immunohistochemistry staining of the control (**A,B**) and experimental groups (**C-H**) after 3, 7 and 14 days of orthodontic tooth movement. (**A**) magnification of 40x; (**B, C, H**) 200x; (**D, E, F**) 100x; (G) 400x. AB indicates alveolar bone; PDL, periodontal ligament; R, root; Ob, osteoblasts; E, endothelial cells; h, hialinized area; F, fibroblasts.

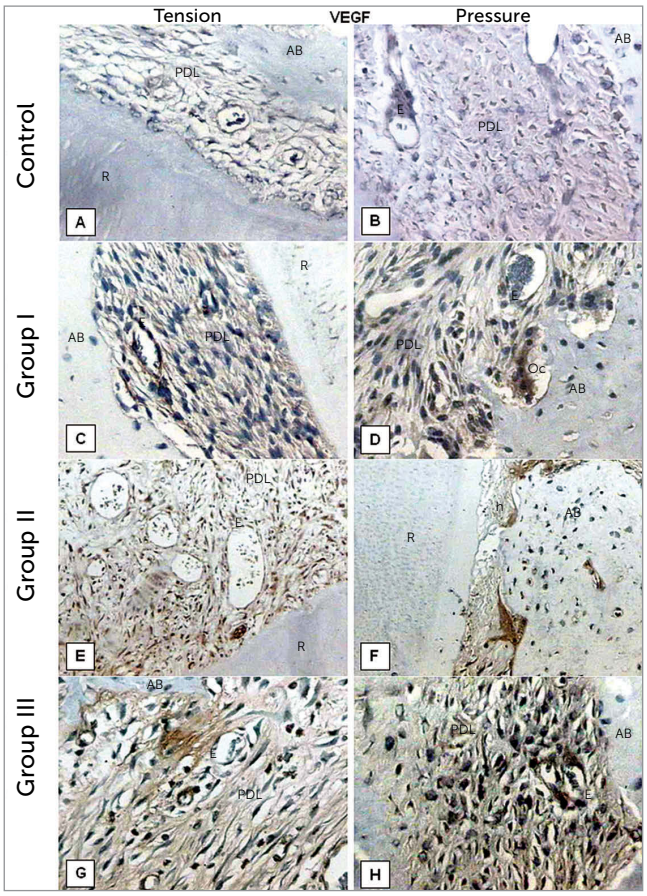
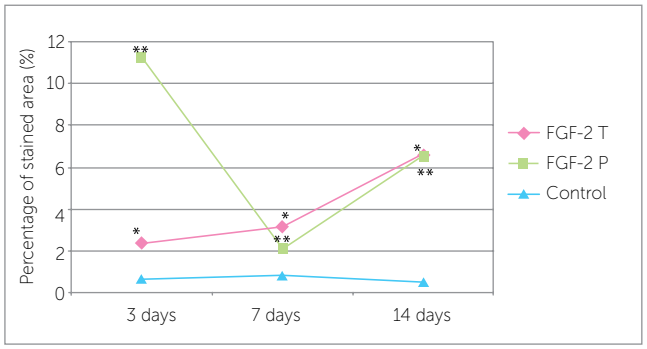


Figure 5 - VEGF immunohistochemistry staining of the control (**A,B**) and experimental groups (**C-H**) after 3, 7 and 14 days of orthodontic tooth movement. (**A, E, F**) magnification of 100x; (**B, C, D, G, H**) 200x. AB indicates alveolar bone; PDL, periodontal ligament; R, root; E, endothelial cells; Oc, osteoclasts; h, hialinized area.

Table 1 - Percentage of FGF-2 and VEGF stained areas (%) on tension and pressure sides of the three experimental groups.

	FGF-2		VEGF	
	Tension	Pression	Tension	Pressure
Group 1	2.40 ± 0.69[a]	11.25 ± 3.30[a*]	1.28 ± 0.52[a]	7.56 ± 2.34[a*]
Group 2	3.16 ± 0.96[a]	2.06 ± 0.94[b]	3.78 ± 1.04[b]	2.70 ± 0.54[b]
Group 3	6.63 ± 1.07[b]	6.56 ± 0.77[c]	3.83 ± 1.25[b]	3.20 ± 0.66[b]

Values account for mean and standard deviation (±). Different letters on the column indicate statistically significant difference between groups as well as between tension and pressure sides (P < 0.05).



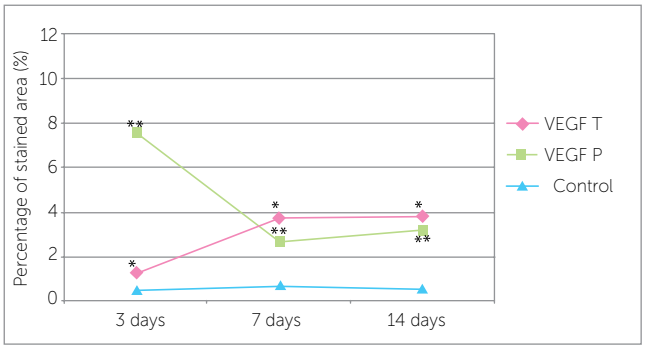


Figure 6 - Percentage of FGF-2 and VEGF stained area (%) in the experimental and control groups, after 3, 7 and 14 days of orthodontic tooth movement; * and ** indicate statistically significant differences between experimental and control groups (P < 0.05). T indicates tension side; P, pressure side. FGF-2 control values: group I (0.68 ± 0.26); group II (0.80 ± 0.20); group III (0.50 ± 0.19). VEGF control values: group I (0.50 ± 0.21); group II (0.72 ± 0.10); group III (0.56 ± 0.22).

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when light forces are used. Likewise, accumulation of osteoclasts near the hyalinization areas, which led to bone resorption on the pressure side, has been described.[39,40] In our study, the presence of resorption lacunae containing osteoclasts on alveolar bone surfaces close to the hyalinized areas on the pressure side of PDL was observed. Cells such as macrophages, foreign body giant cells and osteoclasts remove this hyalinized necrotic tissue after a few days of force application, allowing tooth movement through the alveolar bone.[17]

We demonstrated that FGF-2 and VEGF are expressed in rat periodontal ligament cells, even at basal levels in control areas of PDL, thereby suggesting a constitutive production of these molecules by PDL cells. The expression of both FGF-2 and VEGF was assessed during experimental orthodontic tooth movement, indicating that upregulation of these cytokines could be associated with PDL remodeling. It is possible that this process suffers influence of these important angiogenic growth factors, since orthodontic forces alter blood flow in the periodontal region, initiating a cascade of biochemical and cellular processes that are responsible for these biological events.[12,23,24]

On the pressure side, PDL cells showed intense expression of FGF-2 three days after experimental tooth movement, which was concomitant with the observation of a higher number of osteoclasts and bone resorption in this group, thus indicating that this growth factor plays an important role during orthodontic movement. On day 7, a significant decrease of FGF-2 expression, as well as a lower number of osteoclasts were noted. One possible explanation is that there is dissipation of the applied orthodontic force due to tooth movement in the arch. A new increase in FGF-2 expression recorded on day 14 could be associated with PDL remodeling in this phase of orthodontic movement. FGF-2 has the ability to accelerate periodontal tissue regeneration at the final phase of tissue repair in alveolar bone defects by promoting angiogenesis and inducing growth of immature PDL cells.[24]

On the tension side, a gradual increase in FGF-2 was observed from day 3 to 14 of the induced orthodontic tooth movement, which is in agreement with the neoformation events observed in this region of PDL.[16,32] After 14 days of orthodontic force application, a regeneration of periodontal tissue was observed, as well as a significant expression of FGF-2. It seems that FGF-2 is capable of inducing chemotaxis and mitogenesis of various PDL cells, thus, inducing tissue regeneration processes.[24,34]

There was a higher expression of VEGF on day 3 on the pressure side, probably due to the elevated number of osteoclasts observed in this area on the first days of experimental tooth movement. This could be explained by the ability of VEGF in inducing osteoclast differentiation.[1,14] Continuous compressive forces enhance VEGF production and angiogenic activity in PDL cells, which may contribute to periodontal remodeling during orthodontic tooth movement.[23] These reports suggest that VEGF expression in compressed periodontal tissue may play an important role in bone resorption, as well as in the promotion of angiogenesis in hyalinized tissues and adjacent areas on the pressure side. Moreover, through biological properties such as vascular permeability and chemotaxis, VEGF may provide the degenerated tissues with many cell types, for instance, fibroblasts, macrophages and multinucleated giant cells.[23]

On the tension side, there was a moderate expression of VEGF by the PDL cells, although an increase in this cytokine was observed along the three experimental periods. This is consistent with the demonstration of VEGF expression in osteoblasts on the tension side of mouse incisors and the predominance of alveolar bone formation that is characteristic of this region.[16,22] Constitutive VEGF expression may contribute to PDL homeostasis by regulating blood circulation and bone metabolism.[23]

The higher expression of FGF-2 observed in this study during the first days of experimental tooth movement, when compared to VEGF, could be related to cellular events observed in the initial phase of inflammatory response resulting from the orthodontic force applied to the tooth. The generation of an acute inflammatory process, characteristic of orthodontic movement, may be responsible for the secretion of FGF-2.[20,26,30] This growth factor is considered the most potent mitogen for periodontal cells and it may be important in wound healing, since it promotes angiogenesis and induces the development of immature PDL cells, thus, accelerating periodontal regeneration.[24,31] Moreover, it seems that there

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is an optimal compressive force for VEGF production in PDL cells, and an excessive force results in decreased VEGF production.[23]

CONCLUSION

The present study demonstrates that important alterations occur in PDL during experimental orthodontic tooth movement, in which bone formation and apposition on tension side and bone resorption on pressure side are the main events. The expression of both FGF-2 and VEGF is elevated during experimental orthodontic movement. It also varies with time, which can be related to the remodeling processes of PDL. FGF-2 levels were higher than VEGF levels in PDL during the first days of experimental orthodontic movement, thereby suggesting greater involvement of this protein in PDL remodeling. Moreover, the expression of these growth factors at basal levels in control areas of PDL suggests a constitutive production of these proteins by PDL cells.

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Changes in skeletal and dental relationship in Class II Division I malocclusion after rapid maxillary expansion: a prospective study

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DOI: http://dx.doi.org/10.1590/2176-9451.19.3.075-081.oar

Objective: To assess skeletal and dental changes immediately after rapid maxillary expansion (RME) in Class II Division 1 malocclusion patients and after a retention period, using cone beam computed tomography (CBCT) imaging.

Methods: Seventeen children with Class II, Division 1 malocclusion and maxillary skeletal transverse deficiency underwent RME following the Haas protocol. CBCT were taken before treatment (T_1), at the end of the active expansion phase (T_2) and after a retention period of 6 months (T_3). The scanned images were measured anteroposteriorly (SNA, SNB, ANB, overjet and MR) and vertically (N-ANS, ANS-Me, N-Me and overbite).

Results: Significant differences were identified immediately after RME as the maxilla moved forward, the mandible moved downward, overjet increased and overbite decreased. During the retention period, the maxilla relapsed backwards and the mandible was displaced forward, leaving patients with an overall increase in anterior facial height.

Conclusion: RME treatment allowed more anterior than inferior positioning of the mandible during the retention period, thus significantly improving Class II dental relationship in 75% of the patients evaluated.

Keywords: Palatal expansion technique. Angle Class II malocclusion. Clinical trial. Orthodontics.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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How to cite this article: Baratieri C, Alves Jr M, Bolognese AM, Nojima MCG, Nojima LI. Changes in skeletal and dental relationship in Class II Division I malocclusion after rapid maxillary expansion: a prospective study. Dental Press J Orthod. 2014 May-June;19(3):75-81. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.075-081.oar

Submitted: January 29, 2013 - **Revised and accepted**: April 05, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Angle[1] defined Class II malocclusion as the distal relationship of thelower first molar in relation to the upper first molar. Studies have recently shown that in addition to the anteroposterior and vertical problems related to Class II malocclusions, posterior transverse discrepancy is also frequently associated with it.[2]

Diagnosis of posterior transverse discrepancy often passes unnoticed at clinical examination as this problem is camouflaged by the Class II skeletal pattern. The characteristics of Class II malocclusion, in all three spatial planes, pre-exist in deciduous dentition and persist into mixed dentition without correction.[3] As soon as transverse maxillary deficiency is diagnosed, rapid maxillary expansion (RME) should be implemented regardless of other skeletal alterations because transverse maxillary growth ends earlier than growth in other directions.[4]

The majority of studies assessing RME outcomes showed that the mandible rotated downward and backward,[5] which is usually an unwanted effect in Class II patients. Clinical observations and case reports reveal either an improvement or correction of the sagittal relationship in Class II patients during the retention period following RME.[6]

Cone beam computed tomography (CBCT) allows a complete scan of the face within a few seconds, with less ionizing irradiation than CT[7] or full-mouth radiographic survey for orthodontic diagnosis.[8] Recent technological advances in dental software allow cephalometric concepts and tools to be combined with CBCT advantages.

Despite a large number of studies reporting on the effects of RME, most of them failed to specify or distinguish the type of malocclusion (Class I, II or III) in the subjects evaluated. Accordingly, there is a lack of information surrounding Class II malocclusion patients who underwent RME as the only treatment intervention. Therefore, the aim of this study is to use CBCT imaging to assess changes in dental and skeletal relationships in Class II, Division 1 malocclusion patients immediately after RME as well as after a 6-month retention period.

MATERIAL AND METHODS

This prospective study was carried out in the Department of Orthodontics of the Federal University of Rio de Janeiro with the approval of the Institute of Collective Health Studies Research Ethics Committee (ref.128/2009-0052.0.239.000-09) and with an informed consent form signed by patients and parents.

Seventeen white Brazilian subjects (8 boys and 9 girls with mean age of 10.67 and 10.05 years old, respectively) presenting Class II Division 1 malocclusion and maxillary transverse skeletal deficiency were selected and diagnosed to receive RME therapy. In addition, patients were followed for the following six months.

In selecting the sample, the following inclusion criteria were applied: Chronological age ranging from 7 to 12 years old; overjet greater than 3 mm; Class II molar (unilateral or bilateral) and skeletal (ANB ≥ 4°) relationship; maxillary skeletal transverse deficiency (distance from J point to facial frontal line > 12 mm);[9] skeletal maturation CS1 through CS3 as evaluated by the Cervical Vertebral Maturation method.

All patients were submitted to RME following the Haas protocol.[4] The appliances were standardized with stainless steel wire, 0.047-in in diameter (Rocky Mountain Orthodontics) and expansion screw of 11 mm (Dentaurum, Magnum – 600.303.30). Upon insertion, the expansion screw was activated four turns (0.2 mm per turn) on the first day, and on the following days it was activated two turns per day, (0.4 mm daily). The active phase varied from 2 to 3 weeks, depending on the individual maxillary transverse deficiency originally diagnosed. Afterwards, the expander screw was stabilized with a 0.012-in double thread ligature and was passively kept in place for the following six months after which the appliance was removed.

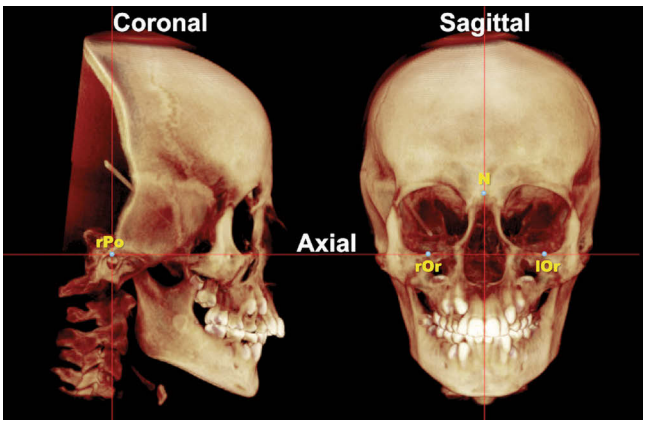


Figure 1 - 3D digital image of the head after orientation by axial, coronal and sagittal planes used as references.

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CBTC scans were taken before treatment (T_1), immediately after stabilization of the expansion screw (T_2), and after removal of the expander (T3). The scans were performed with the same cone beam machine (i-CAT, Imaging Sciences International, Hatfield, Pennsylvania, USA), according to a standard protocol (120 KVp, 3 mA, FOV 13x17 cm and voxel 0.4 mm). Volume data at T_1, T_2, and T_3 were exported in DICOM (digital imaging and communication in medicine) format into Dolphin Imaging software® (Charsworth, Calif, USA).

Once imported by means of specific software tools, each 3D-volumetric data set was standardized using reference planes. The three planes are shown in Figure 1 and are defined by an axial plane passing through right and left infraorbitale points as well as right porion; a coronal plane passing through left and right porion perpendicular to the axial plane of choice; and a sagittal plane passing through the nasion point perpendicular to the axial and coronal planes of choice.

After standardization of head positioning, anatomical points (Sella, Nasion, A point, B point, Anterior Nasal Spine, and Menton) were analyzed through mid-sagittal slice images. Subsequently, landmarks 0.025 mm in diameter were identified (Table 1). The following measurements were performed (Fig 2): SNA (anteroposterior maxillary position), SNB (anteroposterior mandibular position), ANB (anteroposterior maxillo-mandibular relationship), N-ANS (upper anterior facial height), ANS-Me (lower anterior facial height), N-Me (anterior facial height), overjet, overbite, rMR (right molar relationship), and lMR (left molar relationship). Molar relationship was determined as the perpendicular distance from the tip of mesiobuccal cusps of upper first permanent molar to the mesiobuccal sulcus of lower first permanent molar on the same side. Values of rMR and lMR could not be obtained at T_2 because of the artefacts caused by orthodontic bands in these CBCT images.

Measurements were performed separately at each time (T_1, T_2 and T_3) by the same examiner with a one-week interval in between. Intraexaminer reliability values were determined by means of intraclass correlation coefficient (ICC), with 95% confidence interval. Fifteen CBCT scans were randomly selected and remeasured by the same examiner (CB) within 2 weeks, under the same conditions, and compared

Table 1 - Definition of landmarks

Landmarks (abbreviation)	Definition
Orbitale (Or)*	Most inferior point on infraorbital rim
Porion (Po)*	Most superior point of anatomic external auditory meatus
Nasion (N)	Midsagittal point at junction of frontal and nasal bones at nasofrontal suture
Sella (S)	Midpoint of rim between anterior process at mid-sagittal plane
A point (A)	Deepest point of the maxillary alveolar bone concavity at mid-sagittal plane
B point (B)	Deepest point of the mandibular alveolar concavity at mid-sagittal plane
Anterior nasal spine (ANS)	Most anterior limit of floor of nose, at tip of ANS at mid-sagittal plane
Posterior nasal spine (PNS)	Most posterior point along palate at mid-sagittal plane
Menton (Me)	Most inferior point along curvature of chin at mid-sagittal plane

* Bilateral landmark

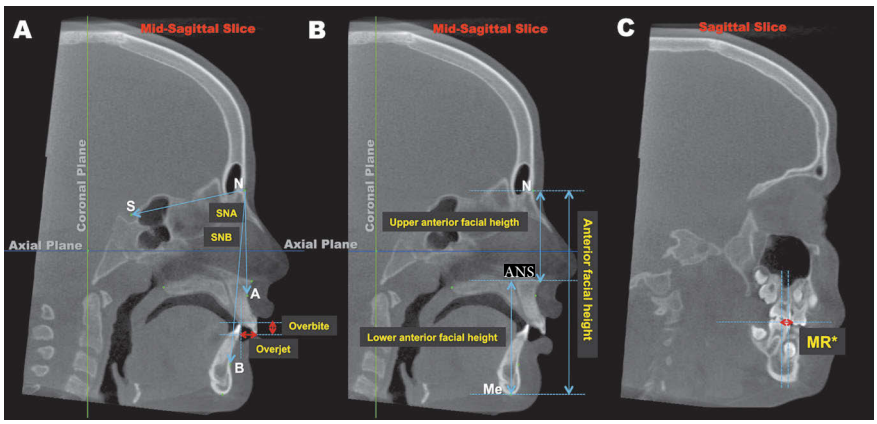


Figure 2 - Sagittal slice with landmarks and measurements. **A**) SNA, SNB, overbite and overjet; **B**) N-Me, N-ANS and ANS-Me; C. MR* (right molar relationship and left molar relationship).

with the first measurements. All measurement error coefficients were found to be close to 1.00 and within acceptable limits (higher than 0.95, except for MR measurement that was 0.91). The mean measurement difference obtained was less than 0.4 mm and 0.3º, which was considered not significant.

Means, standard deviations, minimum and maximum values were calculated for each measurement. After finding normal data distribution by means of the Kolmogorov-Smirnov non-parametric test, statistically significant differences were identified using paired Student's t-test ($P < 0.05$ - 95% interval confidence) between T_2 and T_1, T_3 and T_2, and T_3 and T_1. The percentage of patients who had the same qualitative mean changes during the interval T_1-T_3 was also calculated. Patients were considered to have increased measurement (mean difference ≥ 0.5 mm); no change (-0.5 mm >and <0.5 mm); and decreased measurement (≤ –0.5 mm). Statistical analysis was carried out using the SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Separation of the mid-palatal suture was clinically confirmed in all patients with increased opening of inter-incisor diastema or within 3-5 days following expander activation. These data were confirmed on the CBCT image at T_2. During the retention period, one of the patients returned without the expander, thus, his data were not computed at T_3. Transverse deficiency was corrected in all patients. Data of RME transverse effects were previously published.[10]

Table 2 shows the descriptive analysis (minimum, maximum and standard deviation) of measurements

Table 2 - Descriptive analysis of measurements obtained in before treatment onset (T_1), immediately after expansion (T_2) and after retention (T_3).

	T_1 (n = 17)			T_2 (n = 17)			T_3 (n = 16)		
	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
SNA	74.38	86.20	79.71 ± 3.31	76.88	86.07	80.92 ± 2.99	76.53	86.07	80.09 ± 2.98
SNB	66.8	77.2	73.15 ± 3.41	67.71	76.6	72.92 ± 2.66	69.34	77.6	73.7 ± 2.72
ANB	4.00	9.49	6.61 ± 2.10	4.24	10.70	8.00 ± 2.25	2.50	10.03	6.39 ± 2.03
N-ENA	36.94	55.80	46.87 ± 4.54	36.84	56.52	47.27 ± 5.34	37.93	56.66	47.92 ± 4.76
ENA-Me	53.96	71.87	60.33 ± 4.16	56.59	74.23	61.30 ± 4.31	54.92	73.97	60.75 ± 4.41
N-Me	95.21	116.7	107.2 ± 6.06	94.96	117.57	108.6 ± 6.66	96.18	119.22	108.7 ± 6.51
Overjet	3.5	13.7	7.98 ± 3.56	3.51	14.67	9.38 ± 3.49	3.94	12.4	7.5 ± 2.78
Overbite	1.35	6.68	4.36 ± 1.61	0	5.5	2.59 ± 1.79	1.62	7.67	4.51 ± 1.78
RMd	0.5	9.09	3.18 ± 2.5	---	---	---	-2.68	6.83	1.84 ± 2.76
RMe	0.5	8.33	3.56 ± 2.27	---	---	---	-2.83	7.7	2.04 ± 2.59

n = number of patients; Min = minimum; Max = maximum; SD = standard deviation.

Table 3 - Results regarding skeletal and dental changes between pre-treatment and post-expansion ($T_2 - T_1$), post-retention and post-expansion ($T_3 - T_2$), and post-retention and initial ($T_3 - T_1$).

	T_2-T_1 (n = 17)	T_3-T_2 (n = 16)	T_3-T_1 (n = 16)
	Mean ± SD	Mean ± SD	Mean ± SD
SNA	1.21* ± 1.96	-0.83* ± 1.28	0.38 ± 1.32
SNB	-0.23 ± 2.05	0.78* ± 1.26	0.55 ± 1.76
ANB	1.39*** ± 1.09	-1.61*** ± 1.32	0.22 ± 0.84
N-ENA	0.40 ± 1.88	0.65 ± 1.31	1.06* ± 1.45
ENA-Me	0.97* ± 1.40	-0.55* ± 0.90	0.42 ± 1.40
N-Me	1.44*** ± 1.82	0.02 ± 1.18	1.46*** ± 1.42
Overjet	1.4* ± 1.96	-1.87*** ± 1.50	-0.47 ± 1.33
Overbite	-1.76*** ± 0.72	1.91*** ± 0.92	0.15 ± 0.56
RMd	---	---	-1.33** ± 1.23
RMe	---	---	-1.55** ± 1.55

n=number of patients; SD= Standard Deviation; Level of significance = * P < 0.05;**P < 0.01; ***P < 0.001

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obtained before treatment onset (T_1), immediately after expansion (T_2) and after retention (T_3). Table 3 shows Student's t-test results yielded between the following intervals: T_2-T_1, T_3-T_2 and T_3-T_1. Significant differences were identified immediately after RME (T_2-T_1) as the maxilla moved forward (SNA mean increase was 1.21°), the mandible moved downward (ANS-Me mean increase was 0.97 mm and N-Me mean increase was 1.44 mm), overjet increased in 1.4 mm and overbite decreased in 1.76 mm. During the retention period (T_3-T_2), the maxilla relapsed backward (SNA mean decrease was 0.83°) and the mandible was displaced forward (SNB mean increase was 0.78°), improving Class II ANB relationship (mean decrease of 1.61°), although patients were left with an overall increase in anterior facial height.

Table 4 shows a qualitative description of changes found within T_1-T_3. Class II dental relationship (rMR and lMR) improved in 75% of patients.

DISCUSSION

This study is part of a long-term prospective clinical investigation into the effects of RME on Class II malocclusions using CBCT imaging.[10,11] Understanding the effects of RME on Class II, Division 1 patients is of paramount importance, since transverse maxillary deficiency is often associated with this malocclusion.

Immediately after RME therapy, Class II relationship was worse in the anteroposterior and vertical dimensions. The maxilla significantly moved forward, whereas the mandible moved backward to a lesser degree. Skeletal changes were previously reported by Haas[12] and have been recently confirmed by meta-analysis[13] and systematic reviews.[14-16] Dental changes mirrored skeletal changes by showing significant increase in overjet and decrease in overbite. Changes in dental and skeletal relationships were more likely to be associated with premature contacts involving palatal cusps and dental-alveolar inclination caused by RME[17] than to inferior displacement of the maxilla. This effect was confirmed by the significant increase in buccal inclination (7.31°/6.46°)[10] found in upper first molars immediately after RME.

The 6-month retention period with the Haas expander did not only maintain the new skeletal, alveolar and dental transverse dimensions, (1.66 mm, 4.69 mm and 5.89 mm, respectively, $P < 0.001$),[10] but also resulted in significant decrease in dentoalveolar angulation of original levels. The wider maxilla allowed mandible to shift forward more than upward, therefore improving skeletal and dental relationships. This was revealed by overjet decrease, overbite increase and MR improvement.

By the end of the assessment period, sagittal skeletal changes were not significantly different when compared with initial data, except for patient's vertical dimension. However, Class II dental relationship significantly improved in 75% of patients. Studies assessing untreated Class II malocclusions determined that dental and skeletal patterns were not self-corrected,[3,18] but became even worse.[19] Wendling et al[20] observed

Table 4 - Number and percentage of patients with increased (≥ 0.5), no changes (- 0.5 > and < 0.5) or decreased (≤ - 0.5) measurements during the interval T_1-T_3.

	T_1-T_3		
	Increased n(%)	No changes n(%)	Decreased n(%)
SNA	6 (37.5)	9 (56.25)	1 (6.25)
SNB	8 (50)	5 (31.25)	3 (18.75)
ANB	5 (31.25)	3 (18.75)	8 (50)
N-ENA	13 (81.25)	3 (18.75)	----
ENA-Me	8 (50)	5 (31.25)	3 (18.75)
N-Me	13 (81.25)	2 (12.50)	1 (6.25)
Overjet	4 (25)	2 (12.5)	10 (62.5)
Overbite	3 (18.75)	11 (68.75)	1 (6.25)
RMd	1 (6.25)	3 (18.75)	12 (75)
RMe	1 (6.25)	3 (18.75)	12 (75)

n = number of patients

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that some patients had spontaneous Class II correction after RME during the retention period (6-12 months) in cases of moderate Class II malocclusions. McNamara et al[21] recently observed great improvement (1.8 mm) in MR after RME therapy in 81% of Class II patients when compared to non-treated controls (0.3 mm).

No statistically significant vertical changes were identified immediately after RME. This differs from previous studies that used cephalometric imaging[5,22-25] and reported downward displacement of the maxilla. However, after the retention period, a significant increase in the superior anterior facial height was observed in 81.25% of patients examined herein (N-ANS increased 1.06 mm). In contrast to RME active phase, the retention period was longer which could possibly explain the vertical growth of the maxilla over this period.[26,27] It is expected that untreated 9-year-old subjects would undergo vertical growth of 1.5 mm per year for boys and 1.2 mm for girls.[26] Mc Namara et al[21] observed a facial height increase of 3.4 mm in a RME group and 4.2 mm in the control group over a mean observation period of 3.7 years.

Despite the fact that the present study only assessed Class II Division 1 malocclusion patients, the severity of malocclusion was not considered (Table 2). The large variability of skeletal involvement may precipitate different responses to the same therapy. Vertical changes, resulting either from RME or growth, may limit horizontal mandibular changes and hinder forward positioning of the menton.[28] Vertical maxillary control during the active phase and the retention period would allow further anterior repositioning of the mandible.

The number of patients included in the present study, although sufficient to detect statistically significant changes, is likely insufficient to generalize the results to all Class II malocclusions. The lack of a control group was a limitation of the present study; however, a control group was unfeasible for the present study due to ethical reasons, since it is impossible not to intervene when a diagnosed transverse discrepancy is present.

The routine use of CBCT is not recommended for orthodontic procedures, given that conventional images emit lower radiation doses. However, some orthodontic patients require temporomandibular images, frontal and lateral cephalograms, panoramic, periapical, occlusal or bite-wing radiographs. It is worth noting that the effective dose related to a full-mouth radiographic survey, as reported by Gibbs,[8] and the sum of the effective doses for panoramic, lateral cephalometric and periapical images are similar, if not higher than that of CBCT without a 3D evaluation. This study used CBCT images because a 3D evaluation had also been carried out for other analyses and some data had already been previously reported.[10,11]

CONCLUSIONS

A 6-month retention period with the Haas expander after RME therapy in Class II Division 1 malocclusion patients allowed the mandible to be positioned significantly more forward and exhibit an improved anterior position rather than an inferior position. This improved Class II dental relationship in 75% of the patients evaluated.

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Comparative study of friction between metallic and conventional interactive self-ligating brackets in different alignment conditions

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.082-089.oar*

Objective: The aim of this study was to compare the friction between three bracket models: conventional stainless steel (Ovation, Dentsply GAC), self-ligating ceramic (In-Ovation, Denstply GAC) and self-ligating stainless steel brackets (In-Ovation R, Dentsply GAC).

Methods: Five brackets were used for each model. They were bonded to an aluminum prototype that allowed the simulation of four misalignment situations (n = 10). Three of these situations occured at the initial phase (in which a 0.016-in nickel-titanium wire was used): 1. horizontal; 2. vertical; and 3. simultaneous horizontal/vertical. One of the situations occurred at the final treatment phase: 4. no misalignment (in which a 0.019 x 0.025-inch stainless steel rectangular wire was used). The wires slipped through the brackets and friction was measured by a Universal Testing Machine.

Results: Analysis of variance followed by Tukey's Test for multiple comparisons ($\alpha = 0.05$) were applied to assess the results. Significant interaction ($p < 0.01$) among groups was found. For the tests that simulated initial alignment, Ovation® bracket produced the highest friction. The two self-ligating models resulted in lower and similar values, except for the horizontal situation, in which In-Ovation C® showed lower friction, which was similar to the In-Ovation R® metallic model. For the no misalignment situation, the same results were observed.

Conclusion: The self-ligating system was superior to the conventional one due to producing less friction. With regard to the material used for manufacturing the brackets, the In-Ovation C® ceramic model showed less friction than the metallic ones.

Keywords: Orthodontic brackets. Friction. Esthetics.

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Submitted: February 14, 2013 - **Revised and accepted**: August 16, 2013

How to cite this article: Jakob SR, Matheus D, Jimenez-Pellegrin MC, Turssi CP, Amaral FLB. Comparative study of friction between metallic and conventional interactive self-ligating brackets in different alignment conditions. Dental Press J Orthod. 2014 May-June;19(3):82-9. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.082-089.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Over the last few years, one of the most widely studied fields in orthodontic research has been the performance of self-ligating brackets due to its alleged advantages over conventional ligation systems.[1-4] In addition to retaining the wire inside the bracket slot, the ligation system works in symbiosis with the wire and increases the effectiveness of dental movement.[5]

Friction is represented by the formula: friction = μ x F, in which μ represents the coefficient of friction and F is the perpendicular force when surfaces are in contact. According to Kusy and Whitley,[6] in order to move the tooth along the arch, the applied force needs to overcome static friction at approximately 50% of the total force applied to the tooth. Thus, high levels of force are needed in situations of high friction. Several articles have shown a significant reduction in friction when self-ligating brackets are used.[7-14]

Another factor directly related to friction at the bracket-wire interface is the material with which the orthodontic accessory is fabricated, since surface roughness directly interferes in the amount of friction produced. Therefore, when choosing the best bracket for dental movement, particularly in mechanics when sliding is a preponderant factor, it is imperative to comparatively assess friction generated by metallic, esthetic, and hybrid brackets (esthetic brackets with metal slots).

In addition, misalignment (horizontal, vertical, horizontal/vertical) or complete alignment may have some type of influence on friction. In horizontal misalignment, friction caused by the ligation system is of primary importance, because in an attempt to displace the wire in the labial direction, there is contact between the wire and the bracket slot and, therefore, direct resistance to the ligation system used. Conversely, in case of vertical misalignment, phenomena such as binding (a region of extremely close contact between the wire and the slot) and notching (the permanent deformation of the wire when it is in contact with the sides of the slots) are more important factors than the ligation system itself when considering the increase of friction.[15,16] The simultaneous combination of vertical and horizontal misalignments is a situation of crucial importance, since any misalignment may either reduce or add friction. Last, in complete alignment, the use of rectangular wires for sliding movements is considered relevant as they may exert some pressure in the ligation system, a factor that may increase friction.[15]

Therefore, additional research studies are necessary to further investigate not only friction of the ligation systems, but also the composition of orthodontic accessories.

MATERIAL AND METHODS

Experimental design

The factors under study in this experiment were as follows:

I) type of bracket: a) metallic self-ligating bracket (In-Ovation R®, GAC International Inc., Bohemia, USA); b) ceramic self-ligating bracket (In-Ovation C®, GAC International Inc., Bohemia, USA); and c) conventional stainless steel bracket (Ovation®, GAC International Inc., Bohemia, USA).

II) Alignment and leveling situation:

- 1) Horizontal misalignment – 1 mm (0.016-in nickel-titanium wire);
- 2) Vertical misalignment – 1 mm (0.016-in nickel-titanium wire);
- 3) Horizontal/vertical misalignments– 1 mm (0.016-in nickel-titanium wire)
- 4) No misalignment – 0 mm (0.019 x 0.025-in stainless steel wire.

The combination of factors under study resulted in 12 experimental groups (n = 10). The quantitative response variable was the measurement of friction (KgF) obtained in a universal testing machine. Table 1 shows the experimental groups studied.

Bracket bonding

To conduct the tests in this study, a prototype, similar to the one used by Ogata et al[17] was used. The device enabled bonding of five brackets per test

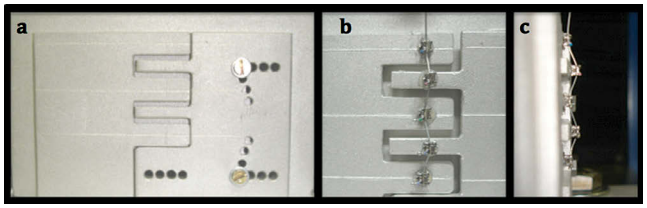


Figure 1 - **A**) Prototype especially designed for the present study. **B**) Vertical malalignment. **C**) Horizontal malalignment.

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Table 1 - Experimental groups.

Bracket	Alignment
In-Ovation R self-ligating metallic bracket (GAC International Inc., Bohemia, USA)	Horizontal malalignment: 1 mm Vertical malalignment: 1 mm Horizontal/vertical malalignment: 1 mm Alignment: 0 mm
In-Ovation C self-ligating ceramic bracket (GAC International Inc., Bohemia, USA)	Horizontal malalignment: 1 mm Vertical malalignment: 1 mm Horizontal/vertical malalignment: 1 mm Alignment: 0 mm
Ovation conventional metallic bracket (GAC International Inc., Bohemia, USA).	Horizontal malalignment: 1 mm Vertical malalignment: 1 mm Horizontal/vertical malalignment: 1 mm Alignment: 0 mm

Table 2 - Mean and standard deviation (SD) of friction force expressed in KgF for each experimental group.

Group	Malaligment condition			
	0 mm	1 mm horizontal	1 mm vertical	1 mm horizontal/vertical
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Ovation	$0.340^{Ac} \pm 0.024$	$0.370^{Abc} \pm 0.024$	$0.480^{Aa} \pm 0.046$	$0.410^{Ab} \pm 0.041$
In-Ovation R	$0.154^{Bc} \pm 0.061$	$0.220^{Bb} \pm 0.033$	$0.061^{Bd} \pm 0.020$	$0.370^{Aa} \pm 0.024$
In-Ovation C	$0.158^{Ba} \pm 0.031$	$0.067^{Cb} \pm 0.027$	$0.053^{Bb} \pm 0.027$	$0.132^{Ba} \pm 0.018$

Means followed by the same letters (upper case in the column and lower case in the line) are not statistically different ($p > 0.05$).

with the purpose of simulating a dental hemi-arch from the central incisor up to the maxillary second pre-molar. It was composed of five winglets designed to bond the brackets. Each one of the winglets had demarcations that allow bonding of the orthodontic accessory in a standardized vertical position. The prototype contained screws for adjustment and spacers that allowed variation of bracket position in horizontal misalignment, as well as in vertical misalignment (Fig 1A).

The prototype face to which the brackets would be bonded was first submitted to airborne aluminum oxide particle abrasion in order to increase bond strength.

Each one of the three bracket groups was composed of five brackets. In the first group, In-Ovation C® esthetic self-ligating brackets were used; in the second group, In-Ovation R® metallic self-ligating brackets; while in the third group, Ovation® conventional metallic brackets were used. All brackets slot measured 0.021 x 0.028-in. Both self-ligating and conventional brackets were used following the Straight-Wire technique and Roth prescription. For the Ovation® model, elastomeric ligatures measuring 1.2 mm in internal diameter were used to tie the wire to the slot (Morelli®, Sorocaba, Brazil).

To conduct the tests, the brackets were placed in passive position so as to prevent any possibility of torque, angulation or rotation, which could affect the results. For this purpose, a stainless steel wire 0.021 x 0.025-in guide (Morelli®, Sorocaba, Brazil) was used. The wire guide was set to the testing machine, passing through all the brackets. The orthodontic accessories were then bonded to the winglets of the prototype using Transbond XT® resin (3M Unitek, Monrovia, USA). This resin was light cured by means of Ultralux EL® (Dabi Atlante Indústrias

Médico-Odontológicas Ltda, Ribeirão Preto, Brazil) for 40 seconds on each bracket.

Friction test

The prototype was coupled to the EMIC DL-2000® precision machine (EMIC, São José dos Pinhais, Brazil) and the tests were conducted in dry state. The EMIC machine, with a load cell of 20 KgF, promoted traction of the wire inside the bracket slots affixed to the prototype. Traction was done at a speed of 0.5 mm/min at a trajectory of 1 mm. Data was obtained in KgF.

Four different tests were conducted based on the alignment situations: 1) horizontal misalignment — 1 mm (0.016-in nickel-titanium wire): horizontal variation of brackets at 1 mm, adjusting the position of the prototype by using three 1 mm-thick spacers placed between the mobile piece and base; 2) vertical misalignment — 1 mm (0.016-in nickel-titanium wire): vertical variation of brackets at 1 mm by changing the position of the screws in the corresponding perforations; 3) horizontal/vertical misalignments– 1 mm (0.016-in nickel-titanium wire): a combination of horizontal and vertical misalignments; and 4) No misalignment — 0 mm (0.019 x 0.025-in stainless steel wire): brackets were horizontally and vertically aligned.

Each bracket/wire/adjustment combination of the prototype was tested 10 times, totaling 120 series of tests (n = 10). After each test, new elastomeric ligatures were placed on the conventional brackets by means of Mathieu tweezers. Nickel-titanium and stainless steel wires were replaced after each bracket was tested.

Statistical analysis

Statistical tests were prepared by the SAS JMP 8® program (SAS Institute Inc., Raleigh, NC, USA), and the Analysis of Variance complemented by Tukey's multiple comparison test with significance level set at 5%.

RESULTS

Table 2 shows the results obtained for all experimental groups. Significant difference between the bracket group and the simulation of misalignment was found ($p < 0.01$). In other words, when the position was fixed at 0 mm (using 0.019 x 0.025-in stainless steel wire), the groups with In-Ovation R® and In-Ovation C® self-ligating brackets had the lowest friction values. Although these values were statistically similar among groups, they differed from conventional Ovation brackets ($p < 0.01$).

With regard to horizontal misalignment, all groups presented significant differences. Conventional Ovation® bracket showed the highest friction, followed by In-Ovation R® and In-Ovation C® brackets ($p < 0.01$).

Lower friction was found in In-Ovation C® self-ligating brackets when the simulation of misalignment in the prototype was modified to 1 mm, vertically. There was no statistically significant difference in comparison to In-Ovation R® bracket. Ovation® bracket showed significantly higher friction ($p = 0.01$).

In horizontal/vertical misalignment, lower friction was found for In-Ovation C® bracket, which was statistically different in comparison to In-Ovation R® and Ovation® brackets, with higher friction values ($p < 0.01$).

DISCUSSION

With a view to providing greater effectiveness in orthodontic mechanics, knowledge about the importance of friction at the bracket-wire interface is one of the most relevant factors and the objective of several research studies.[2,6,13,14,18,19,20]

The aim of this study was to compare friction between self-ligating and conventional ligation systems in different situations: horizontal misalignment which simulates, for example, buccal displacement of teeth; vertical misalignment, which simulates infraocclusion of maxillary canines[21] and both clinical situations that may occur together. Additionally, dental alignment (no misalignment), in which only sliding mechanics is needed, was also considered. A specially designed prototype that allowed testing of these different situations was used. The study by Reznikov et al[22] also used a methodology that allowed horizontal and vertical misalignments. However, their tests did not include simultaneous misalignments, and, therefore, did not reflect the real clinical practice of orthodontic treatment.

When considering self-ligating brackets, the present study opted to use active system composed

of a flexible cobalt-chromium clip that undergoes deflections when it is in horizontal contact with the wire. The self-ligating brackets selected were In-Ovation R®, metallic model, and its similar esthetic version, In-Ovation C®. Both are very similar in design, the only difference is related to the raw material used in their fabrication. In-Ovation R® is made through the system known as MIM (metal-injection-molded), while In-Ovation C® is fabricated with the CIM system (ceramic-injection-molded) with polycrystalline ceramic.[23] The conventional model (Ovation®) used in the tests is also fabricated by the MIM system.

Friction experiments rarely use brackets from the same manufacturer, but oftentimes compare brackets from different manufacturers.[5,8,9,12,14,24,25,26] On the contrary, the methods employed in this study allowed standardization of the raw materials and technology used for the fabrication of metallic brackets, thus favoring the interpretation of results. Pizzoni et al,[11] for instance, compared the frictional forces of different brands of self-ligating brackets, and showed that different metal alloys incorporated into the composition of clips may have influenced roughness and, consequently, friction produced by brackets.

In order to simulate a clinical situation, the present study used five brackets forming a hemi-arch from the central incisor up to the maxillary right second pre-molar, similar to the study conducted by Krishnan et al.[10] In contrast, other studies[27,28] used only one bracket for each test, which may be a limitation when the objective is to simulate clinical practice as closely as possible. Another important aspect to be discussed is that although the ideal situation was replacing brackets after each test, this was not considered in this study. Each bracket was tested ten times. In spite of that, Kapur et al[29] observed that there was neither increase nor decrease in friction when brackets were repeatedly used.

The present study used a conventional stainless steel bracket with elastomeric ligatures as control group. Elastomeric ligatures reduce chair time due to being easy to use. Some studies state that elastomeric ligatures produce more friction[30,31] or similar friction[32] to stainless steel ones. Thorstenson and Kusy[31] reported that when angulation exceeds the critical contact angle for binding, the binding component overwhelms the frictional component and the effects of ligature type and method are minimal. Thus, further studies should confirm the effects of ligature type on friction resistance in misalignment situations.

Using a prototype in both misalignment and alignment situations led us to select orthodontic wires with different cross-sections. During the misalignment stages, a 0.016-in nickel-titanium wire was used, similarly to what is recommended by Henao and Kusy.[8] As for the alignment stage, a 0.019 x 0.025-in wire was used so as to represent the treatment stage in which dental alignment has already been established. Stainless steel alloy is normally recommended for this purpose for presenting less roughness than other alloys.[30,33]

Comparative assessment between the three brackets revealed that the alignment situation showed 50% lower friction in both self-ligating methods, In-Ovation R® and In-Ovation C®, in comparison with conventional Ovation® brackets. This result suggests better performance of the self-ligating system, even when esthetic brackets are chosen, and corroborates the findings reported by Voudouris et al.[23]

There was a significant difference in the performance of the three bracket types used for horizontal misalignment at 1 mm, in which In-Ovation C® proved to be superior to In-Ovation R®which, in turn, was superior to Ovation®. In this case, the self-ligating system showed a distinct advantage over the conventional one. Considering the superiority of In-Ovation C® over In-Ovation R®, similar results have been found in the literature.[34,35] Heo and Baek[35] observed that Cr-Co clips incorporated to In-Ovation-C® brackets showed more freedom within the bracket slot, thus reducing friction. However, both In-Ovation® models use the same cobalt-chromium clips. Therefore, the difference in friction among them must be attributed to the greater smoothness of the esthetic model.[23]

When the prototype was adjusted to simulate vertical misalignment at 1 mm, In-Ovation C® and In-Ovation R® brackets had statistically similar friction values that were superior to the Ovation® bracket. It is probable that, in addition to the action of the ligation system in friction, binding and notching effects (when the wire is permanently deformed, making sliding difficult) may have decisively influenced

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sliding mechanics.[36] Thus, the self-ligating system showed lower friction than the conventional one. It is known that the critical angle (θc), which is the angle (θ) at which the archwire first contacts the edges of the slot, is an important factor that enhances the binding component in in vertical misalignment (or second order angulation).[15] For self-ligating brackets, the θc is 3.8°, whereas for conventional brackets, the θc is 3.1°.[15] This condition is especially important for conventional brackets because the θc is easily surpassed, thereby enhancing resistance to sliding. However, when friction resistance is considered, as there was no statistically significant difference between In-Ovation R® and In-Ovation C®, binding and notching effects may be more significant than surface roughness of the bracket slot.

Horizontal/vertical misalignment showed that bracket surface roughness is imperative in these conditions, since In-Ovation C® showed less friction than In-Ovation R® and Ovation®. Similarity between the two latter metallic brackets showed that, in this situation, the ligation system is not a decisive factor, but rather the raw material used for its fabrication.

After individual assessment of each bracket, Ovation® conventional model showed higher friction when the prototype was misaligned in the vertical direction, only. In the horizontal and horizontal/vertical misalignments, values were respectively lower and similar. The lowest friction values in sliding mechanics were obtained when the brackets were aligned (0 mm) in the prototype. Once again, results suggest that binding and notching effects generated more friction than the ligation system. Apparently, horizontal misalignment reduces binding and notching effects, probably because the wire moves forward from the bottom of the slot, decreasing the vertical effects.

As for In-Ovation R® brackets, higher friction was observed in the horizontal/vertical misalignment, followed by horizontal misalignment, alignment and vertical misalignment. In the case of self-ligating brackets, rigidity of the cobalt-chromium clip showed important effects of friction in situations of horizontal misalignment. It may also be suggested that this rigidity does not allow reduction in binding and notching effects in the horizontal/vertical misalignment, as it occurred with conventional Ovation® brackets. The decisive action of the clip in the aligned position (0 mm) may once again be observed due to the thickness of the wire, 0.019 x 0.025-in. Excessive deflection of the clip occurs because the upper horizontal wall of In-Ovation® is 0.018-in, while the horizontal wall of the wire is 0.025-in. This may cause extreme deflection of the clip, associated with the rigidity of the Co-Cr alloy, which drastically increases friction.

One factor was of paramount importance to explain the results of In-Ovation C® brackets: the clip receives a rhodium coat[34] that improves its cosmetic value by removing metallic brightness, rendering the clip opaque. According to the manufacturer's instructions, rhodium coat increases the rigidity of cobalt-chromium, which is a characteristic of this alloy when subjected to heat treatment. Due to this increased rigidity, it is hypothesized that the wire causes lower deflection of the clip. Thus, because the clip is not deflected in the horizontal misalignment; the 0.016-in wire has more space inside the slot, which results in significantly reduced friction in comparison to the same situation experienced by In-Ovation R®. Voudouris et al[23] demonstrated that the lower friction promoted by In-Ovation C® may be attributed to the new ceramic-injected molding technique that produced a smoother, glass-like slot in In-Ovation- C®. Heo and Baek[35] observed that the In-Ovation C® clip has a rounded shape that may result in lower seating forces and lower friction. Nevertheless, all these hypotheses need to be further clarified.

It is important to point out that friction in vertical misalignment did not cause a great alteration in In-Ovation C® due to the rigidity of the clip. Another interesting result may also be observed in the alignment of the prototype brackets. There was a significant increase in friction when the 0.019 x 0.025-in wire was used, probably because there was no gap in the wire inside the slot, as occurred when the 0.016-in wire was used. In this situation, friction in In-Ovation C® bracket was similar to that found for In-Ovation R®.

Thus, both ligation system and composition might decisively influence tooth movement in situations of horizontal, vertical and vertical/horizontal misalignments, as well as during sliding mechanics, since they directly influence friction.

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CONCLUSION

It is suggested that:

» In-Ovation R® and In-Ovation C® self-ligating bracket systems showed lower friction at all alignment levels tested in this study in comparison with the conventional Ovation® bracket system, except for the horizontal/vertical misalignment in which In-Ovation R® showed similar friction in comparison to the Ovation® bracket.

» Friction was similar for self-ligating metallic and ceramic brackets, except for horizontal and horizontal/vertical misalignments, in which the ceramic model showed lower friction.

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Insertion torque *versus* mechanical resistance of mini-implants inserted in different cortical thickness

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.090-094.oar*

Objective: This study aimed to measure insertion torque, tip mechanical resistance to fracture and transmucosal neck of mini-implants (MI) (Conexão Sistemas de PróteseT), as well as to analyze surface morphology.

Methods: Mechanical tests were carried out to measure the insertion torque of MIs in different cortical thicknesses, and tip mechanical resistance to fracture as well as transmucosal neck of MIs. Surface morphology was assessed by scanning electron microscopy (SEM) before and after the mechanical tests.

Results: Values of mechanical resistance to fracture (22.14 N.cm and 54.95 N.cm) were higher and statistically different ($P < 0.05$) from values of insertion torque for 1-mm (7.60 N.cm) and 2-mm (13.27 N.cm) cortical thicknesses. Insertion torque was statistically similar ($P > 0.05$) to torsional fracture in the tip of MI (22.14 N.cm) when 3 mm cortical thickness (16.11 N.cm) and dense bone (23.95 N.cm) were used. Torsional fracture of the transmucosal neck (54.95 N.cm) was higher and statistically different ($P < 0.05$) from insertion torsional strength in all tested situations. SEM analysis showed that the MIs had the same smooth surface when received from the manufacturer and after the mechanical tests were performed. Additionally, no significant marks resulting from the manufacturing process were observed.

Conclusion: All mini-implants tested presented adequate surface morphology. The resistance of mini-implants to fracture safely allows placement in 1 and 2-mm cortical thickness. However, in 3-mm cortical thickness and dense bones, pre-drilling with a bur is recommended before insertion.

Keywords: Orthodontic anchorage procedures. Torque. Orthodontics.

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Submitted: March 10, 2013
Revised and accepted: May 10, 2013

How to cite this article: Santos RF, Ruellas ACO, Fernandes DJ, Elias CN. Insertion torque *versus* mechanical resistance of mini- implants inserted in different cortical thickness. Dental Press J Orthod. 2014 May-June;19(3):90-4. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.090-094.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Conventional intraoral anchorage (not supported by implants) might fail due to lack of rigidity of support structures or as a result of patient's noncompliance during treatment, especially with regard to the use of extraoral appliances. Therefore, since conventional anchorage systems present some limitations, whether biomechanical or with regard to patient's cooperation, the use of mini-implants (MI) is an excellent alternative in cases requiring maximum anchorage.[1]

Although MI may sometimes pose problems such as excessive clinical mobility, they are considered a safe, simple and low-cost anchorage method able to solve many difficulties related to anchorage. In order to improve stability, modifications have been made to screw design and surface treatment (sandblasting, acid-etching and microthreads).

In order to succeed in using a new product or a new technique, it is essential to test it. According to Barlow,[2] the decision on whether to buy newly developed products or to use specific methods must be based on strong evidence of clinical efficacy, as well as on understanding the influence of these products over orthodontic treatment.

Insertion and removal of MI are simple procedures that can be performed by the orthodontist himself.[3] They have a high success rate, between 84 and 92%,[4-7] but are associated with certain risks, among which fracture is the most important. Mini-implant fracture normally occurs during the insertion procedure.[8] A surgical intervention might be necessary to remove the fractured part when tooth movement is planned. Testing MI placement in different types of cortical bone is, therefore, of paramount importance to improve the safety of these devices.

The aim of the present study was to assess the surface morphology of MI after their insertion and removal in artificial bone, and to analyze their placement torque in different circumstances of cortical thicknesses, comparing these values with those of mechanical fracture resistance.

MATERIAL AND METHODS

A total of ten mini-implants (1.5 mm in diameter, 6 mm in length, and transmucosal profile of 1 mm; Conexão™, São Paulo, Brazil) with a modified screw pitch (reduction in the threads interval in the cervical portion) were tested.

Surface morphology was analyzed by scanning electron microscopy at 20 kV (JEOL LSM-5800). MIs were placed in aluminum sample holders with the use of double-adhesive ca'rbon tape. Each MI was observed under magnification of 25, 50 and 150 so as to check surface finishing, presence of machining defects or corrosion, and the shape of the tips and threads.

Mechanical tests were performed to measure the insertion torque and resistance to fracture of the MI tip and the transmucosal profile.

Insertion tests were carried out on the basis of ASTMF117 (Standard Test Method for Driving Torque of Medical Bone Screws) and F1622 (Standard Test Method for Measuring the Torsional Properties of Metal Bone Screw). The tests were performed in an EMIC DL 10.000 testing machine, with a 100 N load cell, displacement of 1 cm/min. Maximum placement and fracture torque values were recorded.

Mini-implants were inserted into blocks of polyurethane resin provided by Nacional Ossos.™ At the top of the block, resin with a density of 40 pcf (0.62 g/cm3) was applied to simulate cortical bone thicknesses of 1, 2 and 3 mm, whereas at the bottom portion, resin of 20 pcf (0.32 g/cm3) was applied to simulate cancellous bone. A 1-mm bur was used for perforation. The system consisted of two grips which forced the MI against the resin block (initial force of 400 gf) when compressed by an elastic force.

To measure the fracture torque, mini-implants were attached to the devices shown in Figures 1 and 2. In the set up test, one of the grips was unable to rotate, while the other was free to move. To test the mechanical fracture resistance of the tip, the MI was inserted into the fixed grip up to the first three threads, while the insertion-removal key was secured in the other grip and attached to the head of the MI. To test the mechanical fracture resistance of the neck (transmucosal profile), the same system was used, with the difference that the MI was attached up to the second thread below the transmucosal profile. This testing device has an accuracy of 0.02 N.cm.

Data from all groups were analyzed using the SPSS for Windows software (v17.0; SPSS, Chicago, IL, USA). Means, standard deviations, medians, as well as minimum and maximum values were calculated. Normality and equality of variance of data were checked by the Kolmogorov-Smirnov test.

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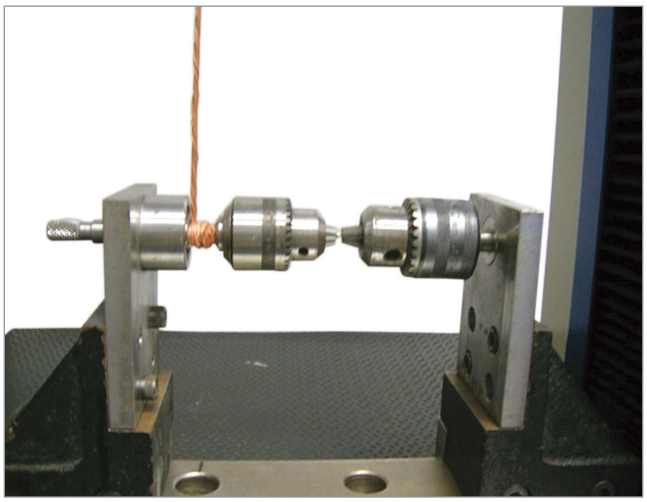


Figure 1 - Device used for mini-implant torsional tests.

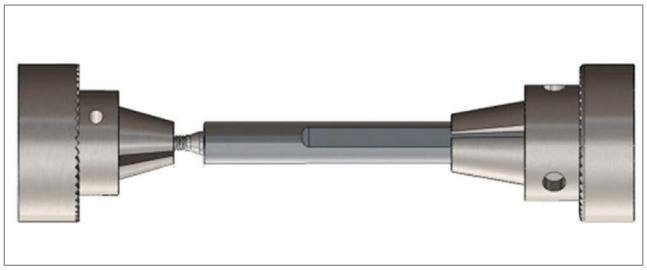


Figure 2 - Approximate view of the device used for testing fracture torque, showing one MI attached to one grip and the insertion-removal key attached to other.

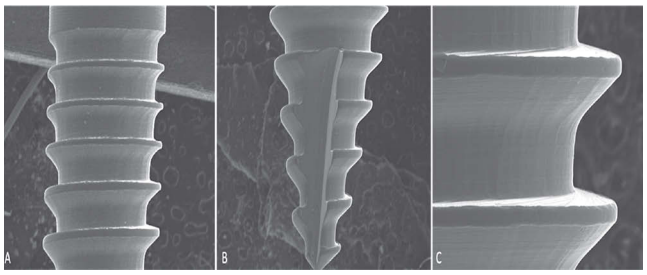


Figure 3 - Photomicrographs of the mini-implants studied. **A**) Area next to the transmucosal profile where mechanical fracture resistance test was performed (x50); **B**) Area next to the tip where mechanical fracture resistance test was performed (x50); **C**) Image of mini-implant body (x150). Smooth surface without defects, and tip with a cutting area.

Results were statistically analyzed using one-way ANOVA with the Tukey's post-hoc test to detect differences among groups. P-value of < 0.05 was accepted as statistically significant.

RESULTS

Figure 3 shows design modification (reduction in the distance between threads in the cervical portion), body and tip of mini-implants after insertion and removal. Photomicrographs of the mini-implants studied reveal smooth surface without defects, such as cracks and porosities, and without images that suggest corrosion. The tip presented a cutting area suitable for self-tapping.

Descriptive analysis of insertion and fracture torque values is shown in Table 1. MI tip fracture torque strength is lower than fracture torque strength of MI transmucosal profile.

DISCUSSION

In Orthodontics, the use of mini-implants began with the purpose of providing anchorage and have proved to be an excellent alternative. The results have been so encouraging that these devices have been widely used.[9]

Surface morphology of the evaluated MI was similar to most MIs evaluated in the literature,[9,10,11] presenting a smooth surface without significant damage resulting from the manufacturing process, and without signs of corrosion (Fig 3). Changes in morphology through surface treatment or mechanical modification might result in alterations in the growth and differentiation of osteoblasts.[12] The presence of irregularities may increase osseointegration and, as a consequence, hinder MI removal. After insertion and removal, mini-implants showed no signs of deformation, even under high insertion torque (23.95 N.cm for dense bone).

Table 1 - Insertion torque at different conditions, MIs resistence to fracture by torsion (N.cm²) and statistical analysis.

		Mean ± SD	Variation	Statistical difference*	Statistical difference*
Insertion torque	1 mm	7.60 ± 0.13	7.32 - 8.09	B (P < 0.001)	B (P < 0.001)
	2 mm	13.27 ± 0.34	12.30 - 13.89	C (P = 0.003)	C (P < 0.001)
	3 mm	16.11 ± 0.23	15.52 - 16.61	A (P = 0.070)	D (P < 0.001)
	dense bone	23.96 ± 0.11	23.50 - 24.11	A (P = 0.949)	E (P < 0.001)
Torque	Tip	22.14 ± 3.70	18.00 - 25.60	A	
Fracture	Transmucosal	54.95 ± 6.98	48.20 - 65.85		A

* Different letters in the same column mean statistical differences (P < 0.05).

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Mini-implants can be placed in a wide range of sites,[13] with the paramedian region of the palate, retromolar space, and especially interdental areas, being the most common sites. Areas between adjacent teeth normally present a cortical thickness of 1 or 2 mm.

As density and cortical thickness increase, it is necessary to drill the MI site. Edentulous areas, for example, require predrilling. For most locations where MI are placed (cortical thickness of 1 and 2 mm), the protocol is predrilling with a hand drill at the same place where the anesthesia puncture is performed. Cortical perforation with a hand drill ensures MI stabilization, which allows insertion into bone tissue. In the present study, the torque necessary to insert mini-implants into cortical thicknesses of 1 and 2 mm was lower than the torque that causes its tip to fracture (7.60 and 13.27 x 22.14 N.cm, respectively), threby respecting a safety margin.

However, for cortical thickness of 3 mm and high density bones, such as edentulous areas, predrilling using a motor-driven handpiece at low rotational speed and under irrigation is necessary to minimize the risk of fracture. Although mini-implant placement under the aforementioned circumstances is less common, it might be the best indication for some clinical cases. The torque necessary to insert mini-implants into dense bone was higher than the fracture torque, although fracture did not occur during the placement procedure. This is probably associated with two facts: drill diameter (1 mm) close to the screw thread diameter where the fracture occurred (on the cutter), and the presence of this cutting area on the tip itself. Pithon et al[14] observed that fracture torque strength is influenced by mini-implant shape. Design modification such as reduction in the distance between pitches, and the presence of a cutting tip, might consequently have influenced the values obtained.

Fracture torque strength values of the mini-implants assessed herein demonstrated that they are suitable for clinical use. It is important to emphasize, however, that MI placement in thick cortical or in dense bone requires predrilling with a drill. Moreover, the fracture torque strength values obtained in the present study were equal to or higher than those found in other studies using different brands of MI.[10,11,14,15,16] This difference is probably associated with mini-implant shape, manufacturing process, and methodology used in this research.

The concern about fracture resistance is justified by the importance of performing a safe insertion procedure without risks of fracturing the mini-implant.[10,11] Therefore, a MI with fracture torque strength higher than the torque necessary for insertion into bone tissue must be chosen. Although the incidence of fracture is not high (about 4%[17]), it might occur due to manufacturing process problems, professional mistake during placement, and — especially — application of excessive insertion torque. The latter is probably the reason for the lower success rate of mini-implants among beginners, since they commonly produce high torsional stress during placement.[3] When using a mini-implant that has a fracture torque strength higher than its insertion torque, there is less chance of fracturing the device during placement, which could be demonstrated by placing it in cortical thicknesses of 1 and 2 mm. Consequently, the use of insertion key coupled to a torque gauge or with torque limiter, is recommended. The insertion torque values obtained in the present study suggested that torque be limited to a maximum of 15 Ncm. Should a higher insertion torque be required, the placement procedure must be stopped and predrilling with a drill must be performed. Cases in which predrilling has already been done, a drill with a larger diameter, approaching the diameter of the mini-implant, must be used. It is important to emphasize that this situation is not common and is normally restricted to old edentulous areas.

It is important to choose proper-sized transmucosal profile (neck) in accordance with the thickness of the soft tissue region where the MI will be installed, thus allowing the platform (region between the head and the transmucosal profile) to be well adapted to the soft tissue without causing excessive ischemia. Transmucosal profile greater than soft tissue thickness will create a gap between the platform and the soft tissue, threby favoring bacterial plaque accumulation and leaving the MI in greater contact with the cheek or lip. It may also induce the professional to make a mistake because in order to bring the platform close to the soft tissue, he/she will try to insert part of the transmucosal profile in the bone, thus excessively increasing the insertion torque and the risk of fracture.

Stability achieved by mini-implant is one of the criteria used to evaluate the possibility of load application. The greater the primary stability is, the safer the clinical use of

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MI. In the present study, insertion torque values were higher than those normally found in the literature. This difference may be associated with the reduction in the distance between threads in the cervical portion, since it increases the number of threads and bone-implant contact area.

Although removal torque was not evaluated, it is normally lower than the insertion one. Cheng et al[4] evaluated the removal torque of 46 MI removed from patients, and found values ranging from 10.78 to 21.07 N.cm. These values are lower than the fracture torque of MIs assessed in the present study.

CONCLUSIONS

Mini-implants with microthreads presented smooth surface with proper finishing and without signs of deformation after insertion and removal.

Fracture resistance of the transmuosal profile was higher than the insertion torque in the different tested situations.

Fracture resistance of MI tip was compatible with its placement in cortical thicknesses of 1 and 2 mm. However, for 3 mm cortical and dense bones, predrilling is recommended.

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Effect of 0.12% chlorhexidine in reducing microorganisms found in aerosol used for dental prophylaxis of pacients submitted to fixed orthodontic treatment

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.095-101.oar*

Objective: This study aimed at assessing, *in vivo*, whether the prior use of 0.12% chlorhexidine as mouthwash would decrease air contamination caused by aerosolized sodium bicarbonate during dental prophylaxis. The study was conducted with 23 patients aged between 10 and 40 years old who were randomly selected and undergoing fixed orthodontic treatment.

Methods: The study was divided into two phases (T1 and T2) with a 30-day interval in between. In both phases, dental prophylaxis was performed with aerosolized sodium bicarbonate jetted to the upper and lower arches for 4 minutes. In T1, 10 minutes before the prophylaxis procedure, the participants used distilled water as mouthwash for one minute; whereas in T2, mouthwash was performed with 0.12% chlorhexidine. Microbial samples were collected in BHI agar plates for microbiological analysis. Two dishes were positioned on the clinician (10 cm from the mouth) and a third one at 15 cm from the patient's mouth. The samples were incubated for 48 hours at 37°C. Results were expressed in colony-forming units (CFU).

Results: Statistical analysis carried out by means of Student's t test, as well as Wilconxon and Kruskal-Wallis tests revealed that the prior use of 0.12% chlorhexidine as mouthwash significantly reduced CFU in the three positions studied ($P < 0.001$).

Conclusion: The prior use of 0.12% chlorhexidine as mouthwash significantly reduced contamination caused by aerosolized sodium bicarbonate during dental prophylaxis in the orthodontic clinic.

Keywords: Aerosol propellant. Effects of air contamination. Chlorhexidine.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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How to cite this article: Santos IRM, Moreira ACA, Costa MGC, Barbosa MC. Effect of 0.12% chlorhexidine in reducing microorganisms found in aerosol used for dental prophylaxis of pacients submitted to fixed orthodontic treatment. Dental Press J Orthod. 2014 May-June;19(3):95-101. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.095-101.oar

Submitted: March 18, 2013 - **Revised and accepted**: August 18, 2013

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INTRODUCTION

Cross infection control and biosecurity issues are crucial to the dental practice. Healthcare professionals and patients are often subjected to several risks, among which is cross infection.[1] Reducing it is a major challenge for dentists, researchers and microbiologists.[2]

In some cases, microorganisms overcome the security measures adopted, thus putting patients and professionals at risk. This often occurs as a result of professional negligence with regard to biosecurity, which intensifies the cross infection cycle in the dental office.[3] The orthodontic practice differs from other dental specialties by the volume of patients assisted per day, which increases the chances of cross infection.[4] Additionally, orthodontic treatment with fixed appliances increases biofilm accumulation.[5,6]

Given the negative effects of plaque accumulation during orthodontic treatment, orthodontists are constantly searching for new techniques and material that benefit and protect both patients and clinicians.[7,8]

The use of antimicrobial agents can help to maintain the integrity of tooth structure.[5] Chlorhexidine is a chemical agent with antimicrobial properties capable of inhibiting bacterial growth and reducing the number of these microorganisms in the oral cavity, including *Streptococcus* associated with the development of caries.[2,9]

Aerosol particles may contain viruses, such as those of the acquired immunodeficiency syndrome (AIDS) and hepatitis B (HBV), which can penetrate through the clinician's, assistant's and patient's respiratory tract and conjunctiva membranes.[6,10]

For this reason, it is essential that clinicians and assistants cooperate to avoid cross-contamination as a result of the use of aerosol equipment by means of which microorganisms can be introduced and spread within one meter around the operative field.[11]

The aim of this *in vivo* study was to assess whether the prior use of 0.12% chlorhexidine as mouthwash would decrease contamination caused by aerosolized sodium bicarbonate during dental prophylaxis of patients undergoing fixed orthodontic treatment.

MATERIAL AND METHODS

This quantitative longitudinal study was conducted with patients undergoing orthodontic treatment carried out by the Postgraduate Programm in Orthodontics, School of Dentistry, Federal University of Bahia (UFBA).

All participants were strictly treated in accordance with Resolution 196/96 issued by the Brazilian National Health Council (CNS). The research was approved by the UFBA Institutional Review Board through consolidated opinion Nº. 171.801 and registration in SISNEP, CAAE 03798312.2.0000.5024.

Sample size calculation was performed to detect a difference of 20% in relation to the initial data.[12] According to data provided by the G*Power program (version 3.3, G*Power Software, Inc. 1 Mannheim, Germany), 22 individuals were necessary for each group.

Sample characterization

In selecting the sample, the following inclusion criteria were applied:

1) A minimum of five teeth in each quadrant of the upper and lower arches;

2) Absence of systemic diseases;

3) No previous use of antibiotics or antiseptic mouthwash in the last 30 days;

4) No previous professional prophylaxis in the last 30 days.

Initially, a total of 25 patients were selected for this study. After applying the inclusion criteria, the number was reduced to 23, males and females aged between 10 and 40 years, randomly chosen and who were undergoing fixed orthodontic treatment.

To maintain the same treatment conditions and avoid interference in the results, the study was conducted in the same booth of the Postgraduate clinic. Before each procedure, the dental equipment was decontaminated with 2% chlorhexidine and alcohol 70%.[13] The handpiece used to jet the aerosolized sodium bicarbonate was sterilized in an autoclave, and the water used for dental prophylaxis was distilled.

The research was conducted in two phases with a 30-day interval in between. The researcher used the following personal protective equipment: glove, mask, cap, goggles and lab coat; and followed the criteria of ideal biosecurity.[13]

Samples were collected in a dish containing 25 mL of BHI agar (Eximlab Commercial Equipment Laboratory LTD - Paraná - Brazil), placed onto the clinician's face (forehead area) (taped to a skullcap) and identified as P1. Another dish containing

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the same medium was positioned 10 cm from the clinician's mouth (vertical downward direction) and identified as P2. A third dish also containing BHI agar was placed over the patient's thoracic region, 15 cm from the oral cavity and identified as P3 (Fig 1).The dishes were made of 90 mm x 15 mm, sterile, smooth Petri plastic (J. Prolab - Paraná - Brazil). The culture medium used was BHI agar. To avoid contamination, the Petri dishes containing 25 mL of BHI agar were exposed on the auxiliary table before procedure onset.

Jet hand I sodium bicarbonate jet (Gnatus dental medical equipment LTD - São Paulo - Brazil) was used for dental prophylaxis (Fig 2).

First phase (T_1)

The patient rinsed the mouth with 15 mL of distilled water for one minute ten minutes before prophylaxis. Dental prophylaxis was performed for 4 minutes in the upper and lower quadrants of all subjects with sodium bicarbonate jet of which container was filled with distilled water.

Second phase (T_2)

After 30 days, all patients were subjected to a new prophylaxis procedure following the same aforementioned standards. However, mouthwash was performed ten minutes before prophylaxis with 15 mL of 0.12 % digluconate chlorhexidine for one minute.

Microbiological evaluation

After sample collection, the dishes were identified and incubated under aerobic conditions at 37°C for 48 hours. After incubation, the total count of colonies was carried out for each dish using a colony counter model EC 550A (PHOENIX - São Paulo - Brazil). Results were expressed in CFU (Colony Forming Units).

Statistical analysis

Data were tabulated in Excel spreadsheet for Windows 2010 and analyzed in GraphPad Prism (version 5.0, GraphPad Software. Inc., San Diego, CA, USA). Shapiro-Wilk test was used to assess sample normality. Student's t-test was used for data with normal distribution (comparison of two means of P3). As for data with non-normal distribution, Wilconxon test (comparison of two means of P1; comparison of two means of P2; and comparison of both overall means) and Kruskal-Wallis (comparison of three positions in T_1 and comparison of three positions in T_2) were used. Significance level was set at $P < 0.05$ for all analyses.

RESULTS

Assessment carried out in T_1 and T_2 for the dishes previously exposed on the auxiliary table before prophylaxis revealed no significant growth of CFU, with an average of two Colony Forming Units per dish.

Figure 1 shows a BHI agar dish, positioned at P1, where mesophilic bacteria colonies developed during prophylaxis with bicarbonate jet and subsequent incubation.

Comparison between T_1 and T_2

Comparison of CFU means between T_1 and T_2 (mouthwash with distilled water and mouthwash with 0.12 % chlorhexidine) at P1, P2 and P3, revealed statistically significant differences ($P < 0.001$). In T_1, the mean of CFU was 9.05 x 102, while in T_2 it was 5.57 x 102 during dental prophylaxis (Fig 2).

Comparison of dishes positioned at P1 in both T_1 and T_2 phases also revealed statistically significant differences ($P = 0.0074$), as shown in Fig 3. CFU means of 3.21×10^2 were obtained in the first phase, whereas CFU means of 2.05×10^2 were found after mouthwash with 0.12 % chlorhexidine.

Comparison of dishes positioned at P2 in phases T_1 and T_2 also revealed a statistically significant reduction in CFU mean ($P = 0.0051$) (Fig 4).

The dishes positioned in the patient (P3) revealed significant difference between T_1 and T_2 ($P = 0.0035$) (Fig 5).

Comparison among P1, P2 and P3

Figures 6 and 7 compared the means of dishes positioned at P1, P2 and P3 in T_1 and T_2, respectively. The dishes positioned at P1, P2 and P3 showed statistically significant differences in both phases, whereas the dish positioned in the patient (P3) showed higher means in comparison to that positioned in the clinician. In the clinician, P2 showed higher CFU means than P1 in both steps.

DISCUSSION

Given the possible changes in patient's oral microbiota and the increased risk of contamination involved during orthodontic treatment, it is essential that

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preventive methods be employed for all patients.[14] The type, frequency and amount of measures adopted to prevent and maintain oral health will depend on the individual characteristics of the clinician and the patient.

Dental prophylaxis has proved to be one of the most important preventive methods.[15] Studies have shown that the technique of prophylaxis carried out with sodium bicarbonate jet is effective in removing biofilm from all tooth surfaces, as well as from fissures and fossas. It is recommended for patients undergoing orthodontic treatment.[16] In comparison to the rubber cup and pumice techniques, prophylaxis with sodium bicarbonate jet is considered the most advantageous technique for orthodontic patients. In spite of increasing the aerosol formed, the technique increases biofilm removal, reduces operative time and prevents heat release during the procedure.[17,18] For these reasons, sodium bicarbonate jet was chosen for collection and evaluation of the aerosol method in this research.

Another method employed to prevent cross contamination is the use of antimicrobial agents. Chlorhexidine is considered the gold standard in comparison with other substances used to interfere in biofilm formation.[9,19,20] It was most commonly used twice a day as a 10 mL, 0.2% mouthwash solution.[21]

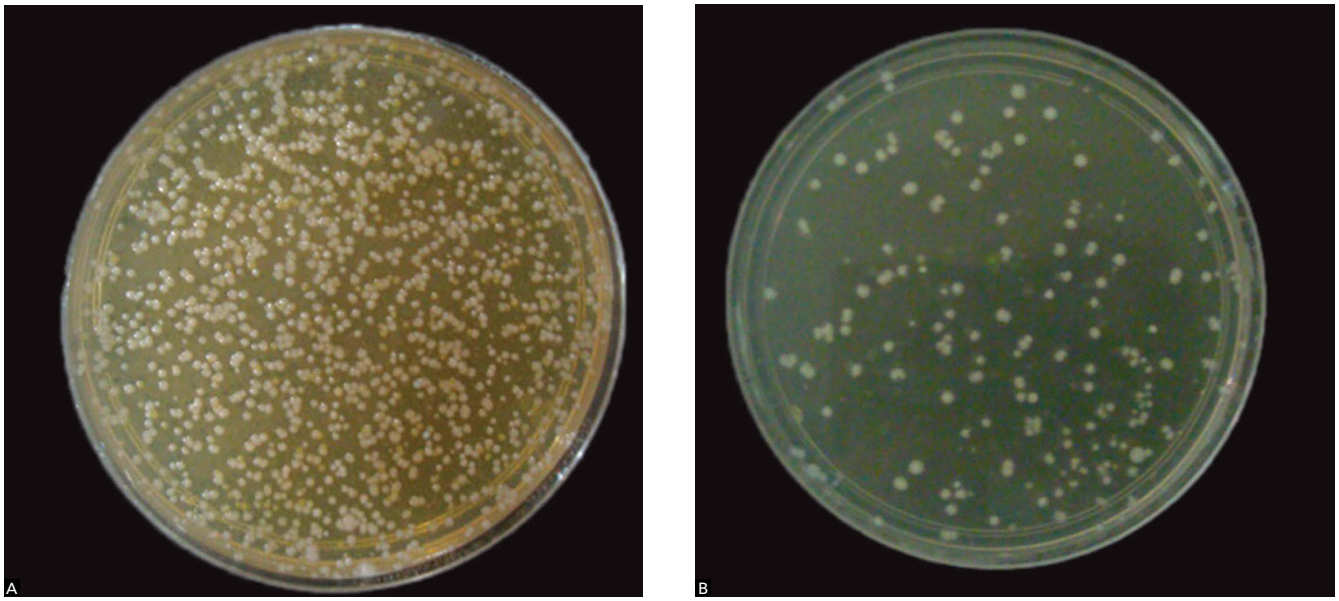


Figure 1 - Dental prophylaxis and sample collection for microbiological analysis with dishes positioned at P1, P2 and P3.

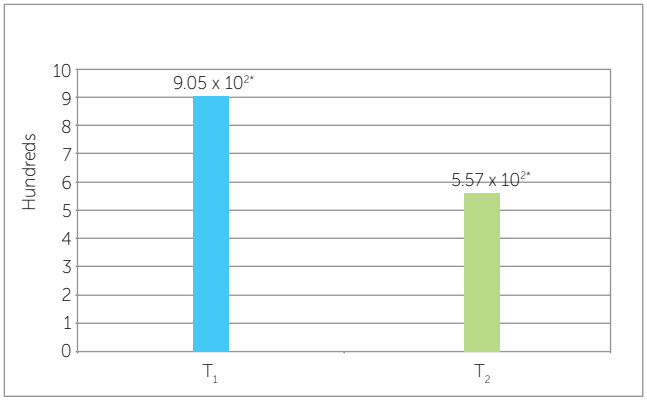


Figure 2 - CFU means generated in dental prophylaxis with sodium bicarbonate spray distributed in T_1 and T_2 ($p<0.001$*). Standard deviation: T_1 = 829.87 and T_2 = 489.02

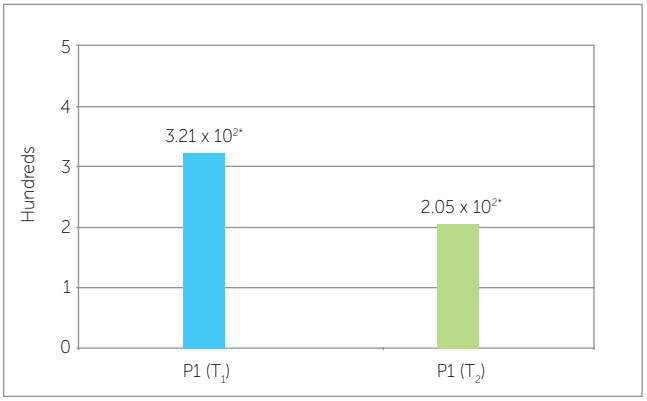


Figure 3 - Comparison of CFU means at P1, in T_1 and T_2. ($p=0.0074$*). Standard deviation P1 (T_1) = 274.79 and P1 (T_2) = 174.34.

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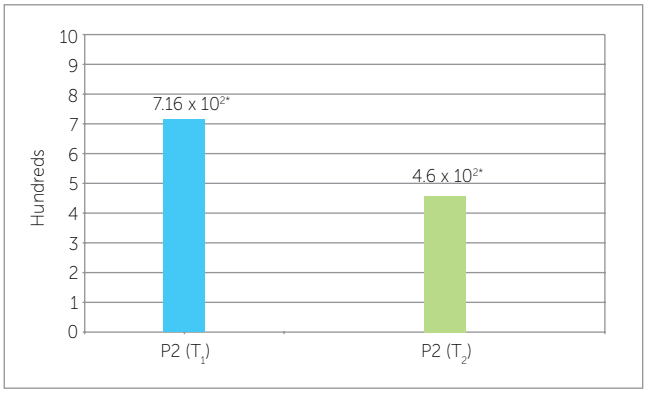


Figure 4 - Comparison of CFU means at P2, in T1 and T2 (p=0.0051*). Standard deviation P2 (T_1) = 351.03 and P2 (T_2) = 226.76.

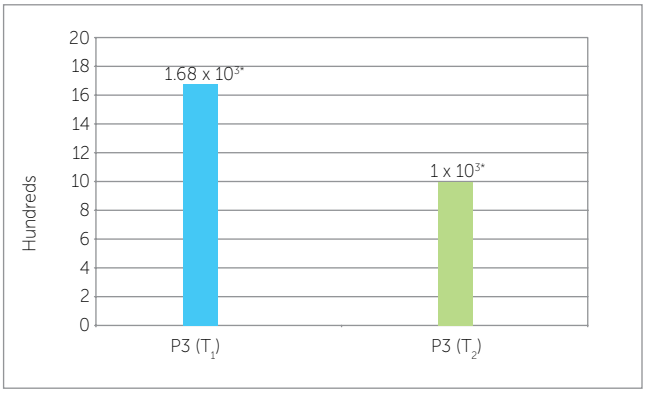


Figure 5 - Comparison of CFU means at P3, in T1 and T2 (p=0.0035*). Standard deviation P3 (T_1) = 953.80 and P3 (T_2) = 554.93.

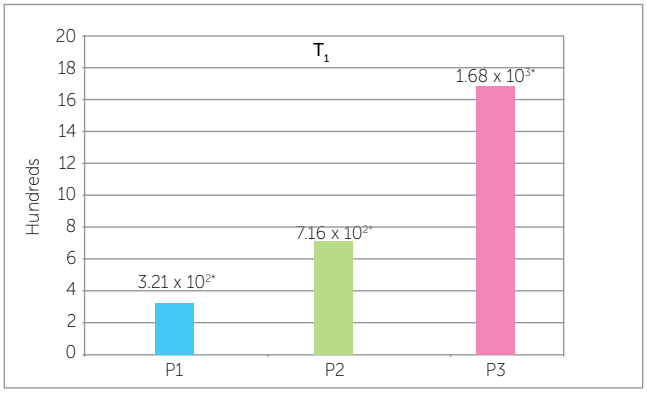


Figure 6 - Comparison of CFU means at P1, P2 and P3, in T_1 (p<0.05*).

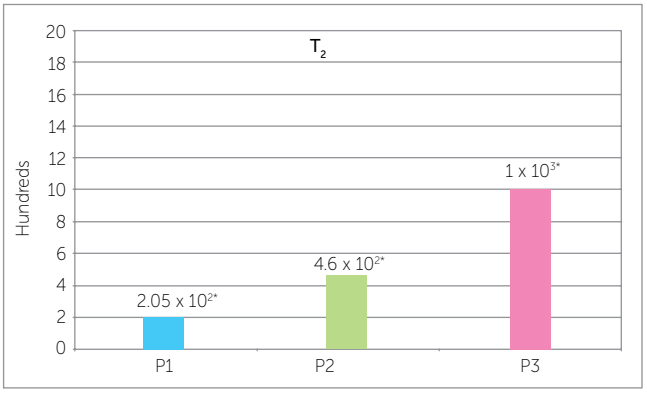


Figure 7 - Comparison of CFU means at P1, P2 and P3, in T_2 (p<0.05*).

However, Keijser et al[22] and Quirynen et al[23] compared the use of 0.12 % and 0.2% chlorhexidine solutions and found that both concentrations decreased contamination and, as a consequence, provided antimicrobial control.

Additionally, other studies have shown that decreasing the concentration and increasing the volume of the solution practically provides the same amount of drug with similar antiplaque effectiveness, but reduced side effects.[22] Thus, mouthwash with 15 mL of chlorhexidine at 0.12% has been used on a large scale. At these concentrations, the recommended time for rinsing is one minute.[20]

This study assessd and compared the clinical efficacy of 0.12 % chlorhexidine solution, used as previous mouthwash for one minute, in reducing contamination in an orthodontic environment. The results of this study reveal that 0.12 % chlorhexidine used as mouthwash ten minutes before dental prophylaxis significantly reduced the CFU number of bacteria present in aerosol produced during prophylaxis of orthodontic patients. This result corroborates the study conducted by Gonçalves et al[12] which assessd, *in vivo*, the contamination generated by aerosol produced by a low-speed handpiece used for dental prophylaxis of non-orthodontic patients. They found a statistically significant reduction in contamination when 0.12 % chlorhexidine was used before the procedure. The additional use of chlorhexidine as a mouthwash 10 minutes before the orthodontic procedure proves to be a favorable alternative to reduce cross-contamination during orthodontic treatment, especially in patients who have poor oral hygiene.

Toroglu et al[24] also conducted a study to assess the efficacy of mouth rinse with 0.12 % chlorhexidine before removing, by means of a handpiece, the excess adhesive material and resin of orthodontic patients. They found that contamination was not significantly reduced, which does not corroborate the present research. The study developed by Toroglu et al[24] did not inform the waiting

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time between the use of 0.12% chlorhexidine and the performance of the procedure.

Chlorhexidine remains active in the mouth where it is slowly released.[25] In the present study, the waiting time of 10 minutes between the mouthwash with 0.12 % chlorhexidine and the prophylaxis procedure proved to be a favorable alternative to reduce cross contamination during orthodontic treatment, especially in patients with poor oral hygiene.

The study conducted by Logothetis & Martinez-Welles[26] compared the use of distilled water and 0.12% chlorhexidine as mouthwash solutions employed 30 minutes before dental prophylaxis to reduce contamination. Their results showed no significant differences, which does not corroborate the present study.

The additional use of an antimicrobial agent such as chlorhexidine may be more effective than mechanical rinsing with distilled water, only. The cationic molecule of chlorhexidine in an oral environment is quickly attracted by the negative charges of bacterial cell surface, which characterizes the bacteriostatic and bactericidal properties of chlorhexidine. Both characteristics are directly related to the concentration of the product.[2,20,22,23] Using low-speed handpiece for dental prophylaxis, Gonçalves et al[12] found an average of 37.2 CFU when comparing prophylaxis with and without previous mouthwash with 0.12 % chlorhexidine.

Studies assessing the amount of aerosol produced by sodium bicarbonate jet used as a method of dental prophylaxis revealed a significant increase of CFU when air/water spray was compared with low-speed traditional prophylaxis.[27,28]

The results yielded by this study revealed high CFU mean (7.31 x 102 CFU). This can be explained by the type of patient selected for the study:Patients undergoing orthodontic treatment tend to have increased biofilm and, as a consequence, increased number of bacteria in the oral cavity. Additionally, it can also be explained by the use of bicarbonate spray which further increases the level of aerosol.

There is a wide variety of studies about the contamination of dental offices, particularly with regard to people directly involved with care.[9,12] Gonçalves et al[12] conducted a study in which they used agar dishes attached to the face of clinicians and assistants, as well as on patient's chest. Results revealed that contamination detected in the clinician resembles that found in the patient's chest.

In the present study, the areas of dish setting were selected so as to include areas where contamination is evident, thus ensuring the reach of the aerosol and the functionality of physical barriers in cross infection control.

CFU means at P3 had significant differences in comparison to P1 and P2 in both phases. The greater the proximity of the working area, the greater the bacterial dissemination.[1] The study by Toroğlu et al[6] assessed the amount of contamination caused by aerosol during removal with handpiece of adhesive material and resin excesses in orthodontic patients. Their results revealed that clinicians should worry about protecting the face, as well as areas of the neck and arms, given that these areas can be easily contaminated by aerosol spray.[6,24]

CONCLUSION

Based on the results of this study it is reasonable to conclude that mouthwash with 0.12 % chlorhexidine performed before prophylaxis procedures significantly reduced contamination caused by aerosol of sodium bicarbonate spray used during dental prophylaxis in patients undergoing orthodontic treatment ($P < 0.001$).

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Discomfort associated with fixed orthodontic appliances: determinant factors and influence on quality of life

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.102-107.oar*

Objective: To investigate the determinant factors of discomfort attributed to the use of fixed orthodontic appliance and the effect on the quality of life of adolescents.

Material and Methods: Two hundred and seventy-two individuals aged between 9 and 18 years old, enrolled in public and private schools and undergoing orthodontic treatment with fixed appliance participated in this cross-sectional study. The participants were randomly selected from a sample comprising 62,496 individuals of the same age group. Data was collected by means of questionnaires and an interview. Discomfort intensity and bio-psychosocial variables were assessed using the Oral Impact on Daily Performance questionnaire. Self-esteem was determined using the Global Negative Self-Evaluation questionnaire. Statistical analysis involved the chi-square test and both simple and multiple Poisson regression analyses.

Results: Although most individuals did not present discomfort, there was a prevalence of 15.9% of impact on individuals' daily life exclusively due to the use of fixed orthodontic appliance . Age [PR: 3.2 (95% CI: 1.2-8.5)], speech impairment [PR: 2.2 (95% CI: 1.1-4.6)], poor oral hygiene [PR: 2.4 (95% CI: 1.2-4.8)] and tooth mobility [PR: 3.9 (95% CI: 1.8-8.1)] remained independently associated with a greater prevalence of discomfort ($P \leq 0.05$).

Conclusions: Discomfort associated with the use of fixed orthodontic appliances exerted a negative influence on the quality of life of the adolescents comprising the present study. The determinants of this association were age, poor oral hygiene, speech impairment and tooth mobility.

Keywords: Adolescent. Orthodontics. Quality of life.

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How to cite this article: Marques LS, Paiva SM, Vieira-Andrade RG, Pereira LJ, Ramos-Jorge ML. Discomfort associated with fixed orthodontic appliances: determinant factors and influence on quality of life. Dental Press J Orthod. 2014 May-June;19(3):102-7. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.102-107.oar

Submitted: April 03, 2013 - **Revised and accepted**: August 31, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Orthodontic treatment can be an uncomfortable experience. Orthodontic appliances are foreign objects inserted into a sensitive area of the body, causing both physical and psychological discomfort.[1] Such discomfort can exert a negative influence on patient's desire to undergo treatment, cooperation and quality of treatment itself.[2] The main factors associated with the discomfort experienced by orthodontic patients are: The type of appliance, amount of force applied in the early stages of treatment, previous experiences with pain and emotional, cognitive and environmental aspects such as culture, sex and age.[2-10]

Thus, depending on the stage, orthodontic treatment may negatively influence patients' quality of life.[11,12] Feu et al[13] have recently conducted a longitudinal study in which they found that patients who had already removed the braces had better indicators of quality of life than those who were still in treatment.[13]

While most studies focus on the operator's point of view, addressing variables such as patient cooperation and adaptability to orthodontic treatment,[2-9] little attention has been given to patients' perception with regard to discomfort.[10] Moreover, a critical analysis of the literature reveals that most studies on patient discomfort during orthodontic treatment address aspects related to pain. Thus, a large number of other variables related to patient's physical and psychological well-being have not been considered. A possible explanation is the fact that most studies do not use adequate tools for assessing the specific impact of the use of an orthodontic appliance on patient's quality of life.

The aim of the present study was to investigate the determinant factors of discomfort attributed to the use of a fixed orthodontic appliance and the effect on the quality of life of adolescents.

MATERIAL AND METHODS

This cross-sectional study was carried out in the Brazilian state of Minas Gerais which has 853 municipalities and is the second most populous state in Brazil, with approximately 20 million inhabitants. Participants were selected from a population of 62,496 individuals aged between 9 and 18 years old. The following inclusion criterion was applied: patient undergoing orthodontic treatment with fixed appliances (braces) for at least six months.

Data were collected from public and private schools of ten different cities (one public school and one private school per city, totaling 20 schools) between October and December, 2010. Both schools and individuals were randomly selected by lots. The number of participants from each city and school was proportional to the actual distribution considering the total number of individuals in this age group residing in the ten cities surveyed. Calculation of sample size was performed using a standard error of 5% or less, 95% confidence interval and 20% prevalence of discomfort associated with the use of orthodontic fixed appliance. The minimal sample size was determined in 246 individuals, to which 20% was added to compensate for potential losses, thus totaling 295 participants.

Discomfort attributed specifically to the use of orthodontic fixed appliances was the dependent variable considered for this study. It was recorded through the Oral Impact on Daily Performances (OIDP) questionnaire answered in the form of an interview.[10] Therefore, any factor associated with another type of discomfort was not included and cannot be considered as a confounding factor. Possible confounding factors such as caries, trauma, gingivitis etc., were controlled, since individuals who reported discomfort associated with some of these conditions did not participate in the statistical analysis of the study. The OIDP is an instrument used to record the impact of oral conditions on an individual's capacity to perform daily activities in the previous six months. This instrument is objective and addresses the main bio-psychosocial consequences of dental problems. For quantification of this variable, the participants were classified as either not experiencing discomfort or experiencing discomfort. Moreover, the total impact per participant was determined considering the frequency and severity of discomfort.

Global Negative Self-Evaluation (GSE) questionnaire was used to assess patient's self-esteem[11]. GSE is a six-item scale. Each item has six response options which are quantified in increasing order from 1 to 6. For classification of self-esteem, the responses of each item are summed up and the result is divided by six, thereby obtaining a self-esteem value which is dichotomized as low self-esteem (scores between 1 and 2.69) and high self-esteem (scores between 2.7 and 6).[10]

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Bivariate analysis (chi-square test) was first performed to determine associations between patient-reported discomfort due to the use of a fixed orthodontic appliance and demographic/ bio-psychosocial variables as well as the specific causes of discomfort ($P \leq 0.05$). The variables that demonstrated a significant association with discomfort were then incorporated into Poison model with robust variance to determine independent associations between predictor variables and discomfort due to the use of a fixed orthodontic appliance. The magnitude of association between each factor and discomfort was determined based on unadjusted and adjusted prevalence ratios (PR), respective confidence intervals (CI = 95%) and p-values (Wald test).

A letter was sent to the adolescents' parents/guardians requesting their participation and explaining the characteristics and importance of the study. An informed consent was required, with no negative consequences for those who refused to participate. This study was approved by the Institutional Review Board of the University Green River Valley (UNINCOR), Brazil.

RESULTS

Two hundred seventy-two individuals participated in the present study (92% response rate). Males accounted for 36% of the sample. The prevalence of impact on daily activities exclusively due to the use of a fixed orthodontic appliance was 15.9%. Only 17.6% of the interviewees reported no impact associated with oral health. The OIDP scores ranged from 0 to 78.5 (mean: 12.8, standard deviation: 9.6; median: 11.6). Among the impacts, 38% were categorized as low-intensity, 20.2% were categorized as moderate-intensity and 13.6% were categorized as severe and very severe-intensity.

Discomfort attributed to the use of fixed orthodontic appliance was significantly associated with difficulties in eating, oral hygiene and speech, as well as tooth mobility, halitosis, impaired taste, and bleeding gingiva (Tables 1 and 2).

DISCUSSION

The results of the present study demonstrate that approximately 16% of participants experienced discomfort due to the use of a fixed orthodontic appliance, which exerted a negative influence on their quality of life.

Table 1 - Association between discomfort reported by patients,due to the use of fixed orthodontic appliance, and demographic/bio-psychosocial variables.

	Discomfort – use of orthodontic appliance		
	Absent n (%)	Present n (%)	p
Age			
9 to 14 years	110 (95.7)	5 (4.3)	< 0.001[C]
15 to 18 years	119 (80.4)	29 (19.6)	
Sexo			
Male	83 (84.7)	15 (15.3)	0.294[C]
Female	155 (89.1)	19 (10.9)	
Difficulty in eating			
No	156 (93.4)	11 (6.6)	< 0.001[C]
Yes	82 (78.1)	23 (21.9)	
Speech impairment			
No	148 (92.5)	12 (7.5)	0.003[C]
Yes	90 (80.4)	22 (19.6)	
Poor oral hygiene			
No	159 (93.0)	12 (7.0)	< 0.001[C]
Yes	79 (78.2)	22 (21.8)	
Difficulty in showing the teeth			
No	185 (87.3)	27 (12.7)	0.825[C]
Yes	53 (88.3)	7 (11.7)	
Difficulty in sleeping			
No	182 (88.3)	24 (11.7)	0.454[C]
Yes	56 (84.8)	10 (15.2)	
Difficulty in maintaining a stable emotional state			
No	201 (87.0)	30 (13.0)	0.564[C]
Yes	37 (90.2)	4 (9.8)	
Difficulty in performing school tasks			
No	198 (85.7)	33 (14.3)	0.035[C]
Yes	40 (97.6)	1 (2.4)	
Difficulty to get along with friends			
No	217 (86.8)	33 (13.2)	0.330[F]
Yes	21 (95.5)	1 (4.5)	

[C], Pearson's chi-square test – [F] Fisher's exact test

Thus, identifying determinants of this discomfort and understanding how such factors affect the physical and psychological well-being of individuals who wear braces can enhance the odds of achieving successful orthodontic treatment.[4]

Perception and intensity of discomfort are directly associated with the individual characteristics of each patient, namely: self-esteem, self-confidence, treatment compliance, expectations, perception of dental esthetics and severity of the malocclusion.[4,16] Self-esteem did not affect the occurrence of discomfort in the present study, but the literature offers evidence that self-confidence

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Table 2 - Bivariate analysis of association between discomfort reported by patients due to the use of fixed orthodontic appliance and specific causes of discomfort

	Discomfort – use of orthodontic appliance		
	Absent n (%)	Present %)	*p*
Pain			
No	171 (85.5)	29 (14.5)	0.096[C]
Yes	67 (93.1)	5 (6.9)	
Missing tooth			
No	230 (87.5)	33 (12.5)	1.000[F]
Yes	8 (88.9)	1 (11.1)	
Tooth mobility			
No	228 (90.8)	23 (9.2)	< 0.001[F]
Yes	10 (47.6)	11 (52.4)	
Position of teeth			
No	224 (88.2)	30 (11.8)	0.257[F]
Yes	14 (77.8)	4 (22.2)	
Shape/size of teeth			
No	228 (87.4)	33 (12.6)	1.000[F]
Yes	10 (90.9)	1 (9.1)	
Deformity of mouth/face			
No	236 (88.1)	32 (11.9)	0.078[F]
Yes	2 (50.0)	2 (50.0)	
Blisters			
No	182 (87.1)	27 (12.9)	0.704[C]
Yes	56 (88.9)	7 (11.1)	
Sensation of dry mouth			
No	220 (86.6)	34 (13.4)	0.141[F]
Yes	18 (100)	0	
Halitosis			
No	226 (90.8)	23 (9.2)	< 0.001[C]
Yes	12 (52.2)	11 (47.8)	
Impaired taste			
No	235 (89.7)	27 (103)	< 0.001[F]
Yes	3 (30)	7 (70)	
Halitosis			
No	226 (89.7)	26 (10.3)	0.001[F]
Yes	12 (60.0)	8 (40.0)	
Gingival bleeding			
No	220 (92.1)	19 (7.9)	< 0.001[F]
Yes	18 (54.5)	15 (45.5)	
Gingival recession			
No	235 (87.4)	34 (12.6)	1.000[F]
Yes	3 (100)	0	
Difficulty opening the mouth			
No	237 (87.5)	34 (12.6)	1.000[F]
Yes	1 (100.0)	0	
Self-esteem (n=271)			
High	215 (88.5)	28 (11.5)	0.137[F]
Low	22 (78.6)	6 (21.4)	

[C], Pearson's chi-square test – [F] Fisher's exact test

Table 3 - Simple and multiple Poisson regression analysis of association between discomfort due to the use of orthodontic appliance, and bio-psycho-social variables.

	Unadjusted Rate ratio			Adjusted Rate ratio		
	PR	(IC 95%)	p*	PR	(IC 95%)	p**
Age (n = 263)						
9 to 14 years	1.0	(1.8; 11.7)	0.002	1.0	(1.2; 8.5)	0.020
15 to 28 years	4.5			3.2		
Difficulty in eating						
No	1.0	(1.6; 6.7)	0.001			
Yes	3.3					
Speech impairment						
No	1.0	(1.2-4.9)	0.012	1.0	(1.1; 4.6)	0.032
Yes	2.4			2.2		
Poor oral hygiene						
No	1.0	(1.6; 6.4)	0.001	1.0	(1.2; 4.8)	0.018
Yes	3.2			2.4		
Difficulty in performing school tasks						
No	1.0	(0.0; 1.2)	0.074			
Yes	0.2					
Pain						
No	1.0	(0.2; 1.3)	0.143			
Yes	0.5					
Tooth mobility						
No	1.0	(2.7; 11.3)	< 0.001	1.0	(1.8; 8.1)	< 0.001
Yes	5.5			3.9		
Halitosis						
No	1.0	(2.4; 10.2)	< 0.001			
Yes	4.9					
Impaired taste						
No	1.0	(1.8; 8.7)	0.001			
Yes	3.9					
Gingival bleeding						
No	1.0	(2.8; 10.8)	< 0.001			
Yes	5.5					
Deformity of mouth/face						
No	1.0	(0.9; 16.8)	0.056			
Yes	4.0					
Self-esteem (n=271)						
High	1.0	(0.7; 4.3)	0.195			
Low	1.8					

* Simple Poisson regression ** Multiple Poisson regression.

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may be affected not only by limitations to speech, but also to visibility of braces, especially during social interactions in which attention is focused on the face and mouth.[4] It is noteworthy that adolescent patients whose reasons for seeking orthodontic treatment are mainly guided by the perception of their appearance feel more as the center of attention among their friends and acquaintances during treatment.[8,15,16,17]

An interesting, unexpected finding of the present study was the lack of association between pain and discomfort. Tooth movement produced by orthodontic appliances causes discomfort and it has been reported that the fear of pain is a key factor dissuading patients from seeking orthodontic treatment.[18] On the other hand, pain during treatment gradually increases within 4 to 24 hours after adjusting the appliance, but returns to normal by the seventh day.[2,19,20,21] Thus, patients can adapt to pain and discomfort with the progression of treatment, as the sensations either stop completely or at least cease to be the focus of attention. This is a possible explanation for the fact that patients of the present study did not cite pain as exerting a negative influence on their quality of life. Moreover, all participants had been undergoing orthodontic treatment for at least six months. This finding could favor the clinical conduct of orthodontists, as future patients should be informed about how and to what extent orthodontic treatment can affect their physical and psychological well-being.

Another aspect concerning pain is the magnitude of force associated with the orthodontic arch, especially during the early phases of treatment. Classical histological studies suggest that light forces are more biologically efficient and less traumatic during orthodontic tooth movement.[12,16] Moreover, the greater the degree of initial crowding, the more teeth will be actively incorporated by the orthodontic archwire and the greater the potential for high degrees of force.[2]

Younger patients demonstrated greater tolerance and adaptation to discomfort caused by fixed orthodontic appliances. This result corroborates findings described in previous studies,[3,20,21] but differs from the findings reported in another study.[2] Such differences may be related to cultural aspects and study design.

Poor oral hygiene, speech impairment and tooth mobility also exerted a negative effect on the daily activities of participants.[17] These findings demonstrate that orthodontists should not overlook the discomfort experienced by wearers of fixed orthodontic appliances and highlight the need for effective orthodontist-patient communication.

Confounding factors, such as blisters, caries and halitosis, were controlled. The dependent variable was discomfort exclusively associated with the use of fixed appliances. Individuals who reported more than one type of discomfort besides the use of the appliance were not included in the statistical model. Further studies, especially those of prospective nature, are necessary to investigate the critical stages of the negative interference of the use of the appliance on the quality of life of individuals.

CONCLUSIONS

1. Discomfort associated with the use of fixed orthodontic appliances exerted a negative influence on the quality of life of the adolescents of the present study.

2. The determinants of this association were: Age, poor oral hygiene, speech impairment and tooth mobility.

ACKNOWLEDGMENTS

The authors wish to thank the Brazilian fostering agencies National Council for Scientific and Technologic Development (CAPES) and State of Minas Gerais Research Foundation (FAPEMIG) for financial support.

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Relationship between facial morphology, anterior open bite and non-nutritive sucking habits during the primary dentition stage

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.108-113.oar*

Introduction: Non-nutritive sucking habits (NNSHs) can cause occlusal alterations, including anterior open bite (AOB). However, not all patients develop this malocclusion. Therefore, the emergence of AOB does not depend on deleterious habits, only.

Objective: Investigate a potential association between non-nutritive sucking habits (NNSHs), anterior open bite (AOB) and facial morphology (FM).

Methods: 176 children in the primary dentition stage were selected. Intra and extraoral clinical examinations were performed and the children's legal guardians were asked to respond to a questionnaire comprising issues related to non-nutritive sucking habits (NNSHs).

Results: A statistically significant relationship was found between non-nutritive sucking habits (NNSHs) and anterior open bite (AOB). However, no association was found between these factors and children's facial morphology (FM).

Conclusions: Non-nutritive sucking habits (NNSHs) during the primary dentition stage play a key role in determining anterior open bite (AOB) malocclusion regardless of patient's morphological facial pattern (FM).

Keywords: Open bite. Face. Primary dentition.

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Submitted: April 03, 2013 - **Revised and accepted**: August 12, 2013

How to cite this article: Fialho MPN, Pinzan-Vercelino CRM, Nogueira RP, Gurgel JA. Relationship between facial morphology, anterior open bite and non-nutritive sucking habits during the primary dentition stage. Dental Press J Orthod. 2014 May-June;19(3):108-13. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.108-113.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION AND LITERATURE REVIEW

Much has been published about facial morphology (FM) analysis.[1,2,3] Orthodontic diagnosis on children requires not only proper occlusal and model analyses, but also a thorough assessment of facial configuration for growth prediction. In most cases, growth assessment means advancing a prognosis and, as a consequence, reducing the need for a more complex treatment in future.[4]

Anterior open bite (AOB) is one of the most common malocclusions in the primary dentition, and non-nutritive sucking habits (NNSHs) are among its etiologic factors.[1,5-9] Continuous thumb and pacifier sucking habits hinder proper teeth and alveolar processes development, especially in the anterior region.[10]

Long-facial morphology (dolichofacial) is closely associated with the development of AOB due to counterclockwise rotation of the mandible and consequent lip incompetence.[10]

AOB is the most prevalent malocclusion in primary dentition.[2,10-13] It is very often associated with the presence of NNSHs,[6,7,8] however, it tends to self-correct when the habit is eliminated at an early stage.[14]

To this day, the effect of facial morphology (FM) on growing patients with complete primary dentition and NNSH is seldom found in the orthodontic literature.[15] Most studies focusing on the association between facial morphology and AOB — with or without NNSH — consider patients in the mixed dentition stage.[11,16,17]

In 2004, Katz et al[1] examined 4-year-old children in the primary dentition stage to assess the relationship between NNSHs, FM and malocclusions. The authors found no association between facial morphology and malocclusion.

Despite the strong correlation between NSSHs and AOB,[18-22] not all children develop this malocclusion of which determinant factors are NNSH-related (duration, frequency and intensity) as well as patient-related (alveolar resistance and growth pattern). In light of a notorious lack of studies focusing on patients in the primary dentition stage, the aim of this study was to test the null hypothesis that there is no relationship between facial morphology (FM), anterior open bite (AOB), and non-nutritive sucking habits (NNSH).

MATERIAL AND METHODS

This cross-sectional study was conducted with subjects randomly selected from a population of children attending elementary schools in the city of São Luís, Brazil. The sample comprised 176 children with primary dentition (96 females and 80 males) aged between 3 and 6 years old (mean age: 4.9 years, maximum age, 6.8 years and minimum age, 2.1 years). The sample was divided into two groups: Group 1 consisting of children with NNSHs, and group 2 comprising children without any history of NNSHs.

The following inclusion criteria were applied: Children in the primary dentition stage; presence of all primary teeth; absence of extensive caries; no significant anomalies of tooth shape or size; no history of previous orthodontic treatment; NNSH and non-NNSH patients. Additionally, children's legal guardians were required to sign an informed consent form. The exclusion criterion was the absence of the habit, only. This study was approved by the Institutional Review Board of CEUMA University under protocol nº 00785/10.

The study was conducted in three major phases. At first, school principals were presented with the permits issued by the City Health Department, the children were selected according to the inclusion criteria and a second meeting was scheduled with the guardians. Secondly, the children's legal guardians were provided with detailed information about the study, its purpose and how the children would be examined. Thereafter, an informed consent form was signed by those who agreed with the research. NNSH data were collected by means of a questionnaire answered by the children's legal guardians. The questionnaire was applied individually by the researcher herself. Thirdly, the study was geared towards examining the children both intra and extraorally by means of an individual clinical assessment. Intraoral examination was performed under natural light with the child positioned in front of the examiner with their dental arches positioned in centric relation. The examiner was previously calibrated and during clinical examination, had no access to the questionnaire that provided information about the children's sucking habits (blinded).

A flexible ruler was used to assess overbite. Measurements were taken from the incisal edge of the maxillary right central incisor to the incisal edge

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of the lower right central incisor. Children with negative overbite and linear measurement greater than 1 mm were deemed to have anterior open bite (AOB).

Extraoral examination was conducted to determine the children's facial morphology (short face, balanced face or long face). The Facial Morphologic[23] index (FMI) was applied based on the ratio between morphological facial height (MFH) and bizygomatic distance (BD) established by means of the following formula: FMI = MFH/BD. Morphological facial height was determined based on the linear distance between the nasion and gnathion, and the bizygomatic distance between the zygomatic points (Fig 1).

A digital caliper (Mitutoyo Digimatic Caliper 200mm/.0005 "- 8"; cat. No. 500 - 147B; Battery: SR44, serial number: BH012006 - Suzano - São Paulo - Brazil) was used for extraoral measurements. Based on the values obtained, children's facial morphology was then classified into short face (< 83.9), balanced face (84.0 to 87.9) and long face (≥ 88.0).[1,23]

To ensure reliability, 36 children were randomly selected and re-assessed after 4 weeks. Numeric variables (bizygomatic distance, morphological facial height and overbite) were remeasured and the difference between the first and second measurements was determined. Dependent Student's t test was applied to assess the significance of differences observed between the two measurements, thereby revealing systematic error, according to Houston.[24] To assess random error, Dahlberg's formula[25] was employed ($Se^2=åd^2/2n$).

Qualitative variables were described by absolute (n) and relative (%) frequencies. The *overbite* variable was described by mean and standard deviation.

To investigate the association between sucking habit and variable AOB, sucking habit and facial morphology, as well as the association between FM, AOB and NNSH, chi-square test was applied. Additionally, when the smallest expected frequency was less than or equal to 5, Fisher's Exact Test was applied.

Relationships were also expressed by odds ratio with confidence interval set at 95%.

One-way analysis of variance (ANOVA) was applied to compare AOB severity between the different facial types.

Level of significance was set at 5% ($p < 0.05$) for all tests. Statistical analyses were performed with Statistica version 5.1 software (StatSoft Inc., Tulsa, USA).

RESULTS

The error of the method results revealed reproducibility of measurements, since there were no systematic or random errors (Table 1).

A statistically significant association was found between NNSHs and the presence of AOB (Table 2). Nevertheless, there was no association between FM and AOB (Table 3).

Overall, children's FM showed no significant association with AOB malocclusion even in the presence of NNSHs. Children with balanced face and with NNSHs had the greatest percentages of AOB, followed by short-faced children (Table 4).

Among children with AOB, those with a short face had more severe anterior open bite, followed by those with a balanced face, and finally, a short face. No statistically significant difference was found between facial morphology and AOB severity (Table 5).

Finally, test power was applied, since no sample size calculation was performed at baseline to validate the results. Test power results showed that the study sample (n = 176) had 80% power to detect a difference of 22 percentage points in the association test between two variables.

DISCUSSION

This study was conducted with a sample of children in the complete primary dentition stage, given that AOB malocclusions often occur during this period. Moreover, only a few studies have focused on this phase of occlusion development, since most researches associating habits with malocclusions focus on the mixed dentition stage.[11,16,17] In addition, studies about facial morphology are scarce both in the mixed dentition and primary dentition stages,[4] particularly those seeking to correlate facial morphology with the presence of non-nutritive sucking habits and anterior open bite.[1]

In Dentistry and other healthcare areas, there is an ongoing concern about the radiation doses applied to patients. Recent studies have been conducted to assess the acceptable doses employed in the different imaging methods[26] with the purpose of reducing radiation in humans. Great emphasis has been given to facial analysis. Morphological facial index is a method used to classify facial patterns (facial morphology) without the need to expose the child to unnecessary radiation.

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Table 1 - Error of the method - results of paired t test and Dahlberg's formula.[25]

Occlusal Indexes	1st Measurement Mean ± SD	2nd Measurement Mean ± SD	p	Dahlberg
Bizygomatic distance	100.17 ± 5.08	100.11 ± 5.14	0.10	0.13
Morphological facial height	84.32 ± 3.88	84.30 ± 3.87	0.26	0.08
Overbite	0.58 ± 2.65	0.57 ± 2.64	0.25	0.04

*Statistically significant: p < 0.05

Table 2 - Association between non-nutritive sucking habits and anterior open bite.

Groups	No AOB		AOB		Odds ratio (IC 95%)	
	n	%	n	%		
NNSH	16	40.0	24	60.0	40	Reference
No NNSH	133	97.8	3	2.2	136	66.50 (17.99 - 245.80)
Total	149	84.7	27	15.3	176	
c2 = 79.49; p < 0.00*						

*Statistically significant: p < 0.05

Table 3 - Association between facial morphology and anterior open bite.

Morphology	No AOB		AOB		Total	*Odds ratio* (IC 95%)
	n	%	n	%		
Short face	56	84.8	10	15.2	66	Reference
Balanced face	46	83.6	9	16.4	55	0.91 (0.34 - 2.44)
Long Face	47	85.4	8	14.6	55	0.87 (0.31 - 2.45)
Total	149	84.7	27	15.3	176	
c2 = 0.07; p = 0.96						

*Statistically significant: p< 0.05

Table 4 - Association between NNSHs, AOB and facial morphology.

Deleterious habit and facial morphology	No AOB		AOB		Total	*Odds ratio* (IC 95%)
	n	%	n	%		
NNSH and short face	6	37.5	10	62.5	16	Reference
NNSH and balanced face	5	35.7	9	64.3	14	0.93 (0.21 - 4.11)
NNSH and long face	5	50.0	5	50.0	10	0.56 (0.11 - 2.90)
Total	16	40.0	24	60.0	40	
c2 = 0.57; p = 0.75						

*Statistically significant: p< 0.05

Table 5 - Comparison among the three facial morphology patterns in terms of overbite in children with AOB, expressed in mm.

	Negative overbite	
Facial morphology	Mean ± SD	p
Balanced face	-3.67 ± 2.00	0.33
Short face	-4.80 ± 1.75	
Long Face	-3.63 ± 2.00	
ANOVA: F = 1.15		

*Statistically significant: p< 0.05

For this reason, it was employed in the present study. It should be added that other studies[1,2] with similar methods were also conducted in the primary dentition stage and previously published in the literature using morphological facial index.

Results yielded with children with non-nutritive sucking habits reveal a 60% occurrence of AOB, which corroborates the values obtained by Sousa et al[2]

(63.4%), but are nowhere near the values found by Katz et al[1] (35.5%). Other authors also found a positive relationship for the NNSH / AOB ratio.[6-8,19-21]

Results revealed no association between facial morphology, NNSHs and AOB. It is speculated that, although NNSHs act as etiological factors of malocclusions,[5-8] facial morphology does not interfere in this process as a facilitating factor in the emergence of this malocclusion during primary dentition.[1]

Katz et al[1] reported that the different types of facial morphology and NNSHs produce independent effects on malocclusions. Among these is AOB which should therefore be studied separately. These authors[1] endorse the idea that genetic factors seem to play a less important role than commonly believed, and that many types of malocclusions are actually acquired rather than inherited. However, Cozza et al[11] refute this idea, stating that chronic non-nutritive sucking habits and the characteristics of facial hyperdivergence (long face) pose significant risks for the development of AOB when occurring together. It should be emphasized, however, that in the aforesaid study[11] assessments were performed based on the cephalograms of children with a mean age of 9 years and 3 months, and in the mixed dentition stage, which differs from the sample used in the present study.

In this study, it was observed that among all children presenting with AOB, 14.6% had long face pattern, 15.2% short face, and 16.4% balanced face. Thus, the fact that patients with long face exhibited the lowest values in determining the onset of AOB shows an independent relationship between the presence of AOB and long face morphology, as well as other morphologies, in agreement with the results of Katz et al[1] and Sousa et al,[2] who applied a methodology that was similar to the one used in this study.

None of the types of facial morphology was prevalent, given that the values of 31.25%, 37.5% and 31.25% found for the balanced face, short face and long face, respectively, showed no statistically significant differences. This contrasts with the findings of Sousa et al[2] and Silva Filho et al[15] who argue that balanced face is the predominant pattern. It is believed that this difference in outcomes may be related to the fact that their investigation was carried out in different regions and in populations with different morphological characteristics.

With regard to the relationship between AOB severity and facial morphology, short-faced children exhibited the highest values of negative overbite, followed by balanced-faced, and long-faced children (Table 5). NNSH duration is of paramount importance in determining AOB emergence.[19] The literature shows that factors such as NNSH duration, frequency and intensity affect AOB severity.[17] This finding probably explains the higher values of negative overbite observed in short-faced children.

CONCLUSIONS

According to the methods applied in this study and after careful analysis of results, it seems reasonable to conclude that non-nutritive sucking habits (NNSHs) during the primary dentition stage play a key role in determining anterior open bite (AOB) malocclusion regardless of morphological facial pattern.

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Comparison of frictional resistance between self-ligating and conventional brackets tied with elastomeric and metal ligature in orthodontic archwires

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.114-119.oar*

Objective: To compare the frictional resistance between self-ligating and conventional brackets tied to different types of wire.

Material and Methods: Abzil Kirium Capelozza (Pattern I) and Easy Clip (Roth prescription) incisor brackets were used. An elastomeric ligature or a ligating wire 0.10-in was used to ligate the wire to the Abzil bracket. Three types of orthodontic archwire alloys were assessed: 0.016-in NiTi wire, 0.016 x 0.021-in NiTi wire and 0.019 x 0.025-in steel wire. Ten observations were carried out for each bracket-archwire angulation combination. Brackets were mounted in a special appliance, positioned at 90 degrees in relation to the wire and tested in two angulations. Frictional test was performed in a Universal Testing Machine at 5 mm/min and 10 mm of displacement. The means (MPa) were submitted to ANOVA and Tukey's test set at 5% of significance. The surfaces of wires and brackets were observed at SEM.

Results: Steel-tied brackets (16.48 ± 8.31) showed higher means of frictional resistance than elastomeric-tied brackets (4.29 ± 2.16) and self-ligating brackets (1.66 ± 1.57) ($P < 0.05$), which also differed from each other ($P < 0.05$). As for the type of wire, 0.019 x 0.025-in steel wire (5.67 ± 3.97) showed lower means ($P < 0.05$) than 0.16-in NiTi wire (8.26 ± 10.92) and 0.016 x 0.021-in NiTi wire (8.51 ± 7.95), which did not differ from each other ($P > 0.05$). No statistical differences ($P > 0.05$) were found between zero (7.76 ± 8.46) and five-degree (7.19 ± 7.93) angulations.

Conclusions: Friction was influenced not only by the type of bracket, but also by the ligating systems. Different morphological aspects were observed for the brackets and wires studied

Keywords: Dental brackets. Wires. Friction. Self-ligating.

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How to cite this article: Leite VV, Lopes MB, Gonini Júnior A, Almeida MR, Moura SK, Almeida RR. Comparison of frictional resistance between self-ligating and conventional brackets tied with elastomeric and metal ligature in orthodontic archwires. Dental Press J Orthod. 2014 May-June;19(3):114-9. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.114-119.oar

Submitted: April 14, 2011 - **Revised and accepted:** March 14, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Orthodontic sliding mechanics is one of the most common methods of translating a tooth in a mesiodistal way, i.e., with canine or anterior retraction. In this technique, tooth movement can be accomplished by free body movement or by guidance of a tooth along an archwire.[2] The major disadvantage of this last mechanism is friction generated between the bracket and the archwire, which tends to resist movement of the bracket and tooth in the desired direction.[2]

Friction is only one part which resistance to movement consists of when a bracket slides along an archwire.[4,9] It is determined by the type and size of the archwire, type of bracket, angulation between the archwire and the bracket slot and the method of ligation. Since this force operates in the opposite direction of the mobile body, it is important that it be eliminated or minimized when orthodontic tooth movement is being planned,[2,8,27] otherwise it may delay tooth movement, increase anchorage requirement, or both.[6,21]

Tooth movement can occur when applied forces adequately overcome friction at the bracket slot-archwire interface.[22] Should a high level of frictional force between the bracket slot and the archwire occur, it might cause binding between the two components and result in little or no tooth movement.[14]

Several "friction-free" brackets, such as the self-ligating ones, have been recently developed.[6] They consist of a preadjusted appliance with a mechanical device built into the bracket in order to close off the bracket slot.[14] This ligatureless bracket system has the advantage of reducing chair time, promoting better oral hygiene and low frictional resistance due to better sliding mechanics.[14,15,26] In addition, it may eliminate potential chances of soft tissue laceration caused by the use of stainless steel wires.[24]

Different experimental methods have demonstrated significant decrease in friction with self-ligating brackets in comparison to conventional ones.[14] Thus, this article aims at assessing frictional resistance and the influence of angulation in the bracket-archwire interface by means of using different types of wires.

MATERIAL AND METHODS

The following maxillary central incisor brackets (angulation 5°) were used in the study: Conventional preadjusted brackets with a slot of 0.022 x 0.030-in Abzil Kirium Capelozza prescription- pattern I- (3M Unitek, São José do Rio Preto, SP, Brazil), self-ligating brackets with a slot of 0.022 x 0.027-in (Roth prescription) (Aditek, Cravinhos, SP, Brazil). It is worth noting that the type of bracket and wires used for this study were made available from a previously published research.[4] Furthermore, the orthodontic brackets assessed in the present study represent the brackets most widely used by clinicians nowadays.

An elastomeric ligature (3M Unitek) or a 0.10-in ligating wire was used for archwire ligation in the Abzil bracket. Three types of orthodontic archwire alloys were evaluated: 0.016-in NiTi wire, 0.016 x 0.021-in NiTi wire and 0.019 x 0.025-in stainless steel wire (Damon Universal, Ormco Corp., Orange, CA, USA). The brackets used on the right side had 0.022-in slots. Ten observations were carried out for each bracket-archwire combination. Each archwire sample was drawn only once through a bracket. Thus, 180 bracket-archwire readings were taken for the study.

The frictional test was carried out in a special appliance (Fig 1) consisting of a base, in which the brackets bonded in the acrylic cylinder with cyanoacrylate adhesive (Superbonder gel, Loctite, Itapevi, SP, Brazil) were positioned at 90 degrees to the wire; and a mobile part

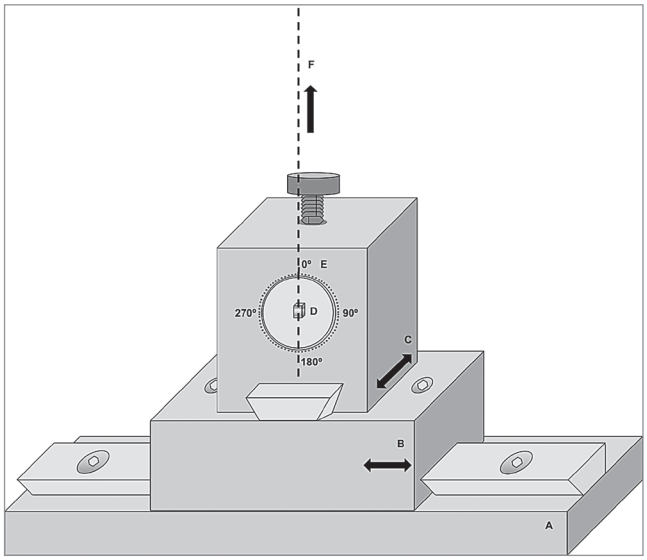


Figure 1 - Testing appliance design: base locked to the testing machine (**A**), horizontal movable bases for bracket/wire alignment (**B** and **C**), bracket bonded to plastic pedestal (**D**), 360-degree display (**E**) and wire specimen attached to the load cell (**F**).

where the wire was fixed. The appliance was mounted in a Universal Testing Machine (DL2000, Emic, São José dos Pinhais, PR, Brazil) and tested at 5 mm/min using 10 mm of displacement for all specimens[23] at zero and five-degree angulations (Fig 1) with a load cell of 50 Kgf. The maximum values for each test were recorded. Means (MPa) were submitted to ANOVA and Tukey's test set at 5% of significance.

In addition, the surfaces of wires and brackets were observed at a Scanning Electron Microscope (SSX-550, Shimadzu, Tokyo, Japan) before and after testing.

RESULTS

When the groups were analyzed according to the type of bracket, steel-tied brackets (16.48 ± 8.31) showed higher means, followed by elastomeric-tied brackets (4.29 ± 2.16) and self-ligating brackets (1.66 ± 1.57) All groups showed statistical differences ($P < 0.05$) when compared to each other (Table 1). When the type of wire was analyzed, 0.019 x 0.025-in stainless steel wire (5.67 ± 3.97) showed lower means, with statistical difference ($P < 0.05$) in comparison to 0.16-in NiTi wire (8.26±10.92) and 0.016 x 0.021-in NiTi wire (8.51 ± 7.95), which did not differ from each other (Table 2). When angulation was analyzed, no statistical differences ($P > 0.05$) were found between zero (7.76 ± 8.46) and five (7.19 ± 7.93) degrees (Table 3). The results of combined factors, type of bracket, type of wire and angulation are shown in Table 4.

Electronic microscopic analysis of wires showed a rougher surface for NiTi wires (Figs 2A and 2C) in comparison to stainless steel ones (Fig 2E) before sliding. The stainless steel wire seemed to have a smoother surface, but after sliding, it revealed wear tracks (Fig 2F). These tracks were more evident in Nitinol wires (Figs 2B and 2D) after sliding. Analysis of bracket surfaces showed a poorly polished surface for conventional (Figs 3A and 3B) and self-ligating ones (Figs 3C and 3D).

Table 1 - Means (MPa) and standard deviation of bracket type.

Steel-tied	**16.48 ± 8.31[a]**
Elastomeric-tied	4.29 ± 2.16[b]
Self-ligating	1.66 ± 1.57[c]

Different lower-case letters in the column indicate significative difference ($P < 0.05$)

Table 2 - Means (MPa) and standard deviation of wire type.

0.016-in NiTi wire	8.26 ± 10.92a
0.016 x 0.021-in NiTi wire	8.51 ± 7.95[a]
0.019 x 0.025-in Stainless Steel wire	5.67 ± 3.97[b]

Different lower-case letters in the column indicate significant difference ($P < 0.05$)

Table 3 - Means (MPa) and standard deviation of bracket angulation.

0°	7.76 ± 8.46a
5°	7.19 ± 7.93[a]

Different lower-case letters in the column indicate significant difference ($P < 0.05$)

Table 4 - Means (MPa) and standard deviation of the type of bracket, wire and angulation.

	0.016-in NiTi wire		**0.016 x 0.021-in NiTi wire**		**0.019 x 0.025-in stainless steel wire**	
	0°	**5°**	**0°**	**5°**	**0°**	**5°**
Steel-tied	22.72 ± 9.28[bB]	19.10 ± 11.57[bB]	15.54 ± 5.33[abB]	21.28 ± 4.92[bB]	9.18 ± 2.32[aB]	11.05 ± 0.71[aB]
Elastomeric-tied	3.82 ± 1.83[aA]	3.77 ± 1.34[aA]	5.57 ± 1.73[aA]	4.03 ± 2.00[aA]	2.41 ± 0.57[aA]	6.15 ± 2.82[aAB]
Self-ligating	0.08 ± 0.08[aA]	0.06 ± 0.06[aA]	2.46 ± 0.94[aA]	2.17 ± 0.96[aA]	2.94 ± 1.87[aAB]	2.28 ± 1.39[aA]

According to Tukey's test, different lower-case letters in the column or different upper-case letter in the line referring to the same material indicate significant difference ($P < 0.05$).

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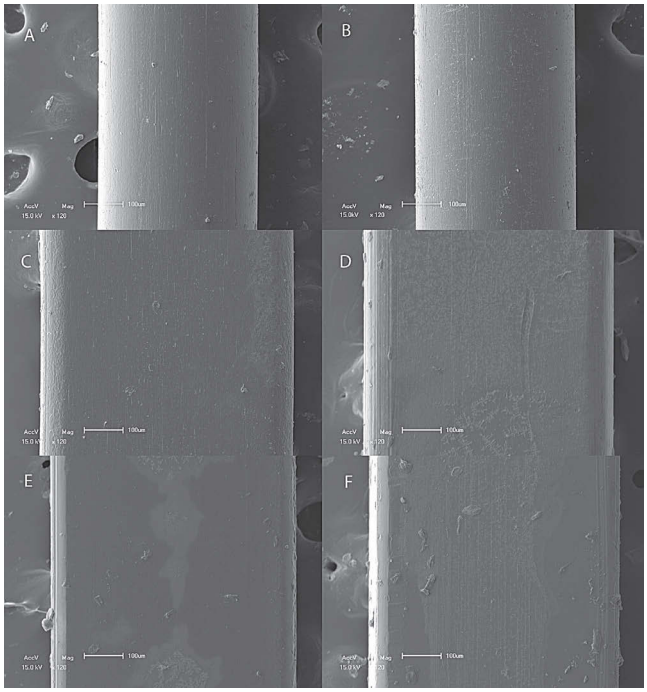


Figure 2 - Wires before and after friction, respectively: 0.016-in NiTi wire (**A** and **B**), 0.016 x 0.021-in NiTi wire (**C** and **D**) and 0.019 x 0.025-in stainless steel wire (**E** and **F**).

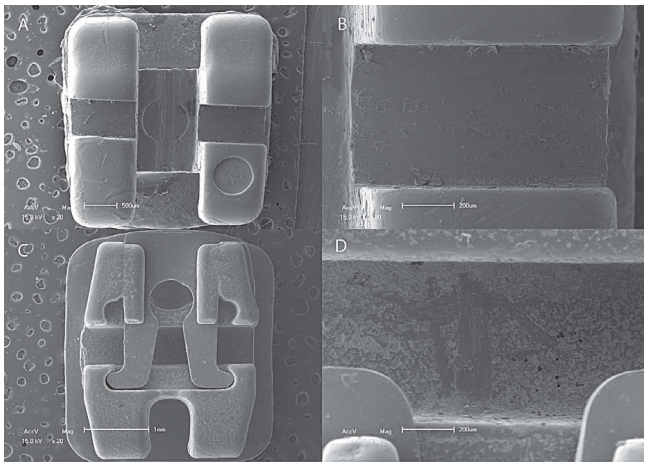


Figure 3 - Steel and elastomeric-tied brackets (**A**), magnified slot (**B**); self-ligating bracket (**C**), magnified slot (**D**).

DISCUSSION

To date, there are two different types of self-ligating brackets available: Active brackets, which feature a spring clip actively pressing against the archwire; and passive brackets, of which self-ligating clip does not press the wire.[23] The present laboratory study was designed to compare friction produced by a passive self-ligating bracket and a conventional metal bracket with different wire dimensions and angulations.

Conventional ligation methods (stainless steel ligature wires or polymeric O-rings) apply force to the archwire pushing it against the depth of the slot, thus, increasing friction.[7] Conversely, passive self-ligating brackets are characterized by the presence of a fourth mobile wall that converts the slot into a tube, allowing the wire to freely move inside the bracket slot, thus, reducing friction levels.[11]

This could be observed in the present study in which self-ligating brackets showed lower friction resistance in comparison to steel-tied and elastomeric-tied brackets, as demonstrated by Hain et al.[12] Elastomeric-tied brackets showed lower friction in comparison to steel-tied ones, thereby corroborating the findings by Bazakidou et al.[1] This would be due to the lack of tight contact, as shown by a steel or elastomeric bracket tied around the archwire.[24] In clinical conditions, low friction may be important, whether in retracting a tooth along a continuous archwire or consolidating space.

With regard to wire alloy, stainless steel was found to be associated with significantly lower levels of frictional resistance in comparison to nickel-titanium alloy. This is in agreement with most reports found in the literature.[8,13,16,17,20] When the morphological features of wires and brackets were analyzed by SEM, a more irregular surface was found in NiTi wires in comparison to steel wires before and after sliding. These findings may explain the friction values observed in the experimental conditions. Surface roughness may play a significant role in the amount of friction produced, as bracket design and ligation technique do.

Bowden and Tabor[3] stated that friction was known to be largely determined by surface roughness. Similarly to the results of the present study, Pratten et al[20] also observed lower frictional resistance for stainless steel brackets as a result of lower surface roughness and greater frictional resistance for NiTi arch wires. Stannard et al[25] also microscopically examined different wires and found that, at first, stainless steel seemed to have a polished surface, however, it revealed wear tracks after sliding. Nitinol wire had a fibrous structure, which indicates lack of polishing during manufacture, and no observable wear tracks.

Elayyan et al[9] speculated that surface quality of archwires might affect the area of surface contact, thereby modifying corrosion behavior and biocompatibility. According to their study, irregular surfaces

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microscopically observed might lead to plaque accumulation inside the surface defects, thus, affecting tooth movement due to entrapment of bracket edges inside them. Moreover, the contact area between the wire and the bracket surface can influence friction,[8,18] which was not considered in the present study.

This study corroborates a previous study[19] in which Nitinol and stainless steel arch wires were compared. The author reported lower friction for Nitinol only when wire-bracket angulation was > 5°. In the present experiment, no angulation higher than 5° was used and no statistical difference was found. According to Read-Ward,[21] the effect of increasing angulation resulted in increased friction, which may be associated with the larger width of the wire when compared to the bracket width slot, producing a larger contact area and probably larger frictional forces.

The present study was not capable of simulating clinical conditions with all the attended variables. In future clinical studies, it would be of great interest to investigate whether self-ligating brackets actually result in faster and more efficient treatment, especially if aging alterations of the self-ligating brackets clip — occurring during the course of orthodontic treatment and which may modify the forces generated during wire engagement in comparison to elastomeric ligatures that are affected by moisture and heat — exhibit rapid force loss and are permanently deformed when stretched.

CONCLUSION

1. Friction was influenced not only by the type of bracket, but also by the ligation system. Self-ligating brackets showed lower means.

2. There were no differences between zero and five-degree angulations with regard to frictional resistance.

ACKNOWLEDGMENTS

Grateful acknowledgment is granted to the Center of Microscopy of UFPel for allowing us to obtain the SEM images.

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Dissatisfaction with dentofacial appearance and the normative need for orthodontic treatment: determinant factors

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.120-126.oar*

Objective: This study aims at assessing the normative need for orthodontic treatment and the factors that determine the subjective impact of malocclusion on 12-year-old Brazilian school children.

Methods: A total of 451 subjects (215 males and 236 females) were randomly selected from private and public schools of Juiz de Fora, Brazil. The collected data included sociodemographic information and occlusal conditions. The esthetic subjective impact of malocclusion was assessed by means of the Orthodontic Aesthetic Subjective Impact Score – OASIS, whereas the malocclusion and the need for orthodontic treatment were assessed by means of the Dental Aesthetic Index (DAI) and the Index of Orthodontic Treatment Need-Aesthetic Component (IOTN-AC).

Results: Prevalence of normative need for orthodontic treatment was 65.6% (n = 155), and prevalence of orthodontic esthetic subjective impact was 14.9%. The following variables showed significant association with esthetic subjective impact of malocclusion: female (p = 0.042; OR = 0.5; CI = 0.2-0.9), public school student (p = 0.002; OR = 6.8; CI = 1.9-23.8), maxillary overjet ≥ 4 mm (p = 0.037; OR = 1.7; ICI = 1-3) and gingival smile ≥ 4 mm (p = 0.008; OR = 3.4; CI = 1.3-8.8).

Conclusion: The normative need for orthodontic treatment overestimated the perceived need. Occlusal and sociocultural factors influenced the dissatisfaction of schoolchildren with their dentofacial appearance.

Keywords: Malocclusion. Orthodontics. Quality of life.

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How to cite this article: Almeida AB, Leite ICG, Melgaço CA, Marques LS. Dissatisfaction with dentofacial appearance and the normative need for orthodontic treatment: determinant factors. Dental Press J Orthod. 2014 May-June;19(3):120-6. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.120-126.oar

Submitted: April 03, 2013 - **Revised and accepted**: June 08, 2013

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Malocclusion is a craniofacial growth and development disorder that may lead to functional problems with esthetic impact and consequent psychosocial implications in children and adults.[1,5] It is considered a public health concern and the third most frequent oral disorder after dental caries and periodontal problems. Thus, orthodontists must include in diagnosis and planning, instruments that highlight the influence of sociocultural components and their relation to the perception of the malocclusion developed by the individual.

Efforts to develop solid diagnostic criteria that allow patients to understand their problems have been the main focus of dentists and orthodontists; however, it is difficult to determine the importance of malocclusion as a facial problem and its impact on the quality of life of the individuals affected.[6] This problem is particularly more complex during childhood due to constant changes in psychosocial and body characteristics and great variability in cognitive development that occur in children of the same age group.[7]

Orthodontic treatment during childhood is generally associated with esthetic problems[8,9] normally related to considerable diversity in patient's perception process.[7,10] Although the esthetic impact of malocclusion greatly influences a child's biopsychosocial development,[11] little attention has been given to its association with normative values of treatment needs.

This study aims at assessing the normative need for orthodontic treatment and the factors determining the subjective impact of malocclusion on 12-year-old Brazilian schoolchildren.

MATERIAL AND METHODS

This cross-sectional study was carried out with 12-year-old Brazilian schoolchildren randomly selected from public and private schools of Juiz de Fora — Minas Gerais/Brazil. Cluster sampling method was used with proportional raffling of school categories: public (local, state and federal) and private. The participating classes and schoolchildren were also raffled.

Sample size (n = 451) was calculated based on demographic data from the "Brazilian oral health report – 2010"[12] considering 38% of estimated malocclusion prevalence at the age of 12,[13] with 95% confidence interval and 5% standard error.[14]

The following exclusion criteria were applied: Craniofacial malformation or syndromes with dentofacial manifestations, previous orthodontic treatment and mental or behavior disorders that could interfere in patient's self-perception of the assessed factors. This project was approved by the Institutional Review Board of the Federal University of Juiz de Fora. Patients' parents or guardians signed an informed consent form.

The collected data included sociodemographic information and clinical features concerning the subjects' occlusal conditions. The schoolchildren answered a questionnaire that included a test to assess the esthetic subjective impact of malocclusion (Orthodontic Aesthetic Subjective Impact Score – OASIS). Malocclusion as well as the need for orthodontic treatment were assessed through the Dental Aesthetic Index (DAI) and the Index of Orthodontic Treatment Need-Aesthetic Component (IOTN-AC). For economic characterization, patients' parents or guardians answered a self-applied questionnaire.[15]

Dental examination

Dental examination followed the World Health Organization criteria for oral health research.[16] All oral assessments were performed by the same orthodontist who was previously calibrated and trained for all indexes used in this study. Intra-observer agreement was calculated by Kappa coefficient (96%).

Dental aesthetic index (DAI)

DAI assesses the esthetic aspects of dental occlusion, identifying the need for orthodontic treatment based on malocclusion severity. Its scale defines severity in a similar manner to orthodontists' judgment. DAI scores equal to or lower than 25 refer to malocclusions with a slight need for orthodontic treatment. Scores varying from 26 to 30 represent malocclusion with elective need for treatment. Scores varying from 31 to 35 represent malocclusion with a high need for treatment. Scores ≥ 36 represent severe malocclusion with compulsory need for treatment.[17]

Orthodontic Aesthetic Subjective Impact Score – OASIS

OASIS measures the subjective aesthetic impact of malocclusion, assessing the degree of dissatisfaction

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of children with their teeth.[13] OASIS has been validated and culturally adapted to Brazilian Portuguese.[18] It comprises 5 questions, with the answers matching into the 7-point Likert scale. This dependent variable was dichotomized into satisfied or dissatisfied. Based on self-perception, the child was asked to identify in the IOTN-AC, the photography that best matched their oral condition. In order to facilitate children's understanding, the Likert scale was reduced to 3 possible answers; maintaining the initial and final scoring limits (5 - 35 points) of the original instrument, which were further added to the answers of the IOTN-AC (1 to 10). Median was used as the cut-off point to define aesthetic malocclusion impact. According to the IOTN-AC criteria, assessment of the need for orthodontic treatment classified the subjects into 3 groups: no need (1-4), borderline cases (5-7) and definite need (8-10).[19]

Statistical analysis

Initially, a descriptive analysis of results was performed. Next, associations between dependent and independent variables were tested by means of the univariate analysis (chi-square test and Fisher's exact test) and both simple and multiple logistic regression analyses (stepwise forward procedure). The lack of an association between variables was considered as the null hypothesis (significance values greater than 0.05). The Statistical Package for the Social Sciences program (SPSS) - SPSS Inc., Chicago, USA, version 8.0, was used for statistical analysis.

RESULTS

The total sample of 451 schoolchildren comprised 215 (47.7%) males and 236 (52.3%) females. With regard to skin color, 299 (66.3%) were white and 152 (33.7%) were classified as non-white. As for their economic level, 373 guardians (82.7%) adequately answered the questionnaire, thus yielding the following results: 8.6% - class A (n = 32); 32.2% - class B (n = 120); 45.2% - class C (n = 169); 13.7% - class D (n = 51); and 0.3% - class E (n = 1) (Table 1).

The normative need for orthodontic treatment and aesthetic subjective impact of malocclusion are presented in Table 2.

Table 3 shows the results of the bivariate analysis for

Table 1 - Sample characterization according to sex, skin color, economic level and school category.

Sample characterization	Absolute frequency (n)	Relative frequency (%)
Sex		
Male	215	47,7
Female	236	52.3
Skin color		
White	299	66.3
Non-white	152	33.7
Economic level		
High (Class A and B)	152	40.8
Intermediate (Class C)	169	45.2
Low (Class D and E)	52	14.0
School category		
Private	126	27.9
Public	162	35.9
State	153	33.9
Federal	10	2.2

Table 2 - Need for orthodontic treatment and aesthetic subjective impact of malocclusion in 12-year-old schoolchildren of Juiz de Fora/Minas Gerais.

Variables	Absolute frequency (n)	Relative frequency (%)
Orthodontic treatment need (DAI)		
No or slight need	155	34.4
Elective treatment	148	32.8
Highly desirable treatment	86	19.1
Compulsory need	62	13.7
Orthodontic treatment need (IOTN-AC)		
No need	362	80.3
Borderline cases	57	12.6
Definite need	32	7.1
Aesthetic Subjective Impact of Malocclusion (OASIS)		
Very satisfied	235	52.1
Satisfied	149	33.0
Dissatisfied	52	11.5
Very dissatisfied	15	3.4

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Table 3 - Association between occlusal alterations and appearance satisfaction of 12-year-old schoolchildren of Juiz de Fora/Minas Gerais.

Occlusal Alterations	Appearance Satisfaction (OASIS)				Odds Ratio (95% CI)	p
	No		Yes			
	(n)	(%)	(n)	(%)		
Missing upper tooth						
Not observed	62	14.6	364	85.4	1	0.457
Observed	5	20.0	20	80.0	1.4(0.5-4.0)	
Missing lower tooth						
Not observed	66	14.8	381	85.2	1	0.567
Observed	1	25.0	3	75.0	1.9 (0.1-18.7)	
Incisor crowding						
None	19	14.0	117	86.0	1	0.425
One or more segments	48	15.2	267	84.8	1.1 (0.6-1.9)	
Incisor spacing						
None	43	14.1	261	85.9	1	0.541
One or more segments	24	16.3	123	83.7	1.1 (0.6-2.0)	
Median diastema						
≤ 1 mm	58	14.2	351	85.8	1	0.209
≥ 2 mm	9	21.4	33	78.6	1.6 (0.7-3.6)	
Maxillary malalignment						
≤ 1 mm	39	13.7	245	86.3	1	0.382
≥ 2 mm	28	16.8	139	83.2	1.2 (0.7-2.1)	
Mandibular malalignment						
≤ 1 mm	36	13.0	241	87.0	1	0.161
≥ 2 mm	31	17.8	143	82.2	1.4 (08-2.4)	
Maxillary overjet						
≤ 3 mm	27	11.0	218	89.0	1	0.009
≥ 4 mm	40	19.4	166	80.6	1.9 (1.1-3.3)	
Anterior crossbite						
No	65	14.8	375	85.2	1	0.754
Yes	2	18.2	9	81.8	1.2 (0.2-6.0)	
Anterior openbite (mm)						
= 0 mm	63	14.5	372	85.5	1	0.245
≥ 1 mm	4	25.0	12	75.5	1.9 (0.6-6.2)	
Molar relationship						
Class I	20	12.0	147	88.0	1	
Class II	44	18.0	200	82.0	1.6 (0.9-2.8)	0.062
Class III	3	7.5	37	92.5	0.5 (0.1-2.1)	0.311
Posterior crossbite						
No	53	14.2	321	85.8	1	0.368
Yes	14	18.2	63	81.8	1.3 (0.7-2.5)	
Gingival smile (mm)						
≤ 3 mm	59	13.7	371	86.3	1	0.002
≥ 4 mm	8	38.1	13	61.9	3.8 (1.5-9.7)	

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Table 4 - Association between socioeconomic variables (number and percentages) and appearance satisfaction of 12-year-old schoolchildren of Juiz de Fora/ Minas Gerais.

Sociodemographic variables	Appearance satisfaction (Oasis)				Odds Ratio	p
	No		Yes			
	(n)	(%)	(n)	(%)	(95% CI)	
Skin color						
Non-white	27	17.8	125	82.2	1	0.216
White	40	13.4	259	86.6	0.7 (0.4-1,2)	
Sex						
Female	42	17.8	194	82.2	1	0.043
Male	25	11.6	190	88.4	0.6 (0.3-1.0)	
Economic level						
High	11	7.2	141	92.8	1	0.004
Intermediate	30	17.8	139	82.2	2.7 (1.3-5.7)	<0.001
Low	13	25.0	39	75.0	11.9 (4.6-30.6)	
School category						
Private	4	3.2	122	96.8	1	0.000
Public	63	19.4	262	80.6	7.3 (2.6-20.6)	

the dependent variable "aesthetic subjective impact of malocclusion" (OASIS), considering the occlusal alterations. Only maxillary overjet ≥ 4 mm, and gingival exposure at smile ≥ 4mm were statisitcally associated with child's tooth appearance dissatisfaction.

Regarding the relationship between the dependent variable and the sociodemographic variables, a statistically significant association was found for school category ($p < 0.001$), low economic level ($p < 0.001$), intermediate economic level ($p = 0.004$) and sex ($p = 0.043$) (Table 4).

Multiple logistic regression for occlusal and sociodemographic characteristics, which were significantly associated at bivariate analysis ($p < 0.20$), indicated the following variables as factors associated with the aesthetic subjective impact of malocclusion: female ($p = 0.042$; OR = 0.5; CI = 0.2-0.9), public school student ($p = 0.002$; OR = 6.8; CI = 1.9-23.8), maxillary overjet ≥ 4 mm ($p = 0.037$; OR = 1.7; ICI=1-3) and gingival smile ≥ 4 mm ($p = 0.008$; OR = 3.4; CI = 1.3-8.8).

DISCUSSION

The need for orthodontic treatment is difficult to be recognized by professionals, given that the decision on the need for orthodontic treatment must integrate clinical criteria and perceptible needs.[18,20,22] Several authors report a tendency to overestimate the need for orthodontic treatment when normative criteria are used.[20,22,23] The present results confirm these findings when DAI values are compared to the aesthetic subjective impact of malocclusion (OASIS).

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However, Marques et al[19] found the opposite in a study conducted with Brazilian adolescents, probably due to the social status related to the use of orthodontic appliances and the free treatment offered by the public institution(as part of the Brazilian public health system) where the study was carried out.

Dental aesthetics has significant implications on an individual's quality of life and psychosocial relationships, being an important factor for those who seek orthodontic treatment.[3,5] In this study, however, the aesthetic subjective impact of malocclusion (OASIS) was significantly ($p < 0.001$) lower than normative needs. Only 14.9% of individuals comprising the sample were not satisfied with their tooth appearance. Although the aesthetic subjective impact of malocclusion (OASIS) was strongly associated with normative impact (DAI), the difference in the frequencies found leads to important reflections on the need for orthodontic treatment. Once aesthetics is considered one of the most important aspects in orthodontic treatment,[3,5] the instrument used to assess its impact should be more closely related to the self-perceived need for orthodontic treatment and appearance satisfaction than to normative indexes, only. Yet, they were significantly different in this study.

Normative need for treatment (DAI) was strongly associated with the aesthetic subjective impact of malocclusion ($p = 0.007$). However, when occlusal alterations were analyzed separately, only the variables overjet ≥ 4 mm and gingival smile ≥ 4 mm were statistically significant. Association between great overjet and gingival smile with appearance satisfaction has been reported in other studies.[7,24,25] Increase in overjet is strongly associated with the risk of dental injuries due to lack of labial seal and exposure of upper teeth. Additionally, the social impact of this problem must be considered as an important factor for facial stigmatization. The same occurs when gingival smile is assessed.[5,7] In the present study, these problems clearly affected patients' dental dissatisfaction.

Except for skin color, all other sociodemographic variables showed statistically significant association with the aesthetic impact of malocclusion. In agreement with other studies, this impact was more significant in females[23,26] and intermediate economic level. Yet, after logistic regression, only sex and school remained significantly associated with the impact of malocclusion.

Some occlusal conditions related to aesthetic impairment, such as incisor crowding, upper and lower misalignment and missing teeth, were not associated with the aesthetic subjective impact of malocclusion (OASIS). This finding was in disagreement with a previous study which showed an association between this instrument and occlusal alterations.[23] This fact highlights the great variability and complexity of perception of facial aesthetics, with significant differences between normative and self-perceived values.[27,30] The exclusive use of normative criteria to determine the need for orthodontic treatment does not consider the subjective aspects related to the individual's perception and the psychosocial implications of malocclusions. For this reason, it tends to overestimate the prevalence of malocclusion with treatment need. This is particularly important for the planning of health policies, especially in underfunded public health services.[6,20,21]

CONCLUSIONS

- The normative need for orthodontic treatment overestimated the perceived need.
- The variables sex, school category, maxillary overjet ≥ 4 mm and gingival smile ≥ 4 mm negatively influenced patient's satisfaction with dentofacial appearance.

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Class I malocclusion with severe double protrusion treated with first premolars extraction*

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.127-138.bbo*

Angle Class I malocclusion with bymaxillary protrusion is characterized by severe buccal tipping of incisors, which causes upper and lower lip protrusion. First premolars extraction is recommended to reduce facial convexity as a result of anterior teeth retraction, which keeps canines and first molars in key to occlusion. In order to yield orthodontic results that are compatible with ideal esthetic and cephalometric outcomes, the space closure phase needs to be carried out with overbite and incisors torque control. The majority of cases also requires maximum anchorage of posterior teeth. This case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) as a requirement for the title of certified by the BBO.

Keywords: Angle Class I malocclusion. Orthodontic space closure. Orthodontic anchorage procedures.

INTRODUCTION

This paper reports the case of a 38-year and 6-month-old female patient who sought orthodontic treatment to improve facial esthetics and smile. Her medical history revealed no significant issues, except for allergy to iodine. Additionally, her clinical exams revealed that, even though the patient had good oral hygiene habits, she was susceptible to calculus formation — especially between mandibular incisors— and generalized gingival recession that included her upper central incisors. She had proper functional relationship between the tongue and the perioral muscles, associated with a nasal

» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

* Clinical case report approved by the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

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How to cite this article: Moresca R. Class I malocclusion with severe double protrusion treated with first premolars extraction. Dental Press J Orthod. 2014 May-June;19(3):127-38. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.127-138.bbo

Submitted: April 3, 2014 **Revised and accepted**: April 15, 2014

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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breathing pattern. Functional analysis of occlusion revealed that lateral guidance was performed by the canines on the right side, and by the first premolars on the left side. Anterior guidance was short, but did not completely disoccluded the posterior teeth. There were no signs or symptoms of parafunctional habits or temporomandibular dysfunction.

DIAGNOSIS

The patient had a balanced facial pattern associated with convex profile and upper and lower lip protrusion (Ls-Line S = 2 mm; Li-Line S = 1 mm), which provided her with decreased nasolabial angle and mentolabial sulcus, as well as increased nasolabial fold; however, without affecting passive lip sealing. At smiling, she clearly presented maxillary incisors protrusion and a wide buccal corridor (Fig 1).

Her dental analysis (Figs 1, 2) revealed Angle Class I malocclusion with 2 mm overjet and overbite. Teeth crowding was present at the lower dental arch with -6 mm discrepancy, infralabial inclination of tooth #41, linguoversion of tooth #32 and mesial infralabial inclination of tooth #33, which caused a 0.5-mm shift from the lower midline to the left. As for the upper dental arch, there was mild rotation of tooth #12. Both dental arches were severely elongated in the anteroposterior direction. Excess lingual tipping of lower premolars and molars caused transverse constriction.



Figure 1 - Initial facial and intraoral photographs.

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Patient's panamoramic radiograph revealed mesially tipped upper first molars (Fig 3). Periapical and interproximal radiographs of incisors revealed generalized reduction in alveolar bone crest height, which was more severe for the lower incisors. The exams also revealed excess restorative matter on the distal surface of tooth #14 (Fig 4).

Cephalometrically speaking (Fig 5, Tab 1), the patient had dentoalveolar bymaxillary protrusion associated with loss of Class II skeletal pattern caused by excess maxilla (SNA = 90.5°; SNB = 85°; ANB = 5.5°) and increased facial convexity (convexity angle = 14°). Nevertheless, these cephalometric values may have been influenced by severe protrusion (1-NA = 10 mm; 1-NB = 15 mm) and

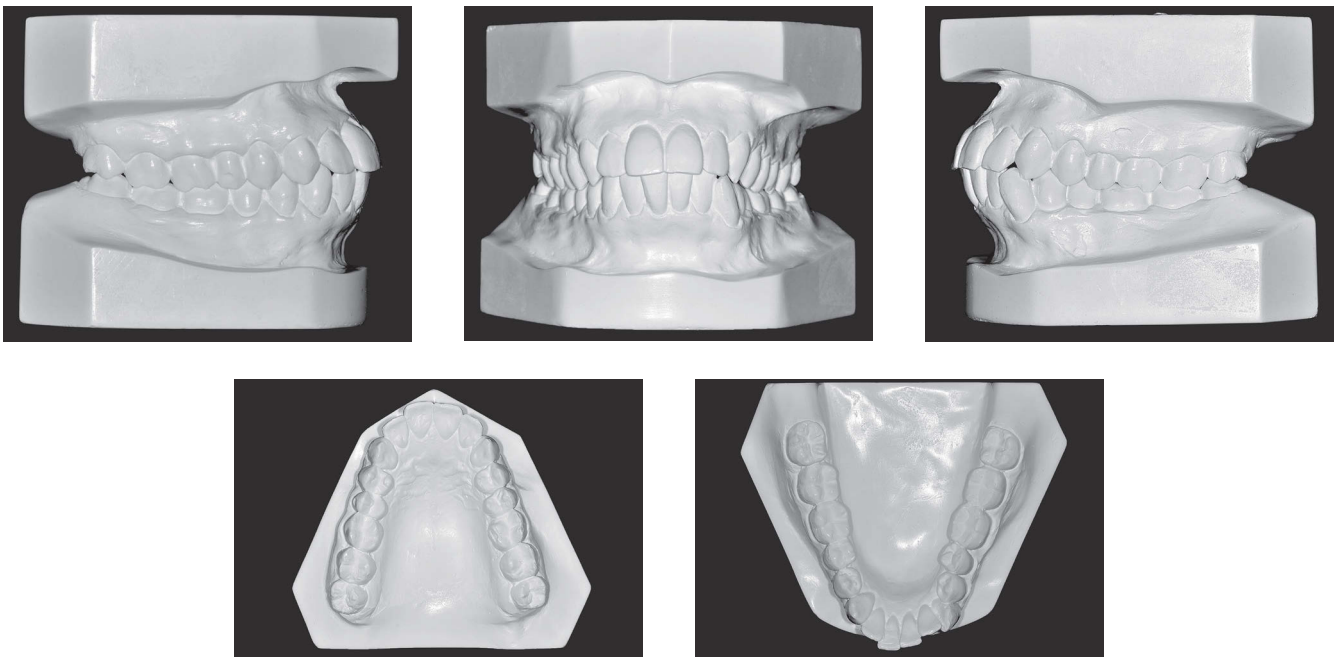


Figure 2 - Initial casts.

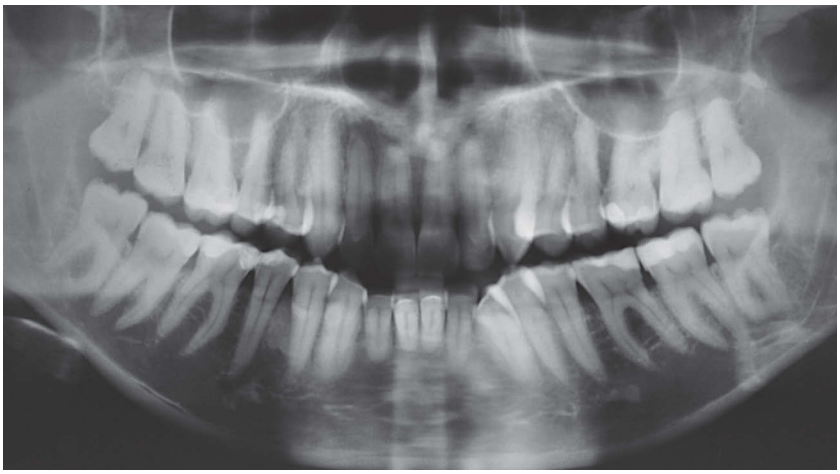


Figure 3 - Initial panamoramic radiograph.

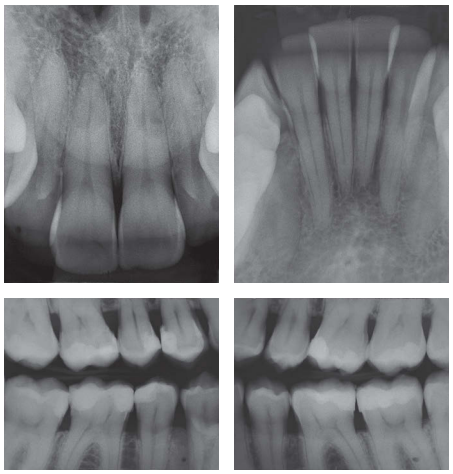


Figure 4 - Initial periapical and interproximal radiographs of incisors.

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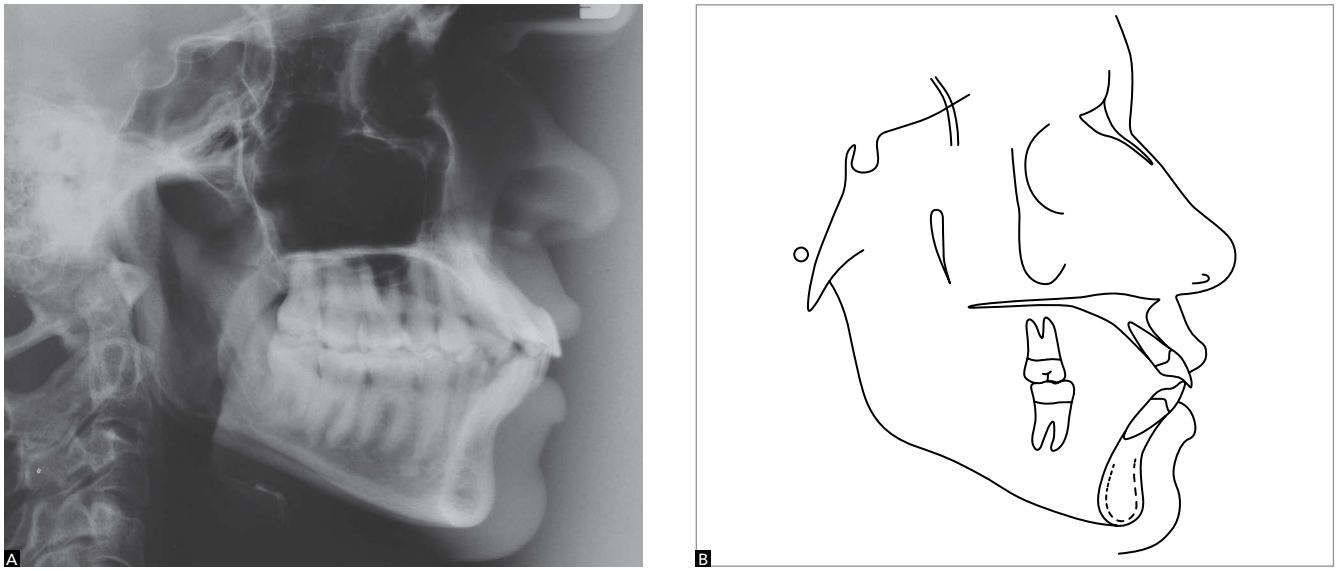


Figure 5 - Initial lateral cephalogram (**A**) and cephalometric tracing (**B**).

buccal tipping (1-NA = 32°; 1-NB = 51°; IMPA = 114°; 1/1 = 92°) of upper and lower incisors.

TREATMENT PLAN

Facial esthetics considered, treatment plan aimed at reducing lip protrusion, increasing nasolabial angle and softening the nasolabial fold. To make such alterations feasible, first upper and lower premolars extraction was recommended. According to the Visual Treatment Objective (VTO),[1] a method that permits the analysis of tooth movement, the case was classified as in need for maximum anchorage. In other words, anterior teeth should be completely retracted towards the extraction spaces without allowing the posterior teeth to move mesially. To this end, mini-implants were indicated as an anchorage resource.[2]

Two other alternative treatment plans were considered. One of them included second premolars extraction, whereas the other included third molars extraction followed by distalization of dental arches with anchorage provided by miniplates. Nevertheless, neither possibilities were considered, since they required more complex and more invasive anchorage resources as well as longer treatment time.[3,4]

Initially, treatment plan included orthodontic appliance placed up to the second molars in both dental arches. Subsequently, first premolars extraction and mini-implant placement was performed on the four quadrants between second premolars and first molars, 8 mm far from the orthodontic arch on the attached gingiva and perpendicular to the buccal cortical bone.[5,6,7] Initially, mini-implants were used for partial canine retraction with active lacebacks[8] gaining space for alignment of incisors and preventing their buccal inclination.

To close remaining extraction spaces, mass retraction of anterior teeth was performed by means of sliding mechanics[9] with active tie-backs hooked to mini-implants so as to produce an inclined force vector.

Case finishing was performed by repositioning of brackets followed by releveling and intercuspation with braided 0.019 x 0.025-in archwire and intermaxillary elastics. Retention consisted of a wraparound removable appliance for the upper arch, whereas for the lower arch a lingual arch bonded to the second premolars was recommended.

TREATMENT PROGRESS

Orthodontic treatment was carried out using passive self-ligating pre-adjusted fixed appliances (MBT 0.022 x 0.028-in) on both arches, including second molars. Since the use of temporary orthodontic anchorage devices was not considered, tubes were bonded to

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the molars. Subsequently, first premolars extraction was requested and mini-implants were installed.

Alignment and leveling procedures began with NiTi SE 0.014-in wires followed by 0.016-in wire installed on both arches. During this period, canines, especially the lower ones, underwent distalization that provided space for incisors alignment and, as a result, prevented buccal tipping. Distalization was performed with active lacebacks placed from the mini-implants to the brackets installed on the canines. Lower lateral incisors were only included in the archwire after proper space was obtained. After initial alignment, anterior teeth remained conjoined to prevent space opening. After the 0.016-in archwire was used, NiTi SE 0.014 and 0.016-in archwires were simultaneously installed. The association between arches aims at eliminating the slack established between leveling archwires and passive self-ligating brackets,[10] thus providing better rotational control and second-order expression. It is estimated that the association between 0.014 and 0.016-in archwires results in a total diameter of 0.021-in, which completely fills the brackets and tube slots.[11] Alignment and leveling were completed with the use of NiTi SE and stainless steel 0.019 x 0.025-in archwires. The former were distally bended to aid in the control of incisors buccal tipping, whereas the latter received hooks welded to the lateral incisors and canines, in addition to being diagramed and coordinated in accordance with the method advocated by Trevisi.[12] During the visit booked for stainless steel archwire placement, the clinician also performed passive tie-backs with metallic 0.008-in ligatures extended from the hooks of the second molars to the hooks welded to the archwires. This procedure was performed to avoid proclination of anterior teeth with torque expression embeded in the brackets installed on these teeth.

Retraction of anterior teeth was performed by sliding mechanics carried out in association with mini-implants.

Active tie-backs were installed from the mini-implants to the hooks welded to the archwires and activated 3 mm every 28 days[13] (Fig 6). The vertical position of mini-implants (placed approximately 8 mm from the orthodontic wires) was planned so as to produce an inclined force vector that, in association with sliding mechanics, would aid in achieving torque and overjet control during retraction of anterior teeth. This mechanics had a tendency towards distal tipping of first molars — more severe in the upper first molars — as a result of friction established between the tube and the orthodontic archwire. Such undesired movement was overcome in the subsequent phases of treatment.

Patient's intermediate register was performed in the final phase of anterior retraction after yielding the desired clinical outcomes. Based on patient's clinical and cephalometric exams, the clinician decided to remove the mini-implants and conclude residual space closure by mesially moving posterior teeth with the use of elastomeric chains, and keeping patient's anterior teeth conjoined with the use of metallic ligature acting as anchorage unit.

Based on clinical as well as radiographic findings and after space closure, the brackets were repositioned to improve occlusal relationship. From this moment onwards, the teeth remained conjoined in order to prevent space reopening. Treatment planning included intercuspation with 0.019 x 0.025-in braided archwires; however, due to the atypical anatomy of some teeth, treatment finishing included first and second-order bends performed in 0.016-in stainless steel archwires with the aid of 3/16-inch medium intermaxillary elastics arranged in triangle in canines and premolars. After assuring that esthetic,

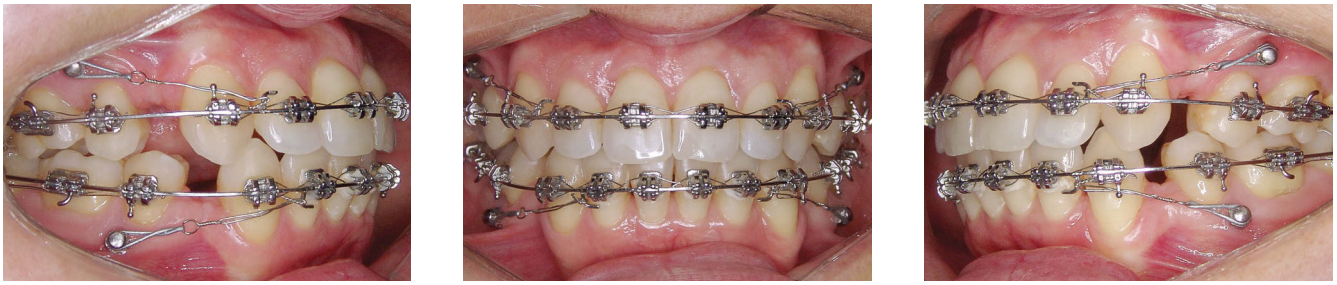


Figure 6 - Progress of the anterior retraction phase.

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occlusal and functional outcomes were achieved, the orthodontic appliance was removed. The phase of retention included an upper removable wraparound retainer used during the day and night within the first 6 months and during the night over the remaining period of time. In the mandibular arch, a 0.020-in stainless steel 5 x 5 intercanine bar was installed to ease incisors and canines interproximal space.

Treatment outcomes were achieved within the 27 months that comprised the active phase.

RESULTS

Final treatment outcomes were considered highly satisfactory and met the objectives set at treatment onset. Patient's subjective facial analysis revealed a balanced facial profile with significant reduction in lip protrusion and nasolabial fold, as well as decreased incisors protrusion and buccal corridor at smiling (Fig 7). Additionally, upper and lower lips had a reduction of 4 mm and 2 mm, respectively, in relation to the S-line (Steiner), as shown in Fig 11 and Table 1.



Figure 7 - Final facial and intraoral photographs.

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In fact, the facial alterations occurred in response to movement applied to incisors. Upper incisors were retracted in 3 mm, with 2° of tipping in relation to the NA line; whereas the lower incisors were retracted in 9.5 mm, with 25° of tipping in relation to the NB line. Additionally, there was a reduction of 24° in the IMPA angle. These changes caused an increase of 33° in the interincisal angle (Figs 11, 12; Tab 1). It is worth noting that, despite achieving significant retraction of incisors, treatment outcomes revealed excellent overbite control (Figs 7, 8), which decisively contributed to restore esthetics and function. Cephalometric tracing superimposition revealed that tongue movement and intrusion of incisors occurred simultaneously (Fig 12). Such movement pattern (retraction and intrusion) also contributed to restore the periodontal health of incisors and to decrease gingival recession.

After initial alignment, black spaces emerged between lower incisors as a result of bone loss — previously observed at treatment onset — and triangular-shaped incisor crowns. During treatment finishing, interproximal enamel reduction was recommended to eliminate the black spaces. Nevertheless, this procedure could cause disproportional dental volume between the arches and, as a result, hinder overbite correction. Additionally, black spaces did not affect patient's smile esthetics and, for this reason, they were maintained instead of eliminated (Fig 7).

With regard to occlusion, case finishing was achieved with canines and first molars in key to occlusion and good intercuspation of posterior teeth (Figs 7, 8). From a functional standpoint, proper adaptation of anterior overjet and overbite as well as torque control achieved for all teeth allowed incisal guidance to be protrusively obtained and lateral guidance to be obtained by means of canines without any occlusal interference.

In general, treatment achieved good root parallelism, with distal angulation of canine roots and upper first molars, as revealed by the intermediate panamoramic radiograph. Nevertheless, in the finishing phase, improvements in occlusal relationship

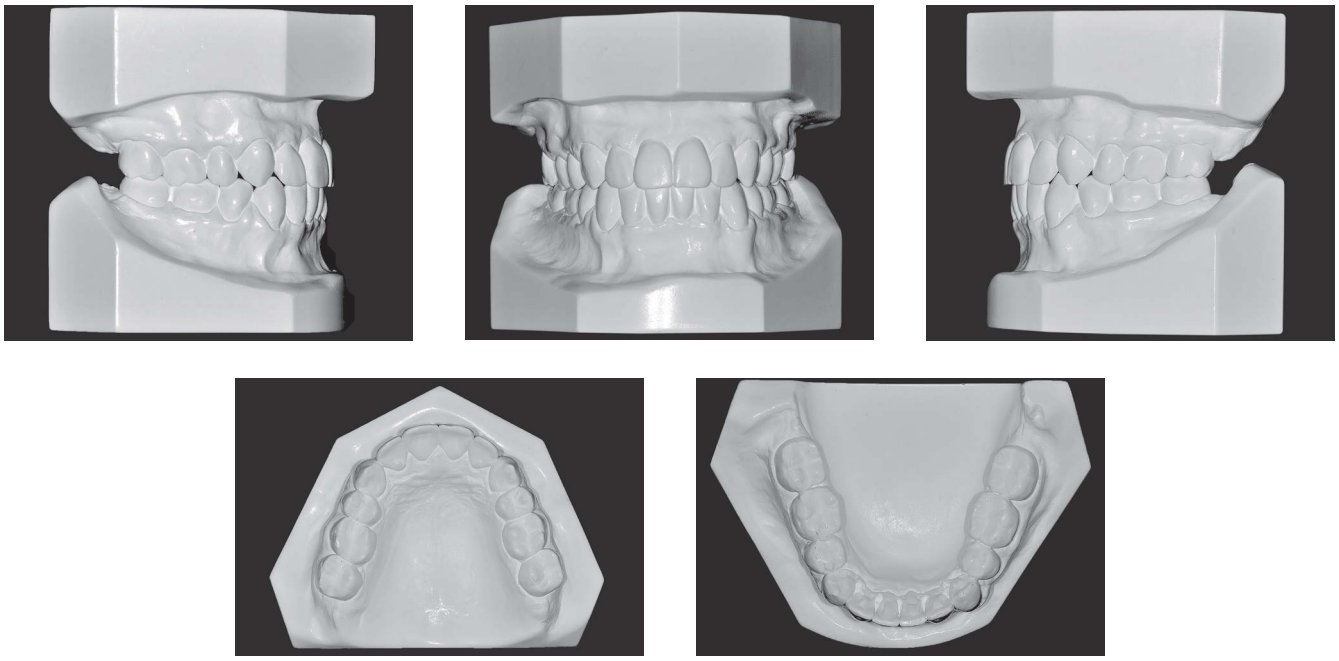


Figure 8 - Final casts.

were prioritized over correction of root angulation (Fig 9). Foreshortening of the distal root of tooth #46 and rounded incisors root, especially in the upper incisors (Figs 9, 10), were identified. This finding may be related to the association established between movements of retraction and intrusion performed on those teeth.[14] Additionally, panamoramic radiographs (Fig 9) revealed that third molars remained unfavorably positioned. For this reason, they were extracted and are not shown in the final photographs and casts.

As expected, significant skeletal alterations did not occur. There was a reduction of 4º in the ANB angle and of 13.5º in the facial convexity angle (Fig 11, Tab 1) as a result of significant remodeling observed in the area of points A and B. Moreover, treatment with extractions provided significant improvements in patient's facial profile (Fig 12).

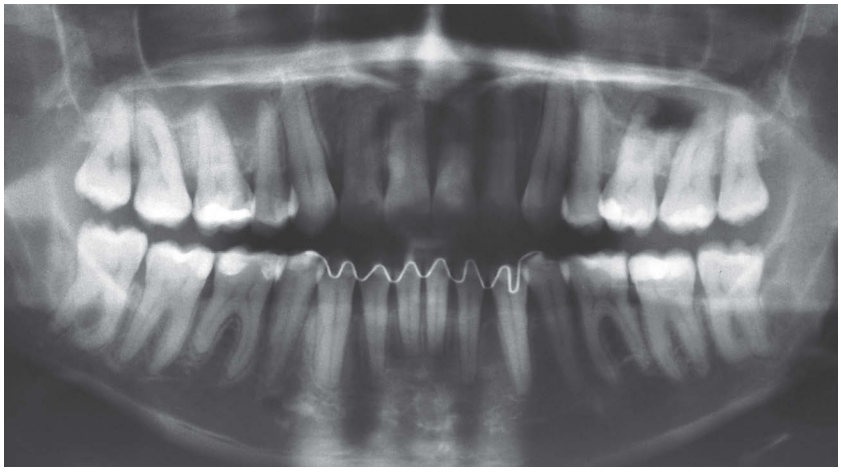


Figure 9 - Final panamoramic radiograph.

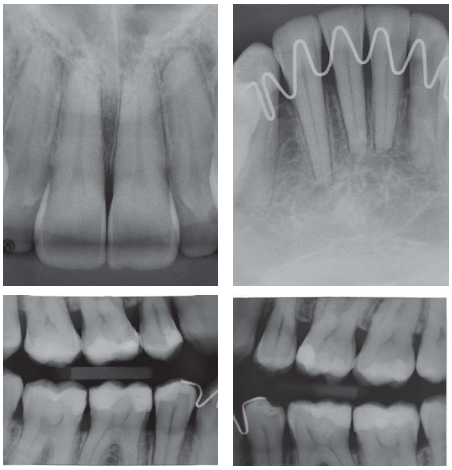


Figure 10 - Final incisors periapical and interproximal radiographs.

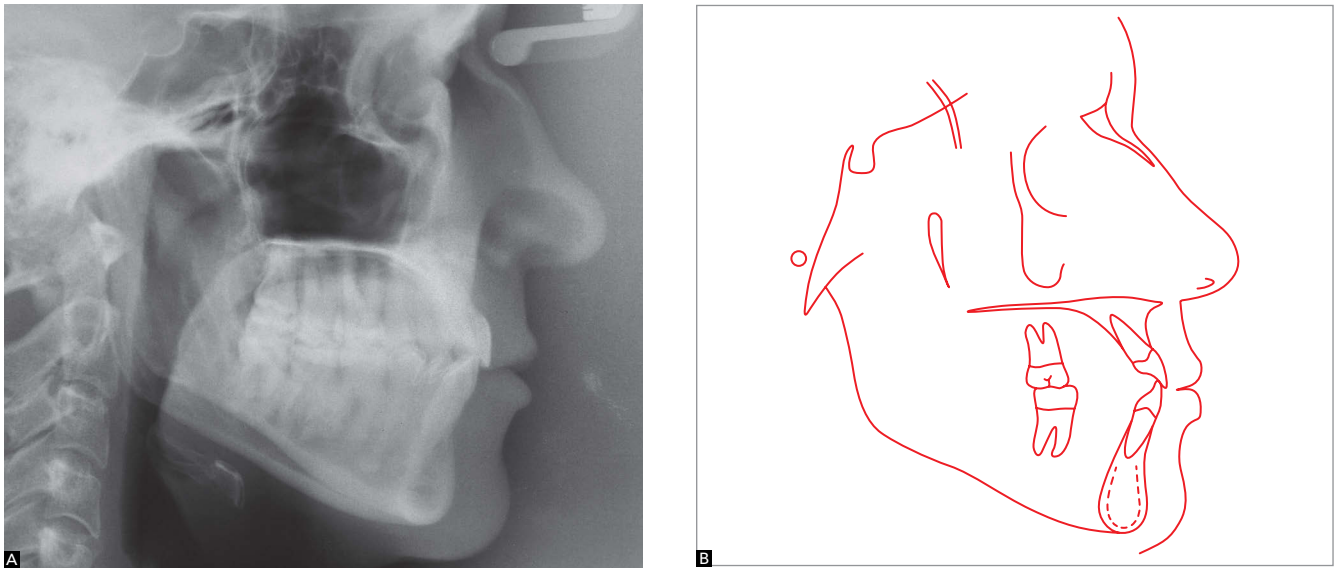


Figure 11 - Final lateral cephalogram (**A**) and cephalometric tracing (**B**).

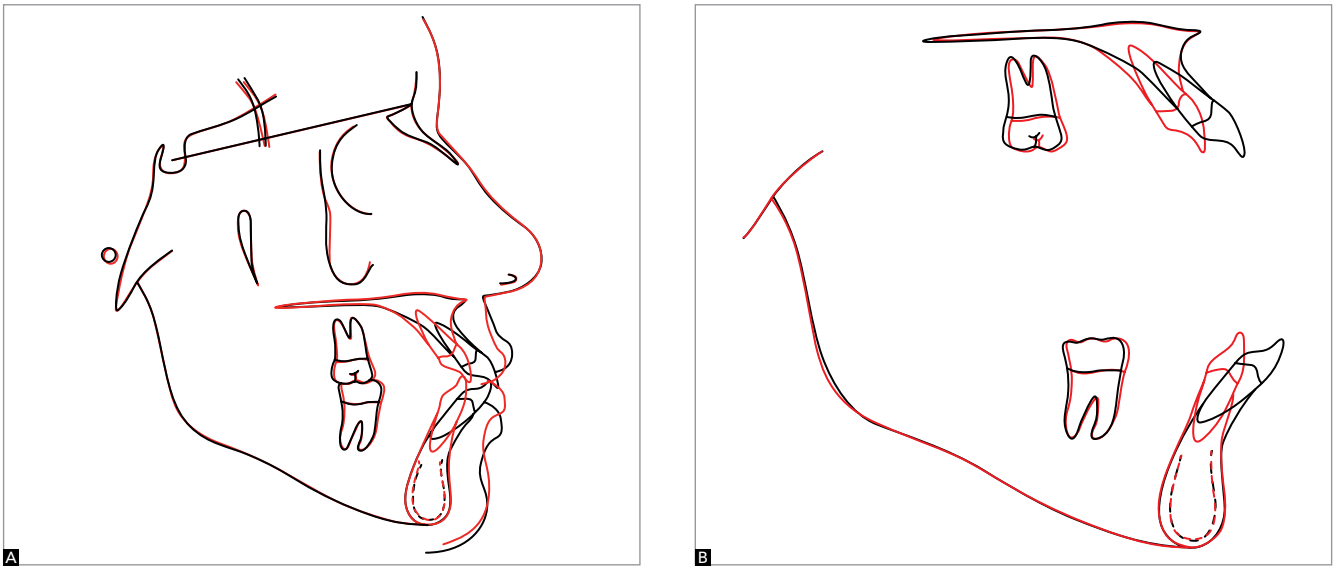


Figure 12 - Initial (black) and final (red) cephalometric tracing total **(A)** and partial **(B)** superimposition.

Table 1 - Cephalometric measurements.

	Measurements		Normal	A	B	Dif. A/B
Skeletal pattern	SNA	(Steiner)	82°	90.5°	88.5°	2
	SNB	(Steiner)	80°	85°	87°	2
	ANB	(Steiner)	2°	5.5°	1.5°	4
	Angle of convexity	(Downs)	0°	14°	0.5°	13.5
	Axis Y	(Downs)	59°	59°	58.5°	0.5
	Facial angle	(Downs)	87°	91°	90°	1
	SN-GoGn	(Steiner)	32°	31°	27°	4
	FMA	(Tweed)	25°	24.5°	25°	0.5
Dental pattern	IMPA	(Tweed)	90°	114°	90°	24
	1.NA (degrees)	(Steiner)	22°	32°	30°	2
	1-NA (mm)	(Steiner)	4 mm	10 mm	7 mm	3
	1.NB (degrees)	(Steiner)	25°	51°	26°	25
	1-NB (mm)	(Steiner)	4 mm	15 mm	5.5mm	9.5
	$\frac{1}{1}$ - Interincisal angle	(Downs)	130°	92°	125°	33
	1-APo	(Ricketts)	1 mm	12 mm	4 mm	8
Profile	Upper lip – Line S	(Steiner)	0 mm	2 mm	-2 mm	4
	Lower lip – Line S	(Steiner)	0 mm	1 mm	-1 mm	2

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FINAL CONSIDERATIONS

Bymaxillary protrusion is common among different ethnic groups. It is characterized by severe buccal tipping of anterior teeth and results in lip protrusion as well as increased facial convexity.[15] Conventional treatment includes extraction of first premolars to minimize facial convexity by retracting the anterior teeth and keeping canines and first molars in key to occlusion.[16,17] Drobocky and Smith[18] reported that 95% of patients treated with extraction of four first premolars have an average reduction of 3.4 mm and 3.6 mm in upper and lower lip protrusion in relation to the E line (Ricketts).

Nevertheless, although this treatment approach provides great previsibility of results, treating bymaxillary protrusion by means of tooth extraction is a challenge for the orthodontist, especially during the space-closure phase. The main challenge is with regards to anchorage maintenance, since mesialization of posterior teeth may minimize retraction of anterior teeth and, as a result, hinder the esthetic and cephalometric objectives of orthodontic treatment. Particular attention should be given to torque control of incisors, since uncontrolled buccal tipping of incisors crown and, as a result, increased overbite may occur.[5]

Therefore, it is key that the orthodontist choose an efficient space closure method that also effectively controls potential side effects. After pre-adjusted fixed appliances were introduced, sliding mechanics has been considered as an alternative for space closure.[19] This method allows simultaneous retraction of incisors and canines. It is recommended that a 0.019 x 0.025-in stainless steel archwire be used in association with brackets and tubes with 0.022 x 0.028-in slots. Force may be produced by elastics or NiTi closed springs adapted between mini-implants and hooks welded to the archwire between canines and lateral incisors (Fig 6). In comparison to the use of archwires with loops, the sliding mechanics method is simpler, more esthetic and comfortable for the patient. Additionally, it produces lighter forces.[13,20] Nevertheless, it is more sensitive in addition to being influenced by factors that hinder sliding of orthodontic archwires, such as friction, less torque control of anterior teeth and overbite.[21] Adding more torque on the orthodontic archwire and using brackets with greater torque are recommended to control tipping of incisors.[22]

With regard to anchorage control, there seems to be no significant difference between mass retraction of six anterior teeth and segmental retraction with initial distalization of canines followed by retraction of incisors.[23] In both methods, anchorage of posterior teeth is reinforced with conventional additional devices that, in certain situations, may be little effective or may strongly need patient's compliance. Such limitations are currently minimized with the use of mini-implants which have proved efficient in providing anchorage control and avoiding undesired mesial movement of molars, in addition to being widely accepted by patients.[24] Mini-implant placement require minimally invasive procedures and are reasonably affordable.

Sliding biomechanics involved in mass retraction of anterior teeth aided by the use of mini-implants has some advantages that differ from other conventional methods of space closure. It is recommended that mini-implants used to aid sliding mechanics be placed between the roots of second premolar and first molar, 8 mm far from the orthodontic archwire.[5,6,7] Mini-implants are apically placed in relation to the hook welded to the archwire and, for this reason, provide an inclined line of action of force that controls movement of anterior teeth. Decomposition of force results in a horizontal vector, responsible for retracting the anterior teeth; and a vertical vector, which contributes to achieve intrusion of these teeth during retraction and, as a consequence, allows effective overbite control. As the applied force goes below the center of resistance of anterior teeth,[25,26] it promotes movement that is likely to provide lingual tipping of these teeth (Fig 13). Nevertheless, should an inclined force be applied, it results in deflection of the orthodontic archwire, which simulates accentuation of upper the curve of Spee and favors torque control of anterior teeth (Fig 14). Such effect is of particular importance for passive self-ligating brackets, since they are less effective in the expression of torque.[27] It is worth noting that deflection is extended to posterior teeth. As a result, it increases friction between the wire and the molar tubes, causing distal movement of these teeth.

Vertical positioning of mini-implants may vary according to the degree of the intrusion vector.

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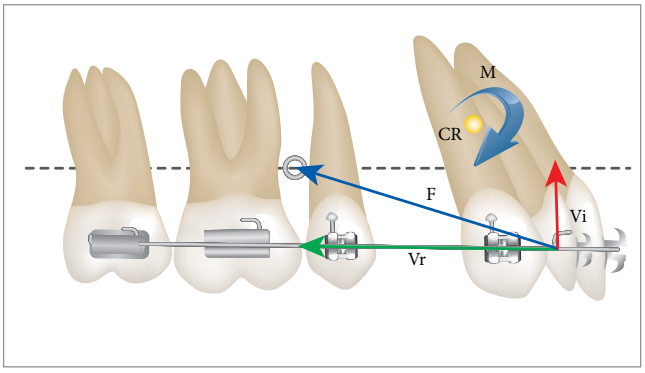


Figure 13 - Schematic representation of forces produced by sliding mechanics associated with mini-implants: F = force produced by active tie-backs; Vr = horizontal retraction vector; Vi = vertical intrusion vector; M = incisors buccolingual tipping moment, with F going below the center of resistance (CR) of anterior teeth.

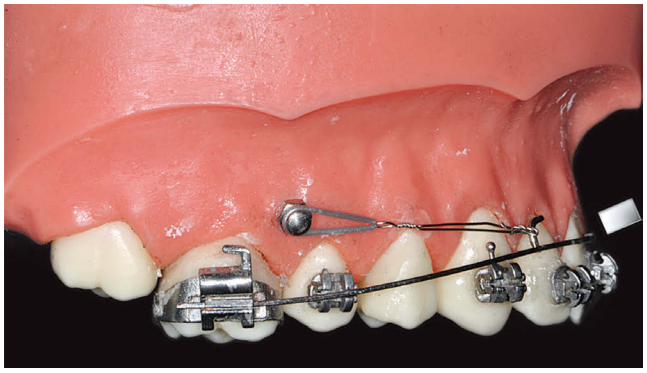


Figure 14 - Effect of force applied to the orthodontic archwire during sliding mechanics associated with mini-implants.

Mini-implants more apically or cervically placed provide an intrusion vector of greater or lower degree that acts over anterior teeth. In order to avoid undesired tipping of the anterior occlusal plane, it is necessary that mini-implants be placed at the same height, taking both sides into account.

Additionally, it is worth noting that the use of mini-implants requires longer treatment time to provide complete space closure in comparison to the use of conventional resources. Such increase in treatment time may be caused by the movement produced by anterior teeth, given that posterior teeth do not contribute to minimize extraction spaces. More extensive movement of incisors may provide a higher risk of root resorption.[14]

The results of this study and the orthodontic literature led us to conclude that sliding mechanics associated with the use of mini-implants produces satisfactory effects for the treatment of bymaxillary protrusion with extraction of first premolars. Nevertheless, treatment success is primarily related to correct diagnosis and planning as well as to proper biomechanical principles applied to achieve the desired orthodontic movement.

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From conventional to self-ligating bracket systems: Is it possible to aggregate the experience with the former to the use of the latter?

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DOI: *http://dx.doi.org/10.1590/2176-9451.19.3.139-157.sar*

Introduction: Orthodontics, just as any other science, has undergone advances in technology that aim at improving treatment efficacy with a view to reducing treatment time, providing patients with comfort, and achieving the expected, yet hardly attained long-term stability. The current advances in orthodontic technology seem to represent a period of transition between conventional brackets (with elastic modules) and self-ligating brackets systems. Scientific evidence does not always confirm the clear clinical advantages of the self-ligating system, particularly with regard to reduced time required for alignment and leveling (a relatively simple protocol), greater comfort for patients, and higher chances of performing treatment without extractions — even though the number of extractions is more closely related to patient's facial morphological pattern, regardless of the technique of choice. Orthodontics has recently and brilliantly used bracket individualization in compensatory treatment with a view to improving treatment efficacy with lower biological costs and reduced treatment time.

Objective: This paper aims at presenting a well-defined protocol employed to produce a better treatment performance during this period of technological transition. It explores the advantages of each system, particularly with regards to reduced treatment time and increased compensatory tooth movement in adult patients. It particularly addresses compensable Class III malocclusions, comparing the system of self-ligating brackets, with which greater expansive and protrusive tooth movement (maxillary arch) is expected, with conventional brackets Capelozza Prescription III, with which maintaining the original form of the arch (mandibular arch) with as little changes as possible is key to yield the desired results.

Keywords: Orthodontic brackets. Angle Class III malocclusion. Facial pattern.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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How to cite this article: Capistrano A, Cordeiro A, Siqueira DF, Capelozza Filho L, Cardoso MA, Almeida-Pedrin RR. From conventional to self-ligating bracket systems: Is it possible to aggregate the experience with the former to the use of the latter? Dental Press J Orthod. 2014 May-June;19(3):139-57. DOI: http://dx.doi.org/10.1590/2176-9451.19.3.139-157.sar

Submitted: March 20, 2014 - **Revised and accepted:** April 10, 2014

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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INTRODUCTION

Patients with Facial Pattern III and severe Angle Class III malocclusion pose difficulties for the clinical management of sagittal relationship between maxilla and mandible. Should surgery not be an option, clinical management is mainly concerned about guiding the mechanics, since its onset, in order to produce effects that meet the compensatory characteristics of the Pattern. In the mandibular arch: restricted buccal tipping of incisors; maintenance of reduced mesial angulation of anterior lower teeth (except for canines that are usually distally angulated and, now, will be uprighted); and, in the transversal plane, respect to mandatory dentoalveolar compensatory mechanism — a *sine qua non* condition for transverse adjustment between the arches. As for the therapeutic management of the maxillary arch, it highly welcomes transverse gains, increased mesial angulation of canines and controlled protrusion.

Analysis of Patter III patients' dental arches reveals that compensatory changes must be proportional to the degree of malocclusion. As these patients nearly always undergo a functional routine, at least temporarily, the exception will be if these compensatory changes do not occur.[1]

The essence of compensatory treatment performed with these patients is to adapt the concept of normality for the occlusal relationship which is strongly influenced by the degree of sagittal discrepancy between the arches. In these cases, the therapeutic goals are completely individualized and treatment protocol must respect the adapted concept of normality for the occlusal relationship. At compensatory treatment completion, maxillary incisors will be more protruded and buccally tipped in accordance with esthetic limitations; the maxillary arch will be more expanded or with a decreased lingual inclination of posterior teeth; and all upper teeth will be more mesially angulated. All these goals are set for the maxillary arch with a view to increasing its circumference and length. Conversely, opposite goals are set for the mandibular arch: mandibular incisors as well as posterior teeth more lingually tipped, with decreased mesial angulation for all other teeth.[2]

Orthodontics has continuously sought to improve the efficiency of treatment in the attempt to reduce its duration and chair time. Although average treatment lasts between 1 and 2 years, there is an ongoing attempt to reduce it. To this end, several techniques and appliances — including surgical procedures, vibratory stimulation, greater use of individualized archwires and brackets, as well as less frequent indications for tooth extraction — will still be recommended. This article explores three important aspects of such continuous progression: bracket individualization, self-ligating systems and mechanical customization used to achieve greater therapeutic efficacy.[3]

WHEN TO TREAT?

Despite not being the primary objective of this article, it is worth noting that the compensatory approach of Pattern III, Class III patients must safely begin, at least theoretically, in patients whose mandibular growth has ceased. Patient must present signs of skeletal maturity — for girls, 24 months after menarche; whereas for boys, there must be signs of full pubescence, such as voice alterations and facial hair. Such signs may be confirmed by carpal radiograph which reveals that the patient has achieved Haag &Taranger's[4] stage IJ — an indication that compensatory orthodontic treatment may begin or that there is a need for corrected treatment by means of orthognathic surgery. Unlike compensatory treatment of Pattern II malocclusions, should orthodontic treatment be performed before the patient achieves the stage of skeletal maturity, treatment stability is not garanteed even if satisfactory occlusal correction is achieved.[5]

CHOOSING BRACKETS AND LIGATION SYSTEMS IN EACH ONE OF THE DENTAL ARCHES

In order to facilitate one's understanding of the treatment protocol presented in this article, it is important to divide the choice of brackets and ligation system in accordance with each dental arch.

Maxillary arch

Over the last years, self-ligating brackets have been given great emphasis, partially due to producing lower friction. The possibility of theoretically applying force of appropriate magnitude increases the chances of periodontal tissues producing a more physiological response, thus producing more effective dental movements and, as a result, decreasing side effects and reducing treatment time.[6,7]

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Increase in treatment efficacy is defined as the achievement of results which are as good as or better than those obtained by conventional treatment, especially within a shorter period of time. Additionally, increased productivity brings along major benefits for both clinician and patient. In orthodontic treatment, these benefits include a reduced number of visits, reduced chair time, more comfortable treatment, clinical procedures that can be easily performed by the orthodontist, a decreased need for extractions, less invasive treatment procedures and minimized feelings of pain and anxiety for the patient. Additionally, other factors associated with treatment conclusion could also be included, namely: less decalcification or root resorption or even better occlusal outcomes. The major gains of self-ligating systems, which lay the groundwork for approaches that opt for this type of treatment, are as follows: safe and complete positioning of the arch into the slot of the self-ligating bracket, which allows greater control of tooth movement; less resistance to sliding between the bracket and the arch, which increases the expansive capacity of the system; quicker arch removal and placement with a consequent reduction in chair time.[8]

Transverse expansion produced by self-ligating systems is explained by low friction between the bracket and the leveling arch. This fact was demonstrated by a study conducted with 20 patients in which the authors used non-conventional elastometers of low friction. Their results revealed significant transverse expansion during alignment and leveling without further protrusion.[9]

On the other hand, another research assessed patients treated with passive, active and conventional brackets and found no significant differences for the distance between canines, premolars and molars. It is worth noting that no statistically significant difference was observed in the three groups assessed. Furthermore, in the group treated with self-ligating passive bracktes, the distance between canines as well as first and second premolars had slightly higher values in comparison to the other groups.[10]

A significant advantage of a good self-ligating system is its ability to produce higher friction in clinical situations that require movement of a tooth, or a group of teeth, to be restricted along the leveling arch. To this end, a conventional elastometer may be used.[11]

The influence of therapeutic goals over the mechanical management of self-ligating systems is strengthened by a convenient method that includes the use of stops. They are little extensions of telescopic tubes or U-shape 2 to 3-mm open hooks normally positioned in the midline with the primary objective of avoiding distal sliding of wire, which would invariably injure the patient. In the context of the treatment protocol presented in this paper, it is recommended that the stops be placed in the mesial surface of maxillary first molars with a view to favoring protrusion of incisors and mesialization of canines.[12] The possibility of fully exploring this capacity of producing expansion and protrusion within a shorter period of time and in a more effective and, perhaps, more biological manner is what explains our choice of using a self-ligating system to treat the maxillary arch.

Mandibular arch

Individualized brackets were reintroduced and spread in Brazilian literature by Capelozza Filho et al.[13] This type of bracket created an irrevocable culture of customization in Orthodontics which aims at fully respecting the morphology of patient's original malocclusion and, as a result, setting individual therapeutic goals. Capelozza® Prescription III brackets require considerably limited angulation (which certainly is the most important factor for customization), with zero degree for canines and incisors and increased lingual torque of incisors (-6°). For this reason, they are an excellent treatment option to maintain or increase (in a controlled manner) the compensatory features naturally present at the mandibular arch in Class III. This set of brackets aims at minimizing protrusion and eliminating retroclination, which is key to achieve success of compensatory treatment conducted with this type of patient. Nevertheless, customization is clearly not restricted to the choice of brackets. It includes careful bonding, proper selection of more restricted diagrams for the mandibular arch, properly fitted wires and mechanics with Class III rubber bands, all of which decisevely participate in preserving what deserves to be kept and highlighting what should be increased.[2,5,13] Particularly with regards to diagram, it seems important to consider that it is determined in an objective manner, that is, respecting the essence of the arch which,

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in Class III patients, tends to present an increase in the distance between canines and a decrease in the posterior width of the mandibular arch.[16]

According to the literature, mandibular canines of Class III patients present an average difference in angulation of approximately 5 degrees in a distal direction, in comparison to Class I patients. For this reason, Class III patients tend to promote a natural compensation of mandibular incisors. Conversely, their maxillary canines present a smaller difference in mesial angulation of 2 degrees. In short, Class III patients have less tipped mandibular canines (-1.75°) in comparison to Class I patients (3.5°). These values are very close to those suggested for compensation brackets (Prescription III®): zero degree for mandibullary canines.[14]

There is a tendency towards lingual inclination of mandibular incisors in cases of naturally compensated Class III malocclusion, since incisors inclination tends to promote a movement of opposite direction and which is compensatory to the maladjustment that results from a maxillomandibular skeletal imbalance. In other words, Pattern III, Class III patients have maxillary incisors more buccally tipped and mandibular incisors with increased lingual inclination.[14]

It is difficult to preserve the natural compensatory characteristics of the mandibular arch with the use of self-ligating bracktes because, if we compare the degree of expansion achieved by self-ligating and conventional systems, it is clear that there is a stronger tendency for the former to increase the width of the arch.[15] Therefore, since this effect does not agree with treatment primary objective — which consists of preserving the transverse dimension of the manidibular arch — the treatment protocol reported herein chose to use the system of conventional brackets.

CASE REPORT 1

A 36-year and 9 month-old female, caucasian patient sought orthodontic treatment with a chief complaint of anterior crossbite and mandibular prognathism. Her clinical examinations revealed a great difference between maximal intercuspation (MI) and centric relation (CR) in the anteroposterior and vertical direction, with a major impact on face and occlusion (Fig 1). With a view to performing a safe morphological analysis, an acrylic interocclusal device was manufactured (Fig 2) with the mandible in CR, given that this position favored qualitative analysis and, as a result, improved prognosis for a compensatory treatment. For this reason, two analyses were carried out in order to obtain patient's facial morphological diagnosis: one in MI, and another in CR. Her frontal facial analysis in MI revealed little asymmetry, chin deviation to the right, severe anterior proclination, good zygomatic projection, compressive labial seal and decreased lower third. Nevertheless, in CR, analysis revealed that vertical shortening and facial asymmetry were minimized, and a more balanced face without signs of chin deviation (Figs 1A, 1B). Profile analysis confirmed the aforementioned characteristics, both in MI and CR, as well as an increased chin-neck line in MI. Nasolabial angle was closed partially due to the compensation of maxillary incisors, but, especially in MI, due to forced labial seal and consequent decreased ALFH (Figs 1C, 1D). Smile analysis revealed good incisors exposure with normal inclination and slight deviation of the occlusal plane, which was later justified by unilateral crossbite on the right side (Fig 1E).

Occlusal assessment in MI revealed a sagittal relationship between maxilla and mandible of ¾ of Class III on the right side and ¼ on the left side, with anterior and posterior crossbite on the right side without involving second molars. Mandibular incisors were retroclined at a clearly compensatory position as a result of a decreased maxillomandibular step. Median lines coincided with the facial midline (Fig 1F, 1K).

A panamoramic radiograph confirmed the presence of all permanent teeth, with third molars in occlusion and a periodontal condition that was consistent with patient's age. Tooth #14 had a provisional crown as well as an intracanal post and presented favorable conditions for orthodontic treatment onset (Fig 3A).

From a skeletal standpoint, morphological exams of the cephalogram revealed a negative maxillomandibular step with mild mandibular prognathism, especially due to an anticlockwise mandibular rotation, given that the cephalogram was taken at maximal intercuspation. Although mandibular incisors were lingually tipped and strongly compensated, they were also well inserted into the symphysis. Conversely, maxillary incisors were well positioned in the maxillary bone (Fig 3B).

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Figure 1 - Initial photographs: **A**) frontal facial view in maximal intercuspation (MI); **B**) frontal facial view in centric relation (CR); **C**) facial profile in MI; **D**) facial profile in CR; **E**) smiling; **F**) intraoral frontal view in MI; **G**) intraoral frontal view in CR; **H**) intraoral lateral right view in MI. **I**) intraoral lateral left view in MI; **J**) intraoral occlusal maxillary view; **K**) intraoral occlusal mandibular view.

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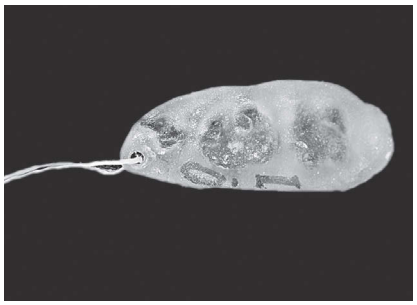


Figure 2 - Acrylic resin device used for occlusal fixation in CR.

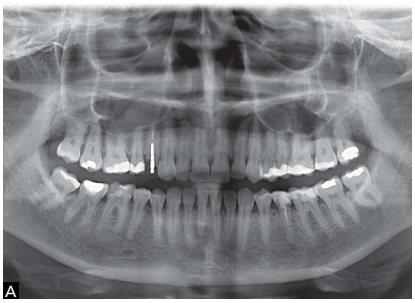




Figure 3 - Initial photographs: **A**) Panoramic; **B**) Profile radiograph.

After collecting all necessary occlusal, functional, cephalometric and face-morphology examinations, and evincing a deviation from CR to MI, we came up with the following diagnosis: adult patient, mild Pattern III, brachyfacial, borderline for Short Face and with an acceptable facial pattern. Relationship between maxilla and mandible of ¾ of Class III on the right side and ¼ on the left side, with anterior and posterior crossbite on the right side. Well-positioned maxillary incisors and retroclined mandibular incisors in relation to the bone. Patient's morphological analysis of the face in CR (Figs 1B, 1D) reinforced the need for compensatory treatment that aimed at increasing volume in the maxillary arch and restricting the mandibular arch. The absence of crowding in the mandibular arch favored such treatment goal, although it hindered an increase in circumference in the maxillary arch.

Treatment plan included the use of Damon MX® standard self-ligating brackets (Ormco), with torque of +12º applied to central incisors, +8º to lateral incisors and 0º to canines, respecting the need for increasing volume in the maxillary arch within esthetic limits — which could be exceeded with the use of high torque brackets (+17°, +12° and +6°, respectively) or by producing, by means of low torque brackets (+7° and +3°, for central and lateral incisors), a weaker protrusion, insufficient to correct crossbite. The mandibular arch received Capelozza® Prescription III brackets (Abzil, 3M™). At first, mandibular incisors were not included in order to avoid protrusion (given that anterior lower crowding was quite discrete) which could have been produced by initial and random leveling of lower teeth (Fig 4).

Capelozza® Prescription III brackets (Abzil, 3M™) have a very positive characteristic that favors the therapeutic goal recommended for this patient: maximum preservation of the mandibular arch or, in small proportions, a modest increase in the natural compensatory characteristics. Torque of -6º would be applied to mandibular incisors to this end. In other words, mandibular incisors would be severely lingually tipped by the mechanics to which brackets would contribute. Although there was no intention of further using rectangular wires in the mandibular arch, this procedure does not break with the concept of maintaining the original form of the arch. Without a doubt, the key factor to achieve treatment success in this compensatory game is the absolute economy of angulations provided by brackets with no angulation bonded from canine to canine, which results in little protrusion and requires less space during leveling.

In this approach, which the orthodontist assumes total control of treatment, bracket bonding was individualized and maxillary incisors were more cervically bonded so as to adjust the incisal curvature of final smile and, at the same time, allow low reading of strong torque embeded in maxillary brackets. Before interpreting this as nonsense, one should remember that, in this case, treatment approach intended to increase maxillary protrusion in accordance with esthetic limitations. Additionally, there is speculation that this treatment protocol stimulates greater bodily buccal movement. Should mandibular incisors be bonded, they were more cervically positioned in relation to the vestibular axis point with the height of previouly leveled canines as reference.

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All aforementioned alterations are favorable in compensatory cases of Pattern III, Class III, as they favor good overbite as well as functional anterior guidance.

With a view to enhancing the position of mandibular orthopedic stability and deconstructing maximal intercuspation, fixed stops made of composite resin were bonded to the lingual surface and incisal third of mandibular incisors with balanced and unifrom occusal contact with antagonist teeth (Fig 4E). This measure favors buccal movement of teeth involved in crossbite, stimulates extrusion of posterior teeth within the posterior interocclusal space created to produce gain in vertical dimension of occlusion (VDO), and, at the same time, improves treatment mechanical efficacy by producing an effect of occlusal unlocking.

Also, with a view to directing movement towards the areas of interest, which were carefully investigated, stops were bonded to the mesial surface of first molars and the arch was adjusted with a space of 2 mm between the wire and the bracket. In other words: The wire was mesially fitted on first molars and passed 2 mm away from the maxillary incisors, thereby stimulating protrusion of these teeth. Additionally, elastometers were placed on premolars and canines so as to concentrate the "outburst" in the anterior region, thereby meeting the primary treatment objective (Fig 5). After correcting anterior crossbite, mechanics was directed towards teeth #14 and 15.

With a view to maintaining the compensatory characteristics, which are also related to the form

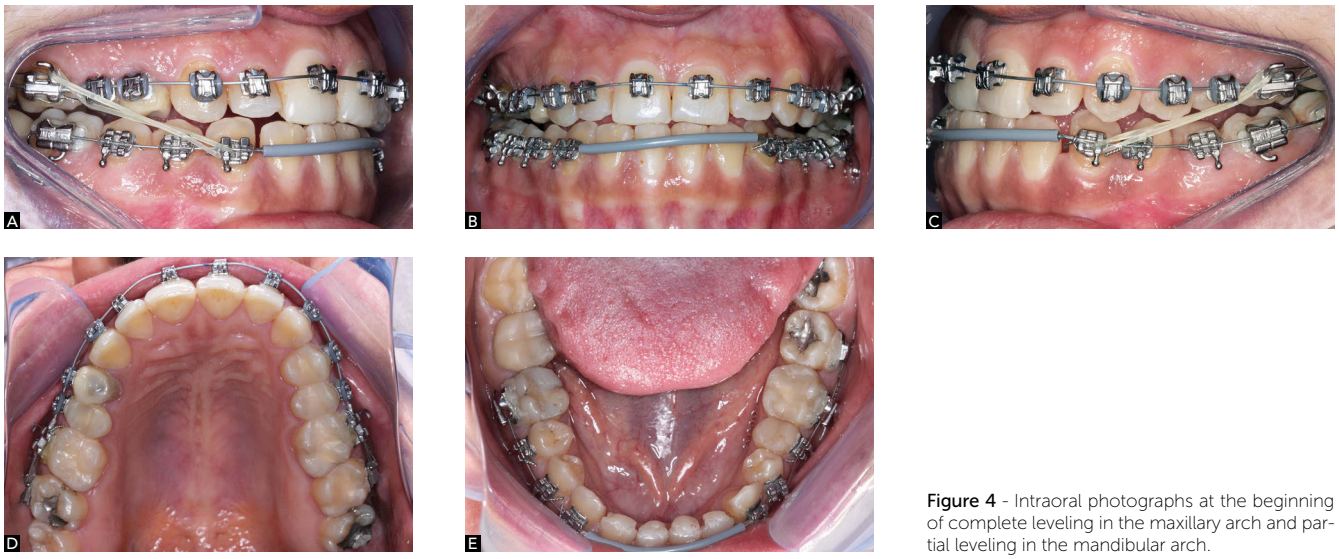


Figure 4 - Intraoral photographs at the beginning of complete leveling in the maxillary arch and partial leveling in the mandibular arch.

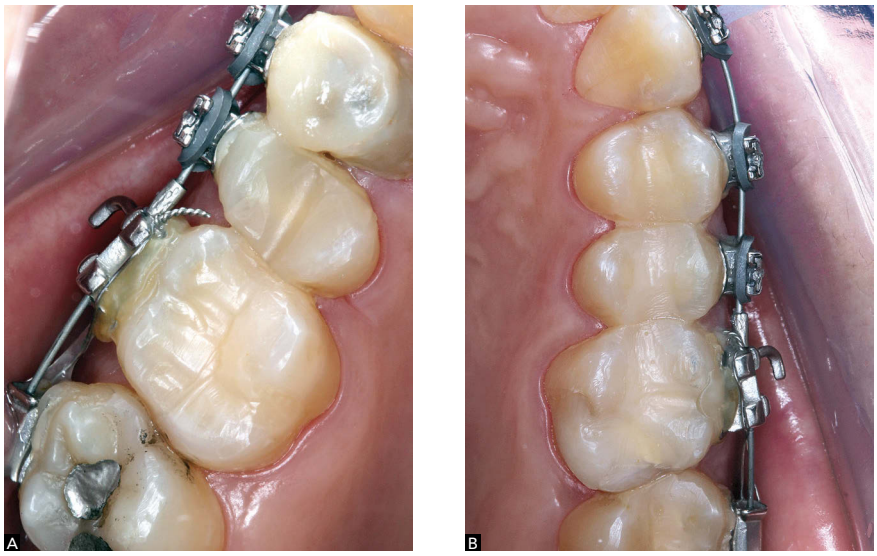


Figure 5 - Photographs depicting right and left maxillary quadrants, highlighting stops placement and the use of elastic modules.

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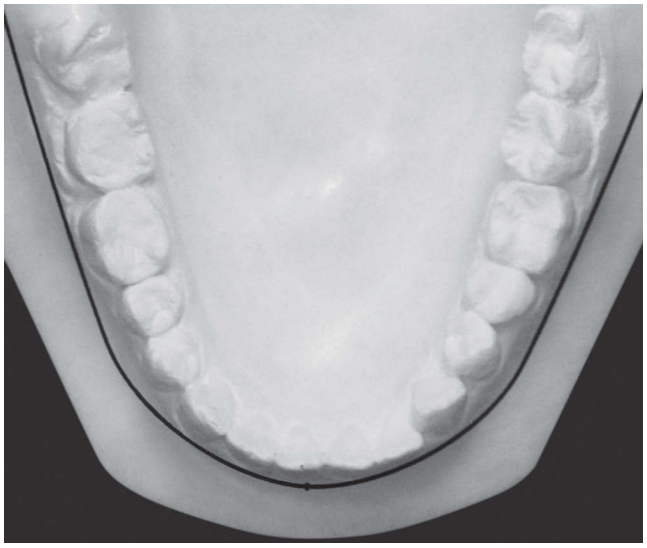


Figure 6 - C6A7 objective anatomic individual diagram.

of the arch, C6A7 diagram was chosen (Fig 6) for favoring slight retroclination of mandibular incisors and protrusion of maxillary incisors. Additionally, in the posterior region, it respected the mandatory dentoalveolar compensatory mechanism of the mandibular arch.[16]

Two months after the onset of leveling in the maxillary arch, a mandibular appliance was installed with immediate use of Class III 5/16" rubber bands supported by hooks placed on maxillary first molars and mandibular canines. This measure immediately prevented mandibular protrusion and, at the same time, produced space gain necessary for future leveling of mandibular incisors without stimulating buccal inclination.

Without a doubt, this treatment phase was the most difficult in terms of mechanics, given that any careless procedure could worsen anteroposterior relationship between the maxilla and the mandible and, as a result, create greater demand for treatment of potential side effects. From this initial phase on, maxillary leveling was conducted with a sequence of archwires evolving to 0.019 x 0.015-in steel wire. As for the mandibular arch, the sequence of archwires stopped at 0.018 steel wires because rectangular wires were not necessary for additional angulation or inclination reading. During the phase of formatting, mandibular arch morphology was consistent with the initial treatment goals. Moreover, even if individualized brackets were used, they were not completely customized and, for this reason, their maximum expression may not suit this type of patient (Fig 7). In the final treatment phase, panoramic and lateral radiographs were taken with a view to assessing tooth positioning and potential biological costs inherent to orthodontic treatment (Fig 8).

Figure 9 shows slight, yet major improvements in lip contact. It also depicts decreased asymmetry initially shown at maximal intercuspation in frontal view. Figure 10 shows good occlusal relationship achieved after removing the appliance.

Figure 11 shows initial and final cephalometric tracings superimposition at treatment completion, which allowed an accurate analysis of the mechanisms that enabled occlusal adjustment. Improvements were achieved due to a set of several small adjustments, namely: correction of discrepancy between CR and MI, retroclination of mandibular incisors and protrusion of maxillary incisors. All these factors added up to magnify the positive impacts on patient's occlusion and face as well as to allow transverse expansion of the maxillary arch and crossbite correction.

Treatment lasted for 15 months, with a total number of 10 visits since the appliance was firtly installed in the maxillary arch until it was removed.

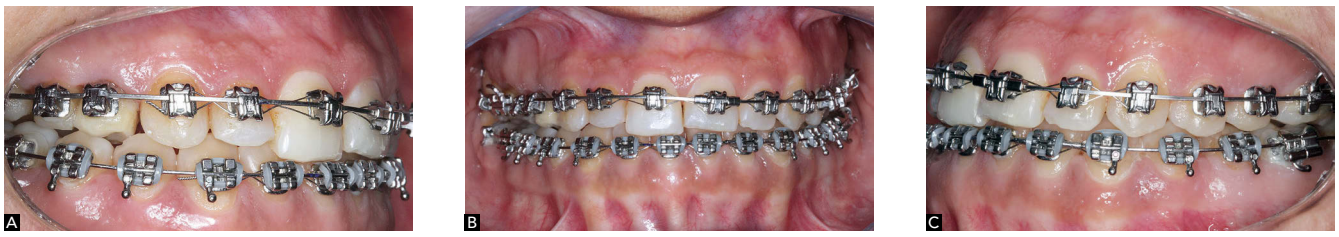


Figure 7 - Intraoral photographs at the end of leveling in the maxillary arch (with 0.019 x 0.025-in wire) and in the mandibular arch (with 0.018" steel wire).

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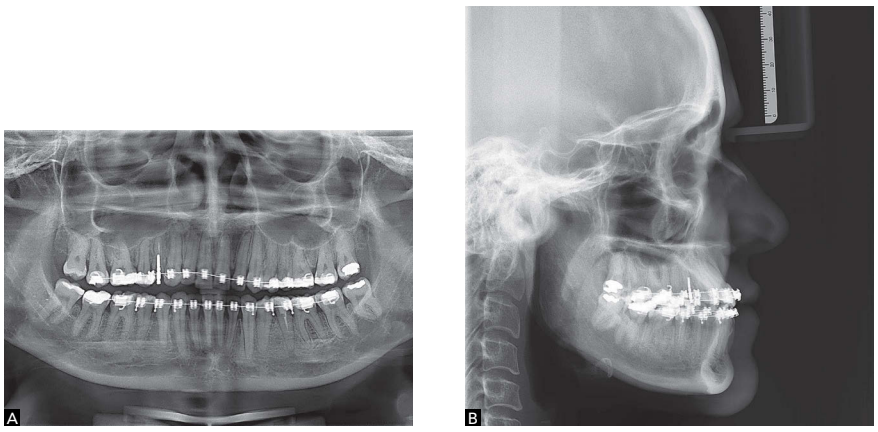


Figure 8 - Radiographs at treatment completion: **A**) Panoramic; **B**) Profile radiograph.



Figure 9 - Final extraoral photographs.



Figure 10 - Final intraoral photographs.

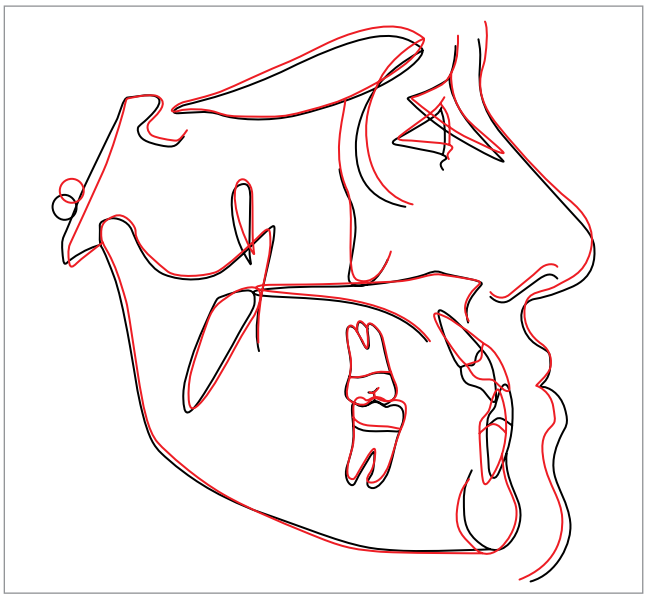


Figure 11 - Initial (black) and final (red) cephalometric tracings superimposition.

CASE REPORT 2

A 26-year and 2-month-old female, caucasian patient sought orthodontic treatment with chief complaint of lack of space for implant placement at tooth #22 site and small-sized tooth #12. Her profile analysis revealed maxillary deficiency and unsatisfactory lip contact with her lower lip ahead her upper lip and open nasolabial angle (Fig 24A). Her frontal facial analysis revealed a balanced face with good acceptability (Fig 12 B). Her smile was characterized by lack of space, disproportional maxillary lateral teeth and tooth #21 darkened by endodontic treatment (Fig 12C).

Her occlusal analysis revealed Class III subdivision malocclusion of ¼ on the right side, crossbite on tooth #12 as well as decreased overbite and overjet. Her mandibular arch showed evident compensation, with retroclined incisors and mandibullary canines with no mesial angulation. Median lines coincided with the facial midline (Fig 12D, 12H).

Panamoramic radiograph confirmed maxillary and mandibular third molars as well as tooth #22 agenesis corrected by an adhesive prosthesis bonded to teeth #21 and 23. She presented general periodontal condition that favored orthodontic treatment (Fig 13A).

From a skeletal standpoint, morphological exams of the cephalogram revealed a negative maxillomandibular step with mild maxillary deficiency and differences between palatal and mandibular planes. Maxillary incisors were buccally tipped as expected. However, mandibular incisors counteracted occlusal analysis as they were well positioned in the symphysis (Fig 13B).

Diagnosis was as follows: adult patient, mild Pattern III, dolichofacial with acceptable face pattern, especially from frontal view. Relationship between maxilla and mandible of ¼ of Class III on the right side, with anterior crossbite on tooth #12, decreased overbite and overjet, agenesis of tooth #22 and increased buccal tipping of maxillary incisors.

Patient's self-perception of facial normality in frontal view reinforced the need for compensatory treatment while eliminating the need for absolute corrective treatment by means of orthognathic surgery for maxillary advancement. In this context, treatment plan was directed towards the protocol presented herein: the use of Damon MX® (Ormco) self-ligating brackets. Unlike case 1, high torque prescription was chosen for the maxillary arch (CI +17º, IL +10º, C +7º) as it required greater protrusion and expansion, both of which were justified by more expressive buccal torque applied to the maxillary arch and Capelozza® Prescription III brackets (Abzil, 3M™) used in the mandibular arch.

In case 2, the greatest challenge was to increase overbite and overjet while opening spaces for appropriate rehabilitation of maxillary lateral incisors without producing the effect of reversing the incisal curvature at smiling — which is quite common in cases requiring major compesantion of maxillary incisors. In order to control such effect, Precription III was used in the mandibular arch with brackets more cervically bonded on maxillary lateral and central incisors.

Once again, with a view to directing movement towards the areas of interest, stops were bonded to the mesial surface of first molars, thereby producing a space between the 0.14" heat-activated wire and the bracket in the anterior region of the maxillary arch. Additionally, elastic modules were used from right and left premolars to right canine as — transverselly speaking — those teeth functioned as reference of normality. Treatment onset on the maxillary arch was of paramount importance, and so was installing the appliance on the mandibular arch 40

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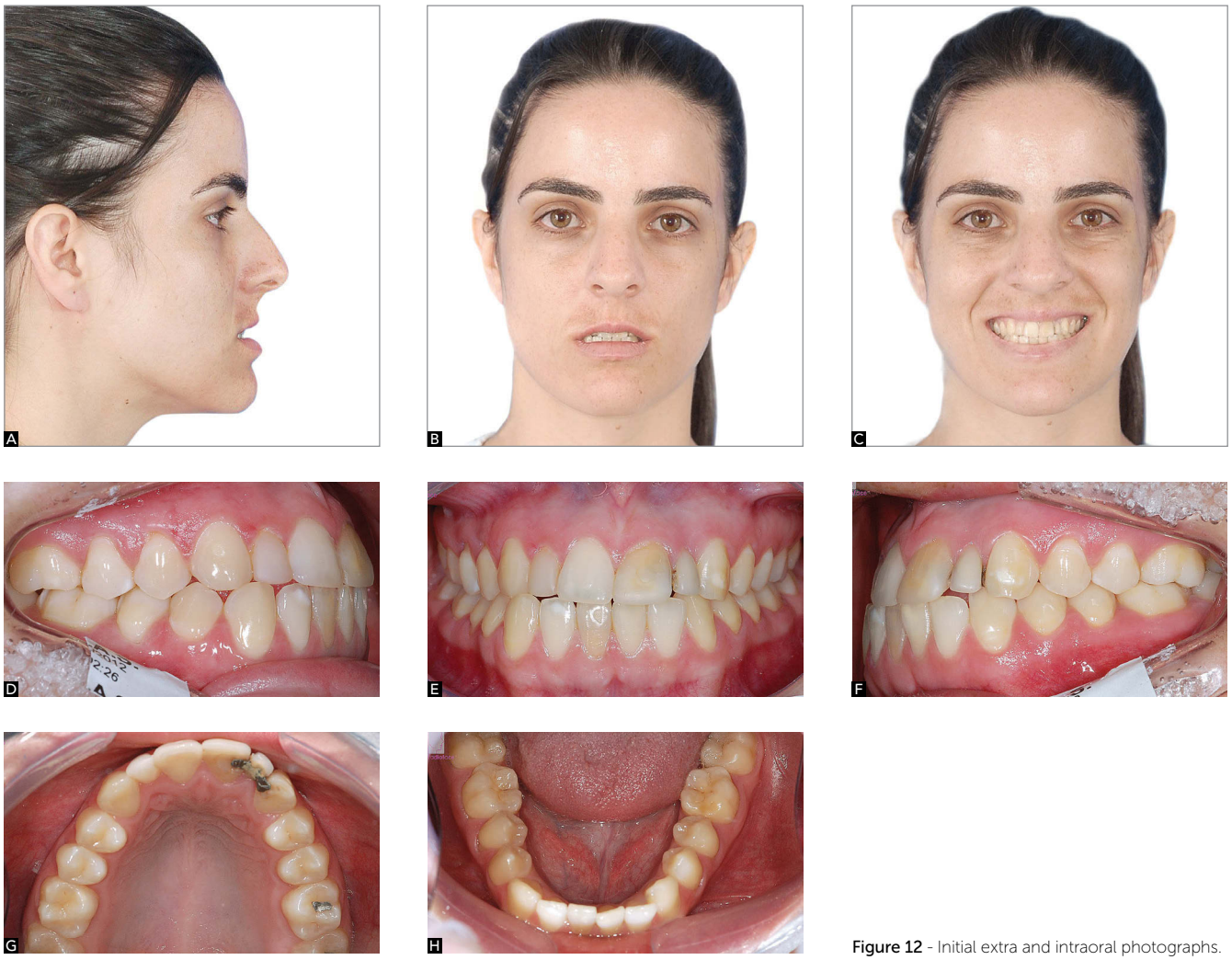


Figure 12 - Initial extra and intraoral photographs.

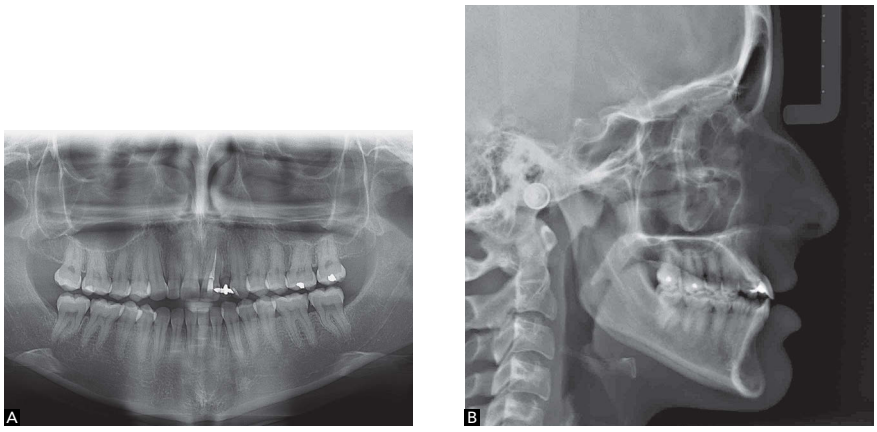


Figure 13 - Initial radiographs: **A**) Panoramic; **B**) Profile radiograph.

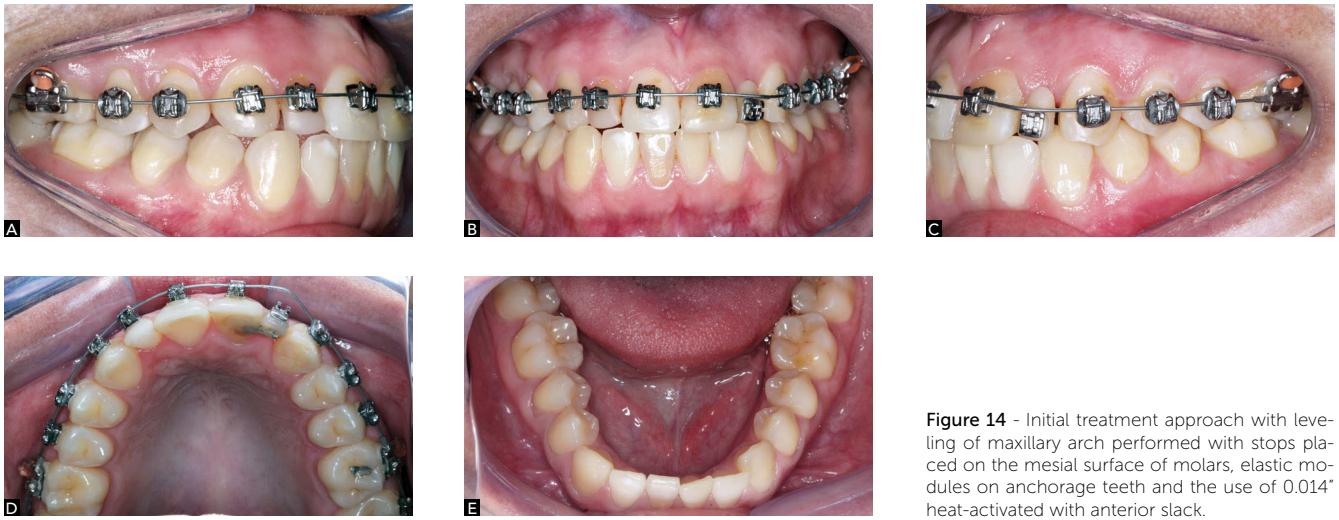


Figure 14 - Initial treatment approach with leveling of maxillary arch performed with stops placed on the mesial surface of molars, elastic modules on anchorage teeth and the use of 0.014" heat-activated with anterior slack.

days after using 0.014 x 0.025-in heat-activated wire in the maxillary arch — 4 months after treatment onset. In other words, it was installed after the form of the maxillary arch, which used to be limited, was more expanded and defined. In order to favor greater anterior overbite, maxillary second molars were not included in leveling. This set of actions is definitively in accordance with the therapeutic goals previously established for patient's compensatory treatment (Fig 14).

C4A7 diagram was chosen (Fig 15) for providing greater freedom to improve the form of the mandibular arch, which was allowed by the great demand for space in the maxillary arch.

The sequence of wires used in the maxillary arch was as follows: 0.014" heat-activated; 0.014 x 0.025-in heat-activated; 0.017 x 0.025-in TMA; 0.019 x 0.025-in TMA and 0.019 x 0.025-in steel wire. As for the mandibular arch, 0.014 NiTi superelastic and 0.016 NiTi superelastic wires were mesially fitted, followed by 0.018" steel wire installed with omega loops.

Figure 16 shows the effect produced with the use of open and closed springs to equalize the space necessary for proper rehabilitation of teeth #12 and #22.

Final panoramic and profile radiographs not only certify safe and trustful results, but also confirm intraosseous space gain for future implant placement on tooth #22 site (Fig 17).

Treatment produced considerable improvements and discreet, yet extremely positive benefits for the face. Thus, it proves the protocol adopted herein to be efficient with regard to the therapeutic goals previously established (Fig 18).

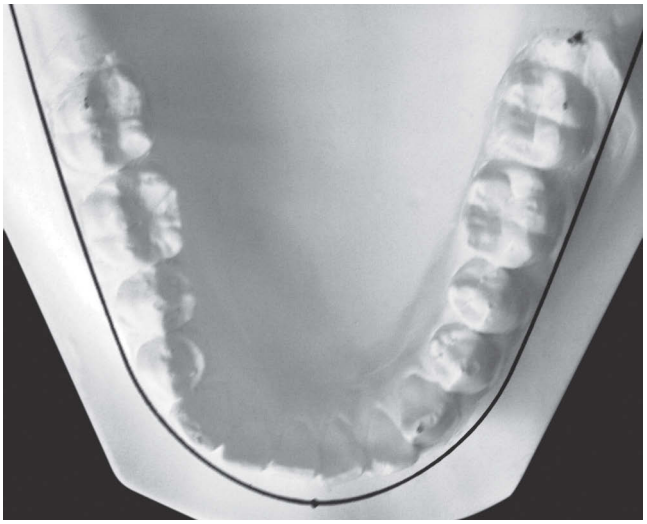


Figure 15 - C4A7 objective anatomic individual diagram.

Cephalometric tracings superimposition helps us understand that right choices were made with a view to achieving functional and esthetic balance of a malocclusion that presents compensatory characteristics inherent to both Pattern III and sagittal relationship between maxilla and mandible aggravated by agenesis in the anterior region of the maxillary arch (Fig 19).

Treatment lasted for 18 months, with a total number of 11 visits.

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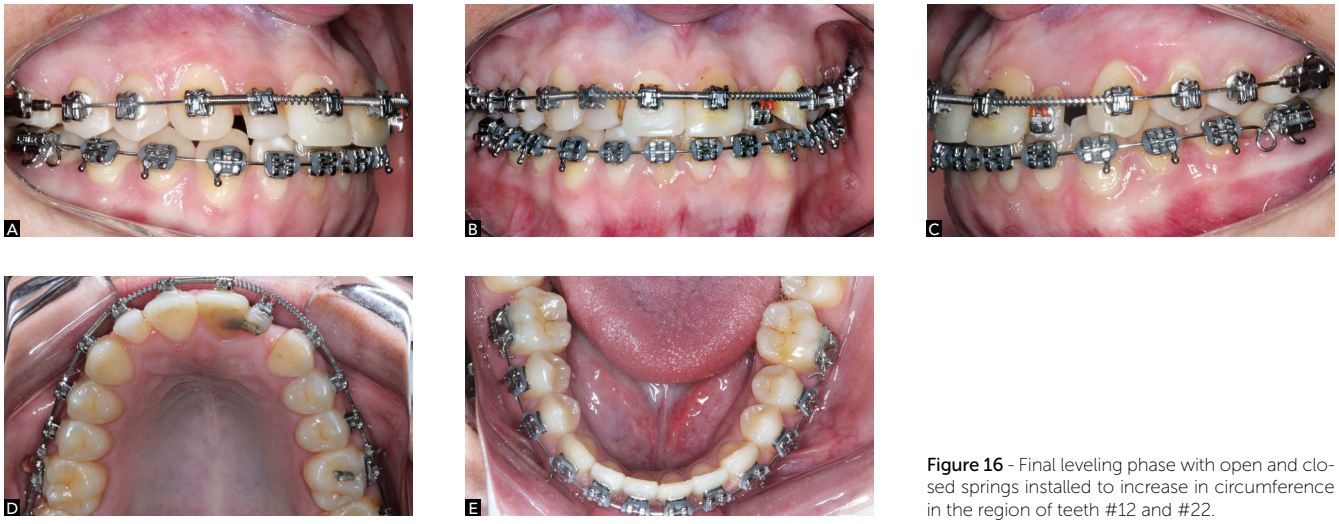


Figure 16 - Final leveling phase with open and closed springs installed to increase in circumference in the region of teeth #12 and #22.

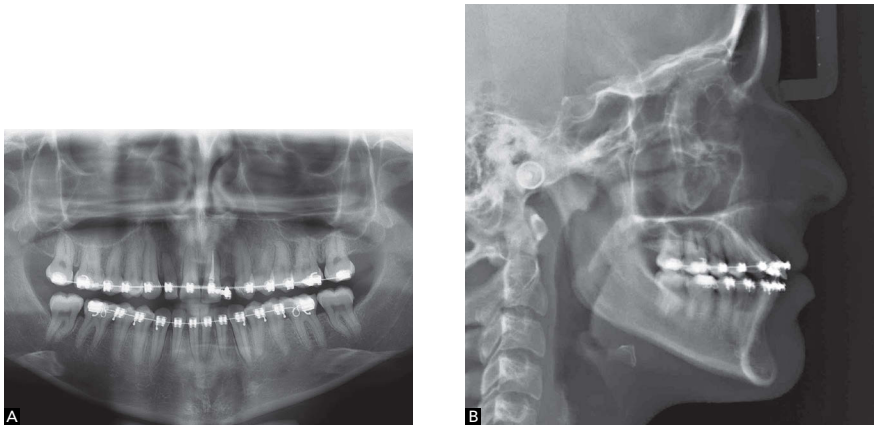


Figure 17 - Radiographs at treatment completion: **A**) Panoramic; **B**) Profile radiograph.

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Figure 18 - Final extra and intraoral photographs.

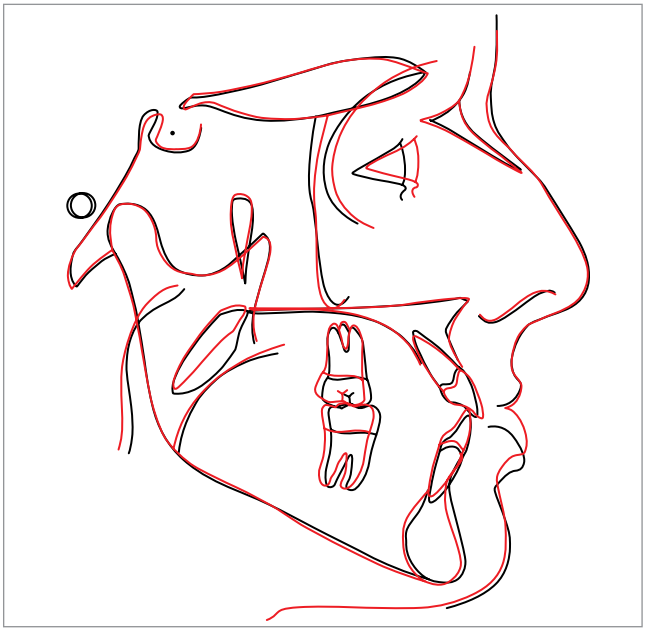


Figure 19 - Initial (black) and final (red) cephalometric tracings superimposition.

CASE REPORT 3

A 23-year-old male, Japanese-descendent patient sought orthodontic treatment with chief complaint of unilateral crossbite on the right side and mandibular shift to the right. His frontal analysis revealed vertically balanced face with discreet laterognathism. His profile analysis revealed clearly balanced maxillomandibular relationship with passive labial seal, slightly open nasolabial angle, well-defined mentolabial sulcus and normal chin-neck line. At smiling, the patient presented some alterations such as reversed incisal curvature in relation to the lower lip curve, asymmetry in the positioning of teeth #13 and 23, and increased lingual inclination of teeth #14 and 15 (Figs 20A, B, C). His occlusal analysis (Figs 20D to 20H) revealed sagittal relationship of ½ of bilateral Class III in the region of second premolars

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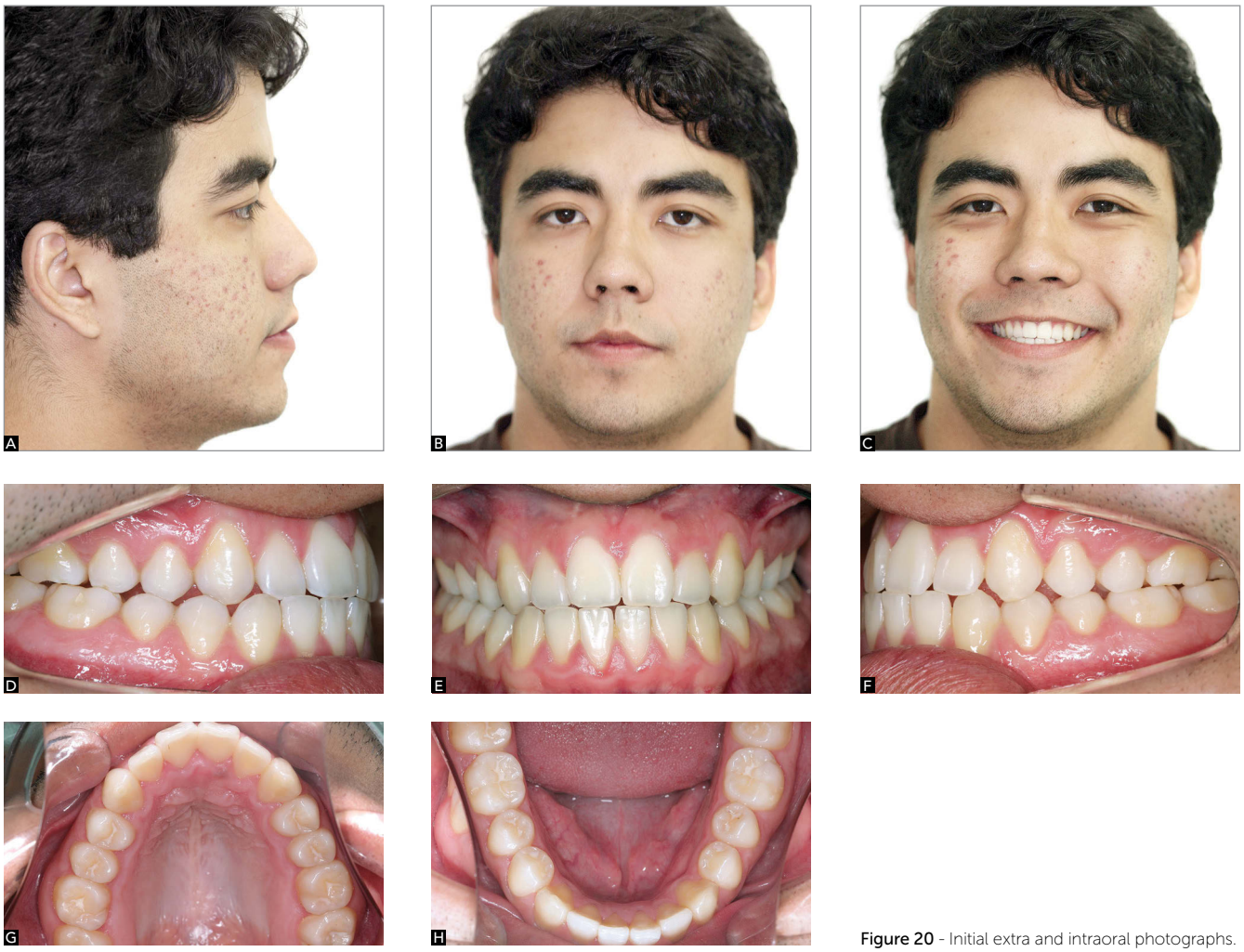


Figure 20 - Initial extra and intraoral photographs.

and of ¼ in the region of canines. This difference in magnitude may be explained by the level of compensation present in mandibular canines and premolars that resigned their mesial angulations. Transverse relationship was impaired by unilateral crossbite on the right side and decreased overbite as well as overjet in the anterior region. Frontal intraoral view revealed a 2-mm deviation of the lower midline to the right coinciding with mandibular skeletal deviation.

Panamoramic radiograph revealed periodontal and structural health that favored orthodontic treatment. Third molars had been previously extracted (Fig 21A). Morphological exams of the cephalogram confirmed all aforementioned positive facial characteristics and revealed something new: vertical maxillary excess unable to negatively affect patient's face or smile. Maxillary and mandibular incisors were well positioned into the jaws (Fig 21B).

Unlike the aforementioned patients, this patient was diagnosed as Pattern I with mild laterognathism to the right, dolichofacial and pleasant face, relationship between maxilla and mandible of ½ bilateral Class III, with unilateral crossbite on the right side and absence of overbite and overjet. He was asked about the possibility of undergoing orthognathic surgery, since the procedure would be the only one capable of correcting asymmetry — one of his chief complaints. Nevertheless, given that mild mandibular shift did not worsen after a year, the possibility of surgery was discarded and compensatory treatment was chosen to solve patient's occlusal problems, thereby enduring his small skeletal defect. Although the patient was Pattern I, the relationship between maxilla and mandible was Class III and granted him occlusal characteristics of Pattern III. For this reason, he was treated under the same protocol employed in cases 1 and 2.

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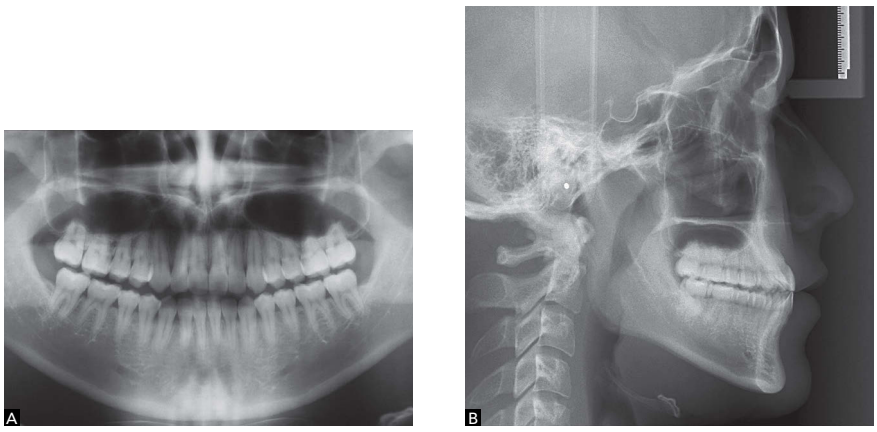


Figure 21 - Initial radiographs: A) Panoramic; B) Profile radiograph.



Figure 22 - A) Initial treatment approach with leveling of maxillary arch performed with stops placed on the mesial surface of molars, elastic modules on anchorage teeth and the use of 0.014" heat-activated with anterior space between teeth #11 and #14.

Once again, we faced the need for controlled maxillary protrusion and expansion as well as restriction of both in the mandibular arch. Figure 22 shows similarities with the aforementioned protocol: treatment onset on the maxillary arch, use of stops and elastic modules with a view to achieving protrusion and expansion in the right anterior and lateral region.

C5A9 diagram (Fig 23) was chosen to preserve the form of the mandibular arch, given that unilateral crossbite on the right side, without deviation from MI to CR, was a predictive factor of potential difficulties in achieving proper transverse control — especially in the case of an adult patient.

The sequence of wires used in the maxillary arch was as follows: 0.014"; 0.016"; 0.014 x 0.025-in; 0.018 x 0.025-in heat-activated; 0.019 x 0.025-in TMA and 0.019 x 0.025-in steel wire. As for the mandibular arch, the following arches were used: 0.014" NiTi superelastic wire mesially fitted; 0.016 and 0.018 steel wires with omega loops. This patient required compensatory bends (Fig 24) for a more individualized treatment finishing, especially due to laterognathism.

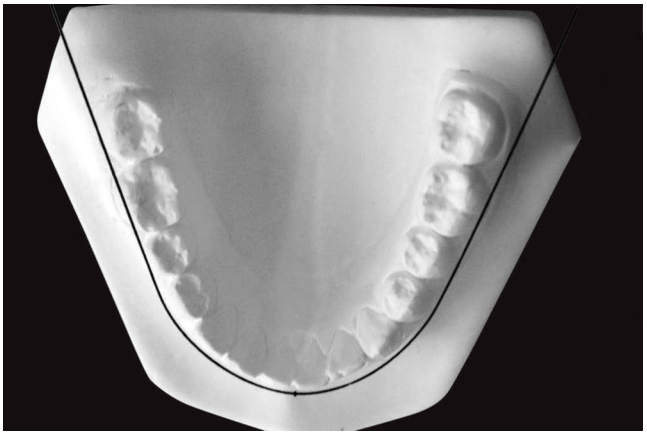


Figure 23 - C5A9 objective anatomic individual diagram.

Final panoramic and lateral radiographs reveal absolute control (Fig 25). Figure 26 certifies protocol efficacy. Patient's face did not change, as expected. Nevertheless, gains in overbite and overjet, correction of unilateral crossbite and Class I relationship established between canines provided him with a functional routine and expressive esthetic benefits.

Initial and final cephalometric tracings superimposition reveals that the effects described in case report 1 and 2 were repeated in case 3 (Fig 27).

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Figure 24 - Final leveling phase with individualized bends for treatment finishing: buccal steps on teeth #16, 26, 12 and 13; and "Z" bend on tooth #21.

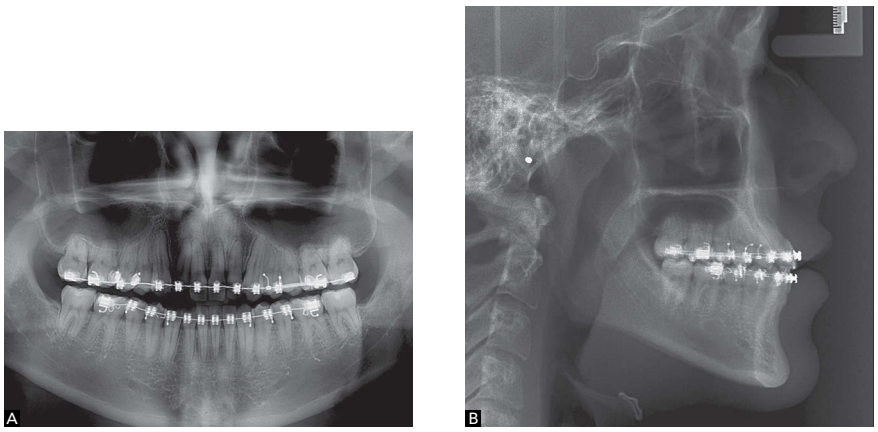


Figure 25 - Radiographs at treatment completion: **A**) Panoramic, **B**) Cephalometric cephalogram.

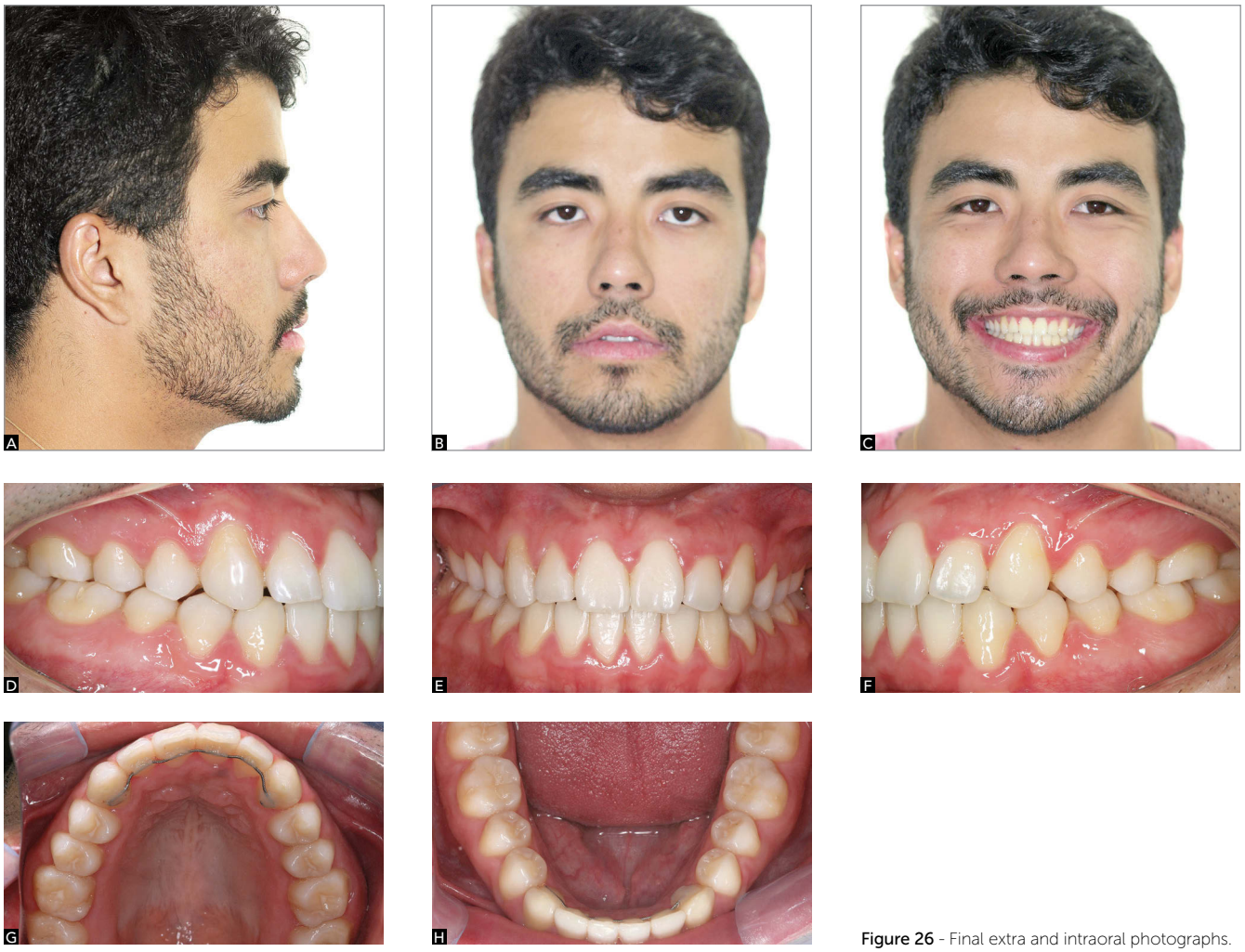


Figure 26 - Final extra and intraoral photographs.

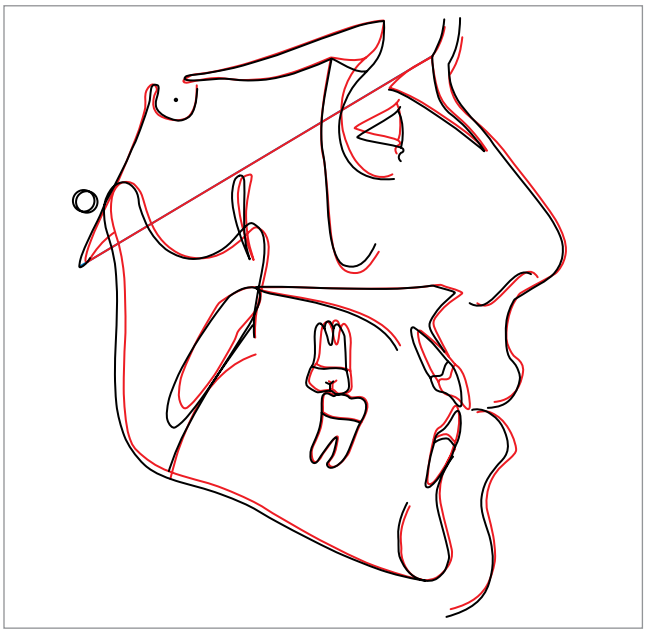


Figure 27 - Initial (black) and final (red) cephalometric tracings superimposition.

Treatment lasted for 24 months, with a total number of 17 visits. Treatment time was greater than expected due to unilateral crossbite, the need for individualization bends and the clinician's learning curve — since this was the first patient treated under the protocol described herein.

FINAL CONSIDERATIONS

The gains in efficiency of alignment and leveling produced by self-ligating brackets have not been scientifically proved. Some recent studies do not seem favorable to confirm the greater productivity of this system, since most of them aim at comparing the magnitude of movement during alignment and leveling without considering the individual variations of the samples.[10,17] From this point of view, self-ligating brackets would be just a more practical method employed to fit and remove archwires. Nevertheless, directing mechanics associated with bracket individualization towards flexile therapeutic goals seems to potencialize treatment outcomes. Carefully using stops and elastic modules to manage friction in self-ligating bracket systems used in areas where movement is less required is a good example of how to explore the maximum productivity of this system, and justifies the methodology employed to treat the patients reported herein.

Using individualized Capelozza® Prescription III brackets (Abzil, 3M™) in the mandibular arch to treat Class III is essential to yield more esthetically tolerated results, given that maximum maintenance of the form of the arch more naturally compensated creates possibilities of moderate gains in the maxillary arch without hindering smile esthetics. This occurs because the ideal morphology for sagittal correction of the arches is limited by smile reading; thereby giving the orthodontist the opportunity to create a less protrusive and less expansive maxillary arch than he would mechanically do.

It seems imperative to treat these malocclusions by means of absolutely individualized methods, seeking to preserve what should remain and strictly change what must be corrected. Treatment that starts on a reasonable or poor occlusal morphology should continuously evolve to improvements so as to prevent a greater demand for treatment.

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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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