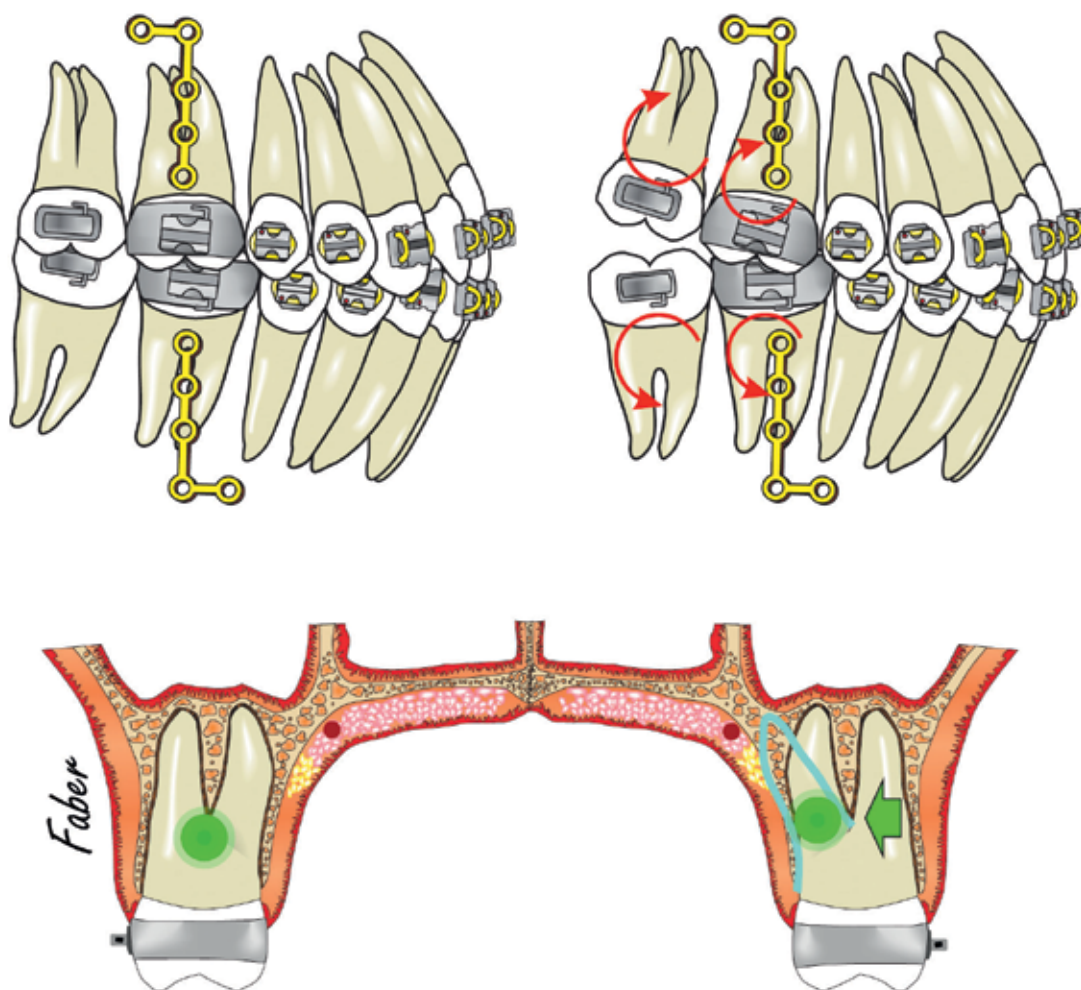


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A journey, I mean, a journal...

A journey of a thousand miles begins with a single step.

Mao Zedong

Frustration and fear of failure are crippling burdens that can discourage one from taking the first step on a yet uncharted course. This might explain why it must have been a daunting task to launch this journal in 1996 at a time fraught with risks and red herrings. The Furquins and their enthusiastic team embarked on the dream of building a legacy meant to fill Brazilian orthodontists with pride. Despite the drawbacks, the first step was taken. It was high time for some of the world's most widely respected orthodontic professionals to prove their mettle and glimpse a horizon far beyond the fences that restrained them.

No matter how thick a forest, every road begins with a humble path being blazed across the vegetation. The first intrepid trailblazers ventured deep into the forest oblivious of obstacles both known and unknown. The dreams and the courage of Daniel Boone in the U.S. and the Villas Bôas brothers in Brazil, are extolled. Why not the Furquins? All these visionaries could plainly see the threat of failure looming, but with feet planted firm on the ground. Time ticks away inexorably and there comes a time when either the forest closes back in or a path is blazed to provide for passage and communication. Little by little, step by step, the path gets longer and longer while the trailblazer picks up a lively pace.

In Maringá, the first pioneering gesture to confront this huge challenge also began with a mere trail in the heart of a pine forest. It was there and then that the Dental Press journal of orthodontics, albeit limited by its own inexperience, emerged with the height of a pine tree in its ideological aspirations. The pathway opened in the jungle of the unknown was celebrated as a milestone. It was a narrow trail, overgrown with thorns, but determined not to perish.

Man (homo) is made out of "humus," (earth), said Nietzsche, and therefore, greater than man himself is his work. Should these men be ready for prosperity, they will be able to prepare disciples of their very same caliber. In 2003, Adilson Ramos, a young, extremely competent and humble professional — to a fault, even — brilliantly carried on the torch of his predecessor. Adilson's branches ('ramos' in Portuguese) grew forth and reached the remote Amazon. In 2005, when I received a letter of invitation to be a reviewer, an honor for this native Amazonian, Adilson expanded the means of delivery and shifted the axis of orthodontic geography in Brazil. With this gesture we had not just a trail, but a dichotomy on Terra Brasilis. The metaphorical road received finishing touches and the SciELO "seal." The journey on this road led to the "Dental Press Journal of Orthodontics and Dentofacial Orthopedics," which became the first specialized Brazilian journal indexed in this very important database along with three other multidisciplinary journals. At that moment the whole world would know it, admire it, and even applaud it.

In 2007, another passerby took to the road and was invited to carry on the management of the work. I must confess that at the time he was a stranger to me, as well I may be a stranger to you today: A lowly backpacker, to many readers. The painstaking "engineer" Faber, with his ubiquitous "niemeyerians" — among many other virtues — dared to dream dreams which some may label as reveries. To be a dreamer and yet meticulous may seem paradoxical. Nevertheless, if you look around you will see great works built by so many Quixotes. Brasília, his homeland, is an example of superb planning. We are happiest when we believe in our own dreams, because the art and action that

go into them bring us closer to the Creator. And much more so when the act of creation is devoid of any futile interest for it is better to enjoy the simple pleasure derived from collaborating and growing exponentially than to idle about in quiet desperation waiting for Godot to sort out one's life. For all, "work" preceded "luck".

Jorge — that's how I fondly call him — paved the way for us by applying international publishing standards. Articles are now submitted online, and the journey, I mean, the journal crossed the boundaries of this vast country to embrace another language: — Yes, we don't have just bananas. Now, we are the *Dental Press Journal of Orthodontics*. Meanwhile, I was invited to occupy the position of assistant editor. So I introduced myself to someone who was only able to recognize me by looking at me askance. And I realize that in today's Brasília there are men who remind us of some of the great souls who helped to conceive it. Maringá joined Brasília on that road that could well serve as a nostalgic example for the entire country. Now, the Belém-Brasília highway in its colossal dimensions and its careful planning epitomizes the pioneering spirit of those who built it almost the size of Brazil.

The journal, I mean, the journey on this road, now paved, signalized and expanded, so pretty and so well built, became the first pathway of our researchers and readers. But all is not peaches and cream: An avalanche of papers congested the editorial traffic, which can be distressing to an editor. Good articles seek publication, but there is a limit even to a(n) (in) commensurate space. The group of road engineers, i.e., editors — relying on the (inter)national competence of Daniela Garib (USP/Bauru-SP), Matheus Pithon (UESB/BA), Flavia Artese (UERJ), Fernanda Angelieri (USP-SP),

Ildeu Andrade Jr. (PUC-MG) and the tireless Telma Martins (UFBA) — is forced to set three parasymphetic goals: Increase the number of online articles, reduce the size of the texts, and the inevitable and painful rejection of good articles. Whenever we say "no" we must stop and consider who is the target of this negative answer. They are often young folks striving to take their dreams to the next level: Sometimes Science is the irrational side of our dreams.

Thus, I am simply delighted to share with you some episodes in the history of this journal. I would also like to extend a heart-felt thank you to those friends who traveled with me along each and every highway: Laurindo and Teresa, Adilson and Jorge, for the presage they conceived and for sprinkling their holy water on me. Furthermore, to the editors and reviewers for sticking with us through this transition. Our duty consists simply in maintaining the quality of the work. Hopefully, there should be no further claims. However, if only I could trick the infamous "regression to the mean" and raise it to the pinnacle of my dreams, I would have, metaphorically, the following: All holes duly filled, a preserved signage and a smoother traffic control. In this case, not regressing would in itself mean progress for those with the challenging mission of maintaining the excellent level of the road where our journey, I mean, journal, is transporting us. After all, Science owes much to statisticians, but is also built by dreamers, who dare to dream and endure the pangs of creation.

Finally, let us move on...

And good reading!

David Normando

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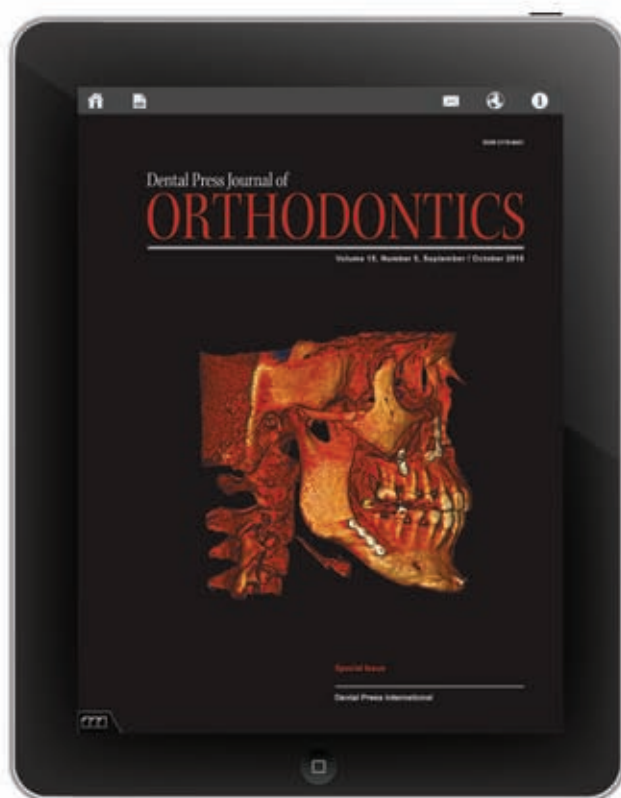
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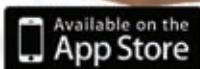
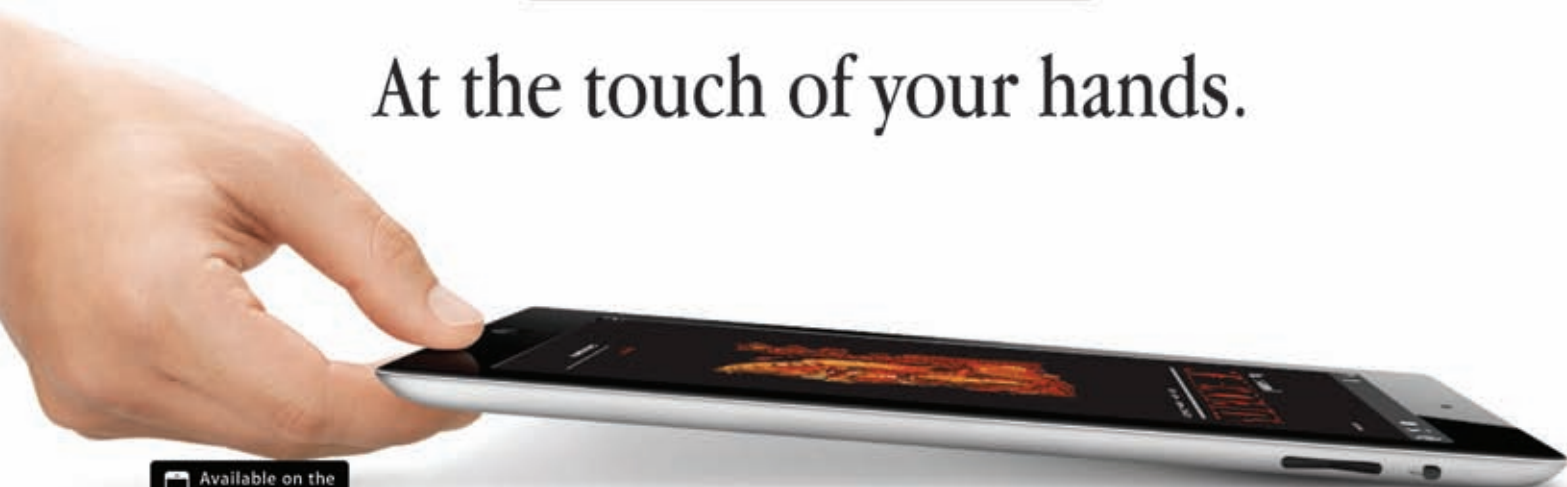


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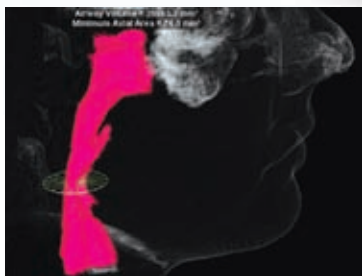
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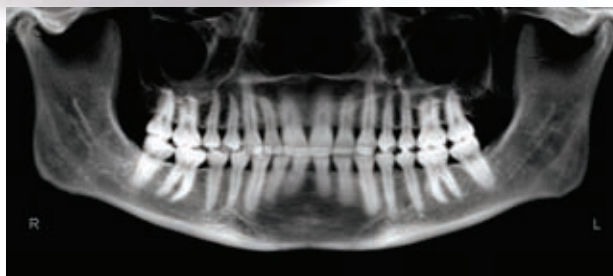
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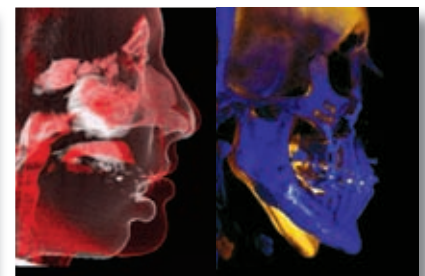
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The impact of orthodontic treatment on periodontal support loss

Ana Cláudia Amorás Alves*

The increase of life expectancy and purchasing power, along with the changes on esthetic concepts, resulted on the increase of the number of adults seeking orthodontic treatment, combining functional benefits to smile esthetics. Because of this change, now, it is part of the orthodontist clinical routine to treat patients, dealing with individuals with periodontal disease or sequelae of this disease.

It has been well established that dental plaque represents a risk factor that is necessary in the pathogenesis of gingivitis and periodontitis, and the progression of periodontal disease depends on the balance between microbial biofilms and immune and inflammatory host responses.^{2,3}

Regarding gingival inflammation, studies^{4,5} show that the installation of orthodontic appliances increases the amount of plaque, which results in formation of gingival hyperplasia and pseudopockets. This situation changes the subgingival ecosystem and facilitates the increasing of periodontal pathogens levels, which express virulence factors that stimulate host cells to release several types of inflammatory cytokines such as interleukin 1 β (IL-1 β), interleukin 6 (IL-6) and interleukin 8, (IL-8) and growth factors such as tumor growth factor (TGF), which modulate the inflammatory response in periodontal tissues.⁶

In turn, orthodontic movement causes reorientation and remodeling of periodontal support tissues during tooth movement, but the application of appropriate mechanical forces causes expected reactions in the periodontal tissue support. The biological events that occur during orthodontic tooth movement on a periodontium of reduced height are the same as for a normal size periodontium, however, some aspects should be taken into consideration when treating a patient with loss of osseous support:¹ (1) Risk of future bone loss, with eventual loss of teeth, (2) These individuals often have complex malocclusion, and (3) Patients with reduced periodontium requires changes in treatment regarding mechanics and orthodontic appliance.

These considerations are based on recent research,^{1,7,8,9} suggesting that orthodontic load may contribute to the destruction of the bone support of patients with periodontal disease—directly, through the induction of proinflammatory cytokines and also by the decreasing expression of matrix proteins and osteogenic protein and not by gingival inflammation. However, the mechanisms of interference in the regulation of these molecules remain unclear.

There are several ways to assess the impact of orthodontic treatment on periodontal tissues.

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Most studies used clinical periodontal parameters such as plaque index and probing depth associated with microbiological analysis.^{4,10} Another way to analyze changes during orthodontic treatment is through molecular analysis of fluid from the gingival sulcus. This analysis indicates immune and inflammatory reactions resulting from microbial challenge and host defenses, as well as the biomechanical stress caused by orthodontic movement, and can provide instructive answers about the orthodontic management of patients with periodontal disease. It is considered a noninvasive method and is easily performed, because the fluid is collected with tips or strips of filter paper, which are processed in the laboratory and analyzed for the presence of biomarkers.^{5,6,9}

Among the mediators identified in the gingival sulcus fluid, the proinflammatory cytokines have attracted particular attention. Among the most studied are IL-1 β , IL-6, IL-8 and Cyclooxygenase 2 (COX-2). Along with inflammatory mediators, growth factors are also important periodontal homeostasis biomarkers, e.g., growth factor Insulin-like 1 (IGF-1) and tumor growth factor β 1 (TGF- β 1), which promote migration, cell differentiation and proliferation, and extracellular matrix synthesis. As osteogenic protein, important components of the periodontium mineralization.^{7,9,11}

Recently, clinical and microbiological changes were correlated with concentrations of cytokines, particularly IL-6 and IL-8 during orthodontic treatment.⁹ The results showed that increased levels of these interleukins, before treatment, correlated with changes in periodontal parameters, such as increased probing depth, one year after treatment. According to the authors, this knowledge can contribute to the decision to start an orthodontic therapy in susceptible patients.

Similar results were also observed in periodontal⁷ ligament cells, which respond to pro-inflammatory stimuli, modulated by mechanical forces.

On the other hand, it showed that biomechanical forces applied longer and with low magnitude exerted anti-inflammatory effect. According to the authors, this observation suggests that the contribution of orthodontic mechanics in periodontal destruction is not mediated by increased periodontal inflammation, but by interference with the expression of osteogenic and matrix protein. Despite the results, the mechanism to explain why the mechanical force had, initially, a proinflammatory effect and, subsequently, anti-inflammatory effect is still unknown and some speculations are made. The periodontium cells become better adapted to mechanical stress? The anti-inflammatory molecules produced in later stages of movement would cause an imbalance in the inflammatory expression?

In addition to the findings that orthodontic stress influences the levels of proinflammatory cytokines and the expression of osteogenic and matrix protein, it is noteworthy that healthy sites of periodontal patients—compared with healthy sites of individuals without periodontal disease—appear to have higher levels of inflammatory molecules (such as IL-1 β , IL-8 and MMP-8) in the gingival ridge fluid.⁶ This suggests that inflammatory mechanisms may occur in the periodontal tissue before they are detected clinically.

Therefore, biomarkers detected in the gingival ridge fluid could serve to assist in screening patients at risk for bone loss, before the decision to submit them to orthodontic movement. The joint participation of biomechanical stress in the process of bone loss in periodontal patients is well established in the literature, but the mechanisms of how biomechanical forces modulate molecular and cellular events in the periodontium are still not fully understood. Better understanding of the interaction of inflammatory and biomechanical signals will optimize methods of orthodontic and periodontal treatment in patients with reduced bone support.¹

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Cementum, apical morphology and hypercementosis: A probable adaptive response of the periodontal support tissues and potential orthodontic implications

Alberto Consolaro*, Renata B. Consolaro**, Leda A. Francischone***

Abstract

Information about orthodontic movement of teeth with hypercementosis is scarce. As cementum deposition continues to occur, cementum is expected to change the shape of the root and apex over time, but this has not yet been demonstrated. Nor has it ever been established whether it increases or decreases the prevalence of root resorption during orthodontic treatment. The unique biological function of the interconnected network of cementocytes may play a role in orthodontic movement and its associated root resorptions, but no research has ever been conducted on the topic. Unlike cementum thickness and hypercementosis, root and apex shape has not yet been related to patient age. A study of the precise difference between increased cementum thickness and hypercementosis is warranted. Hypercementosis refers to excessive cementum formation above and beyond the extent necessary to fulfill its normal functions, resulting in abnormal thickening with macroscopic changes in the tooth root, which may require the delivery of forces that are different from conventional mechanics in their intensity, direction and distribution. What are the unique features and specificities involved in moving teeth that present with hypercementosis? Bodily movements would be expected to occur, since inclination might prove difficult to achieve, but would the root resorption index be higher or lower?

Keywords: Cementum. Hypercementosis. Tooth movement. Root resorption.

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Hypercementosis refers to an adaptive change in the periodontal ligament characterized by increased cementum thickness on the root surface above and beyond the extent necessary to fulfill its normal functions, resulting in abnormal thickening with macroscopic changes in shape (Figs 1, 2 and 3). Its incidence has not yet been determined, but its prevalence ranges between 1.05 and 5.67% in Brazilian patients.^{6,21}

Hypercementosis induces acceleration in the deposition of new layers of cementum by cementoblasts (Fig 4). These cells overlay the root surface in between the periodontal fibers, also known as Sharpey's fibers, which attach to or fuse with the cementum collagen. At the interface with the root surface the cementoblasts yield a slow but steady deposition of the cementum organic matrix into lamellar layers, alternately mineralizing the latter, and thereby determining gross basophilic incremental lines in the tissue sections stained with hematoxylin and eosin (Figs 3 and 4). Cementum thickening occurs by a rhythmic process: After deposition, each new layer of cementum is mineralized by the previous layer. The last layer, a non-mineralized layer, can also be called precementum. When deposition takes place prior

to tooth eruption the cementum can be classified as primary. After eruption, the cementum can be defined as secondary and is formed in response to functional demands.^{22,27,28,29}

The cementoblasts interact with the root surface and the other surfaces of the cell body relate to the extracellular matrix of the periodontal ligament, of which collagen fibers are part. Cementoblast membrane proteins are externally connected with components of the extracellular matrix such as fibronectin, for example. Transmembrane proteins known as integrins are internally connected to cytoskeleton proteins, imparting a stable form and mobility to the cells.

The cementum overlays the root surface, thereby "hiding" or isolating the periodontal ligament dentin and, at the same time, allowing the attachment of periodontal collagen fibers for support and tooth articulation (of the gomphosis type) with the periodontal ligament along the alveolar wall.^{10,30} The term cementum stems from the Latin *caementum* or "cement": Stone particles used to make mortar.

Periodontal activities such as absorbing, directing and distributing forces applied to the tooth may move the periodontal fibers and other components

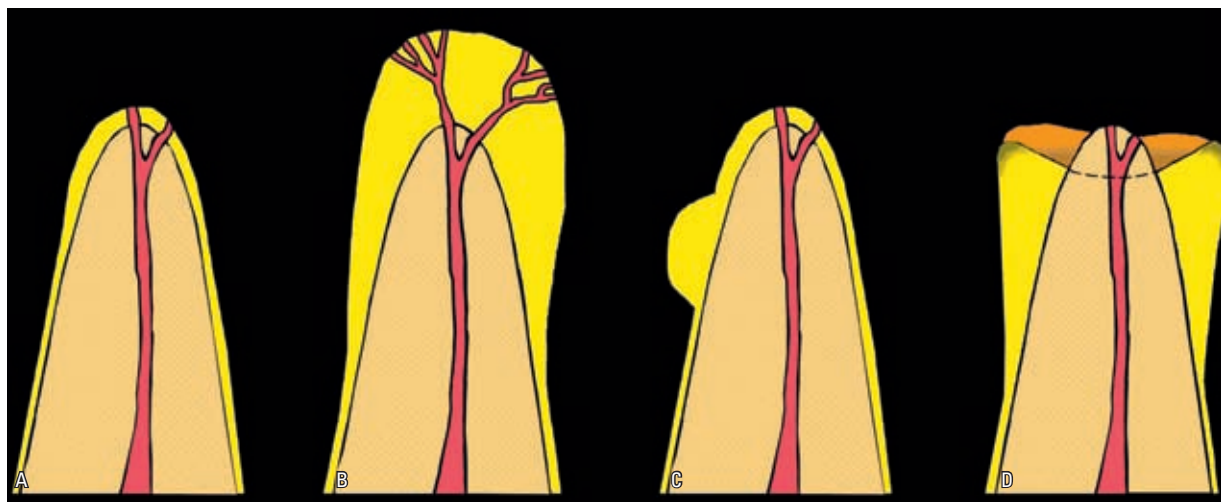


FIGURE 1 - Morphological types of hypercementosis: In (A) the root is normal; in (B) diffuse hypercementosis, when the root assumes a club shape. In (C) focal or localized hypercementosis, which is restricted to an isolated root surface; in (D) hypercementosis in the shape of a shirt sleeve cuff, which does not involve the most apical part and occurs on the periphery, as result of chronic periapical lesion (Source: Pinheiro²⁵).

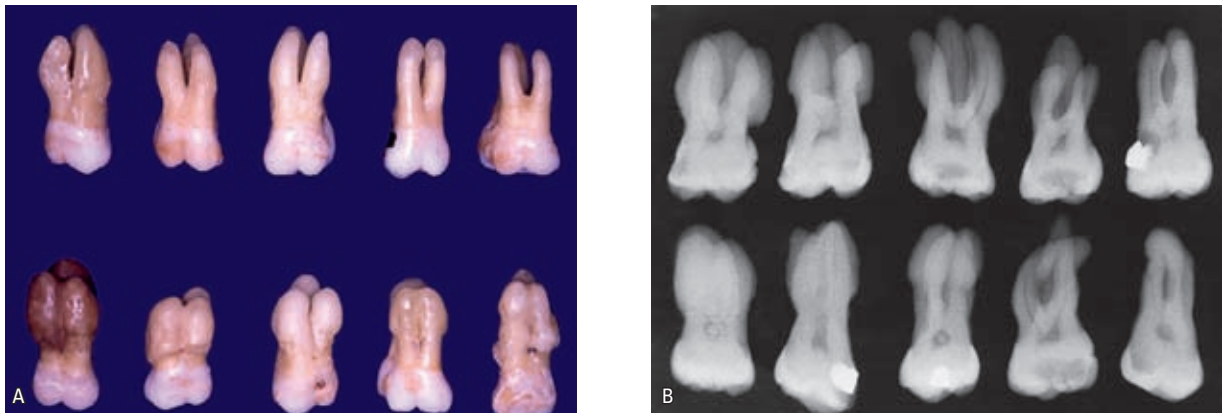


FIGURE 2 - Upper molars are the most affected teeth with hypercementosis, in various intensity levels, as these specimen, obtained from a sample of 21,573 teeth.⁶

of the extracellular matrix, as well as deform the cementoblasts via the cytoskeleton by means of integrins. Cytoskeleton deformation may produce the necessary stimulus for the cellular stress, resulting in increased release of mediators and cementum matrix synthesis on the root surface.

In other words, hypercementosis can be an adaptive response to an increased periodontal functional demand. This may result from an acceleration in deposition or an increase in the amount of cementum matrix as a way to attach more often and in a wider area the periodontal fibers whose function is under greater demand. The collagen in the cementum forms a fibrillar network, which is sometimes parallel to the surface, sometimes irregularly distributed,^{28,29} and when associated with Sharpey's fiber attachments, produces a veritable system of transmission and dissemination of forces applied to the tooth.

Tooth cementum has some intriguing features when compared with bone tissue: It does not undergo remodeling but experiences lifelong deposition.^{1,2,9,15,31} Cementoblasts are formed throughout a person's life from progenitor cells located in the periodontal ligament (Fig 4). Two non-collagenic proteins may be related to the chemical attraction, adhesion and differentiation of pre-cementoblasts on the root surface: Bone sialoprotein (BSP) and osteopontin (OPN).^{5,26}

CEMENTUM CELLULARITY AND APICAL MORPHOLOGY

Cementum matrix deposition by cementoblasts in the cervical and middle thirds of the root does not include cells and the cementum is usually ultimately classified as acellular. Amid the layers of cementum deposition no gaps can be found with cementocytes inside them (Figs 4, 5 and 6).

In the cementum located at the end of the middle third and throughout the apical third the gaps are occupied by cementocytes with numerous interconnecting extensions in the form of a "spider web." The cementocytes are also found in large numbers in furcation areas. Their gaps interconnect with the cementocytes, making metabolic exchanges with the odontoblastic extensions of the neighboring dentin (Figs 4, 5 and 6).

In the bone, a network of osteocytes is formed through contact with approximately twenty cells. This interconnecting network exchanges fluids and mediators, keeping the mineralized bone matrix metabolically active and connected to the internal and external bone surfaces. It is likely that this interconnecting network may capture structural deformations by applying compressive forces and bone stretching, which results in cytoskeleton deformation and release of mediators that stimulate adaptive cellular activities on the surfaces of medullary and cortical spaces.

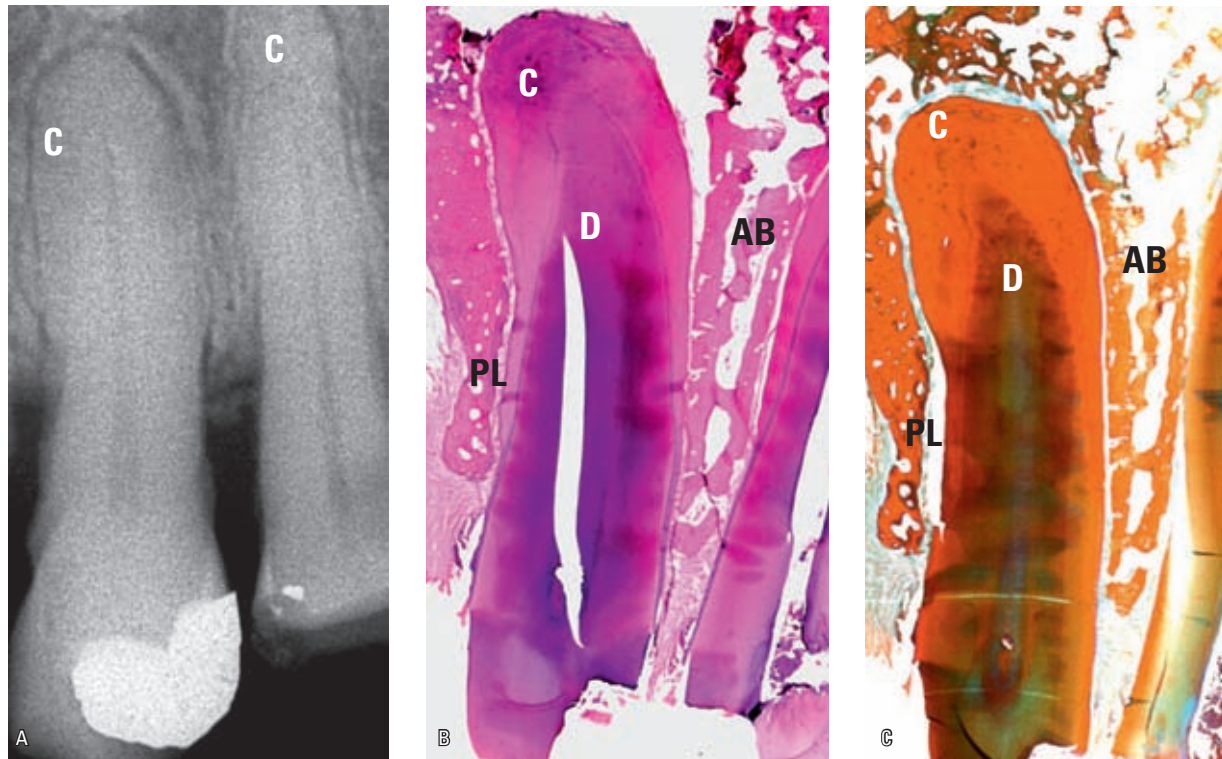


FIGURE 3 - Radiographic and microscopic aspects of hypercementosis. The new cementum layers (C) are continuously deposited on the root surface, changing the apical morphology, which tends to become rhomboid. The limits between the dentin (D) and the cementum remain preserved on tissue sections. The periodontal ligament (PL) continues present with normal structure and organization, joining the tooth to the alveolar bone (AB) (B=HE, 2.5x; C= polychromic, 2.5x).

In the cementum, it is likely that the interconnecting network of cementocytes may help to control the root apex shape. Cementum is not as hard as dentin.¹⁶ Stretching and compression forces delivered to the root, especially to the thinner and more delicate apical third, can deform the interconnecting network of cementocytes and their cytoskeleton. On the surface, the layer of cementoblasts can receive stimuli from cementocytes to slow down or accelerate cementum deposition and respond appropriately to the perceived stimulus.

In conceptual and hypothetical terms one may infer that hypercementosis is an adaptive response of periodontal tissues geared toward increasing the area of support and distribution of occlusal forces. This manner of increasing its surface ratio relative to the neighboring bone can play an important role in coping with excessive occlusal loads⁶ and

even in the absence of antagonists, when occlusal forces are hardly present at all.⁶ Hypercementosis can function as a way to increase the retention or dental attachment in the alveolar bone.

By addressing these issues it may be possible to explain why there are two types of cementum in terms of cellularity: Acellular and cellular, the latter present almost exclusively in the apical thirds and furcation regions, which are under a great deal of mechanical pressure in periodontal physiology. Cementum is the deposition of organic matrix after mineralization while adaptive responses are directly related to the depositing cells, i.e., cementoblasts (Fig 4). As a dental tissue, cementum consists of an almost passive attachment structure for periodontal fibers. The active, responsive portion of the tissue is represented by cementoblasts and cementocytes. The term acellular when referring

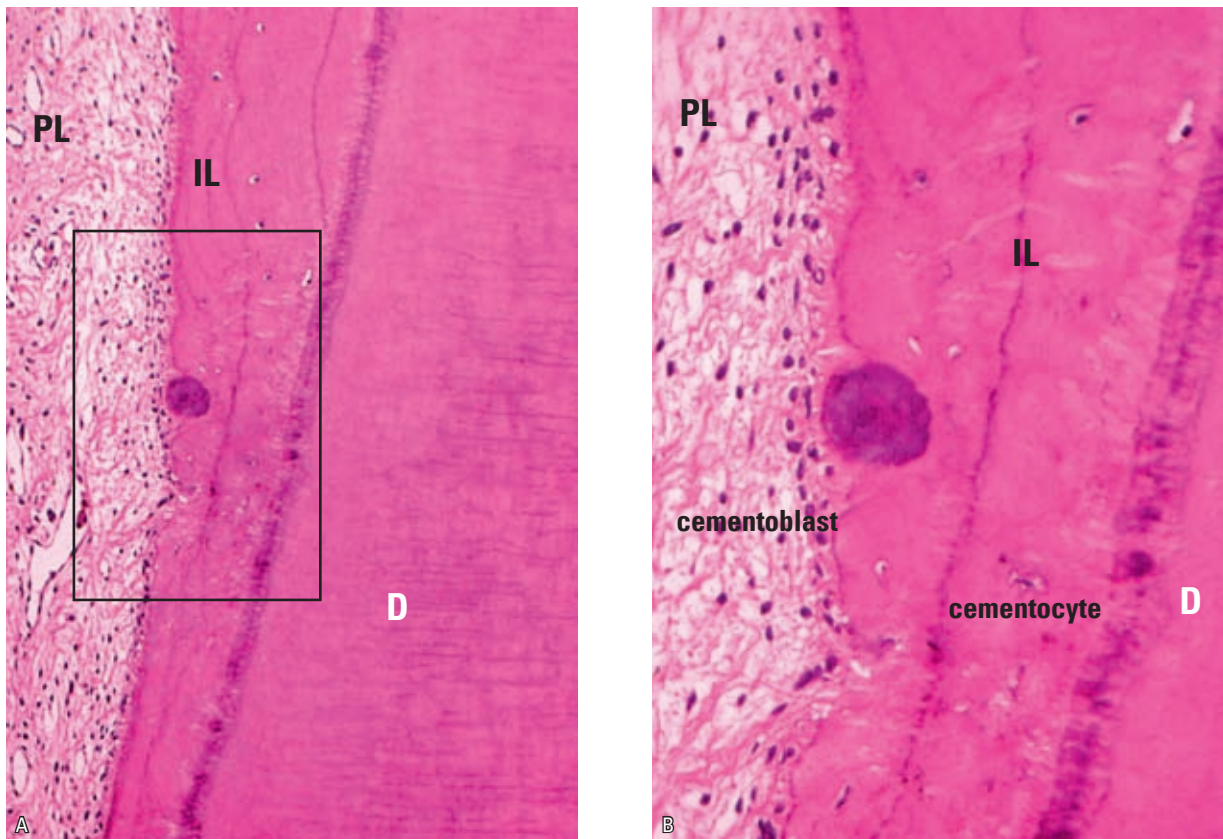


FIGURE 4 - Microscopic aspects of hypercementosis, in tissue sections obtained by demineralization and stained with HE. The periodontal ligament (PL), cementoblasts and cementocytes inside their lacunae can be seen. In the cementum, with thickness increasing from bottom to top, basophilic increment lines can be observed (IL) from the dentin (D). The more basophilic spherical area, corresponds to the cementicle included by the continuous and accelerated cementum deposition (HE, **A**=10x and **B**=25x).

to the cementum is not perfectly suitable because, despite the absence of cementocytes, cementum contains numerous cementoblasts on its surface.

FIBRILLAR CEMENTUM AND AFIBRILLAR OR INTERMEDIATE CEMENTUM

The organic portion of cementum is predominantly constituted of type I collagen, a fibrous component of various tissues, amid proteoglycans and water. In turn, its mineral part comprises 45 to 50% of its volume and is made up predominantly of calcium and phosphate in the form of hydroxyapatite.

The root structure comprises a tissue known as cementum, which actually is not deposited by cementoblasts and nor does it contain fibrillar

components in its structure. Intermediate cementum is comprised of a thin layer of 10 to 20 μm deposited over the outer portion of the dentin during root formation and synthesized by Hertwig's epithelial root sheath (HERS).^{11,22,24}

Prior to fragmenting, HERS deposits intermediate cementum, isolating the dentin from the follicular and periodontal components of the tooth germ.⁸ As it derives from the more cervical part of the enamel organ, HERS synthesizes this thin layer of proteins, which are similar to those of the enamel^{17,18,19} without a fibrillar component. It was therefore named intermediate cementum as it is located between the dentin and the future fibrillar cementum to be deposited by the cementoblasts derived from the dental follicle or sac.

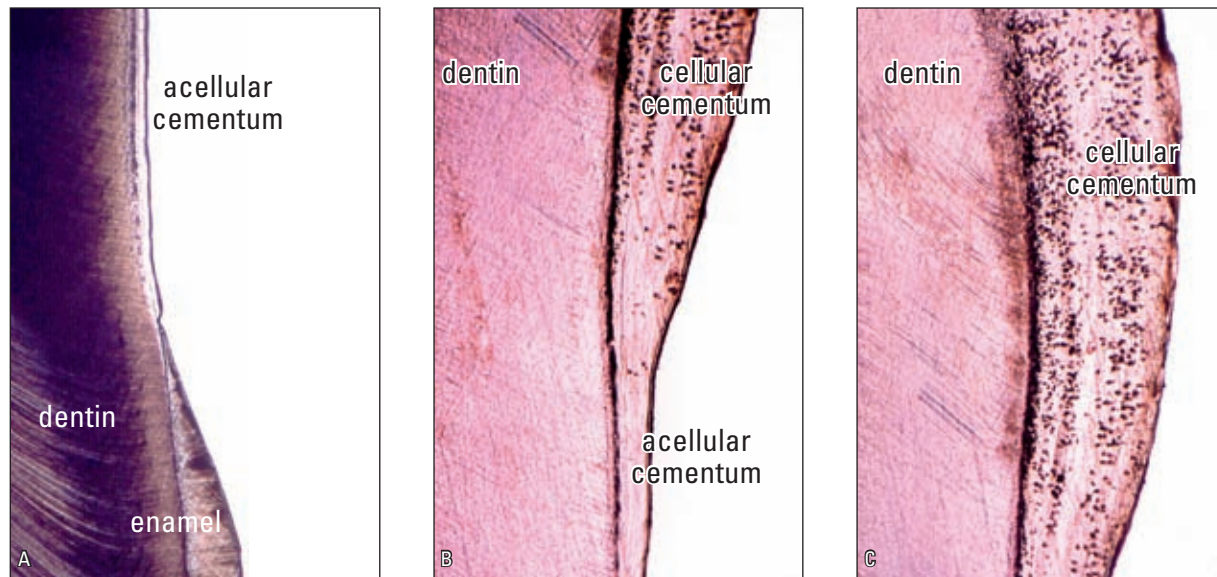


FIGURE 5 - Hypercementosis in tissue sections obtained by grinding, with no demineralization or staining. The cementum presents a uniform thickness in the cervical and middle thirds. The lacunae are in great quantity in the cellular cement in the apical third. Note the growing thickness of the tooth cementum from bottom (cervical) to top (apical) (A=4x, B=10x and C=25X).

It is only after the deposition of this thin layer of intermediate cementum that HERS fragmentation occurs, creating space on the root surface and thereby allowing the dental follicle cells to differentiate into cementoblasts and initiate cementum deposition. It is probable that the molecular components of intermediate cementum and its interaction with the dental follicle cells play an important part in the differentiation of these cells into cementoblasts, and at the beginning of cementum deposition.

Apparently, the intermediate cementum—an afibrillar and acellular tissue—has no direct relationship with the root cementum, but from a structural and anatomical point of view one can say that between the dentin and cementum there is a thin afibrillar, adamantine and aprismatic layer. The presence of enamel on the tooth roots can be observed in the teeth of some animals, such as in the incisors of mice. Although originally described in 1920 by Hopewell-Smith¹² as a homogeneous, hyaline layer, intermediate cementum was only given its definitive name in 1927 by Bencze.⁴

INCREASED THICKNESS OF CEMENTUM AND HYPERCEMENTOSIS: MORPHOLOGICAL ASPECTS AND POTENTIAL ORTHODONTIC IMPLICATIONS

Hypercementosis can be defined as an excessive formation of cementum above and beyond the extent necessary to fulfill its normal functions, resulting in abnormal thickening and changes in the macroscopic shape of the root.²⁵ Once in place, hypercementosis modifies root morphology, both internally and externally, especially in the apical third. In three previous papers the authors of this study investigated the morphological aspects of hypercementosis.^{3,6,25}

Based on the analysis of 21,573 teeth it was found⁶ that the teeth most compromised by hypercementosis were the upper molars (5%), followed by the upper premolars (0.88%) and lower premolars (0.86%), and the lower molars (0.74%). The canines showed very little impairment, the upper incisors were seldom affected and there were no hypercementosis cases among lower incisors.

Among the factors closely associated with hypercementosis is functional stress, as is the case in patients with bruxism, teeth clenching and occlusal trauma. However, many cases of hypercementosis can be found in teeth without antagonists or teeth with destroyed crowns, but with no sign of previous existence of such process. Indeed, there is no evidence of the adaptive and or reactional nature of increased cementum thickness and hypercementosis.

Chronic periapical lesions such as periapical granulomas are another cause often associated with hypercementosis (Fig 1). In the peripheral part of granulomas, the root cementum increases its thickness as a response to inflammatory stimuli arising out of the widespread tissue and cellular mediators. Once the chronic periapical lesion of extracted teeth is removed along with this type of hypercementosis, the apex surrounded laterally by increased cementum produces a shape resembling a "shirt sleeve cuff."⁶

Hurzeler and Zander¹⁵ measured the cementum thickness of single-rooted teeth from 110 randomly selected human teeth, which were serially cut from the apex to the cemento-enamel junction (CEJ). The teeth of subjects aged 17 years on average showed a 0.076 mm cementum thickness while those with an average age of 59 years had three times that thickness, averaging 0.206 mm.

In another work, Zander and Hurzeler³¹ analyzed the thickness of the cementum of 233 single-rooted teeth of subjects between 11 and 76 years old. There was a gradual increase in apical cementum commensurate with aging. In 20-year-old patients the apical cementum showed on average a 0.095 mm thickness; in 30-year-olds, an average of 0.125 mm; in 40-year-olds, 0.155 mm; in 50-year-olds, 0.185 mm and an average thickness of 0.215 mm in 60-year-old patients.

With the purpose of comparing the cementum in different ethnic groups, Muller and Zander²³ studied 61 single-rooted teeth from Indians and found a slightly smaller cementum thickness in the

various age groups than in North Americans from the state of Minnesota.

Information about orthodontic movement of teeth with hypercementosis is scarce in the literature. As cementum deposition occurs steadily, it should therefore change the root and apex shape throughout one's lifetime, but this has not yet been demonstrated. These morphological changes could potentially increase or decrease the prevalence of root resorption in orthodontic treatment since it is a known fact that the root and apex are predictive factors of root resorption when they show a triangular shape or are shaped like a pipette, or lacerated.⁷

Could an increase in cementum thickness be in any way related to a different prevalence of tooth resorption during orthodontic treatment in adults as a result of changes in the root and apex shape? Or might it be due to specific biological factors inherent in the cementum and its interconnecting network of cementocytes?

Root and apex shape has not yet been correlated with patient age. For example, is a triangular shape of the tooth root and apex more prevalent in youths, adults or the elderly? Shouldn't the rhomboid or quadrangular shape of the dental apex be more prevalent in the elderly? Azaz et al^{1,2} reported—in two samples of 60 and 72 unerupted canines—an increase in cementum thickness and in the prevalence of hypercementosis with aging.

In light of these issues and peculiarities of the cementum, both conceptually and in practice, one should carefully distinguish between increases in cementum thickness due to aging and/or functional demand, and a diagnosis of hypercementosis. A more bulging or rounded root and root apex (Figs 1, 2 and 3) may be due to increased cementum thickness which would reflect a variability in root morphology, but within normal limits.

Hypercementosis refers to excessive cementum formation above and beyond the extent necessary to fulfill its normal functions, resulting in

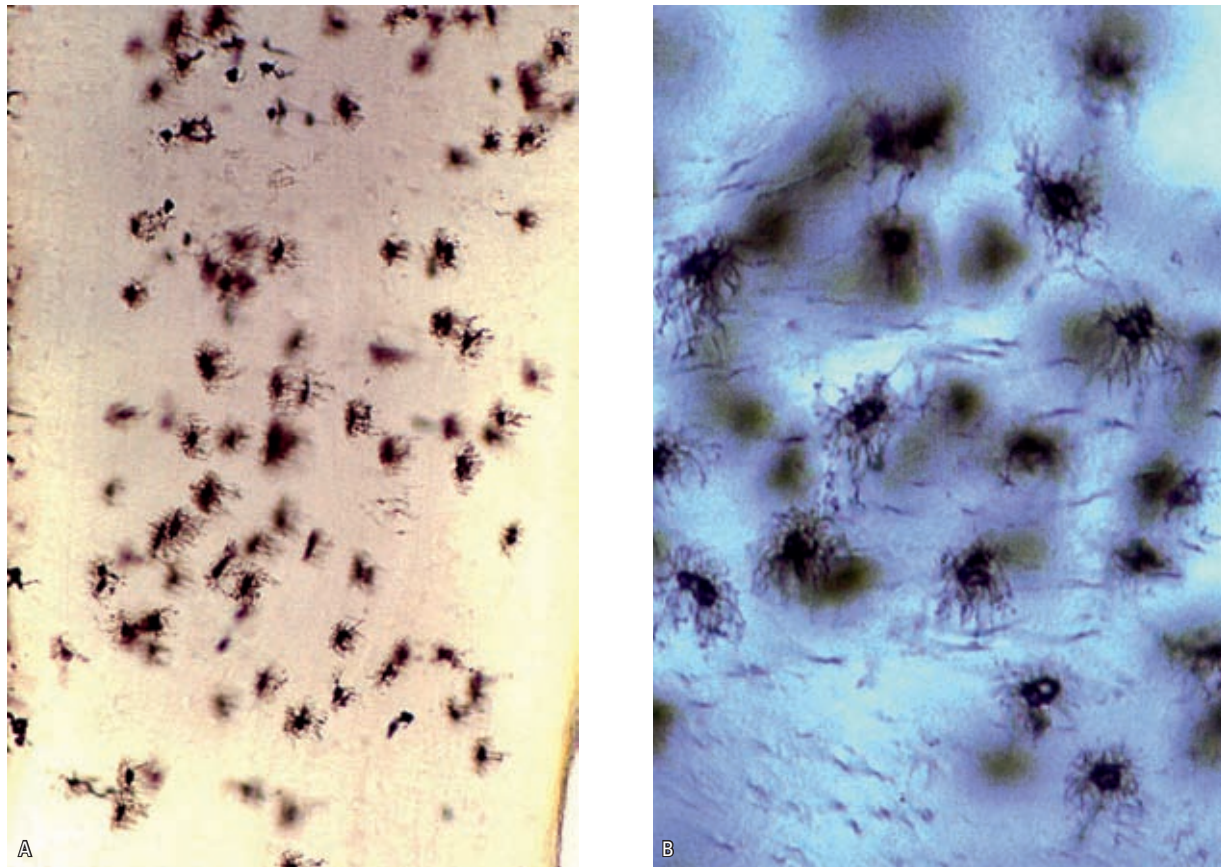


FIGURE 6 - Cementocytes lacunae in area with hypercementosis in tissue sections obtained by grinding, with no demineralization, or staining. Numerous canaliculi can be seen where a number of cytoplasmatic extensions were irregularly distributed and communicated with other cementocytes, allowing for a communicating network of signals and stimuli (A=40x and B=100x).

abnormal thickening with macroscopic changes in the tooth root, which may require the delivery of forces that are different from conventional mechanics in their intensity, direction and distribution. What are the unique features and specificities involved in moving teeth with hypercementosis? Teeth with hypercementosis should be amenable to induced tooth movement, although one published case report²⁰ disclosed difficulties in the effective displacement of compromised teeth.

In their investigations, Humerfelt and Reitan^{13,14} sought to analyze the mobility of teeth with hypercementosis during the orthodontic treatment of three patients of the same family but the issue was associated with deciduous teeth and permanent infraocclusion and/or late eruption.

In other words, their research did not focus only on cases involving teeth with hypercementosis. Their conclusions correlated hypercementosis with tooth loss or eruption delay as well as tooth impaction, and even with dentoalveolar ankylosis resulting from orthodontically moving these teeth, although their inferences were not grounded in reliable data.

An analysis of the effects of continuous cementum deposition on the shape of the root and apex is warranted. These morphological changes may influence the predictive factors of root resorption during orthodontic treatment. In like manner, the effects of orthodontic movement in teeth with hypercementosis have not yet been examined. It may be much more difficult to apply forces and

achieve satisfactory clinical outcomes, as found in a single case published by Mattar Neto et al.²⁰ The movements should probably be almost always bodily movements since it would be challenging to obtain them in the presence of hypercementosis. Would these teeth with hypercementosis, which were moved, exhibit a greater or lesser root resorption index?

In 1999 Barros³ analyzed in tissue sections the internal and external anatomy of dozens of teeth with hypercementosis, from a macroscopic point of view using a stereomicroscope with and without clearing the teeth with xylol as well as optical microscopy. He noted that hypercementosis increased the number of lateral and accessory canals, as well as apical deltas, in addition to narrowing the main channel in the apical third, which also resulted in changes in the direction of the foramen. From an organizational and structural standpoint, the cementum in teeth with hypercementosis appeared normal under optical microscopy.

Moreover, in 2005, Pinheiro²⁵ examined macroscopically 576 permanent teeth with hypercementosis using stereomicroscopy, radiography and scanning electron microscopy. In 85.24% of the teeth examined the roots took on the shape of a club; 8.16% of the teeth exhibited a localized form and 6.6% of the teeth displayed a "shirt sleeve cuff" shape.

Contemporary orthodontics requires further detailed studies on the impact of age-related increased cementum thickness on the biology of induced tooth movement and associated root resorptions. It also requires further analysis of the physical and biological characteristics of hypercementosis in the context of orthopedic and orthodontic treatment.

FINAL CONSIDERATIONS

There is no definitive evidence to address issues such as:

1. If cementum deposition occurs on a continuous basis, is it expected to change the

root and apex shape throughout the person's entire life. However, these changes have not yet been studied. Would these morphological changes act by increasing or by decreasing the prevalence of root resorption in orthodontic treatment?

2. Is the triangular shape of the tooth root and apex more prevalent in youths, adults or the elderly? Shouldn't the rhomboid or quadrangular shape of the dental apex be more prevalent in the elderly?
3. Would an increased thickness of cementum with aging have a positive or negative correlation with the prevalence of tooth resorptions in the orthodontic treatment of adults?
4. Should an accurate diagnosis be established based on the relationship between (a) what appears to be an increased cementum thickness inducing an anatomical change in the normal shape of the root and (b) a hypercementosis, that might involve changes in the shape of the human tooth root.
5. What are the unique features and specificities involved in moving teeth that present with hypercementosis?
6. What is the function of cementocytes? What is the role of cementocytes in induced tooth movement? And in apical tooth resorptions during orthodontic treatment?
7. Could intermediate cementum be present throughout the whole extent of the root surface? Does it determine a higher or lower prevalence of tooth resorptions during orthodontic movement? Does it influence periodontal reorganization after induced tooth movement?

Hopefully, these issues will encourage further research on the unique effects of orthodontic movement on teeth with increased thickness and/or hypercementosis.

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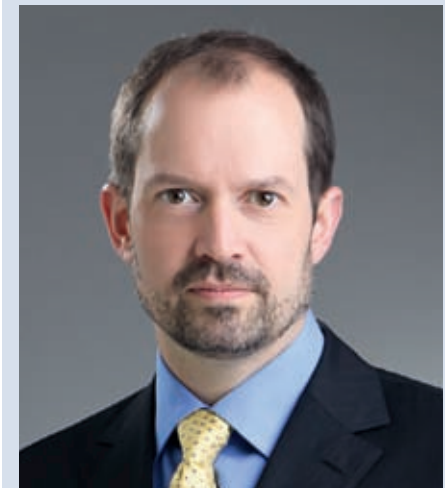
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An interview with Jorge Faber

- Editor-in-chief of the Journal of the World Federation of Orthodontists and former editor of the Dental Press Journal of Orthodontics.
- Associate Professor of Orthodontics, University of Brasília (UnB).
- PhD in Biology – Morphology, University of Brasília (UnB).
- MSc in Orthodontics, Federal University of Rio de Janeiro (UFRJ).
- Received the 2010 Best Case Report of the Year Award for the best case report published in 2009 in AJO-DO, among other prizes.
- Published over 70 articles in scientific journals.



Normally, we lose ourselves among the many things we have to do. In dentistry, I know few professionals who can skillfully combine scientific research, teaching and clinical activity. Professor Jorge Faber is one of them. In fact, he goes far beyond, gives much of his time to deal with the arduous and delightful task of serving as editor of a journal. In this interview, Faber goes through all these activities he performs easily in face of all his intelligence, perfectionism, creativity and organizational pattern. In statistics, a strange taste I share with him, we would say that Jorge is an outlier, for sure he is not normal and the mouth seems too small for this Brasiliense.

One of these days, however, I was surprised when he anticipated a flight to arrive earlier in Brasília—his homeland—in order to study with his daughter. I realized then that Jorge is a caring father, trying to balance the father with the teacher, researcher, publisher, inventor and clinician. There is no social responsibility that does not begin in our own home. Home which he shares with Ana Paula and two children, Pedro and Carolina. Ana Paula, his wife, is Jorge's multidisciplinary support. They got married and had children still young and the little contact I had with him will not allow me even to imagine the major barriers they faced to form a beautiful family allied to professional careers this successful.

This is not all. Jorge, gentle in words and gestures, is a black belt in Karate and, although not so religious, he is a fan of Pope Benedict XVI. In the interview, it is apparent that his great masters now have him as an idol. Those who work with him, also. Those who know him, as well.

Of course he has faults. Friends say it would be massive suicide to invite him to play a soccer match, he is really bad on it. He was left then, to study. Jorge, who graduated at University of Brasília (UnB), got his masters degree in orthodontics from the Federal University of Rio de Janeiro, his PhD in biology from the UnB, where he is, now, an adjunct professor. After five years working as the editor-in-chief of the Dental Press Journal of Orthodontics, he recently assumed the post of editor-in-chief of the Journal of the World Federation of Orthodontists, after a selection process which involved 18 other teachers around the world—an honor for orthodontics of a third world country. Thankfully, not all good Brazilians become soccer players. For Achilles, the heel, for Jorge, the feet. That's good.

David Normando

CLINICAL EXPERIENCE WITH NEW TREATMENT METHODS

When and why did you initiate performing the Anticipated Benefit orthognathic surgery? (Telma Martins de Araújo)

The Anticipated Benefit was an idea I had in 2004, and the first patient underwent surgery in the same year, with Dr João Milki, surgery professor at the University of Brasília (UnB). I received at my office a patient who was referred to me by the Emeritus Professor of Pneumology of UnB Dr Paulo Tavares, with a severe obstructive apnea syndrome. The doctor had thought of orthognathic surgery to solve the problem, because the patient

could not, in any way, use a CPAP equipment. During his first consultation, I realized the obvious. This patient, in particular, couldn't wait about a year and a half to perform surgery, since this is the average time that orthodontic preparation for orthognathic surgery requires.¹ Maybe in a year and a half he could be dead.

The patient was bearer of a dentofacial deformity with a Pattern II. So, he would need lower incisor retraction prior to surgery to increase the overjet and enable mandibular advancement. During the appointment itself, I thought about my experience with Class III compensation with retraction of all lower teeth (Fig 1). In this treatment modality, we can take the lower teeth, that are already in a com-



FIGURE 1 - The titanium miniplates may be used in the jaw to serve as anchors for retraction of all the lower teeth. With this, you can avoid the orthognathic surgery in patients who do not wish to submit to it. The experience with this type of treatment gave me conditions to plan the orthodontic treatment as a whole before the surgery, then, install the appliance and operate without the conventional preparation for orthognathic surgery. Avoiding the conventional preparation does not mean not preparing the case for surgery. In fact, we have with the Anticipated Benefit more involvement with the "preparation" for treatment planning.

pensated position, to a hypercompensated position.

If the lower incisor retraction in Class III compensation is possible, it should be even easier to perform the same retraction during the orthodontic preparation in Class II individuals, where lower protruded incisors are led to an appropriate position within the mandibular symphysis.

I proposed this alternative treatment to the patient during the first consultation, and he accepted it. After he left, I remember, vividly, being seated at my office thinking of other cases: Why shouldn't I also use this in that patient? And also in that other one? Come on. Why shouldn't I use this in all surgical patients? And so it all began.

What are the benefits that you see in the Anticipated Benefit? (Telma Martins de Araújo)

The advantages are many and almost all of them belong to the patient, not to the professionals.

The first and obvious is the, almost immediate, improvement in facial appearance. We have to remember that most patients submit themselves to a surgical orthodontic treatment because they want to improve their esthetic.^{2,3} I used references to support this statement, though it wouldn't be necessary. Any patient or professional who is involved in the treatment of this type of condition knows it perfectly.

The second advantage is that the conventional treatment, mainly in patients with facial Pattern III, worsens facial esthetics considerably during the orthodontic preparation. This characteristic of conventional treatment repel many patients from receiving the surgery benefit and it is, somehow, paradoxical. The paradox lies in the fact that a treatment performed to improve facial esthetics has to, as a matter of fact, worsen it before improving. This entire process is justified because it does not only improve facial esthetics. Patients have important functional gains, of different natures, but it remains a paradox.

Another advantage, one that is not seen at the beginning, is the reduction in treatment time. I estimate that the total time of treatment fall about 40 to 50% in relation to the time needed for the

conventional treatment. Some also ask me if I think the result is different... That response is clear to me: No, I do not believe there is a difference. However, I keep here a caveat. The decompensation through conventional orthodontics—i.e. no skeletal anchorage—often under-decompensates the patient. The balance of this is that the surgical result tends to be smaller than the ideal. So, I think the outcome of both treatments tend to be equal, as long as in conventional surgical orthodontic treatment skeletal anchorage is used as a resource in many cases. Otherwise, I believe that the Anticipated Benefit tends to provide better results.

What are the limitations of use of this technique? (Telma Martins de Araújo)

There are a few, like the need for a longer learning curve by the orthodontist. I think that it is quite imprudent for a professional to start using skeletal anchorage in a surgical case. Only after treatment of various non-surgical cases by means of skeletal anchorage is that someone should treat the first patient with Anticipated Benefit.

The second limitation is that patients with Pattern II with good facial height (Fig 2A) and pronounced curves of Spee, hat will receive mandibular protraction, can remain with a lower facial height if we do not level the lower arch prior to surgery. If we do not intrude the lower incisors before surgery, the result of surgical treatment will be a face longer than ideal. So, if we intrude the lower incisors before the mandibular protraction—using mini-implants, for example—we will have a better treatment result (Fig 2C).

Additionally, in cases where the upper arch is very unlevelled, it can be difficult to plan the final position of the occlusal plane. In these cases it is indicated upper arch leveling prior to the surgery.

In all of these limitations, I do not proceed with conventional preparation for orthognathic surgery, I just align and level the teeth before performing it. Only after surgery I address anteroposterior correction, rotated teeth, etc.

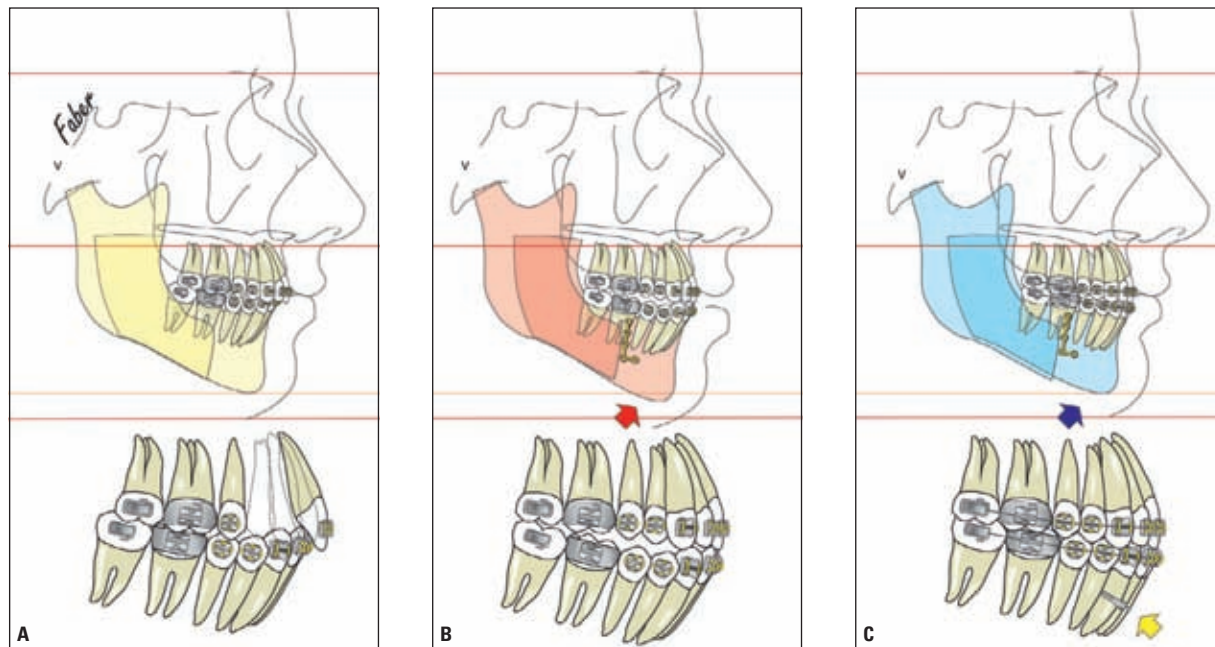


FIGURE 2 - Illustrations representing treatment alternatives for a Pattern II patient with normal face length, through mandibular advancement. The teeth below the cephalometric tracings present a magnification of the occlusal relationship in each of the three cases. The unleveled lower arch with pronounced curve of Spee in patients with Pattern II and normal or increased face length (A) will lead to less than optimal esthetic result after surgery (B), because the mandible after being protracted will necessarily have the menton shifted downward in a final position (red arrow), while an open bite occurs in the region of pre-molars. This situation increases the lower portion of the face. Meanwhile, if the intrusion of the teeth is carried out previously, e.g. using mini-implants, we will have a final treatment result with better facial esthetics (C).

Considering that you have been indicating the Anticipated Benefit in surgical treatments for quite a few years, what is your current view, from the perspective of accumulated experience through time? (Leopoldino Capelozza)

The Anticipated Benefit is a daily reality in my clinic since 2004. When a patient comes to me, I always present the two alternatives and show results of treatment with them. Along these years I never had a patient who said: "I want to do the conventional treatment". The reasons are obvious and I already commented on them in another question.

I particularly think the use of this technique tends to grow even further. It came to stay. However, I cannot declare the concept as something easy to be done. It depends on a large skill on

skeletal anchorage, in particular, on the use of miniplates. This is perhaps the biggest drawback for the use of this approach by many professionals. In addition, it requires the orthodontist to understand surgical planning and be able to provide concrete opinions on it.

For the patient, the experience of treatment with the Anticipated Benefit is grossly superior to conventional treatment. This is not only because of the reduced treatment time but also due to immediate improvement in facial appearance and in respiratory function, when it is compromised leading to snoring and obstructive apnea.

If my son or daughter were to submit to orthognathic surgery, I would do the treatment with the Anticipated Benefit.

What are the possibilities, in your point of view, of dealing with growth in Pattern II patients, mandibular deficiency, through forces applied in miniplates (bone-bone)?

(Leopoldino Capelozza)

The orthopedic possibilities of using skeletal anchorage for the treatment of Pattern II are instigating. However, I see this alternative, as well as the Pattern III treatment with some concern. My concern with these treatment alternatives comes from my experience of over 700 miniplates installed in patients in my private practice.

The biggest complication of using miniplates is the infection in the region of the implant. Dra Taciana Morum performed her master's thesis evaluating the risk factors for infection in 139 miniplates installed in patients from my private practice.⁷ It was noted that the increased plaque index on the miniplate is a strong predictor of infection factor. All sample patients were adults. So, some questions arise: What would be the expected infection rate if we were dealing with youngsters? What are the effects of these repetitive infections in teenagers? It is known by all orthodontists that plaque control in a teenage patient is something harder to be done.

So, my experience suggests that the complication rate perhaps requires the imposition of special measures of plaque control for these patients. Possibly monthly visits to a periodontist would be appropriate and perhaps the association of a chemical plaque control.

With plaque control properly resolved, I believe that we will have promising treatment results with these approaches.

What are the main benefits and disadvantages of using miniplates to correct double protrusion? (David Normando)

The main benefit is to avoid premolar extraction. In other words, it is not to negatively impact on patient esthetics during treatment. Evidences point to the fact that the orthodontic appliance does not hide extraction space and this space totally compro-

mises facial esthetics during the smile.⁵ If we take into consideration that this treatment is motivated mostly by the esthetics, we are facing a conflicting situation for patients, and this drives many of them away from the benefits of orthodontic treatment. I'm sure all orthodontists already heard a phrase like this: "... and I searched an orthodontist at that time and he told me I needed to extract teeth, then I gave up. I'm here 10 years later because...".

The disadvantages are of two natures. The first is the need for another surgery: The removal of the miniplate. The placement surgery does not count here, because it equates to the surgery to remove the premolars. The other disadvantage is that it is a new procedure, that involves a learning curve to deal with the four major side effects.

Two of them always occur (Figs 3A and B), which are molar distal inclination and bite-opening in the posterior region. The other two are occasional: The crossbite tendency of upper molars (Fig 3C) and the emergence of a tissue excess in the lower retromolar region.

The first two are fixed with tip-forward bends, preventing or correcting the inclination. The contraction can be avoided with a transpalatal bar or other common means. The exceeding tissue is avoided with a lot of hygiene. On a few occasions it is necessary to perform a distal wedge surgery to remove the excess of mucosa in the area.

Amid so many of your innovative proposals, perhaps one of the least known among orthodontists is the periodontium distraction with the aim of promoting periodontal bone regeneration. Almost 7 years after its publication in the *Journal of Dental Research*, how do you evaluate the current clinical use of this procedure? (David Normando)

The Periodontal Distraction, name I gave to this technique, still is the approach that promoted the largest supracrestal periodontal regeneration described in the literature. We achieved a periodontal regeneration of 5.5 mm on

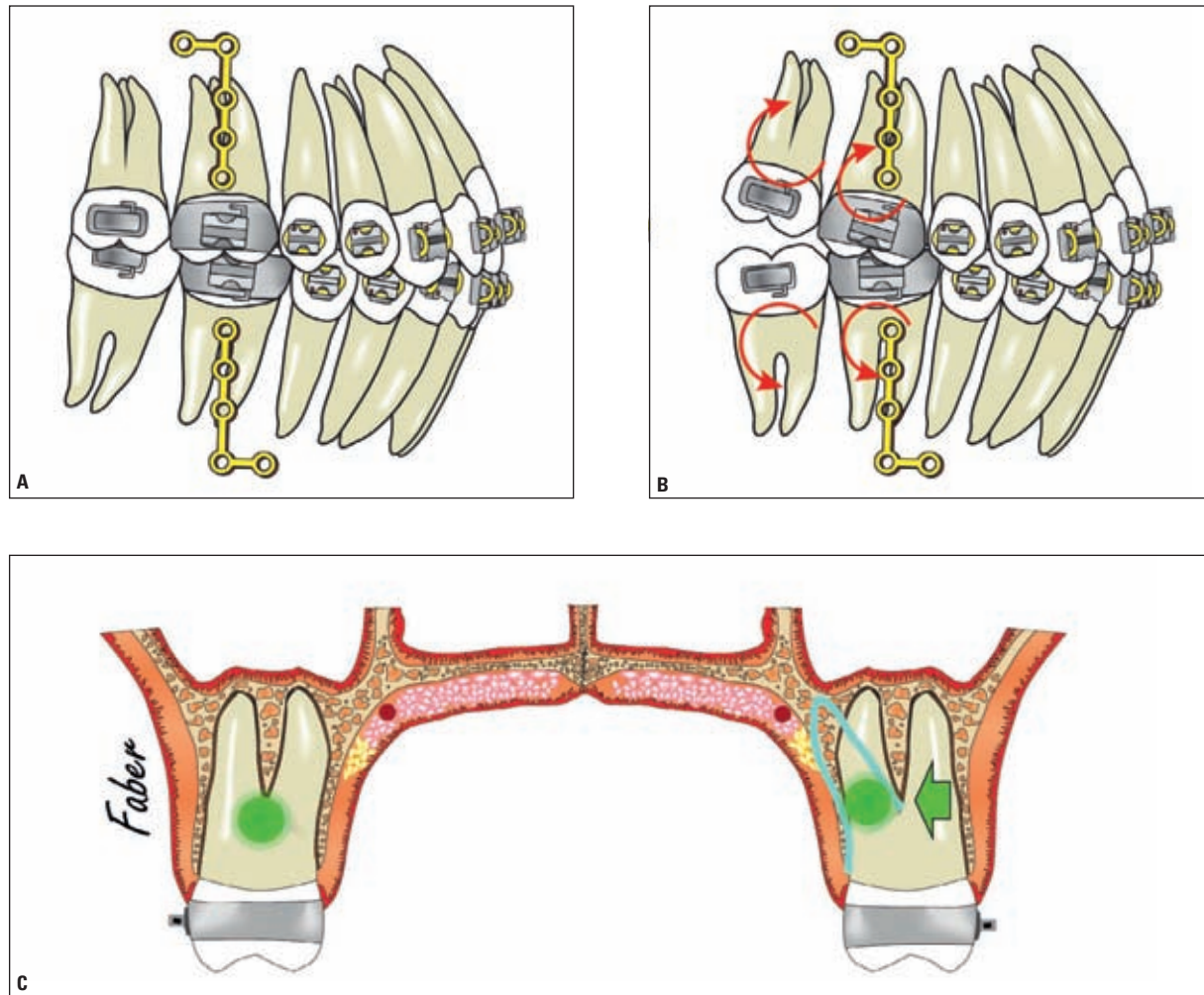


FIGURE 3 - Illustration representing the distalization process of the lower and upper teeth, during the non-extraction double protrusion correction. **A)** Teeth relationship before initiating dental movements. **B)** During retraction, molars tend to rotate around its own center of resistance, leading to a distal tipping and a posterior open bite as well. Both movements can be controlled with the tip-forward bends on molars. **C)** Teeth with too divergent palatal roots tend to move its center of resistance (in green) to the palate. This anatomic variation intensifies the crossbite tendency of upper second molars during distalization.

average, with a few areas showing a regeneration of up to 1 cm.⁸ The procedure is promising. The experience I had in dogs and after treating two patients showed me that applying to patients is easier than doing so in the laboratory. However, I think there are two factors that explain why the technique does not please everyone.

The first is that its father, I mean me, did not continue working on it as needed by being involved with other clinical and academic activities.

I gave more emphasis to the skeletal anchorage and the Anticipated Benefit other than the Periodontal Distraction.

The second is that the implant culture is very deep-rooted due to a number of factors in our area. There is a tendency, refuted by many, of “sacrificing” teeth of an uncertain future in order to install implants. Part of it comes from the own intensity which implants are preached for both dental and patients universe.

In addition, there are strong financial factors. Companies and professionals are very interested in new materials which can be applied in the patient, sold as a product. The Periodontal Distraction regenerates the periodontium of the patient without any new glue, membrane or protein. It requires only one screw with a different design and that is cheap. This cannot be widely sold by a company.

Considering your inventive and visionary genius, what do you predict after the mini-implants, miniplates, new technologies and materials, and advances in biology in relation to the optimization of orthodontic treatments?

(Nelson Mucha)

Orthodontic treatment evolved fantastically over more than 100 years of the specialty's existence. We improved a lot the self-esteem and life quality of millions of people around the world, at the same time we contribute for the health of patients. However, we still have anchors that prevent us from being even more comprehensive and bring those benefits to an even greater number of people. This anchor is the appliance itself.

The fixed orthodontic appliance with brackets was developed by Angle seeking treatment effectiveness. Trying to increase the efficiency of treatment, the Straight-Wire and self-ligating brackets were developed. However, all of these advances were focused on the professional not on the patient.

The bracket was developed at a time when the patient's opinion was not considered. Today this is different. All professionals in the world have already heard from some of their patients, shortly after the appliance's assembly: "Doctor, you have to invent something more modern to do this treatment".

We need to go back to the drawing board to design something totally new in terms of design. The bracket is not an unchangeable icon. The aligners are a beginning, but they still aren't the solution. The orthodontic appliance needs to be more esthetic and less traumatic. This is the great challenge of orthodontics. And to accomplish this

task probably we need to throw away the orthodontic appliance design used today. It is likely that the orthodontic bracket is a future museum piece.

Although it is necessary to develop an appliance with a totally new design, it will not prevent that the information baggage created over the years continue. When moving the position of a tooth from A to B it does not matter if we did this via treatment alternative 1 or 2. Stability, esthetics and other knowledge will tend to be the same.

When contemplating the news and evidence on (1) diagnostic procedures and means; (2) recording process (Cloud); (3) treatment planning; (4) executing; (5) conclusion and (6) stability of results, which constitute important steps in the art and science of orthodontics, it is questioned: In which one of them you predict the greatest breakthroughs and what kinds? (Nelson Mucha)

Recently Artese et al⁶ published an interesting work on the characterization of different open bites and its possible influence on treatment stability of this condition. They have raised an interesting question: Are all open bites equal? This characterization can lead to better diagnosis and treatment plans, and this naturally impacts over other stages of the treatment, including stability.

What the authors have done was to separate the condition in types, to analyze each one differently and, possibly, provide better and more specific ways of treatment. The next step is conducting randomized clinical trials to test the hypothesis of increased stability of these more specific treatments.

Now using this example to answer your question more clearly, we need to better understand the various malocclusions and deformities (improve diagnosis) to define exactly what are the best treatment alternatives for them (improve planning). This can only be done from studies with higher level of evidence, as randomized clinical trials. From this we will have a qualitative leap in the care provided throughout the world.

But, something needs to be said here. None of this will make sense if there will not be a strong action of educators to promote scientific evidence. Much of the information presented at conferences around the world lacks evidence or even are directly against the existing evidence. Old and obsolete ideas reappear on presentations of people who do not study enough to teach about it. We need to be more careful with this.

EXPERIENCE AS AN AUTHOR, REVIEWER, EDUCATOR, INVENTOR AND PUBLISHER

What basic advice would you give to a young researcher trying to have his first article accepted in a scientific journal?

(David Normando)

A good article is always telling a good story. A good novel requires a good storyline and narrative. A good article, a good study design and also narrative. The young author often needs the help of a tutor so he can develop a study with a proper design and also ensure that the subject of the article is interesting, instigating. However, the narrative belongs to him, the author.

To write a good paper it is important to know that many reviews are necessary to achieve proper polishing and brightness. Even today, despite being totally involved with articles, when I write, I do several reviews. Typically, more than ten. Clinical or statistical results of a work may even be awesome, but if the article is not well written, including here language quality it will hardly be published. Can we trust the quality of a study from someone who did not even give his best to write the paper properly? Did this person lead the research with the same lack of criterion that can be verified in the low quality of writing? These are questions that editors and reviewers often do.

Another important issue is to be with an open mind to the criticism that will surely come. During the review process, several controversial or incomplete points are scrutinized by reviewers.

Never mistreat these considerations. On the contrary, see the criticism as a unique opportunity of growth, of ripening. We improve a lot as authors when we accept the criticisms willingly.

In addition, it is interesting to look at articles on the other side, i.e. the reviewer's. This experience is enriching. Offer to revise good articles for journals. We learn a lot with the improvement of the ability to criticize in a based manner. And finally, don't be afraid to try the publication. All recognized and experienced authors have articles rejected for publication. It is part of the game. Sometimes the article is refused in a journal and ends up being accepted in another of even greater projection.

What do you want to suggest to update the scientific publications and make them more attractive, especially for the new generations, besides offering real contribution for scientific knowledge and for those who work in the application of that knowledge?

(Frederico Salles)

We have to bring the reader to the production and evaluation of knowledge process. This mechanism is accomplished through some tools, commented in the answer to the first question of Dr Mucha, such as the assessment of articles by readers and the possibility of adding comments. However, probably journals will migrate to an even bigger interactivity than this.

When a reader completes the analysis of a paper we will work in a way so that he can include also his clinical vision on the subject. Something like "show your experience with this treatment", noting both negative and positive aspects of that therapeutic modality. The journals can also serve as a great discussion forum, like study groups. In this context, we may divide their difficulties in clinical diagnosis, planning and execution in the environment of the journal, enjoying the opinion of several colleagues around the world.

To gather all that thought in a single sentence: We need to increase the interactivity of the reader to the scientific journals.

In a relatively short period of time you moved from a dental school student to an editor-in-chief of a major international publication, the Journal of the World Federation of Orthodontists. Meanwhile you defended a master's degree, a PhD, published several important articles and received the 2010 award for best case report published in the AJO-DO. In addition, initiated skeletal anchorage in Brazil and in the world to the point of having one of the largest global experiences; you were one of the first orthodontists to understand the importance of treating obstructive sleep apnea and to give courses on the subject; you were a pioneer in the use and disclosure of rapid prototyping in orthodontics; developed an innovative periodontal regeneration technique by osteogenic distraction; launched the Anticipated Benefit technique, which in my opinion, revolutionized orthognathic surgery; and was the editor-in-chief of "Dental Press Journal of Orthodontics", one of the few Brazilian scientific publications that compete with their international counterparts. What is the secret of how to use emotional intelligence to do so much in so little time? (Frederico Salles)

In the emotional field, the secret is to keep yourself passionate for dentistry and patients as a young graduate and, as so, believe that anything is possible. I also learned something over the years: whenever someone is about to do something innovative, be sure of it! Because everyone will give you all the reasons in the world why you shouldn't do it. And even after demonstrating that something is viable and good, the criticisms are many. Over time, if ideas are good, they are assimilated. I've lived all this cycle with skeletal anchorage, just to mention one example.

This all becomes a little clearer with the reading of Kuhn.⁴ Mature professionals are naturally settled to the procedures which they already dominate and they do not want changes to occur, young people are different.

In the field of struggling, well, it is no secret, there was a combination of many factors. The first is that I have always been curious and so an avid reader, and as a child I read about everything. At age of 14 I had already read all the Barsa encyclopedia that my father had at home, as well as a large collection of books that included several classics of world literature. In spite of having read a lot of trivia in Barsa (laughs), still being a teenager I started reading a text only if I could learn something from it.

The second factor is that I had a diversified training. I had experienced oral and maxillofacial surgery before becoming an orthodontist, and I took a PhD in biology, which expanded the publication horizons in the biological area. Today, it is clear to me that my diverse interest reflected in my training.

In this way, my dedication, my belief in myself, and the good education were very important for every step taken. But there is one ingredient that makes all the difference in terms of success of new therapies: planning. In any treatment, planning should be done very seriously in order to succeed. It means taking risks, but not being in danger. Any treatment involves a certain risk, that can be understood as the inherent failure rate in any procedure. To be in danger is not planning, by laziness, lack of time, or ignorance. Planning is what allows you to safely transgress borders and innovate.

And finally, I think it is very important to cultivate respect for other people. We can learn from anyone, from the simplest citizen to the winner of a Nobel Prize.

One of our deficiencies as Brazilian authors of scientific papers, in my opinion, regards few prospective clinical work. If you agree, how can we improve and stimulate this kind of research that would lead to major scientific and clinical evidences? (Nelson Mucha)

It is a fact that we publish much, but our studies can still improve the level of evidence. The reasons for this issue are rooted in different soils. The first is that many of our schools of greater

development are relatively new. Among the oldest schools, in general the researchers of high production belong to the first generation of the school that publishes internationally.

An important stimulus to the increase in the number of articles with this quality has to come from editors. At the moment, it is up to the editors to filter more the information produced. Many articles published in the world literature does not help to clarify our ideas about treatment protocols. On the contrary, when a mismanaged study is published, it often adds noise to the information. The pressure of having articles rejected will, of course, make professionals seek the most appropriate study designs. While researchers continue to have space in journals with simple works, it will be difficult to boost them to evolve to more suitable study designs. The process is simple: prospective studies spend more time and energy than other kinds of tests, so why publishing a complex work when I can publish several simpler? And there is more. The two types of work count equally in the curriculum and funding agencies. Finally, we have to take into account that a prospective work in orthodontics typically requires many years to complete. Far beyond the duration of a post-graduate course.

I have been following your professional career long-standing (1991) and I can say, without the fear of making mistakes, that you are one of the bright and promising young professional of world orthodontics. Much is expected from you, including large and pleasant surprises. So, what are your future plans as editor-in-chief of the Journal of the World Federation of Orthodontists? (Nelson Mucha)

The JWFO is a strategic development for the WFO. It will be distributed free of charge for the approximately 8500 current members of the WFO around the world and our goal is to become an important source of information for these professionals. This alone is a great start: Start with more than 8000 subscribers.

The journal will adopt a concise model of articles in electronic format only, but will complement the content written with the use of many videos of interview. My intention with this approach is to infuse the heat of a congress with oral presentations and body language to the “coldness” of scientific articles. I think the authors will probably embrace this creative initiative that will give them the opportunity to expose with more intensity their work and their own image.

Besides, the JWFO offers the possibility of entering in the process of knowledge construction through comments and reviews of articles.

How did you decide to translate most of the Dental Press articles into English as a second language? Was this change worth the effort and cost? (David Turpin)

The evolution of DPJO into English was a process of natural selection, we had already reached the ceiling of impact that publication could achieve by being published in the Portuguese language. This issue was in my conversations with the publisher since I took the journal. However, the decisive step came under pressure from the indexer organs themselves.

To make this step real was not easy. We spent almost a year testing different translators who had the ability to perform a high quality job with the dental scientific English. We felt a great initial resistance from the authors, because many wanted to write their texts themselves. That resistance still exists, but is smaller. Our experience over hundreds of articles is that no Portuguese-speaking author was able to write alone an article that hit our quality criteria. Everyone needs some level of help, even those who worked abroad for years. We need a lot of tact to say that even an author who have a great experience in English is difficult to equate to a professional or a native level of the language.

The cost of these translations runs on behalf of authors. Since the beginning I figured it was fair and valid for the authors to bear these expenses.

The DPJO has a great penetration in Brazil and other countries of Latin America. By translating articles into English, the authors gain in two ways: It increases their international visibility, while maintain the internal impact, since we also publish a mirror of the official English journal in Portuguese. This is the bonus that the authors have, and it is real. We, on the other hand, have doubled our work. I think this is a win-win relationship. Everybody works more, but everybody wins.

Do you see the need to publish portions of the new JWFO in other languages once it becomes established? (i.e., Portuguese, Chinese, or Spanish) (David Turpin)

Some journals, as the PLoS ONE, has, let us say, some versatility with the language. They publish articles in English, however, native authors from other languages, after acceptance of the work, can see their articles also published in their native language. This task aims to increase the visibility of the work of the author in his own country, making it easier to read.

The international characteristic of JWFO maybe leads us to adopt, in the future, a similar system. This approach would tend to increase the interests of the authors of good articles on the journal, as well as publishing in two languages attracted authors to the DPJO.

It seems as though educators and researchers are busy people and not always available to give the editor much time or attention. How did you manage to work with these talented individuals? In other words, what do authors and reviewers expect in return for their support of any journal? (David Turpin)

Authors and reviewers want different things. The author wants recognition of his work, and this is natural. Thus, he wants to publish in a journal that has credibility, and setting out the result of his effort for the greatest number of people as possible. This metric can be partly obtained by the impact factor of a journal.

Reviewers are also generally, authors but this does not always occur. They donate their time to review articles by different reasons. One of them is to show his/her competence to the editorial board. This is one way that many competent professional increased in visibility on the specialty around the world.

In addition the review process is a fantastic study and we improve much as authors when we engage with it. The critical reading of an article makes a professional grow incredibly. However, there is one thing that needs to be said. Critical reading comes with pages of comments, criticisms and reflections. A reviewing that ends up with a reject recommendation and comes after a telegraphic text, typically speaks against the reviewer. It is a sign that he does not want to review the paper or does not know how to do it. In any of the situations he ends up being removed from the list of reviewers.

We at the JWFO have all ingredients to attract quality reviewers and authors. First, because we have the credibility of the organization which maintains this journal: the World Federation of Orthodontists. Second, because the JWFO was born in an odd situation. More than 8000 orthodontists from around the world will receive the journal at no charge as part of their membership to the WFO. Among these professionals, there are many of the most politically influential and scientifically competent. And, finally, the journal proposes to serve as a discussion forum, where each article will receive notes and readers' comments. In addition to this, video interviews are linked to several articles, allowing a greater exposure of authors and their work.

Online publications still present a problem for many of the targeted readers. Do you think the 8500 WFO members are ready for this change? How will you get the attention of the most reluctant members who refuse to search using the JWFO? (David Turpin)

The world has gone through an intense transformation regarding the consumption of information. When the iPad was released, in April 2010, the market received it with discredit. Few understood, at that time that, that the gadget was more than a big iPhone and that it would revolutionize the media consumption. Less than 2 years later, the tablets turned the world upside down (and the DPJO was the first orthodontic journal to be edited for the iPad in the whole world). Many Brazilian universities and schools give each student a tablet, containing all reading sources they will need in the course.

I strongly believe that it will not be the JWFO that will have to struggle to convince readers who reject reading in electronic format. Simply, those who do not leave their comfort zone and seek these information alternatives, very soon, will struggle to keep up to date even on the projects of the manager of their buildings.

When I was a child, the beginning of old age in spirit was not knowing how to switch on the VCR. Today, it is not having an account on a social network and not knowing how to handle a tablet. I am already trying to fight against aging. (laughs).

What orthodontic topics are of greatest interest to the international clinical audience? Once identified, how can you stimu-

late WFO members to submit clinical material of high quality representing these areas of interest? (David Turpin)

The goal of any area in health sciences is the development of secure protocols tested for use in the population. This search led to the emergence of the theory related to the evidence-based clinical practice. The higher the level of evidence of a paper, the more it tends to be accessed and cited.

There is, however, a bias in the interest of curious readers about the papers. Readers are interested in both the highest level of evidence and in those of lower level, such as case reports. These works represent the new. There are new techniques, new protocols, new appliances. Maybe the interest for the new is an intrinsic attribute to the *homo sapiens* and that has led us to create the world as we know it.

There are different ways to attract these two poles. One is to offer rapid publication. My intention is to work with few articles, making our files always somewhat empty. Another one, is the visibility that we hope to offer by means of assess to articles by their readers, similarly to what is done on YouTube, for example. Finally, all this may have brightness intensified by the use of social media. This is an important tool for marketing and dissemination of information.

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Influence of the banded Herbst appliance on dental changes in mixed dentition

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Abstract

Objective: This prospective clinical study was conducted with the purpose of evaluating the influence of the banded Herbst appliance on dental changes during the early treatment of Class II malocclusion. **Method:** The sample consisted of 15 prepubertal subjects (12 boys and 3 girls, initial age: 9 years and 6 months) who were treated with the Herbst appliance. Treatment effects were compared with those of a Class II Division 1 group of 15 subjects (8 boys and 7 girls, mean initial age 9 years and 1 month), not treated orthodontically. Statistical analysis was performed using Student t-test with 5% significance level. **Results:** The results showed that treatment with the banded Herbst appliance in the mixed dentition stage tended to upright maxillary incisors (mean: 4.14°). The maxillary molars were distalized and intruded significantly (mean 2.65 mm and 1.24 mm, respectively), the lower incisors slightly protruded anteriorly (mean 1.64 mm) and the molars showed no significant changes in the horizontal and vertical directions. Furthermore, significant improvements were noted in overbite (1.26 mm), overjet (4.8 mm) and molar relationship (12.08 mm). **Conclusions:** Changes in the upper dental arch were found to be greater than changes in the lower arch. Furthermore, mandibular anchorage loss was reduced due to the anchorage system used in the study.

Keywords: Herbst appliance. Anchorage system. Mixed dentition. Orthodontics. Cephalometry.

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Editor's abstract

The Herbst appliance is indicated for treatment of skeletal Class II malocclusion associated with mandibular retrusion, especially in non-compliant patients, in order to stimulate mandibular growth. Mandibular advancement is accomplished by a tube/piston system supported on bands, crowns or acrylic splints. As a result of tooth-borne or tooth-tissue-borne anchorage (in some cases), the Herbst eventually also promotes undesired dental changes.

The objective of this study consisted in assessing the changes with the banded Herbst appliance in mixed dentition patients. Fifteen patients took part in the treated group (12 boys and 3 girls) with initial mean age of 9.4 years, presenting Class II, Division 1 facial pattern associated with mandibular retrusion; dental Class II, Division 1 relationship; mixed dentition with erupted or currently erupting upper and lower incisors; absence of severe crowding in the lower dental arch, and crossbites. The Herbst tube/piston system was supported on maxillary and mandibular first molar bands (by means of a cantilever), combined with a transpalatal bar in the upper dental arch and a lingual arch in the lower dental arch. Mandibular advancement was performed in one single step until an edge-to-edge incisor relationship was reached. Patients were treated for 7 months.

The effects produced by the Herbst were compared with those of a control group whose subjects were recruited from the archives of the Burlington Growth Centre, University of Toronto/Canada, composed of 15 children (7 girls and 8 boys) with mean initial age of 9.08 years, with Class II, Division 1 malocclusion associated with mandibular retrusion. These individuals were followed up for approximately 1 year (final mean age of 10 years). Through the analysis of cervical vertebrae in lateral cephalograms it was found that children

of both groups were in stages 1 and 2 of skeletal maturation, i.e., in the pre-pubertal growth spurt period. Lateral cephalograms obtained at the beginning and end of treatment/evaluation of both groups were traced and cephalometric points of interest were scanned using a flatbed scanner. Cephalometric variables related to vertical, sagittal and angular maxillary and mandibular incisors and first molars were measured by Dentofacial Planner Plus 1.2 software. To study the error, all tracings were once again scanned and the variables measured by the same operator within a two-week interval. The intraclass correlation test was used to determine method error.

Due to a mismatch in the assessment times of the experimental and control groups, the data were annualized and subjected to the independent t test for comparing the groups in the initial phase and comparing the changes that took place during the study period ($p < 0.05$). The results indicated that the minimum intraclass correlation index achieved was 0.983, and the method was therefore considered accurate. Thus, the means reached between the first and second measurements were used for each variable. When the experimental and control groups were compared in the initial phase it was found that there was similarity in more than 50% of the variables.

The Herbst promoted several dental effects such as relative intrusion (inhibition of vertical development) and distalization of first molars caused by a force vector delivered by the telescopic system in the upward and posterior direction. Furthermore, the lower incisors protruded and the molar relationship was adjusted relative to the control group. The Herbst also decreased the overbite and overjet of treated patients. The authors concluded that changes in the anchorage system are recommended with a view to minimizing the dental effects produced by the Herbst appliance in the mixed dentition.

Questions for the authors

1) The Herbst assessed in the study was anchored in the lower arch, with a lingual arch positioned at a distance of 3 mm from the anterior teeth. Considering that the patients were in the mixed dentition stage and that the lower first molar moved mesially in relation to the pogonion during treatment (although with no statistically significant differences compared to the control group), was there any clinically significant impact on leeway space?

No. The Herbst appliance moved the molar mesially by 1.11 mm. This movement occurred in the same direction as the lower molar in the control group (0.24 mm), but in a slightly more pronounced manner. In addition, when patients entered van der Linden's second transitional phase, the lower molar would be expected to move mesially (late migration of the molars). However, molar movement occurred earlier during treatment with the Herbst appliance. The purpose of using a lingual arch at a distance of 3 mm would be to minimize lower incisor flaring, since there was no direct contact between the anchorage system and these teeth, which reduced the force produced by the telescope system in this region. Moreover, it would also reduce the risk of trauma to the lingual mucosa of the lower incisors caused by inserting the lingual arch in the region.

2) Considering the results, which modifications in the banded Herbst appliance system are recommended by the authors?

Since it has been well established that different types of anchorage can provide different dentofacial responses, we recommend that clinicians be aware of these dentofacial changes induced by different designs of the Herbst appliance in order to develop a better treatment strategy for each patient. In our study, the Herbst appliance simulated, in the upper jaw, the effect of a high pull headgear, i.e., there was intrusion and distalization of the molars. With the purpose of minimizing this dental effect, we suggest incorporating more teeth into the anchorage structure because

the lower the number of teeth included in the anchorage system, the greater the dental changes observed. And the more teeth are included in the anchorage structure, the greater the anchorage control, since more skeletal changes will tend to occur in relation to the dental changes. Therefore, a wire segment could be welded to the upper bands in the buccal and palatal sides, extending to the region of deciduous canines. This wire extension should therefore be secured with composite resin in deciduous molars and canines.

3) What are the advantages and disadvantages of using the Herbst appliance combined with first molar bands?

One of the factors that led us to use the banded Herbst appliance was the fact that patients were in the mixed dentition phase. Therefore, using this anchorage structure would not interfere with the tooth eruption process when permanent teeth eventually replaced primary teeth. Another reason is that cleaning is easier with this type of anchorage and consequently the risk of decalcification, caries and enamel fractures is reduced when compared to the Herbst appliance with acrylic splints, for example. Furthermore, removal of the banded structure and bonding material on the proximal surfaces after treatment is easier to perform when compared to structures with acrylic splints or metal crowns. The banded Herbst appliance barely interferes with chewing and is less traumatic to the periodontium compared to the Herbst appliance with metal crowns. In terms of cost, the banded anchorage structure is more affordable when compared to other anchorage structures. However, the major disadvantage of the banded structure used in this study is that it provides less anchorage control. Additionally, there is increased risk of band weld failure, especially in the upper molars, and trauma to the lingual mucosa of lower incisors.

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Study of tension in the periodontal ligament using the finite elements method

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Abstract

Orthodontic movement is process of transformation of a physical stimulation into a force applied to a tooth, with a biological response identified as bone remodelling. Although it is possible to measure the force applied on a tooth, its distribution around the root is irregular forming areas of higher concentration of tensions, which do not correspond to the force initially applied. To evaluate the behavior of the periodontal ligament after the application of an external action and to prove which would be the areas of higher tension generated in the periodontium, the Finite Elements Method (FEM) was used in comparison to the results obtained *in vivo* on experimental models in rat. To test the error susceptibility of the technique used in the experimental model, the force application was simulated in three different heights on the mesial surface of the molar. The resulting histological analysis was compared with the result obtained for the computational code and disclosed that the greater focus of osteoclasts in activity had coincided with the compressed areas of the periodontal ligament. The alteration of points of force application generated areas of more extensive deformations in the periodontal ligament, as the point of application was more distant of the initial point, the horizontal force vector became bigger. These results demonstrate that the FEM is an adequate tool to study the distribution of orthodontic forces. The sensitivity of the experimental model used was also observed in relation to the installation of the dental movement device, which should be considered depending on the objective of the research.

Keywords: Finite Elements Method. Orthodontics. Tensions.

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Editor's abstract

Orthodontic tooth movement is achieved when forces are applied to teeth and transmitted to the supporting periodontium, which triggers the remodeling of the alveolar bone by means of bone deposition in the traction area and bone resorption in the area under pressure. Studies to define parameters to guide orthodontic practices are conducted considering two aspects: Experiments with human beings or animals; and numerical analyses conducted using the finite element method (FEM). FEM analysis is an excellent computational resource for the evaluation of tooth structures in the several areas of dentistry and a low-cost and practical alternative to test materials and techniques. The purpose of the present study was to evaluate, using numerical experiments, the results of *in vivo* trials and to test the sensitivity of the technique used for tooth movement. Experimental model and finite element analyses were conducted. For the experimental analysis, tooth movement was induced in the maxillary left first molars of rats (n=6) using a nickel-titanium closed coil spring at a force of 0.25 N. Seven days after coil spring activation, the animals were killed and histological slides were prepared. To analyze the tooth structure using FEM analysis, tooth geometry was defined and the rat's maxillary molar was extracted and photographed using a stereomicroscope. The photograph was printed on graph paper, and the coordinates of interest were obtained.

Nine-node tetrahedral finite elements for plane stress of the ADINA 8.3 computational code were used to create the discretization mesh (Fig 1). The forces were applied to sites located at 0.38 mm, 0.64 mm and 0.83 mm (Fig 2) while the same anchorage point was kept for the three situations. The purpose was to evaluate the effect of height on the application of force and error susceptibility of the technique applied to the experimental model of tooth movement and to small deviations in the spring position in relation to the occlusal surface of the tooth. Histological analysis was compared with the result obtained using the computational code and revealed that the greater foci of active osteoclasts were found in areas compressed by



FIGURE 1 - Finite element mesh; square indicates reference site for application of forces (cervical margin of tooth).

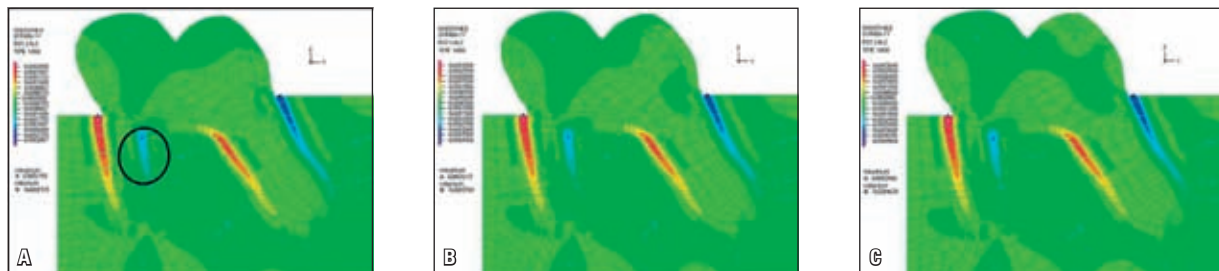


FIGURE 2 - Deformations due to forces applied to sites at 0.38 mm, 0.64 mm and 0.83 mm from the cervical margin.

the periodontal ligament. The change in force application sites generated larger deformation areas in the periodontal ligaments as the application was more distant from the initial site and the horizontal force vector was greater.

The authors concluded that FEM analysis is

an adequate tool to study the distribution of orthodontic forces. Additionally, the sensitivity of the experimental model in relation to the placement of a device to promote tooth movement should be considered depending on the objective of the study to be conducted.

Questions for the authors

1) Do the authors believe that orthodontists will have access to finite element methods (FEM) in the future to plan their cases using computational modeling?

Finite element analysis is not the application of some commercial software. It is an approximation method for the study of complex structures and, therefore, requires knowledge of engineering to be applied. For an orthodontist to be capable of using it, it is necessary to obtain qualifications by thoroughly studying this application method, which has been well established in engineering, and to acquire basic knowledge in this area. We believe that it can be directly applied to research to evaluate orthodontic techniques, appliances and new mechanical resources. Case planning will benefit from the results of these studies.

2) What are the limitations of using FEM analysis when working with biological responses?

The greater difficulty is the mechanical representation of the actual behavior of biological tissues in the mathematical models that are to be analyzed using FEM. However, in studies conducted in recent years, efforts have been made to ensure that simulations come increasingly closer to reality. Another limitation of this study is the simulation of masticatory movements, whose representation is limited when compared with actual mastication.

3) Is FEM analysis useful only for isolated evaluations, or is it also used for complex systems, such as a full maxillary arch with a fixed appliance associated with an extraoral appliance and intermaxillary elastics?

FEM analysis may be used for planning and testing complex mechanical systems, such as designing aircrafts, bridges and buildings. Therefore, it can also evaluate the behavior of the stomatognathic system in general, such as mastication, or the composition of both arches. Materials with different behaviors, such as human tissues, appliances or elastic bands, may also be evaluated simultaneously. However, as the system becomes more complex, the number of variables, such as muscles and ligaments, is high, and this requires that the researcher should have extensive experience in bioengineering and master FEM analysis.

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The influence of asthma onset and severity on malocclusion prevalence in children and adolescents

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Abstract

Objective: The influence of asthma, its severity levels and onset time on malocclusion occurrence were investigated. **Methods:** The sample was composed by 176 children/adolescents, of both genders, aged 3 to 15 years, that were divided in two groups. The asthma group (AG) enrolled 88 children/adolescents that were seen at the Breathe Londrina Program. The asthma-free group (AFG) enrolled 88 preschool and school children recruited in 2 public schools. Malocclusion diagnosis was made according to WHO criteria (OMS, 1999). **Results:** A higher prevalence in malocclusions in asthmatic patients in mixed dentition was observed when compared to controls ($p < 0.05$). On the other hand, these results were not observed for deciduous ($p > 0.05$) and permanent dentition ($p > 0.05$). A significant association was seen between asthma onset time and marked maxillary overjet ($p < 0.05$), and open bite ($p < 0.05$) in the mixed dentition, being both conditions more common among those that have presented the symptoms of asthma prior to 12 months of age. **Conclusion:** The results of this study indicate that the early manifestation of asthma at first year of life can cause dentofacial changes. Therefore, the prompt diagnostic of the illness, as well as the establishment of a proper therapy could improve the symptoms and chronic complications of asthma and also reduce its impact on craniofacial development.

Keywords: Asthma. Malocclusion. Child. Adolescent.

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Editor's abstract

Asthma is a chronic disease that often affects millions of people at any age worldwide, regardless of their ethnicity and strata. The disease affects the lower airways leading to the closure of the bronchi, and to difficulty in exhaling. Asthma can promote mouth breathing, which causes changes in functional muscle posture commanding the oral activities and, consequently, it may influence jaw development, tooth position and occlusal relation. The authors' proposal with the present work was to evaluate the influence of asthma, its different degrees of severity and onset time in the prevalence of malocclusion. This observational cross-sectional study investigated 176 children and adolescents 3-15 years of age. The study population was divided into two groups of 88 patients: Asthma group (AG) and Asthma-free group (AFG). Data collection was performed by two examiners (dentists),

one responsible for the interview with the parents and the other for the breathing test and nasal examination. In possession of the data, statistical analysis was applied where a higher prevalence of malocclusion in asthmatic patients in the mixed dentition was observed when compared to control patients ($p < 0.05$). On the other hand, these results were not observed in the deciduous ($p > 0.05$) nor in the permanent dentition ($p > 0.05$). No significant differences were found between asthma and control groups regarding molar relationship, presence of spaces, crowding, crossbite, overjet and open bite. A statistically significant association between age at asthma onset and the presence of severe overjet ($p < 0.05$) and anterior open bite ($p < 0.05$) in the mixed dentition was observed. It was concluded that the early asthma onset in the first year of life can cause dentofacial changes, becoming important a prompt diagnosis and treatment of the disease.

Questions for the authors

1) To what do the authors attribute the greater prevalence of malocclusion in asthmatic patients only in the mixed dentition?

Essentially to the sample size, since most of the study participants had mixed dentition. The larger the sample size, the greater the chance of detecting problems.

2) The fact that research participants are patients on maintenance treatment of asthma with continuous use of potent inhaled corticosteroid and nonsteroidal anti-inflammatory agents may have influenced the results?

Yes, it may. What is expected is that the treatment reduces the malocclusions because it improves the patient's respiratory status. The study showed that there is an association between the expression of asthma before 12 months and the

occurrence of severe open bite and overjet in patients with mixed dentition. So the prompt disease diagnosis and institution of treatment could influence malocclusions.

3) What questions generated by the study could continue this line of research?

The study provides clues about the influence of disease manifestation time and the malocclusion occurrence. As future prospects studies should clarify how does the prompt diagnosis and treatment of the disease in the first year of life affect malocclusion development.

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Assessment of the orthodontic knowledge demonstrated by dental school undergraduates: recognizing the key features of Angle Class II, Division 1 malocclusion

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Abstract

Objective: To investigate the ability of undergraduate students in diagnosing Angle Class II malocclusion and evaluate the clinical approach of these students toward a patient displaying this condition. **Methods:** The sample consisted of 138 students attending the last semester of 10 dental schools in the State of Rio de Janeiro/Brazil assessed by questionnaires with closed questions. They were presented with photographs and dental casts of a patient in the mixed dentition, with Angle Class II malocclusion, increased overjet and overbite, deviated dental midlines and anterior diastemas in the upper arch. **Results:** It was found that students easily identified increased overjet (92% of students), followed by the presence of diastemas (89%), midline deviation (84.7%) and increased overbite (77.3%). Conversely, approximately half the sample (n=70 or 51% of the students) were able to identify bilateral Angle Class II malocclusion. Nearly all agreed on the need for treatment and that it should be provided by a specialist (n=131 or 95%), but found it difficult to determine the ideal moment to start orthodontic treatment: 48.9% of the sample would begin treatment at the end of the mixed dentition, 41.7% would indicate treatment during deciduous dentition and 7.9% during permanent dentition. **Conclusions:** On completion of their undergraduate courses, students encounter difficulties in diagnosing Class II and even find it hard to articulate ideas about a basic treatment protocol to correct this malocclusion.

Keywords: Interceptive orthodontics. Angle Class II malocclusion. Diagnosis.

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Editor's abstract

The diagnosis of the alterations on the sagittal and vertical maxillomandibular components, either isolated or combined, requires theoretical knowledge and practical training. The aim of this study was to evaluate the capacity to diagnose and elaborate a treatment plan for Class II malocclusion in dental school undergraduate students. The sample was composed by 138 undergraduate students in their last semester at the university, selected from 10 different dental schools in

the state of Rio de Janeiro/Brazil. A standardized technique for data collection was used, through the application of questionnaires. Each questionnaire was attached to a clinical case (Figs 1 and 2). No radiographs were shown, with the purpose of simulating a routine clinical appointment. After analyzing the material presented to them, the students were questioned about Angle classification, the existence of intra-arch problems, the ideal phase to start treatment and their possible referral to a specialist. The data collected was



FIGURE 1 - Extraoral photographs of the patient whose clinical case was presented to the students.

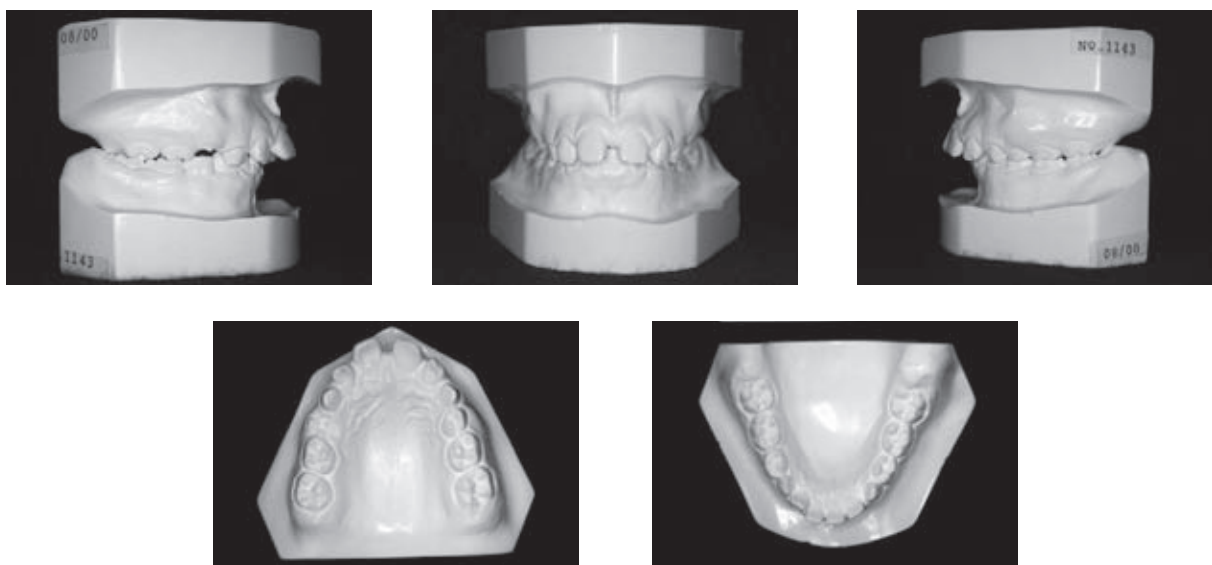


FIGURE 2 - Photographs of the dental cast presented to the students.

processed and analyzed using EpiInfo 6.04 software, and graphics were obtained using Microsoft Excel 2004. The results showed that the students found it easy to identify an increased overjet (92% of the students), the presence of diastemas (89%), midline deviation (84.7%) and an increased overbite (77.3%). On the other hand, only half of the sample (n=70, or 51% of the students) was able to recognize bilaterally the Angle Class II malocclusion. Almost all of the students agreed to the necessity of treatment and that it should be

made by a specialist (n=131, or 95%), however they found it hard to recognize the ideal moment to start the orthodontic treatment: 48.9% of the sample chose to start treatment at the end of the mixed dentition, 41.7% at the deciduous dentition, and 7.9% at the permanent dentition. The authors conclude that the students finish the undergraduate course with some difficulties in the diagnosis of Class II malocclusion, and knowledge deficiency to structure a treatment plan to correct this malocclusion.

Questions for the authors

1) To what do you attribute the fact that only 50% of the questioned students were able to recognize Class II, division 1 malocclusion?

We understand that the educational curriculum can be quite different when it comes to analyzing 10 different institutions. Some schools rely only on theoretical classes and lab activities, while others have also a specific clinic for orthodontics. Clinical activity helps, undoubtedly, on the apprehension of the knowledge by the student.

Another important matter to be considered is the fact that the undergraduate orthodontics course is usually given two semesters ahead of the last semester (the exact moment when the study was conducted) and many students think of past disciplines as useless, dropping this knowledge.

2) In the authors' opinion, which knowledge on orthodontics should a general practitioner dominate?

In our opinion a general practitioner should dominate the following subjects: Normal development of the dentition in children and adolescents, diagnosis and classification of malocclusions, and prevention and interception of malocclusions during the development of occlusion. We also consider important to have the basic

knowledge regarding appliance installation and the materials used in this procedure, so they can guide their patients, though on a superficial manner, and diagnose orthodontic treatments that might be poorly conducted.

3) What is the solution that the authors could propose to improve the quality of the undergraduate courses in orthodontics in Brazil?

Excluding external factors related to the selection of students when entering dental schools, which seems out of our field of action, we would propose the setting of a wider and more homogeneous educational curriculum in orthodontics amongst dental schools. The inclusion of clinical activities in all universities would help settling the theoretical learning.

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Assessment of soft profile characteristics in Amazonian youngsters with normal occlusion

Wilson Maia de Oliveira Junior*

Abstract

Objective: The present study aimed to determine from a sample of Amazonian youngsters, with normal occlusion, the mean values for soft profile characteristics using cephalometric radiographs obtained in lateral norm. **Methods:** The cephalometric radiographs of the 30 youngsters, being 15 males and 15 females, with mean age of 21.6 years old, were assessed. For statistical analysis, central tendencies and dispersion measurements (mean and standard deviation) were used and, for both the comparison of the mean values of males and females and the correlations between the measurements of the soft profile and bony profile, the unpaired Student's t-test was applied. **Results and Conclusion:** After obtaining statistical data, parameters were set based on the cephalometric norms regarding the specialized literature, revealing that all variables presented a normal distribution pattern. There was sexual dimorphism for the following measurements: ANB, NAP, ANS-Me, N-ANS, Sn'-Me', and N'-SN'. Norms were determined for all the assessed measurements. Statistical differences were observed between the norm found in the present study and those found in the specialized literature.

Keywords: Soft profile. Normal occlusion. Amazonians.

INTRODUCTION

Using information extracted from anamnesis, facial analysis, clinical examination of the oral cavity, dental casts and radiographic exams, most importantly the cephalometric radiograph, diagnostic and treatment plan accuracy is enhanced, allowing professionals to set the ideal goals for a given orthodontic condition.

Facial morphology could be evaluated using subjective facial analysis, which might prove sufficient to determine parameters without the need for numerical values.⁴ However, not always a good facial balance means excellent occlusion following some numerical parameters of normality.

Major contributions have been proposed over the years in the field of cephalometric analysis

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assisting on the diagnosing and setting numerical values aimed at achieving pleasant aesthetic results.^{12,15,17,21,24,25,29}

Most authors understand and respect the relevance of cephalometric analysis in the literature, however they question the use of a set of values disregarding facial variations, ethnic background, cultural aspects, and especially the individual preferences of patients.^{9,10,16,18,31}

Facial pattern outcome may fall short of what is desirable if the approach is based only on mean dental and skeletal values obtained from cephalometric analyses without performing a comprehensive facial examination, in which dental and skeletal measurements do not always match the soft tissue parameters.³

Given the growing importance of orthodontic diagnosis and the need to set unique standards of normality for each population, the present research aimed to study the characteristics of a sample of Brazil's Amazonas State youths²³ from a lateral cephalometric standpoint by evaluating the values found in this investigation and correlating them with the sagittal occlusal relationship as traditionally defined in mainstream literature.²

OBJECTIVE

Based on the cephalometric assessment of the craniofacial patterns of Brazilians adolescent, from the Amazon State, with normal occlusion, the study sought to examine the following variables:

1. The soft tissue characteristics regarding the standards recommended in the literature.
2. Whether there are correlations regarding some soft tissue measures.
3. Whether there is sexual dimorphism.

MATERIAL AND METHODS

Sample

The sample comprised 30 subjects: 15 males and 15 females, all Caucasian, from the Brazilian State of Amazonas, whose parents and

grandparents hailed from the same Brazilian state. They were all students enrolled at UFAM (Federal University of Amazonas) with permanent dentition, normal occlusion² and no history of orthodontic treatment. The mean age was 21 years and 6 months, ranging from 17 years and 2 months to 26 years. The sample was selected from young people living in the Amazonas' capital city, Manaus.

Methods

Lateral radiographs were obtained of each patient as well as a panoramic radiograph, intra- and extraoral photographs and a pair of dental casts.

Radiographic method

Lateral radiographs were obtained at the Center for Dental Radiology Ltda (RADIOCENTER), Manaus (AM) using an Orthotalix X-ray equipment, model 9200, manufactured by Dentsply, attached to a cephalostat, set at 70 kVp, 10 mA and time exposure of 1.2 seconds. The lateral radiographs with true vertical plane were obtained according to the following protocol:

1. Each patient was placed in the cephalostat in a standing position, their body relaxed, looking at the image of their own eyes reflected in a 29 x 34 cm mirror fixed in front of them at a distance of 1.55 m. This mirror was previously set according to their height as they stood with their feet parallel to each other and slightly apart, and teeth in maximum intercuspation (MI).
2. Then the ear-rods were smoothly inserted and positioned at the entrance to the external auditory canals, taking care not to change the head position set in step 1.
3. A thin metal chain with a pendulum weighing 25 g was hung over the edge in front of the patient's nose (1 to 3 cm), serving as a vertical plumb line, perpendicular to the horizontal plane due to gravitational force.

4. The chassis position was adjusted in both the vertical and horizontal planes. The chassis cartridge was moved so that it lightly touched the patient's right shoulder without changing his posture.
5. The radiograph was then obtained.

Obtaining the cephalogram

The cephalograms were obtained using tracing paper placed on top of the radiographs. The tracings were performed using 0.5 mm black lead.

Anatomical drawing

The following anatomical cranial structures³² were traced. The point where the ear-rods were positioned was replaced by the porion anatomical landmark when the shadows of the right and left points did not match.

- » Glabella and nasal bones profile;
- » Soft tissue profile;
- » Sella turcica;
- » Maxilla;
- » Mandible, including the condyle;
- » Maxillary and mandibular central incisors;
- » Maxillary and mandibular first molars.

Cephalometric measures

Angular hard tissue measures

» **ANB** – Angle formed by the intersection of NA (Nasion–point A) and NB (Nasion–point B) lines.²⁶

» **NAP** – Depicts the bony profile through the use of the points nasion, A and pogonion (N-A and Pg).¹¹

» **I.NA** – Describes upper incisor inclination in relation to the maxilla.³⁰

» **I.NB** – Describes lower incisor inclination in relation to the mandible.³⁰

Linear hard tissue measures

» **I-NA** – Describes the protrusion or retrusion of maxillary incisors.³⁰

» **I-NB** – Describes the protrusion or retrusion of mandibular incisors.³⁰

» **ANS-Me (ALFH)** – Describes the anterior lower facial height through the distance between the anterior nasal spine (ANS) and the menton (Me).²⁰

» **N-ANS** – Distance between the nasion and anterior nasal spine skeletal points; depicts the length of the midface.

» **Overjet** – Greater dental overlap in the horizontal direction, measured from the most anterior point of the labial surface of lower incisors, parallel to the occlusal plane.

» **Overbite** – Greater dental distance in the vertical plane between the incisal edge of the upper incisors and the incisal edge of the lower incisors.

Angular soft tissue measures

» **ANB angle in soft tissue** = $a'n'/n'b'$ – Characterizes the facial discrepancy between maxilla and mandible, as measured through upper and lower lip inclination.

» **Angle of the chin/neck line** = $sn'/gn'-gn'/c'$ – Characterizes the angle of the lower face.

» **Angle of facial convexity** = $g'/sn'/pg'$ – Characterizes the kind of soft tissue profile.

» **Labionasal angle** = $cm'/sn'/Ls'$ – Characterized by upper lip inclination and/or size of nasal prominence.

» **Labiomental angle** = $Li'/Lm'/pg'$ – Characterized by lower lip inclination and/or mandibular prognathism or retrognathism.

Soft tissue linear measures

» **n-subnasale** – Linear length from the soft tissue nasion point to the subnasale angle.

» **Subnasale-me'(ALFH')** – Soft tissue anterior lower facial height.

STATISTICAL METHOD

In assessing the data for all cephalometric measures, the central tendency and dispersion measurements were obtained (mean and standard deviation) and for comparing mean values between male and female subjects and correlating soft tissue and hard tissue measures, Student's unpaired t-test was applied.

It was also checked whether or not the sample measurements corroborated the values reported in the literature. In cases of sexual dimorphism verification was performed separately in male and female subjects. However, where dimorphism was not present the comparison was performed using the entire sample, with no gender differentiation.

Subsequently, the correlation between the hard tissue measures was assessed using Pearson's⁶ correlation and other tests to verify if this correlation was different from zero.

RESULTS

After the cephalometric tracings were performed

TABLE 1 - Central tendency and dispersion measures. t-test and significance. Variables compared between males and females.

Variables	Gender	Mean	Standard Deviation	t	p-value	Significance
ANB	Female	3.23	1.25	3.99	0.04%	**
	Male	1.53	1.08			
NAP	Female	4.00	3.57	2.95	0.63%	**
	Male	1.13	1.19			
1.NA	Female	26.50	4.30	-0.99	33.00%	ns
	Male	28.20	5.10			
1.NB	Female	27.13	6.25	1.91	6.60%	ns
	Male	23.17	5.04			
1-NA	Female	5.57	1.80	0.20	7.70%	ns
	Male	6.60	2.28			
1-NB	Female	7.00	2.37	0.17	20.40%	ns
	Male	5.73	2.50			
ANS-Me	Female	69.40	5.21	-2.88	0.76%	**
	Male	74.80	5.06			
N-ANS	Female	54.03	4.53	-2.78	0.96%	**
	Male	58.53	4.34			
ANB'	Female	7.63	1.64	-0.11	91.00%	ns
	Male	7.70	1.57			
G'/Sn'/Pg'	Female	12.57	3.48	0.41	68.00%	ns
	Male	11.93	4.85			
ÂNL	Female	100.17	13.76	-0.97	34.00%	ns
	Male	104.97	13.27			
ÂLM	Female	120.40	13.03	-1.24	23.00%	ns
	Male	125.50	9.21			
Sn'-Me	Female	72.33	3.94	-3.57	0.13%	**
	Male	79.80	7.08			
N'-SN'	Female	55.57	4.85	-3.07	0.47%	**
	Male	60.13	3.12			
Overjet	Female	2.60	1.20	0.24	81.00%	ns
	Male	2.50	1.07			
Overbite	Female	2.40	0.89	-0.71	48.00%	ns
	Male	2.67	1.14			

ns= nonsignificant; * = significant at $p \geq 1\%$; ** significant at $p < 1\%$.

and the measurements obtained, Table 1 was formulated to depict the means, standard deviations and Student's t-test with their respective significance, aiming to verify similarities of means between genders. Table 2 presents the means, standard deviations, and t-test results with their respective significance used to assess the similarities of means between the values found by

the present study, for males and females, and those found in the literature after comparing the means between the two groups (male and female). Correlations between cephalometric and soft tissue examinations are shown in Table 3. Figures 1 to 12 present the measures for which correlations were assessed, showing significance in Figs 6, 8, 9, 11 and 12.

TABLE 2 - Central tendency and dispersion measures. t-test and significance. Variables compared between male and female with the means reported in the literature.

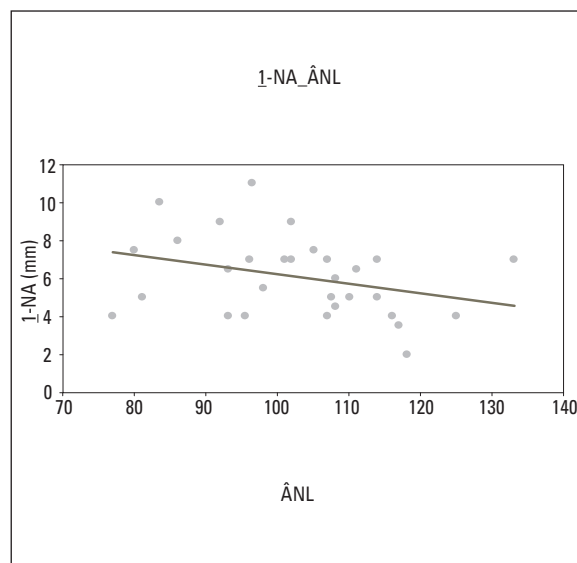
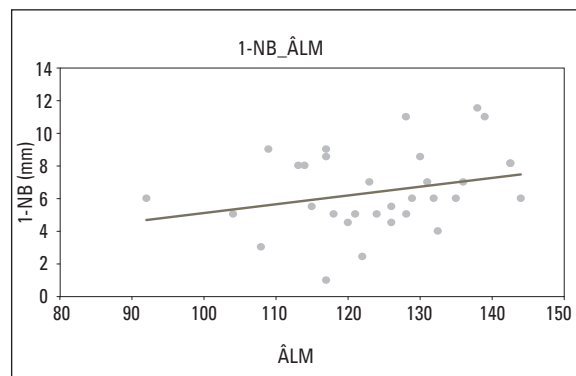
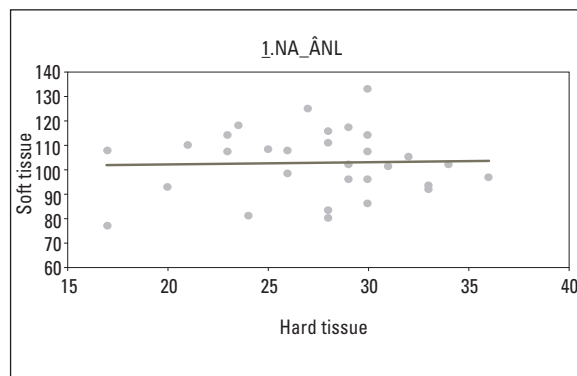
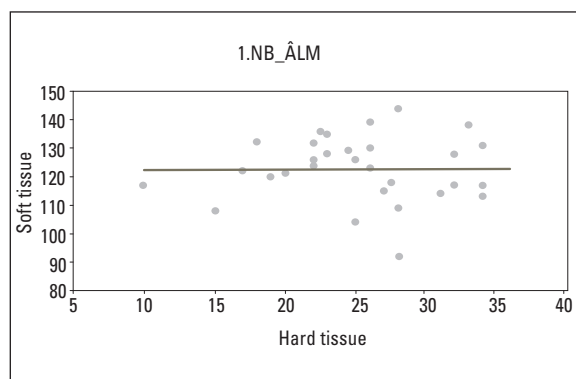
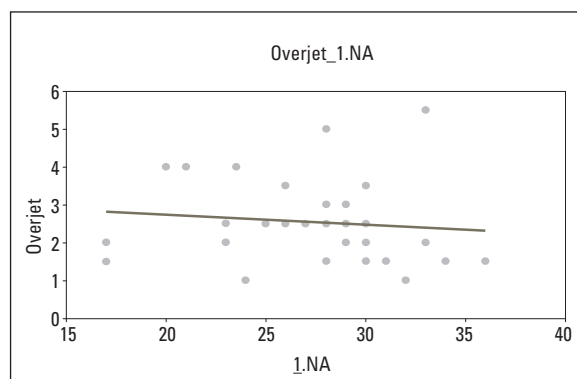
Variables	Gender	Observed means	Authors' values	t	p-value	Significance
ANB	Female	3.23	2.00	3.82	0.19%	**
	Male	1.53	2.00	-1.68	12.00%	ns
NAP	Female	4.00	0.00	4.34	0.07%	**
	Male	1.13	0.00	3.70	0.24%	**
1-NA	Female	27.35	22.00	6.22	0.00%	**
	Male					
1-NB	Female	25.15	25.00	0.14	89.0%	ns
	Male					
1-NA	Female	6.08	4.00	7.01	9.76%	ns
	Male					
1-NB	Female	6.36	4.00	2.31	11.32%	ns
	Male					
ANS-Me	Female	69.40	74.00	-3.42	0.41%	**
	Male	74.80	74.00	0.61	55.00%	ns
N-ANS	Female	54.03	53.70	0.29	78.00%	ns
	Male	58.53	53.70	4.31	0.07%	**
ANB'	Female	7.67	5.30	8.22	0.00%	**
	Male					
G'/Sn'/Pg'	Female	12.25	12.00	0.33	74.00%	ns
	Male					
ÂNL	Female	102.57	110.00	-3.02	0.53%	**
	Male					
ÂLM	Female	122.95	124.00	-0.51	62.00%	ns
	Male					
Sn'-Me	Female	72.33	72.50	-0.16	87.00%	ns
	Male	79.80	72.50	3.99	0.13%	**
N'-SN'	Female	55.57	57.80	1.78	9.60%	ns
	Male	60.13	57.80	2.90	1.20%	*
Overjet	Female	2.55	2.50	0.25	81.00%	ns
	Male					
Overbite	Female	2.53	2.50	0.18	86.00%	ns
	Male					

ns= nonsignificant; * = significant at $p \geq 1\%$; ** significant at $p < 1\%$.

TABLE 3 - Correlations and significance between soft tissue and hard tissue variables.

Variables	Correlation	p-value	Significance
ANB x ANB'	0.393	3.20%	*
NAP x G'/Sn'/Pg'	0.178	34.70%	ns
$\underline{1}.NA \times \hat{A}NL$	0.027	88.80%	ns
$1.NB \times \hat{A}LM$	0.005	97.70%	ns
ANS-Me x Sn'-Me'	0.748	0.00%	**
N-ANS x N'-SN'	0.614	0.00%	**
Overbite x $\underline{1}.NA$	0.034	86.10%	ns
Overbite x $1.NB$	-0.458	1.10%	*
Overjet x $\underline{1}.NA$	-0.110	56.30%	ns
Overjet x $1.NB$	-0.505	0.40%	**
$\underline{1}.NA \times \hat{A}NL$	-0.328	7.70%	ns
$1.NB \times \hat{A}LM$	0.239	20.40%	ns

ns= nonsignificant; * = significant at $p \geq 1\%$; ** significant at $p < 1\%$.

FIGURE 1 - Correlation between $\hat{A}NL$ and $\underline{1}.NA$ (mm).FIGURE 2 - Correlation between $\hat{A}LM$ and $1-NB$ (mm).FIGURE 3 - Correlation between $\underline{1}.NA$ and $\hat{A}NL$.FIGURE 4 - Correlation between $1.NB$ and $\hat{A}LM$.FIGURE 5 - Correlation between overjet and $\underline{1}.NA$.

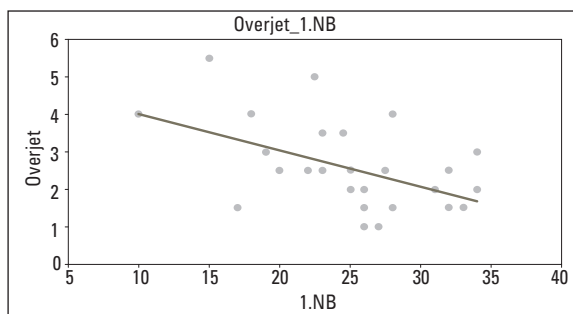


FIGURE 6 - Correlation between overjet and 1.NB.

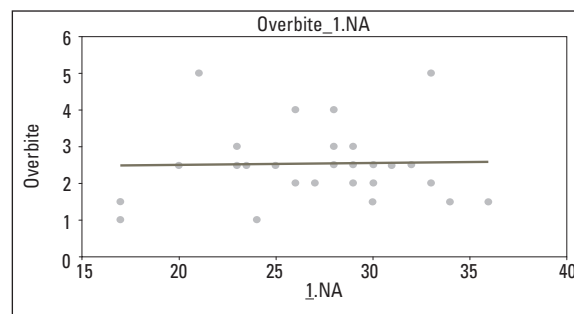


FIGURE 7 - Correlation between overbite and 1.NA.

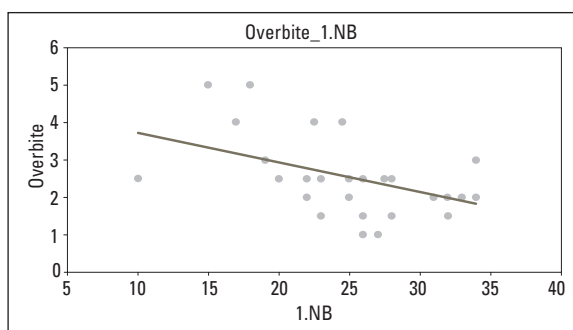


FIGURE 8 - Correlation between overbite and 1.NB.

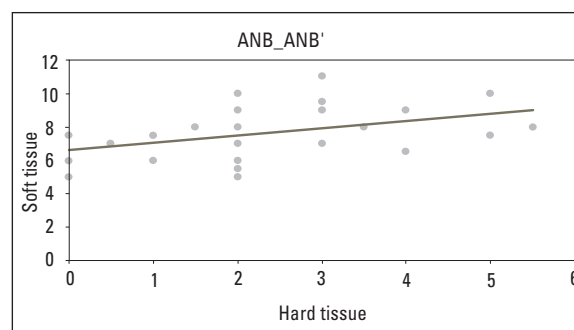


FIGURE 9 - Correlation between ANB and ANB'.

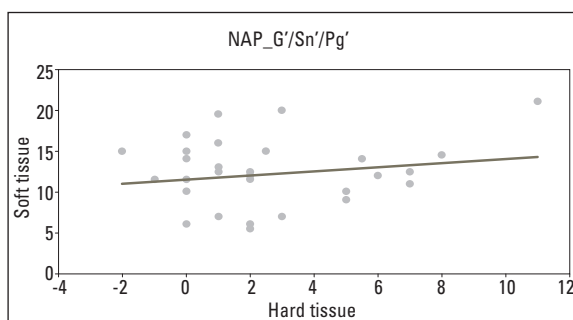


FIGURE 10 - Correlation between NAP and G'/Sn'/Pg'.

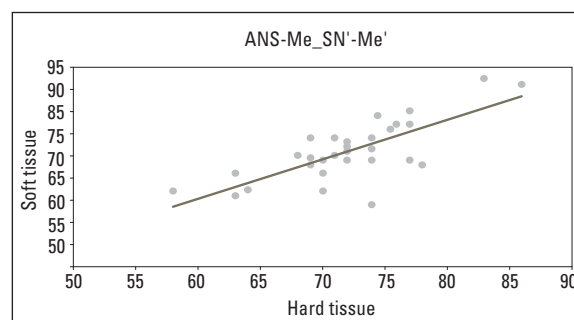


FIGURE 11 - Correlation between ANS-Me and SN'-Me'.

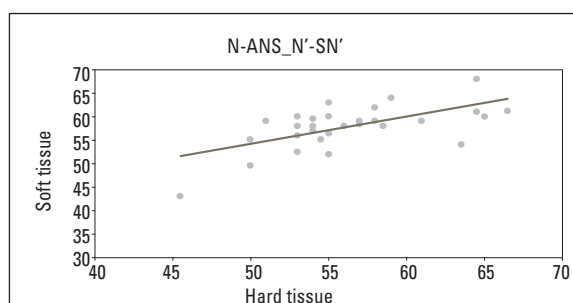


FIGURE 12 - Correlation between N-ANS and N'-SN'.

DISCUSSION

ANB

The mean and standard deviation of angle ANB were $3.23 \pm 1.25^\circ$ for females and $1.53 \pm 1.08^\circ$ for males (Table 1), with significant differences between the genders. Significant statistical differences were also found when comparing the male and female groups using the values reported in the literature (Table 2),

which was indicative of greater convexity in young Amazonian youths.^{1,7,14,19,22,30}

Sexual dimorphism was found in the female group, who exhibited a mean value of 3.23.²³

NAP

The mean and standard deviation of NAP angle were $4 \pm 3.5^\circ$ for females and $1.13 \pm 1.8^\circ$ for males (Table 2), which showed statistically significant differences, indicating sexual dimorphism with greater convexity in females. On the other hand, the mean value of 2.57° found for the whole sample showed no significant difference when compared with literature values. However, the values detected in Caucasians, i.e., 1.6° (adults) and 4.2° (children), point to lower convexity than in Amazonians, while regional studies have found 9.8° , suggesting greater convexity in this ethnic group.^{11,22,23,26}

It is known that the NAP angle varies in the different ethnic groups and this fact should be considered when diagnosing and planning treatment.²³

1.NA

The mean and standard deviation for 1.NA angle were $27.35 \pm 4.7^\circ$ (Table 2). Statistically significant differences were found in the dentofacial pattern between the axial inclination in the upper central incisors and the NA line, indicating a more anterior dental inclination in Amazonian patients when compared with the values found in the literature.²²

1.NB

A value of 25.25° (Table 2) was found in the Amazonian sample, indicating more proclined lower incisors.^{1,7,19,23,30}

1-NA

The mean and standard deviation for the maxillary central incisor distance were 6.08 ± 2.04 mm (Table 2). No statistically significant differences were found, however a tendency of greater pro-

clination was observed in Amazonians' maxillary central incisors when compared to the values reported in the literature.³⁰

1-NB

The mean found for the Amazonians was 6.36mm. This finding indicates that this group's protrusion is higher than the values reported in the literature.^{1,7,19,23}

ANS-Me

It seems reasonable to accept as desirable the mean value obtained for this measure (72.8mm) when comparing the two groups (male and female). However, in separating the groups there were no statistically significant differences in males, but there were statistical differences in the female group.²⁰

Nasolabial angle

The mean and standard deviation of the nasolabial angle were $102.57 \pm 13.5^\circ$ (Table 2), showing significant difference for this variable in comparison to mean values found in the literature.^{3,13,28}

There was no significant difference between genders for this variable (Table 1).

Labiomental angle

The mean and standard deviations found for this angle were $122.95 \pm 11.12^\circ$ (Table 2), ranging between 110° and 152° . The mean values and standard deviations observed for males and females were respectively $120.4 \pm 13.03^\circ$ and $125.5 \pm 9.21^\circ$ (Table 1) and when these values were statistically compared to the values described in the literature, no difference was found.^{27,33}

Facial convexity angle

The mean and standard deviation observed in this sample were $12.25 \pm 4.16^\circ$ (Table 2). The values of this angle for females ($12.57 \pm 3.48^\circ$) and males ($11.93 \pm 4.85^\circ$) were not statistically different (Table 1).

Based on what has hitherto been described, it can be seen that there is reasonable consistency between exams. This was predictable and supports the key objective of this investigation, which is precisely to determine how and when these measures correlate.^{7,17}

The results showed no significance for the following measures: $\perp$ -NA X $\hat{A}NL$; 1-NB X $\hat{A}LM$; $\perp$.NA X $\hat{A}NL$; 1.NB X $\hat{A}LM$; Overjet X $\perp$.NA; Overbite X $\perp$.NA; NAP X $G'/Sn'/Pg'$.

Moderate correlation was found for angles ANB X ANB' ($r=0.39$), significant at 3.20%, in a direct relationship, i.e., the greater the hard tissue ANB angle, the greater the soft tissue ANB' angle, showing that skeletal discrepancy strongly reflects facial morphology.

Moderate correlation was also found for measures Overbite X 1.NB ($r=-0.45$), significant at 1.1%, in an inverse relationship, i.e., the greater the overbite, the smaller the 1.NB angle.

High correlations were found for the following measures:

» ANS-Me X Sn'-Me' ($r=0.74$), significant at 0%, in a direct relationship, i.e., the greater the anterior lower facial height measured in the hard tissue, the greater the soft tissue measure of the anterior lower facial height.

» N-ANS X N'-SN' ($r=0.61$), significant at 0%, in a direct relationship, i.e., the greater the anterior midfacial height measured in the hard tissue, the greater the anterior midfacial height measured in the soft tissue of the radiographic image.

» Overjet X 1.NB ($r=0.5$), significant at 0.4%, in a direct relationship, i.e., the greater the overjet, the greater the 1.NB angle measured in the teeth and hard tissue respectively.

In checking the correlation between skeletal and soft tissue values for the measures described in Table 3, it was observed that skeletal and facial convexity NAP X $G'/Sn'/Pg'$ ($r=0.17$) showed no correlation, probably because the NAP angle is measured by its supplement, i.e., measured using the AP line's superior elongation, which helps to

define the degree of convexity, and/or due to the facial convexity angle reading, which is measured inferiorly, justifying the lack of correlation owing to the tendency toward mandibular retrusion that characterizes the Amazonian sample.

At first it was expected that a correlation between the values for inclination and protrusion of upper incisors and the nasolabial angle $\perp$.NA X ANL ($r=0.02$) and $\perp$ -NA X $\hat{A}NL$ ($r=-0.32$) would be found, which did not occur. This was probably caused by the fact that the composition of the $\hat{A}NL$ angle is dependent on the shape of the nose, which, in fact, means that one may on occasion find significant incisor inclination, and given the nose shape, the measurements of the nasolabial angle may vary, i.e., even in the presence of different tooth inclinations one can still find the same nasolabial angle, since the latter holds no significant correlation with the upper incisors and, by inference, must exhibit high dependence on the position and shape of the base of the nose (columella).

The linear distances from the skeletal nasion to the anterior nasal spine and from the soft tissue nasion to the subnasale (middle third), as well as from the skeletal anterior nasal spine to the menton and from the subnasale to the soft tissue menton (lower third), all measured with cephalometry, showed statistically significant correlations of 0.01% N-ANS X N'-SN' ($r=0.6$) and ANS-Me X Sn'-Me' ($r=0.74$), precisely because the two measurement methods have similar designs.

Probably the best test for orthodontic diagnosis is subjective facial analysis. However, further research is necessary, acquiring practice and experience, as well as clinical judgment to define balance, harmony, beauty; observing the correlations present in each type of malocclusion, exercising caution and patience to manage the diagnosis and appropriate treatment plan, keeping in mind that distinct facial and aesthetic features are bound to emerge depending on the region in which one lives. Therefore, orthodontics has a vast research

field, that requires further study methods in order to establish an evidence-based orthodontics.

FINAL CONSIDERATIONS

Several studies have demonstrated the clinical importance of individualizing cephalometric analyses in terms of dental and skeletal patterns of Brazilians and their influence on soft tissue profile. From a genetic standpoint, the mixing of races in Brazil accentuates the difficulty in finding cephalometric measurements capable of epitomizing a "Brazilian pattern." Faced with these efforts to standardize measures, orthodontists should treat each case by taking into account the patient's individual characteristics as well as their own clinical experience in correctly interpreting the data.

Although Brazilians born in the Amazon State, southern Brazil, São Paulo State and São Paulo City share the same nationality, it is understandable that values change from region to region since Brazil is a country with continental dimensions inhabited by a diverse ethnic, cultural and religious population, in contrast to other nations. Therefore, it affords fertile ground for investigations of this nature.

CONCLUSIONS

In determining the mean values of normality for skeletal, dental and soft tissue cephalometric measures for young Amazonians with normal occlusion and a mean age of 21 years and 5 months, it was concluded that:

1. The facial soft tissue characteristics relative to the values advocated by other authors showed statistical differences in the following cephalometric measures: Angular measures ANB', G'/Sn'/Pg', nasolabial angle, and mentolabial angle; and linear measures Sn'-Me and N'-SN', indicating a more convex profile in young Amazonians.

2. Significant results were observed in the following correlations: ANB X ANB', ANS-Me X Sn'-Me', N-ANS X N'-SN', and Overjet X I.NB. No statistically significant values were found for other correlations.

3. Sexual dimorphism was found in the following cephalometric measures: ANB, NAP, ANS-Me, N-ANS, Sn'-Me and N'-SN', characterizing greater convexity in young Amazonian females compared to males with normal occlusion.

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Evaluation of transverse changes in the dental arches according to growth pattern: a longitudinal study

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Abstract

Objective: To evaluate changes in intercanine (LICW and UICW) and intermolar (LIMW and UIMW) widths on the dental arches of subjects with normal occlusion and Angle Class I malocclusion during the transition to permanent dentition, and evaluate whether or not facial pattern influences on the normal development of the dentition and occlusion. **Methods:** Nineteen Caucasian Brazilian children were selected, with ages ranging from 6 to 8.6 years at T1 and from 10.10 to 14.2 years at T2. Their second records consisted of study dental casts and a lateral cephalometric radiograph. To obtain intermolar and intercanine widths a three-dimensional scanner unit (digitizer MicroScribe 3DX) was used connected to a microcomputer. To analyze changes at T1 and T2 Student's paired t-test was applied, whereas Spearman's correlation analysis was used to assess the relationship between measurements obtained at T1 and T2 and the facial pattern, both at 95% level of confidence. **Results:** The mean values found on each assessment time (T1 and T2) were statistically different ($p=0.000$ for LICW, $p=0.001$ for UICW, $p=0.000$ for UIMW, and $p=0.046$ for LIMW), regardless of the facial pattern. The anterior dimensions, UICW and LICW, increased by 3.21 mm and 1.52 mm, respectively. And the posterior dimensions, UIMW and LIMW, increased by 2.16 mm and 0.50 mm, respectively. Only UIMW showed a significant correlation with the facial pattern ($p<0.01$). **Conclusion:** There was an increase in dental arch width during the transition period from primary or mixed dentition to permanent dentition irrespective of facial pattern. Only the changes observed in the maxillary intermolar width were associated with the facial pattern.

Keywords: Transverse changes. Intercanine width. Intermolar width. Facial pattern.

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INTRODUCTION

Dimensional changes in dental arches are compensatory mechanisms that occur as a result of growth and are required in order to maintain a balance between the functional and structural needs of the face and dentition.^{4,18} The dimensions of the dental arches change systematically during growth and development period, even if no treatment is administered.⁸

The dimensions and morphology of the dental arches have considerable impact on orthodontic diagnosis and treatment planning, affecting space availability, dental esthetics, dentition stability and the prospects for a favorable development.^{11,15}

Changes in the dimensions of the dental arches have been studied since 1890, when Zsigmondy,²⁹ using three sets of dental casts from an individual sample of children between the ages of 6 and 17 years, measured for the first time the length of the dental arches. Clinch¹⁰ and Sillman²³ however, were the first to present the development process of the dentition since birth.

Many authors have investigated the transverse changes that occur during the development of dentition and occlusion, which consist mainly of the intercanine and the intermolar widths.^{2,3,7,14,22,25}

By studying the development of dental arches in children aged 5 to 8 or 9 years a rapid increase in intercanine width was observed (4 mm in the maxilla and 3 mm in the mandible). The cusp tips of canines were used as reference points for the measurements.²

Another assessment that has been performed in longitudinal studies is related to the occlusion type, that can be established early in life. In other words, based on the characteristics of the occlusion of deciduous teeth it is possible to predict the occlusion of permanent teeth.^{1,7,22,24} By observing the maxillary and mandibular intercanine width from birth to adulthood in a longitudinal study, the behavior of these dimension in the different stages of dentition were reported.

It was found that from birth to 13 years of age a continuous increase in the maxillary and mandibular intercanine width occurred, whereas no significant changes were detected after that age.²⁵

A study that sought to correlate the facial pattern with the dental arches' width found some relatively weak correlations in non-growing individuals.¹² Studies that subdivided the sample by gender found that, in women, the correlation was only identified in the region of maxillary second premolars, with no correlation in the mandible. In men, correlations were found in maxillary and mandibular intercanine and inter-first premolar width and maxillary inter-second premolars and first molars.¹²

In general, studies available in the literature describe the changes in the dental arches by attempting to correlate them with the type of occlusion, individual growth pattern,^{12,20} gender,¹² existence of crowding or spaces,¹² among others.

Correlation studies have only addressed growth pattern on specific occasions, both with growing and non-growing subjects. These studies are essential for planning preventive actions or treatment, for which successful outcomes depend, in part, on changes in the teeth and facial growth¹⁸. Therefore, identifying any potential relationship between growth pattern and dimensional changes in the dental arches caused by normal growth could alter prospects, orthodontic planning and treatment.

OBJECTIVE

The aim of this longitudinal study was to evaluate transverse changes in the dental arches of individuals with normal occlusion or Angle Class I malocclusion during mixed dentition and to assess whether these changes correlate with the growth pattern of the individuals.

MATERIAL AND METHODS

Sample selection

This research project was approved by the Ethics in Research Committee of the Center of

Biological and Health Sciences (CEP-CCBS) at the Catholic University of Paraná, identified by file number 111.

To obtain the initial complementary exams of the subjects, the 1998 records archived at the Graduate Dentistry Program department, Orthodontics concentration area, were utilized. Selection of the initial sample was intentional and convenient, comprising 19 Caucasian Brazilian children (7 males and 12 females) aged between 6 and 8.5 years, displaying normal occlusion or Angle Class I malocclusion.

From these individuals, dental casts and lateral cephalometric radiographs were obtained in the year 2003, when they were aged between 10 years and 10 months and 14 years and 2 months old.

Obtaining and evaluating lateral cephalograms

Lateral cephalograms were obtained in the Radiology Clinic of Dentistry, Pontifical Catholic University of Paraná, according to the technique standardized by Broadbent.⁵

All cephalometric tracings were performed twice by a single operator, three months apart. The angular measurements were taken with the aid of a protractor with 0.5 degree accuracy, with values being rounded up to the highest degree. The linear measures were determined with a digital caliper with 1/10 mm accuracy.

The measures considered for this purpose were FMA, SN.GoGn and the PFH/AFH Index. Individuals with FMA values lower than 21°, SN.GoGn lower than 30° and Index greater than 0.75 were classified as brachyfacial, whereas individuals with FMA between 21° and 29° (inclusive), SN.GoGn between 30° and 34° (inclusive) and index between 0.65 and 0.75 (inclusive) were classified as mesofacial and finally those with FMA angular values over 29°, SN.GoGn higher than 34° and Index values lower than 0.65 were classified as dolichofacial. When all measures were considered, only those

individuals who remained in the same facial pattern group from beginning to end were included in the sample. No subject was excluded due to changes in facial pattern.

Study dental casts fabrication

Study dental casts were made from alginate impressions obtained with sterile trays and wax bite registration of dental occlusion in habitual maximum intercuspation. These casts were used to obtain measurements of the upper and lower dental arches.

Measurement of digitized dimensions

For landmark demarcation, pre-determined points were used on the upper and lower study dental casts according to the method described by Moyers.¹⁹

After proper calibration of the device and operator the data gathering process was initiated using a three-dimensional scanner unit, Digitizer MicroScribe 3DX (Fig 1) (Immersion, California, USA) connected to a computer as a measuring instrument.

The points shown in Figures 2 and 3 were scanned into an Excel spreadsheet (Microsoft, Redmond, USA), where the study measurements were calculated.

All dental casts were scanned at two different times to control error. Therefore, the values used in the study were the arithmetic means between these two assessments.

» Intercanine width – The distance between the cusps of the upper canines were measured to obtain the upper intercanine width (UICW) and similarly, the distance between the cusps of the lower canines were measured to obtain the lower intercanine width (LICW) (Figs 2 and 3).

» Intermolar width – The distance between the midpoint of the mesiopalatal, distopalatal, mesiobuccal and distobuccal cusps of the maxillary first molars were calculated to determine the upper intermolar width (UIMW). In the case of



FIGURE 1 - Digitizer MicroScribe 3DX.

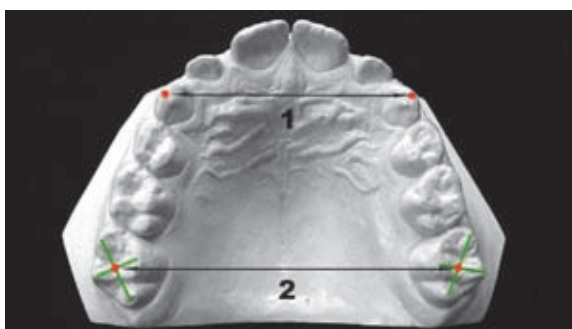


FIGURE 2 - Upper intercanine width (1), Upper intermolar width (2).

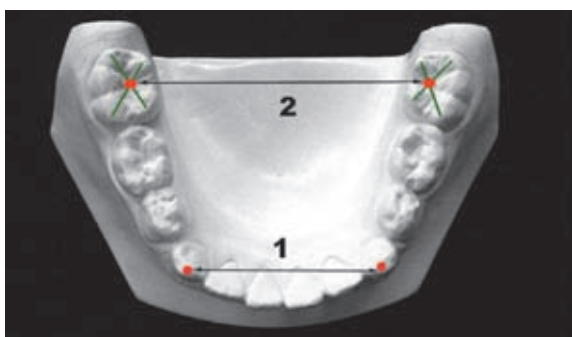


FIGURE 3 - Lower intercanine width (1), Lower intermolar width (2).

the lower intermolar width (LIMW) the distances between the midpoint of the mesiolingual, distolingual, mesiobuccal and distobuccal cusps (Figs 2 and 3) were measured.

When a tooth was missing at the time of final evaluation due to the physiological replacement of a deciduous tooth by a permanent tooth, this measure could not be determined and therefore the data were excluded from the sample. Due to this fact, in those cases the sample consisted of only 18 individuals instead of 19.

METHOD ERROR

Reproducibility of all data was confirmed by Dahlberg's Formula. The paired t-test (Table 1) was applied to test for systematic error. The test confirms that the measurements obtained were not statistically different at a significance level of 5% for $n-1$ degrees of freedom, since the t values were lower than 2.03, confirming that the data are reliable.

STATISTICAL ANALYSIS

All dimensions presented a normal distribution when analyzed by the Kolmogorov-Smirnov test at 5% alpha level. Therefore, a paired Student's t-test was applied to check for differences between T1 and T2 for all arch widths examined, initially disregarding the facial pattern.

TABLE 1 - Paired t-test to evaluate systematic error.

Variable	n	Difference between means	s ²	t
UICW	36	0.1288	0.15177	1.9850
LICW	38	0.1289	0.20444	1.7580
UIMW	36	-0.0563	0.11815	0.9842
LIMW	36	-0.0719	0.12124	1.2396

Note: t values according to $n-1$ degrees of freedom, lower than 2.0301 for $n = 36$ and lower than 2.0262 for $n = 38$, indicating that there is no difference at a significance level of 5%.

The descriptive analysis of the variables was performed according to facial pattern, regardless of the assessed moment. The Spearman correlation test with a confidence level of 95% was used to verify whether there was any correlation between the facial pattern and variations in the transverse dimensions of the dental arches.

RESULTS

The descriptive statistics of the variables revealed higher mean values at T2 than those found at T1. Thus, after an interval of five years all the variables analyzed showed some increase, and this difference was statistically significant at a level of $p \leq 0.05$ for all variables studied (UICW, LICW, UIMW and LIMW) (Table 2).

The variable that showed the greatest variation was upper intercanine width, and the lowest variation was found between the lower molars (Fig 4). Descriptive statistics (Fig 5) and Spearman correlation test (Table 3) revealed that UIMW was the only variable that correlated with the facial pattern.

DISCUSSION

The longitudinal observation of how the set of features characterizing the dental arches evolves and interrelates is a reliable method to explain its normal development. The advantages are: the fact that variability between individuals is put into proper perspective; serial comparisons are enabled; temporary problems are suppressed over time; and any extraordinary events or errors in the measurements are more easily detected and corrected.

Despite substantial advantages, longitudinal studies are not so common due to certain hurdles that hinder or discourage researchers.²¹ Among the disadvantages are the longer time that is required to complete the studies, higher cost and reduced sample size over time.^{19,21} However, these limiting factors do not outweigh the excellent results obtained by the longitudinal studies.

In order to deal with some of the shortcomings of this longitudinal study, it is important above all to analyze results with caution.

TABLE 2 - Descriptive statistics of variables analyzed and Student's t-test for mean differences between the two observation times (T1 and T2).

Variable	Statistics	Time		Difference	t	p
		initial	final			
Upper Intercanine Width (UICW)	mean	30.94	34.15	3.283	-7.025	0.000
	standard deviation	1.90	2.49	—		
	minimum	28.70	29.69	—		
	maximum	34.82	38.35	—		
Lower Intercanine Width (LICW)	mean	25.38	26.90	3.238	-3.967	0.001
	standard deviation	2.17	1.61	—		
	minimum	21.15	23.71	—		
	maximum	28.13	29.28	—		
Upper Intermolar Width (UIMW)	mean	46.15	48.31	1.893	-6.149	0.000
	standard deviation	2.78	2.47	—		
	minimum	41.64	44.84	—		
	maximum	50.48	52.04	—		
Lower Intermolar Width (LIMW)	mean	42.53	43.03	0.527	-2.154	0.046
	standard deviation	2.23	2.79	—		
	minimum	39.95	38.23	—		
	maximum	45.83	46.53	—		

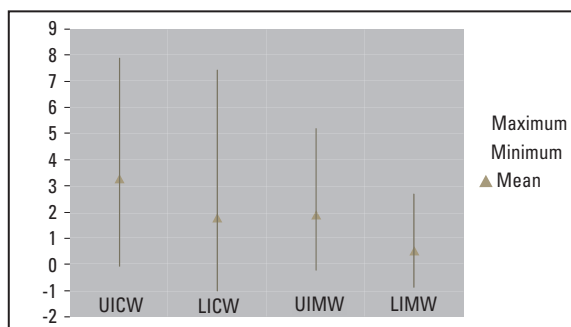


FIGURE 4 - Variation of the dimensions evaluated between T1 and T2 showing maximum and minimum variations found.

TABLE 3 - Spearman correlation test.

Variable	Spearman Coefficient (R)	t	p
UICW	0.05	0.19	0.850
LICW	0.31	13.23	0.203
UIMW	0.61	30.48	0.008*
LIMW	0.29	12.06	0.245

*p<0.001.

The number of subjects (n) diminished considerably in some groups, making the sample of brachyfacial patients become greatly reduced. Therefore interpretation of the results according to the facial pattern should be carefully used.

Inter canine width

Final values of upper and lower intercanine widths in relation to initial values showed statistically significant increases of 3.21 mm and 1.52 mm ($p=0.000$ and $p=0.001$), respectively, for the upper and lower arches. Several other studies that examined samples in a similar age range yielded results that are close to those observed in the present study.^{14,25} However, Sinclair and Little²⁶ found a decrease of 0.75 mm when analyzing orthodontically untreated individuals aged from 7 to 17 years. This decrease can be explained by the age range differences between the samples, since, after the complete eruption of permanent teeth, a decrease in intercanine width occurs.^{2,25}

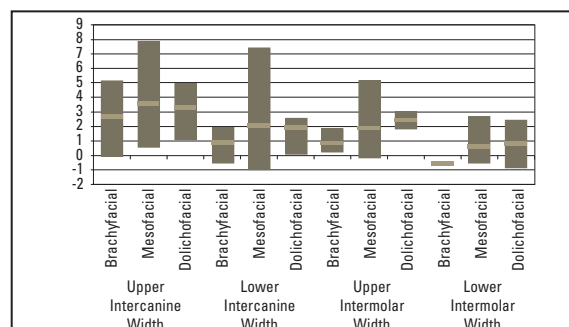


FIGURE 5 - Descriptive statistics of the changes observed between T1 and T2 for each facial pattern, showing means, maximum and minimum limits.

The clinical applicability of this outcome, considering the gradual increase in intercanine distances during the transition from deciduous to permanent dentition, can prove very helpful, confirming some treatment approaches which suggest the correction of crowding at a later stage.²⁷

Intermolar width

The values found for upper and lower intermolar width in this study revealed a statistically significant increase from T1 to T2 ($p=0.000$ for UIMW and $p=0.046$ for LIMW). Regarding the upper intermolar width the increase reached 2.16 mm and as to the mandibular intermolar width it increased 0.50 mm. These values are similar to those observed in the literature.^{2,16,25} However, Moorrees¹⁷ and Brown⁶ found stable intermolar widths in longitudinal studies involving subjects without prior orthodontic treatment.

Relationship with the facial pattern

In the present study, the analysis of variations in the intercanine and intermolar widths showed that only the upper intermolar width correlated significantly with the growth pattern ($p=0.008$) as the value of the correlation coefficient (R) was greater than 0.6. The value of R^2 (0.3721) shows that just over 37% of LIMW variations are explained by the facial pattern, while almost 63% of the changes are determined by other variables which were not the focus of this study.

In another study, which also did not take into account the gender and ethnicity of the evaluated patients, but only the relationship with the facial pattern, the lower intermolar widths were greater in individuals with a more horizontal pattern when compared to vertical ones.²⁰

However, despite some studies concluding that there was no relationship between the transverse dimensions of the arches and the facial pattern^{9,12,20} there are others showing that it depends on the individual's gender, i.e., other determinant variables were identified.¹²

The literature shows that brachyfacial men tend to have larger maxillary and mandibular widths than mesofacial men.⁹ However, no significant differences were found when comparing the arch widths in brachyfacial versus mesofacial⁹ women.

In any case, studies that found relationships between facial pattern and transverse dimensions show increases in these dimension as the facial pattern becomes more horizontal. The findings were attributed to the muscle pattern of these patients.^{13,28}

In the present study, although the Spearman's correlation test pointed to a relationship between facial pattern and variations in the transverse dimensions of the dental arches in only one of the variables studied (UIMW), decrease of the

sample according to facial pattern may have generated a false negative.

However, it would be adequate to pursue longitudinal studies with a representative sample size of individuals during growth period, in a way that the subdivision into different facial patterns, as well as gender and race, could be made without drastically reducing the sample size. This type of study would also allow professionals — above and beyond the mere identification of correlations between facial patterns and dental arch dimensions — to verify whether variations between dolichofacial, mesofacial and brachyfacial individuals become increasingly apparent as the individual grows or if such variations are already present at an early age.

CONCLUSIONS

Given the nature of this longitudinal study, the sample studied and the results achieved, the following conclusions could be drawn:

- There were increases in maxillary and mandibular intercanine widths.
- There were increases in maxillary and mandibular intermolar widths.
- A correlation was found between maxillary intermolar widths and facial pattern.

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Cephalometric deviations present in children and adolescents with temporomandibular joint disorders

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Abstract

Introduction: Temporomandibular disorders (TMD) have proved to be a risk factor for developing hyperdivergent facial growth patterns. **Objective:** The aims of this study were: (1) Assess differences between the cephalometric measurements in children with articular TMD and a control group, before and after mandibular growth peak according to cervical vertebral maturation; and (2) Identify a predictive model capable of differentiating patients with TMD and control group patients based on early cephalometric characteristics. **Method:** The study included children and adolescents with maximum age of 17 years, divided into experimental group (n=30) diagnosed with articular TMD—according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) for children and adolescents—subdivided according to growth stage, called pre-peak (n=17) and post-peak (n=13) and control group (n = 30), matched by gender, skeletal maturity stage of the cervical vertebrae and classification of malocclusion. Lateral cephalometric and craniofacial structures were traced and their relations divided into: Cranial base, maxilla, mandible, intermaxillary relations, vertical skeletal relations and dental relations. Differences between the means for each variable were evaluated by applying the statistical Student t test for independent samples. **Results:** The means of the variables analyzed in the pre-peak showed no statistically significant differences. However, analysis of post-peak showed that the experimental group displayed decreased SNA and SNB and increased SN.Gn and I.NB ($p<0.05$). **Conclusion:** It was possible to identify a predictive model able to differentiate patients with TMD and asymptomatic controls from early cephalometric characteristics.

Keywords: Facial growth. TMD. Malocclusion.

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INTRODUCTION

Although the treatment need for temporomandibular disorders (TMD) is directly related to pain and functional disability produced by these conditions, the presence of clinical signs and symptoms arising from changes in morphology and/or function of the temporomandibular joint (TMJ), such as joints sounds, are much more frequent.

Currently, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),¹⁰ represents the most studied diagnostic tool regarding validity and accuracy of TMD's diagnostic classification based on specific diagnostic criteria. This system, through its physical axis, allows the possibility of multiple diagnoses for one individual, being the joint disorders divided into two broad categories not mutually exclusive: The disc displacements, with or without reduction; and arthralgia, osteoarthritis and osteoarthrosis of the temporomandibular joint.¹⁰

The RDC/TMD was not originally designed for use in children and adolescents, but was modified and validated for this purpose by Wahlund et al³³ and was later applied to this population group by several researchers.

Among the articular TMD, disc displacement with reduction may be clinically recognized by the occurrence of a clicking sound during opening and closing mouth movements, eliminated when the mouth is open sustaining maximum protrusion. In the diagnosis of articular disc displacement without reduction although there may be a history of joint clicks, the same must be absent at the time of diagnosis, associated with limitations and/or uncorrected deviation of mandibular movement.¹⁰

Degenerative changes of the TMJ are characterized by the presence of clinical signs of continuous joint sounds in the form of crepitus. According to RDC/TMD, crepitation can be accompanied by arthralgia, known as osteoarthritis or, in the absence of pain, osteoarthrosis.¹⁰

The temporomandibular joint arthralgia is characterized by pre-auricular spontaneous pain or pain induced by palpation and/or function.¹⁰

Population studies about the prevalence of articular disorders' signs described above, in children and adolescents, showed that 8% to 29% of the assessed population showed clicking sounds in the TMJ, while only 1% displayed crepitus.¹¹

Several factors distinguish the stomatognathic system of adults, children and adolescents, for example, the components of the masticatory system, which undergo different growth and development patterns.³² During this development process, the craniofacial structures can be influenced by several factors such as congenital abnormalities,¹⁵ uncontrolled hormonal levels,¹³ arthritis,¹⁷ condylar hypoplasia,⁴ deleterious breathing habits,³⁴ trauma,³ infections,¹⁹ and orthopedic forces.²⁴ Such factors can alter the tissue adaptive capacity during growth and thus alter facial morphology.^{25,26}

The studies that correlate articular TMD and facial growth patterns were conducted in adult patients,^{1,2,6,16} as well as in children and adolescents.^{24,25,26,31}

Thus, the involvement of TMJ by degenerative changes or disc displacements proved to be an important risk factor for identification of individuals with hyperdivergent facial growth patterns. However, the pathophysiological processes responsible for this relationship are not yet fully established.

Ahn et al² evaluated the presence or absence of anterior disc displacement diagnosis in 134 women, using magnetic resonance image (MRI). The means of 36 cephalometric variables were compared and the discriminant analysis model was conducted to determine which are the most important factors for identifying patients with anterior disc displacement.

The posterior position of the mandible, mandibular clockwise rotation, the increase of labial inclination of lower incisors and the increase of

overjet intensified gradually with the progression of internal derangement of TMJ, and subjects with bilateral joint disorders showed the largest dentofacial morphological changes. Discriminant analysis was able to correctly classify 79% of subjects and demonstrated that those with the smallest angle between the long axis of the lower central incisor and the Frankfort plan and greater overjet had an increased risk to develop articular TMD.

The lack of knowledge regarding when the patient was affected by these disorders, which are more prevalent in ages subsequent to completion of facial growth, becomes a potential bias in establishing the real power of this association, which can be further important if early identified.

It seems therefore, important to identify, during the different stages of skeletal maturity that makes up the facial growth, signs of articular TMD, evaluating the real impact of these disorders on the facial growth pattern. It is expected therefore to show that the awaited changes in cephalometric measurements occur mainly in the later stages of facial development after the mandibular growth peak (stages III and IV of cervical vertebral maturation).

The aims of this study were: (1) To evaluate differences between the cephalometric variables selected for identification of facial growth pattern in children and adolescents with articular TMD and control group free of that disorder before and after the mandibular growth peak, according to cervical vertebral maturation (CVM) and (2) Identify a predictive model able to differentiate patients with TMJ disorders and asymptomatic controls based on early skeletal cephalometric characteristics.

MATERIAL AND METHODS

This study followed an observational and cross-sectional protocol, performed at the Preventive Orthodontics Clinic of the Petrópolis Medical School (Rio de Janeiro State, Brazil), including

patients aged up to 17 years old of both genders. It was approved by the Scientific and Research Ethics Committee of the mentioned school.

Before performing any procedure all patients received detailed information about the research and signed a consent form.

The experimental group comprised 30 patients diagnosed with articular TMD, subdivided into two groups according to the corresponding growth period, named pre-peak of growth spurt ($n=17$) and post-peak of growth spurt ($n=13$). The inclusion criteria were: (1) Articular TMD Group II or III, according to Axis I of RDC/TMD for children and adolescents—the Portuguese version; (2) Good quality lateral radiographs obtained prior to orthodontic treatment, carried out in the same cephalostat (Cerdo Radiology Clinic, Petrópolis, RJ).

The following exclusion criteria were used: (1) Diagnosis of juvenile rheumatoid arthritis or other systemic joint diseases; (2) Orthodontic treatment prior to examination.

The control group consisted of 30 volunteers without TMD, matched by gender, cervical vertebral maturation index and Angle's classification of malocclusion. Inclusion criteria were the same adopted for the study group except for the need of articular TMD diagnosis, Groups II and III, according to Axis I of RDC/TMD for children and adolescents, Portuguese version, which becomes an exclusion criteria in addition to the others previously related to the study group.

The clinical examination conducted, part of the Axis I diagnosis protocol of RDC/TMD for children and adolescents, Portuguese version,²⁷ has been applied and validated in adolescents in previous studies,³³ comprising 10 question.

The lateral cephalometric radiographs were traced and the cephalometric points determined. The landmarks were digitized on an X-Y coordinate system through software Radiocéf (Radio Memory, Belo Horizonte, MG, Brazil). Craniofacial structures and their relations

were divided into the following categories for analysis: Cranial base, maxilla, mandible, intermaxillary relations, vertical skeletal and dental relations (Table 1, Figs 1, 2, 3 and 4).

The angular and linear measurements were taken from the analysis previously described by Downs,⁹ Jarabak¹⁴ and McNamara.²¹

The measures found were tabulated. Means and standard deviations for each variable in the patient sample were calculated using the statistical software SPSS (SPSS Inc, Chicago, USA).

The differences between the means for each of the variables selected for the group of patients with articular TMD and the control group were evaluated by applying Student t test for independent samples and the discriminant analysis with stepwise entry for patients in post-peak of pubertal growth spurt. The differences

that had less than a 5% chance of having occurred by chance ($p < 0.05$) were considered statistically significant.

To test the magnitude of the measurement error for the cephalometric variables in this study, the lateral radiographs of 15 patients and volunteers were randomly chosen and measured again. By applying Dahlberg's⁸ formula, the error found was between 0.31 and 0.79 mm for linear measurements and 0.30 and 0.98° for angular measurements.

RESULTS

Patients in the experimental group—articular TMD ($n=30$)—had a mean age of 9 years old (range 5-17 years old), being 12 individuals (40%) males and 18 (60%) females. Of these, 7 were in stage I of cervical vertebral maturation (23%), 10 in stage II (33%), 12 in stage III (40%) and 1 in stage IV (4%).

In the control group—no articular TMD ($n=30$)—the average age was 10 years old (range 5-14 years old), and presented the same distribution for gender and cervical vertebral maturation index found in the experimental group due to the pairing of the samples.

When the total experimental and total control groups were subdivided according to the stage of skeletal maturity, assessed by the cervical vertebral maturation index, into the subgroups pre-peak of pubertal growth spurt and post-peak of pubertal growth spurt, the means of the analyzed variables in the pre-peak of pubertal growth spurt period showed no statistically significant differences (Table 2).

However, the analysis of post-peak of pubertal growth spurt showed that the experimental group had mean values for SNA and SNB angles decreased, and the facial axis angle (SN.Gn) and lower incisor inclination (1.NB) increased in relation to the mean values found in the control group, revealing statistically significant differences (Table 3).

Cranial base	Maxilla	Mandible	Intermaxillary relationship
S-N (mm)	S.N.A (degrees)	S.N.B (degrees)	A.N.B (degrees)
S-Ar (mm)	Co.A (mm)	Co-Gn (mm)	N.A.P (degrees)
S.N.Ar (degrees)	NperpA (mm)	NperpPog (mm)	
	Go-Me (mm)		
Vertical Skeletal relationship		Dental relationships	
Ans-Me (mm)		1.NA (degrees)	
S-Go (mm)		1-NA (mm)	
N-Me (mm)		1.NB (degrees)	
Ar-Go (mm)		1-NB (mm)	
S.Ar.Go (degrees)		1.1 (degrees)	
Ar.Go.Me (degrees)			
SN.Go.Gn (degrees)			
SN.Gn (degrees)			
SN.PO (degrees)			
Ar.Go.Na (degrees)			
Na.Go.Me (degrees)			
Sum (degrees)			

TABLE 1 - Linear and angular cephalometric measurements.

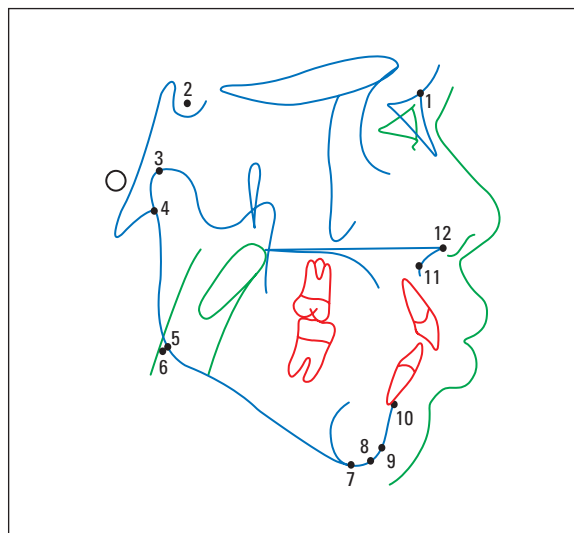


FIGURE 1 - Points used in this study: 1= N; 2= S; 3= Co; 4= Ar; 5= anatomic Go; 6= cephalometric Go; 7= Me; 8= Gn; 9= Pog; 10= B; 11= A; 12= Ans.

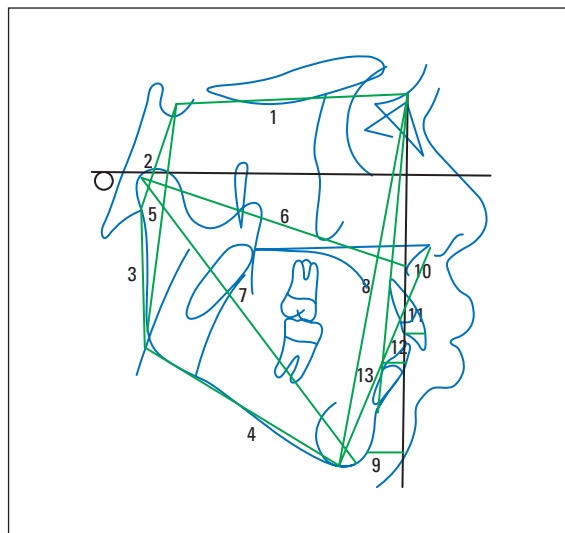


FIGURE 2 - Lines used in this study: 1= S-N; 2= S-Ar; 3= Ar-Go; 4= Go-Me; 5= S-Go; 6= Co-A; 7= Co-Gn; 8= N-Me; 9= NPog-P; 10= NA-P; 11= 1-NA; 12= 1-NB; 13= Ans-Me.

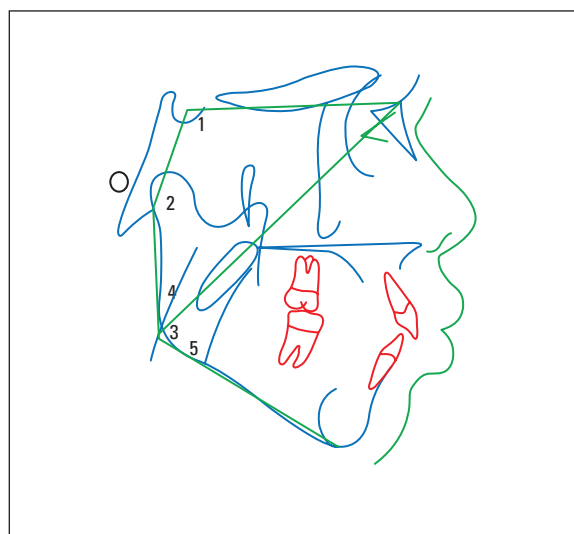


FIGURE 3 - Angles used in this study: 1= S.N.Ar; 2= S.Ar.Go; 3= Ar.Go.Me; 4= Ar.Go.Na; 5= Na.Go.Me.

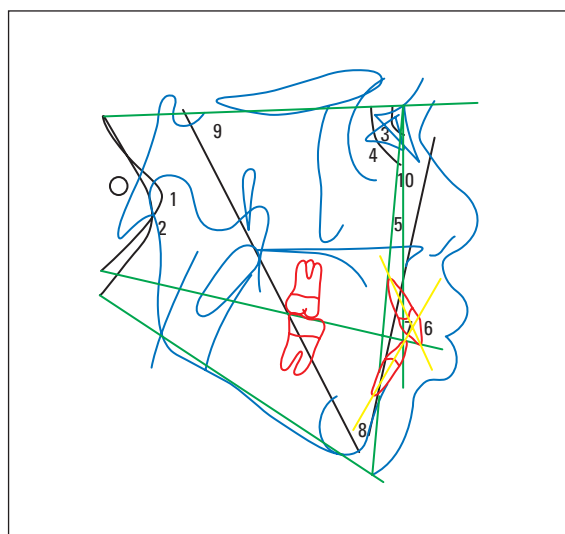


FIGURE 4 - Angles used in this study (continuation): 1= SN.PO; 2= SN.GoGn; 3= S.N.A; 4= S.N.B; 5= A.N.B; 6= I.1; 7= 1.NA; 8= 1.NB; 9= SN.Gn; 10= N.A.Pog.

The discriminant analysis, with stepwise variable input, was applied only to variables whose differences between experimental and control groups had previously shown to be statistically significant. When performed in patients in the post-peak of pubertal growth spurt, as demonstrated by the cervical vertebral maturation index, it were selected

two variables: SNA and lower incisor inclination. The discriminant function nonstandard coefficients led to the following equation, which gives each new subject an individual score to classify them as a patient with articular TMD or control.

$$\text{Individual score} = 0.829 \times (\text{S.N.A}) - 0.645 \times (\text{I.NB})$$

TABLE 2 - Distribution of means and standard deviations for cephalometric variables in patients with pre-peak vertebral maturity.

Cephalometric variables	Experimental Group (mean± DP)	Control Group (mean± DP)	p
Cranial base			
S-N (mm)	67.35±3.53	66.44±5.04	0.546
S-Ar (mm)	32.37±3.04	30.56±4.44	0.176
S.N.Ar (degrees)	123.45±5.23	124.58±6.35	0.575
Maxilla			
S.N.A (degrees)	82.05±3.03	81.39±4.34	0.611
Co.A (mm)	84.17±6.25	83.91±8.35	0.921
NperpA (mm)	1.19±3.70	1.03±3.69	0.898
Mandible			
S.N.B (degrees)	4.30±1.91	3.98±4.63	0.799
Co-Gn (mm)	108.35±7.95	109.76±7.61	0.600
NperpPog (mm)	-5.52±6.38	-2.44±4.67	0.117
Go-Me (mm)	66.87±5.34	69.21±5.68	0.224
Intermaxillary relationship			
A.N.B (degrees)	4.30±1.91	3.98±4.63	0.799
N.A.P	8.57±4.53	6.71±7.21	0.375
Vertical skeletal relationship			
Ans-Me (mm)	64.31±63.79	63.79±4.65	0.788
S-Go (mm)	68.25±6.10	67.23±5.68	0.619
N-Me (mm)	110.40±7.96	110.24±7.69	0.952
Ar-Go (mm)	39.22±3.86	39.46±3.50	0.853
S.Ar.Go (degrees)	144.92±6.86	145.38±5.93	0.836
Ar.Go.Me (degrees)	129.66±6.75	126.15±5.37	0.104
SN.GoGn (degrees)	35.52±4.82	36.08±5.27	0.748
SN.Gn (degrees)	67.97±3.69	68.29±3.19	0.791
SN.Po (degrees)	18.17±4.59	18.15±4.19	0.990
Ar.Go.N (degrees)	53.77±5.43	52.27±2.76	0.316
N.Go.Me (degrees)	75.87±4.47	73.94±4.33	0.211
Sum	398.12±4.50	396.12±3.73	0.167
Dental relationships			
1.NA (degrees)	24.48±6.04	22.45±8.65	0.434
1-NA (mm)	4.38±1.77	4.62±2.30	0.737
1.NB (degrees)	31.25±7.24	26.56±8.54	0.094
1-NB (mm)	6.24±2.14	6.77±5.34	0.710
1.1 (degrees)	122.57±11.30	128.07±15.26	0.241

TABLE 3 - Distribution of means and standard deviations for cephalometric variables in patients with post-peak vertebral maturity.

Cephalometric variables	Experimental Group (mean± DP)	Control Group (mean± DP)	p
Cranial base			
S-N (mm)	70.85±3.47	67.81±5.23	0.094
S-Ar (mm)	33.93±3.20	33.58±3.74	0.801
S.N.Ar (degrees)	125.26±6.25	125.53±6.31	0.914
Maxilla			
S.N.A (degrees)	78.25±3.55	82.90±4.53	0.008
Co.A (mm)	86.19±5.73	87.93±3.69	0.368
NperpA (mm)	-0.13±4.04	2.79±3.63	0.065
Mandible			
S.N.B (degrees)	74.69±3.63	79.26±4.75	0.011
Co-Gn (mm)	114.51±7.80	115.94±3.46	0.552
NperpPog (mm)	-7.08±8.77	-2.52±7.95	0.178
Go-Me (mm)	73.03±5.84	72.97±3.35	0.974
Intermaxillary relationship			
A.N.B (degrees)	3.55±2.98	3.71±2.89	0.891
N.A.P	6.45±6.57	6.92±6.03	0.852
Vertical skeletal relationship			
Ans-Me (mm)	68.88±6.83	67.93±4.46	0.678
S-Go (mm)	73.42±6.42	72.99±4.36	0.842
N-Me (mm)	121.26±9.21	115.37±7.58	0.088
Ar-Go (mm)	42.18±3.53	43.12±3.99	0.532
S.Ar.Go (degrees)	146.10±7.19	141.92±7.34	0.155
Ar.Go.Me (degrees)	125.76±5.59	128.02±4.42	0.265
SN.GoGn (degrees)	38.59±7.15	34.35±4.87	0.090
SN.Gn (degrees)	72.08±5.13	67.85±4.12	0.029
SN.Po (degrees)	18.85±6.32	15.19±4.47	0.101
Ar.Go.N (degrees)	50.06±4.24	53.39±4.87	0.075
N.Go.Me (degrees)	75.82±6.25	74.66±4.31	0.588
Sum	397.18±7.90	395.45±4.41	0.499
Dental relationships			
1.NA (degrees)	27.38±5.05	23.90±7.83	0.190
1-NA (mm)	6.67±3.59	5.44±3.00	0.355
1.NB (degrees)	30.50±4.07	26.41±5.52	0.042
1-NB (mm)	6.41±4.85	5.64±2.02	0.603
1.1 (degrees)	119.26±6.34	124.86±10.29	0.108

The score found for the experimental group was 45.20 and for the control group was 51.96. The critical score, calculated as the average of the scores found for the experimental group and control group was 48.58. Thus the percentage of subjects correctly classified was 80.76%, leading to misclassification of 2 subjects in the experimental group (15.39%) and 3 control subjects (23.08%).

DISCUSSION

The condyle plays an active role in mandibular growth, which varies according to its cartilage primary potential. Children and adolescents have high adaptive capacity, so that the components of their TMJ and dentoalveolar regions undergo shape and size changes during growth.¹² Such changes tend to be more relevant during the pubertal growth spurt, which corresponds to the period of greatest relative mandibular growth.

The displacement of the articular disc has the ability to change the joint function, possibly exceeding the adaptive capacity of the growing tissues.³² During mandibular growth, when proliferation of the condylar cartilage provides the joint fibrocartilaginous tissue, the articular disc displacement can result in rupturing of the cell proliferation layer. This disruption can reduce the formation of extracellular collagen and proteoglycan matrix, which contribute to the process of condylar growth.²⁰

Experiments with animals, in which anterior displacements of the articular disc were surgically obtained in rabbits, and the posterior ligament kept intact over the condyle, demonstrated that the jaw of these animals became significantly shorter on the same side of the disc displaced, which resulted in a midline shift to the affected side. The mandibular asymmetry was not observed in the control group, with no displacement of the articular disc.¹⁸

These results suggest that the articular disc

displacement precede the development of asymmetry of the jaw and can therefore be considered as risk factors for these conditions. However, if this sequence of events is relevant to human mandibular growth and development, it has not been determined yet, although it has been previously suggested.^{25,26}

Mandibular asymmetries were also observed by Kambylafkas et al¹⁶ in patients with unilateral osteoarthritis who had mandibular deviation to the affected side. The cephalometric measurements of patients revealed decreased condylar height and increased antegonial depth on the same side of the diagnosis of degenerative articular changes.

In this study, when the total experimental group and control group were subdivided according to the time of skeletal maturity, as assessed by cervical vertebral maturation index, into subgroups pre-peak and post-peak of pubertal growth spurt, the mean variables analyzed in the pre-peak of pubertal growth spurt showed no statistically significant differences.

However, the analysis of post-peak of pubertal growth spurt showed that the experimental group had greater maxillary and mandibular retrusion, increased facial convexity and labial inclination of upper incisors when compared to the control group. These results suggest that the compensatory skeletal and dentoalveolar changes resulting from TMJ disorders manifest themselves preferentially after the mandibular growth peak, a fact that has not been previously demonstrated.

Recently, several studies published, used magnetic resonance images (MRI) for the diagnosis of positional changes of the articular disc and degenerative diseases of the TMJ trying to correlate those diagnoses with changes on the craniofacial measurements of growing patients.^{24,25,26,31} The results showed, almost unanimously, the establishment of a vertical facial pattern and retrognathia with dentoalveolar compensation consistent with this pattern.

However, the relatively high cost of MRI precludes its routine clinical indications for confirmation of the diagnosis of articular TMD, which can be detected clinically with acceptable levels of validity and accuracy.²²

The compensatory proclination of lower incisors is probably related to increased overjet, arising from the posterior positioning of the mandible and its clockwise rotation. This rotation is associated with decreased height of the mandibular ramus found in patients with TMD in different studies.^{1,25,26}

A relative maxillary retrusion, evaluated through the SNA angle, was observed in patients of the experimental group in the post-peak of pubertal growth stage when compared with the control group. Although it has been previously described in studies evaluating cephalometric characteristics of patients with TMD,^{2,6} it has not been discussed satisfactorily, probably due to the absence of obvious relationship between intra-articular changes and maxillary growth. However, the SNA measure uses as reference point A, a dentoalveolar landmark and therefore capable of suffering the influence of possible dentoalveolar compensation on the superior arch due to mandibular changes.

Most published studies relating cephalometric variables and TMD suggest that the lateral cephalometric radiograph could be used to identify patients potentially suffering from internal disorders and/or degenerative changes of the TMJ.^{1,2,6} Recently, certain variables selected from panoramic radiographs also demonstrated to be associated with the diagnosis of TMD,⁷ opening the field for further research in this area.

However, in a study published by Bósio et al,⁵ 56% of symptomatic women with bilateral disc displacement and Angle Class I malocclusion, displayed a mean value for the SNB angle (75.6°) significantly lower than the pattern observed in normal individuals. However, when women with similar articular diagnoses, but presenting Class II malocclusions were divided into Division 1 and

Division 2 sub-groups, no statistically significant difference was found for the angle SNB when compared to normal individuals.

Thus, according to the authors, it would only be possible to diagnose—with acceptable degree of validity—the articular disc displacement based on lateral cephalometric radiographs when the patient develops typical signs or symptoms from TMD, Angle Class I malocclusion and SNB below the average calculated in the above described study (75.6°). This would make the prediction possible, but not very practical and definitely not diagnostic.

Therefore, the identification of certain cephalometric characteristics in specific patient groups can be considered an indicating factor for the necessity of diagnostic tools aimed at early identification of articular changes in children and adolescents, many times neglected.

The discriminant analysis was used previously to establish a predictive formula capable of classifying patients with TMD, with greater reliability.² The two variables selected by the stepwise process were: the inclination of lower incisors in relation to the Frankfurt horizontal plane and the amount of overjet. Thus, patients with internal derangement of the TMJ showed a lower incisor angle and greater overjet than in control subjects with normal joints. The discriminant analysis showed a higher validity in predicting patients with TMD (93.3%) than in the prediction of controls with normal joints (65.9%).

In this study, discriminant analysis was used to classify individuals as patients with TMJ disorders or healthy controls. The stepwise selection of significant variables pointed out two variables, the SNA angle and lower incisor inclination. Patients with TMD showed maxillary retrusion and labial inclination of lower incisors. In this study 80.76% of individuals were correctly classified, but 2 individuals in the experimental group (15.39%) and 3 individuals in the control group (23.08%) were misclassified.

The results of this study demonstrate a relationship between TMJ disorders in children and adolescents and the presence of a hyperdivergent pattern of facial growth. Even though the direction of this relationship can be assumed, it could not be determined due to the cross-sectional nature of this study, where the supposed risk factors and outcomes were assessed at the same time point. Therefore, the hypothesis of these disorders influencing on facial growth pattern must be confirmed by a longitudinal follow up to adulthood, from a growing cohort of patients, with and without TMJ disorders.

Future studies in this direction should also, ideally, consider the different sub-groups of patients with articular disc displacement, according to the RDC/TMD,¹⁰ in the cephalometric evaluation of structural characteristics since, according to Bósio et al,⁵ the position of the articular disc can influence the condylar posi-

tion and thus the jaw position and their cephalometric measurements.

Ren, Isberg and Westesson²⁹ demonstrated that joints with disc displacement have more posterior condylar position than that found in normal joints. Likewise, Ronquillo et al³⁰ and Pullinger²⁸ suggested that patients with articular disc displacement with reduction show more posterior condylar position than in normal joints or cases of articular disc displacement without reduction. Supposing the hypothesis proposed by this study are accepted, more attention should be spent on early identification of clinical signs of TMJ disorders in early stages of development, which could be more appropriately diagnosed and measured by imaging techniques such as MRI. Thus, proper treatment protocols could be developed and introduced to avoid or minimize the undesirable influences of these disorders in facial growth pattern.

CONCLUSIONS

According to the study's findings, it can be concluded that:

1. Differences were found between cephalometric variables SNA, SNB, SN.Gn and I.NB in children with articular TMD and control group free of that disorder, in the

stages of cervical vertebral maturation before the mandibular growth peak.

2. It was possible to identify a predictive model able to differentiate patients with TMJ disorders and asymptomatic controls based on early skeletal cephalometric characteristics obtained by the variables SNA and I.NB.

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Dental age as indicator of adolescence

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Abstract

Aim: The purpose of the present study was to analyze the relationship between root formation of the first premolars and skeletal maturation stages identified in hand-wrist radiographs. **Methods:** A cross-sectional study was carried out involving the panoramic and hand-wrist radiographs obtained on the same date of 232 patients, 123 boys and 109 girls aged 4 years and 5 months to 17 years and 12 months. Root formation stages of the first premolars were related to the ossification stages of the sesamoid bone, epiphyseal stages of the phalanx of the thumb and epiphyseal stages of the radius. **Results:** The studied variables demonstrated statistically significant correlations. **Conclusion:** Roots of the lower first premolars do not reach 2/3 of their complete length before adolescence.

Keywords: Age determination by skeleton. Orthodontics. Bone development.

INTRODUCTION

The concepts of corrective and interceptive orthodontics are founded on the development stage of the occlusion. Corrective orthodontics is the mechanical movement imposed on permanent dentition, whereas interceptive orthodontics is treatment prior to the installment of the permanent dentition. Based on these concepts, orthodontists use dental age as a practical parameter for differentiating early and late treatment.

Moreover, dental age is reported to be a determinant of the proper time for treatment, as seen in Figures 2 to 5.

Figure 2 illustrates the extrusion of tooth #21 in the inter-transitory period of the mixed dentition. Figures 3 to 5 illustrate continuous mandibular advancement applied in pre-adolescence in the same period.

Orthodontists do not always need the growth variable for the application of mechanical

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movement. For instance, the correction of malocclusions without sagittal error does not require growth (Fig 2). As crowding is an intra-arch problem, its treatment does not depend on growth; nor does growth interfere in the treatment. Crowding can be corrected beginning in the first transitory period of the mixed dentition. The same is true for eruption problems, which should be treated during the eruption of the teeth involved (Fig 2).

The remaining potential of facial growth takes on importance in the treatment of malocclusions with sagittal skeletal error, such as Class II malocclusions with mandibular deficiency (Pattern II).^{1,17,21,26}

Growth is a complex biological phenomenon driven primarily by genetics and, in postnatal life, occurs from birth through the skeletal maturation, with a growth spurt in adolescence.⁴ Locating a patient on his/her growth curve is a well-known task for orthodontists and is mainly performed by bone age.^{4,7,12,24} However, the daily practice of occlusal analysis and the practicality of this diagnostic method, makes, on the part of orthodontists, the underestimated dental age a tempting means to be used as the first option to determine adolescence. Is it possible to locate the patient in adolescence based on dental age? By posing this question, the focus of the present study fuels the discussion on the use of dental age as a biological development parameter in orthodontics.

Day-to-day experience with dental age suggests that the occlusion of the upper and lower first premolars immediately precedes adolescence. As the tooth eruption process is closely related to the degree of root formation,³⁰ panoramic radiography is a convenient means for this evaluation.

Bone age, which is currently determined through radiographic images of the cervical vertebrae,^{2,11,16,22} has historically been identified through hand-wrist radiographs.^{4,7,12}

The use of new diagnostic methods is certainly part of the evolution of science, but does not invalidate classic methods of proven reliability. In hand-wrist radiographs, numerous centers of ossification can be assessed in adolescence, such as the sesamoid bone,^{4,5} epiphysis of the proximal phalanx of the thumb¹⁰ and epiphysis of the radius.⁶

The aim of the present study was to determine associations between dental age analyzed in panoramic radiographs and bone age analyzed in hand-wrist radiographs. A further aim was to demonstrate the degree of agreement of skeletal age and dental age by a single examiner and determine whether sexual dimorphisms exists in the development of the upper and lower first premolars.

MATERIAL AND METHODS

Panoramic and hand-wrist radiographs of 232 patients (123 females and 109 males) taken on the same day were selected from the archives of the Profis Preventive and Interceptive Orthodontics Course in the city of Bauru (Brazil) for analysis. Patient age ranged from 4 years and 5 months to 17 years and 12 months (mean= 8 years and 10 months; standard deviation= 2 years and 3 months) (Fig 1).

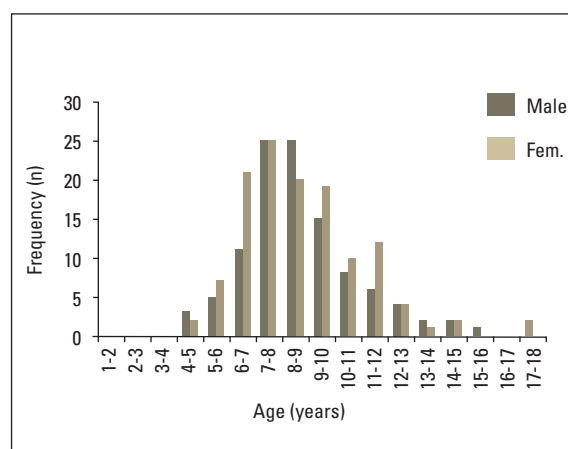


FIGURE 1 - Distribution of the 232 patients of the studied sample, according to age and gender.

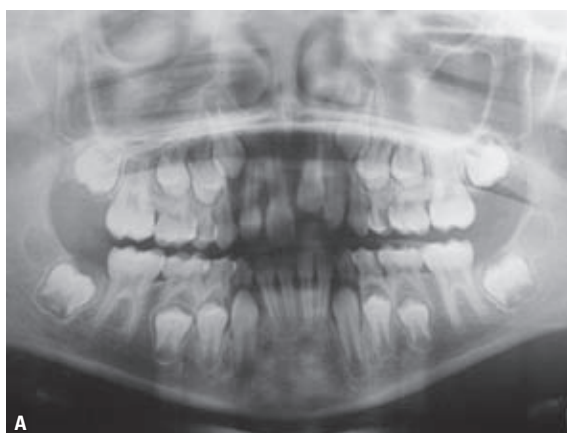


FIGURE 2 - Class I malocclusion with ectopic eruption of tooth #21 diagnosed in inter-transitory period of the mixed dentition. In malocclusions without sagittal error, dental age is determinant of proper treatment time. **A)** Initial panoramic radiograph.



FIGURE 2 (continuation) - Initial dental cast: **B)** right lateral view, **C)** frontal view and **D)** left lateral view.



FIGURE 2 (continuation) - 4X2 upper leveling with rectangular steel wire: **E)** right lateral view, **F)** frontal view and **G)** left lateral view.



FIGURE 2 (continuation) - Leveling of tooth #21 with NiTi wire anchored on continuous leveling: **H)** right lateral view, **I)** frontal view and **J)** left lateral view.



FIGURE 2 (continuation) - Leveling of tooth #21: **K)** right lateral view, **L)** frontal view and **M)** left lateral view.



FIGURE 3 - Class II, division I malocclusion, with anterior open bite diagnosed in the first transitory period of the mixed dentition, development stage equivalent to preadolescence: **A)** right lateral view, **B)** frontal view and **C)** left lateral view.



FIGURE 3 (continuation) - Continuous mandibular advancement with Herbst appliance: **D)** right lateral view; **E)** occlusal view of fixed Haas expander modified for Herbst (upper anchorage); **F)** frontal view. The continuous orthopedic mandibular advancement with the Herbst appliance was instituted at this dental age (early treatment protocol).



FIGURE 3 (continuation) - Correction of sagittal error: **G)** right lateral view, **H)** frontal view and **I)** left lateral view.



FIGURE 3 (continuation) - Retention performed with intermittent mandibular advancement: **J)** right lateral view, **K)** frontal view and **L)** left lateral view.



FIGURE 3 (continuation) - Final mandibular advancement phase: **M)** right lateral view, **N)** frontal view and **O)** left lateral view.



FIGURE 3 (continuation) - End of treatment after removal of fixed orthodontic appliances: **P)** right lateral view, **Q)** frontal view and **R)** left lateral view.



FIGURE 4 - **A)** Initial facial profile analysis revealing mandibular deficiency which follows the Class II malocclusion shown in Figure 3. **B)** Frontal facial analysis. **C)** Orthopedic mandibular advancement had an important facial impact by repositioning the mandible in the face. **D)** Final frontal facial analysis.

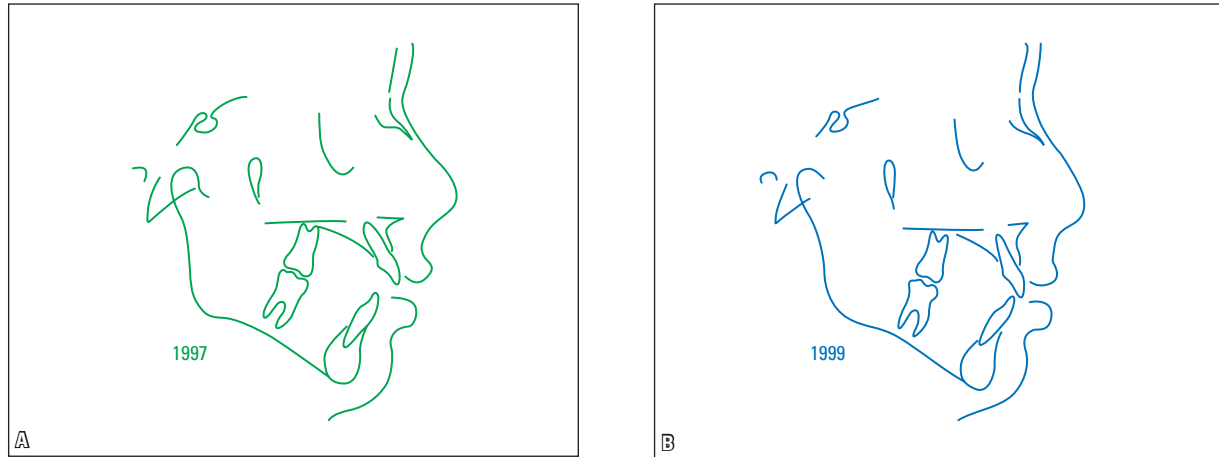


FIGURE 5 - Cephalometric tracings and superimpositions from the patient in Figures 3 and 4 revealing changes in the face and mandible throughout follow-up period (1997 to 2001): **A)** pretreatment; **B)** post-orthopedic mandibular advancement.

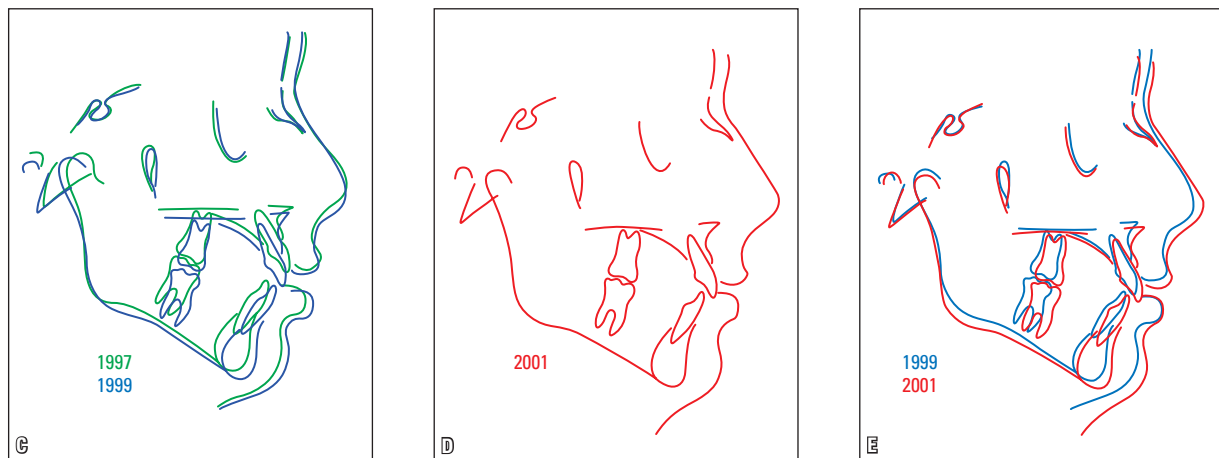


FIGURE 5 (continuation) - **C)** Superimposition 1997-1999, **D)** 2001 (post-corrective orthodontic treatment), **E)** Superimposition 1999-2001.

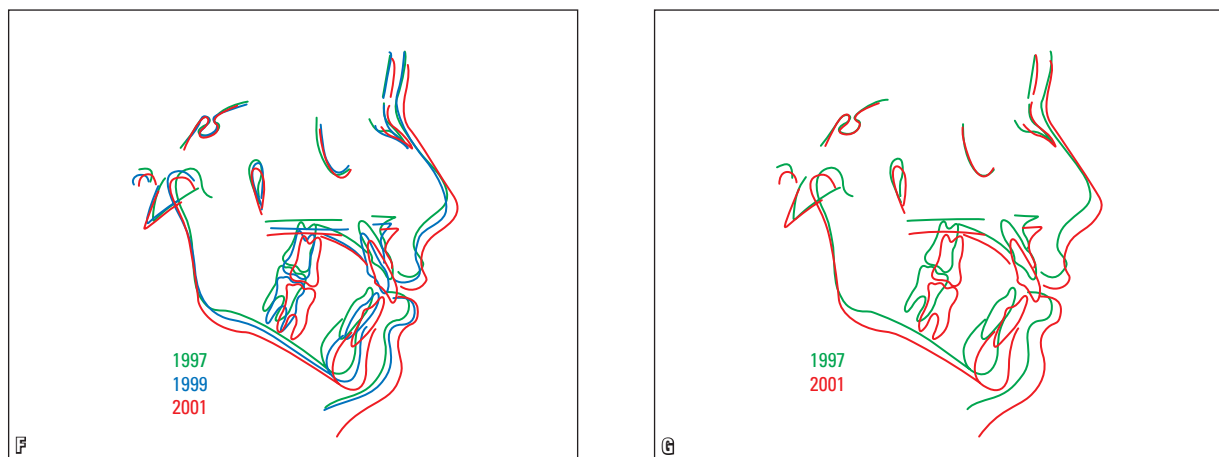


FIGURE 5 (continuation) - **F)** Superimposition 1997-1999-2001, **G)** Superimposition 1997-2001.

Bone age was determined through the evaluation of specific centers of ossification in the hand-wrist radiographs. For such, the degree of ossification of the sesamoid bone, epiphyseal stage of the proximal phalanx of the thumb and epiphyseal stage of the radius were analyzed. A letter from A to M was attributed to each ossification or epiphyseal stage, as illustrated in Figures 6 to 8.

The root development stage of the left upper and lower first premolars was assessed in the panoramic radiographs. For such, the classification system proposed by the authors was used, in which a letter from N to R was attributed to each degree of root formation, as illustrated in Figure 9.

Only radiographs of good quality and no evidence of carious lesions or endodontic problems of the analyzed teeth or their primary predecessors were selected. All panoramic and hand-wrist radiographs were examined separately by a single examiner using an X-ray viewer in a darkened room. The regions of interest, sesamoid bone,

thumb, radius and left upper and lower premolars, were analyzed separately, with the rest of the radiograph covered by a black cardboard. Patient identification such as name, gender and age were also covered on the radiograph, so that the evaluator had no access to this information. After fifteen days, a second analysis was performed of each region of interest in order to determine the reliability of the method (intra-examiner agreement). The Kappa statistic¹⁴ was used as the concordance measure between the first and second evaluations of the radiographs in the identification of the development stage of the left upper and lower first premolars and ossification/epiphyseal stages of the hand-wrist bones.

In cases in which there was no agreement between the first and second evaluations, for the determination of the dental or ossification development stages, a second examiner helped the first examiner determine the stage that best represented the image in the radiograph through a consensus assessment. This only happened in three cases.



FIGURE 6 - Ossification stages of sesamoid bone identified in hand-wrist radiograph: **A)** Absence of calcification (Stage A); **B)** Onset of calcification (Stage B); **C)** Definite calcification (Stage C).

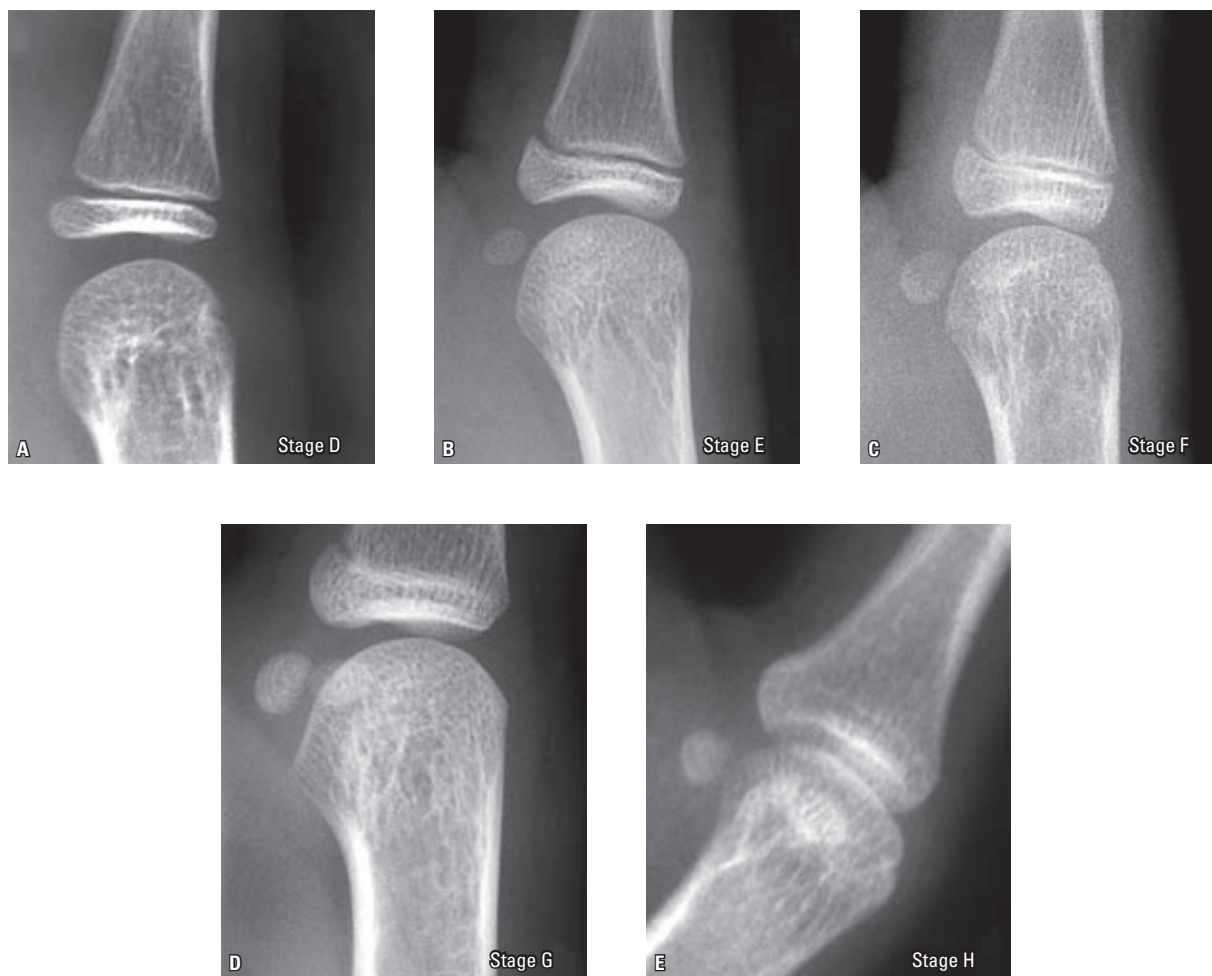


FIGURE 7 - Epiphyseal stages of the proximal phalanx of the thumb identified on hand-wrist radiograph: **A)** Pre-capping (Stage D); **B)** Capping (Stage E); **C)** Fusion onset (Stage F); **D)** Fusion in progress (Stage G); **E)** fusion complete (Stage H).



FIGURE 8 - Epiphyseal stages of the radius identified on hand-wrist radiograph: **A)** Less than diaphysis (Stage I); **B)** Same size as diaphysis (Stage J); **C)** Capping (Stage K).

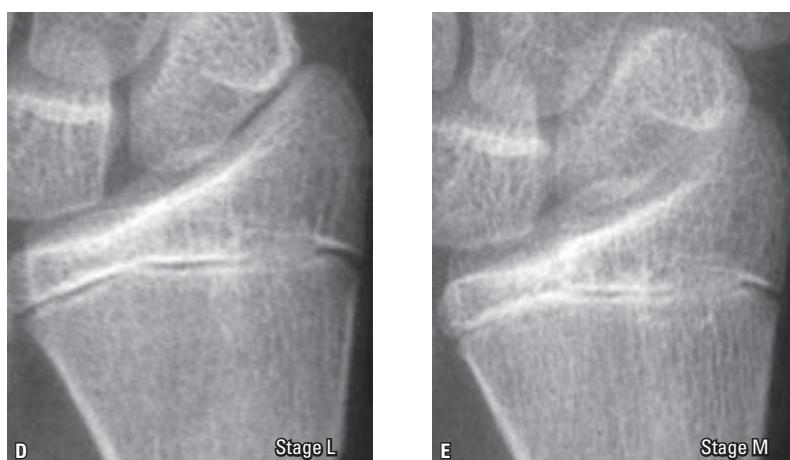


FIGURE 8 (continuation) - **D**) Fusion onset (Stage L); **E**) Fusion in progress (Stage M).

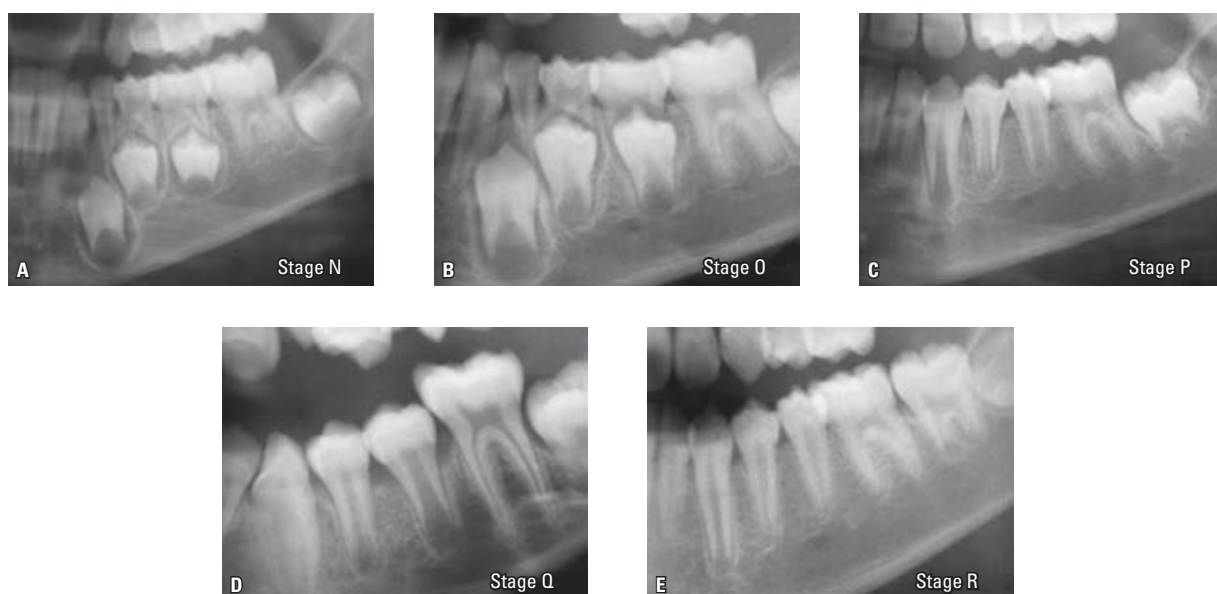


FIGURE 9 - Degrees of root formation of upper and lower first premolars assessed on panoramic radiographs: **A**) Absence of root formation (Stage N); **B**) Root 1/3 complete (Stage O); **C**) Root 1/2 complete (Stage P); **D**) Root nearly complete (3/4) with open apex (Stage Q); **E**) Root complete with closed apex (Stage R).

The existence of sexual dimorphism was evaluated in the development stages of the upper first premolar, lower first premolar and between the upper and lower first premolars. The Mann-Whitney test was used for this evaluation, with a 5% level of significance ($p < 0.05$).

Associations between dental age and bone age were determined by the frequency of dental development stages between different ossification stages. Spearman's correlation coefficients were calculated to determine correlations between these variables.

RESULTS

Table 1 displays the results of the intra-examiner agreement between readings of the radiographs on two separate occasions with a 15-day interval. Kappa values ranged from 0.92 to 1.00, corresponding to nearly perfect agreement.

The Mann-Whitney test revealed no sexual dimorphism in the degree of root formation with regard to the upper first premolar ($p=0.43$) and lower first premolar ($p=0.47$) (Table 2).

However, a statistically significant difference was found in the comparison of the formation of the upper and lower first premolars ($p=0.02$) (Table 2).

TABLE 1 - Intra-examiner test: Percentage of agreement and Kappa index regarding three bone centers assessed on hand-wrist radiographs (sesamoid bone, proximal phalanx of the first finger FP1 and radius) and root formation stages of first lower and upper premolars on panoramic radiographs.

Parameter	% of agreement	K
Sesamoid bone	100.00	1.00
FP1	96.70	0.92
Radius	96.70	0.95
Upper 1 st premolars	97.80	0.97
Lower 1 st premolars	95.60	0.94

TABLE 2 - Sexual dimorphism for the tooth formation degree for upper and lower premolars and the difference in the formation degree among premolars.

Formation degree of upper premolars between genders	Formation degree of lower premolars between genders	Formation degree of upper x lower premolars
p-value = 0.43	p-value = 0.47	p-value = 0.02*

*Statistically significant difference.

TABLE 3 - Relationship between the degree of formation of lower first premolar and bone events of hand-wrist analysis: Spearman's correlation coefficient and p-value.

Comparison	Spearman's	p-value
Lower premolar X sesamoid	0.6299	<0.0001*
Lower premolar X phalanx epiphysis (FP1)	0.4987	<0.0001*
Lower premolar X radius epiphysis	0.5964	<0.0001*

*Significant correlation between variables.

Based on this difference in degree of formation of the premolars, the lower premolar was chosen for comparisons with bone events in the hand-wrist radiographs. Spearman's non-parametric correlation test revealed correlations between the degree of formation of the lower first premolar and hand-wrist bone events (Table 3).

Tables 4, 5 and 6 display the frequencies of the different degrees of lower first premolar formation and different bone events represented by the sesamoid bone, epiphyseal stage of the proximal phalanx of the thumb and epiphyseal stage of the radius.

DISCUSSION

As in the determination of root formation events, the assessment of bone age in hand-wrist radiographs also proved reliable when performed on two separate occasions by the same examiner (Table 1). Thus, there is no doubt regarding the reliability of assessing bone age or dental age, even when employing subjective qualitative methods. The aim of assessing the reliability of the method in the present study was to demonstrate the calibration of the evaluator for the analysis proposed by the authors, classifying different bone stages (sesamoid, epiphysis of the proximal phalanx of the thumb and epiphysis of the radius) and odontogenic stages (degree of root formation of first premolars) using a letter system from A to R (Figs 6 to 9).

The association between the development of the dentition and skeletal maturation has been studied in the literature, with discrepant results reported.^{8,13,15,19,23,29} In the present study, dental age was compared to different ossification events that are determinants of adolescence. The reference chosen for the determination of dental age was root formation of the upper and lower first molars (Fig 9). The choice of these teeth was based on the proximity of their time of eruption to adolescence,^{19,27} which is clinically important information for estimating the

TABLE 4 - Degree of lower first premolar formation and stages of sesamoid ossification.

Sesamoid / Premolar	Absence of ossification	Onset of ossification	Definite ossification	Total
0	74 (31.9%)	-	-	74 (31.9%)
1/3	55 (23.71%)	2 (0.86%)	-	57 (24.57%)
1/2	23 (9.91%)	4 (1.72%)	1 (0.43%)	28 (12.07%)
Open apex (3/4)	25 (10.78%)	11 (4.74%)	14 (6.03%)	50 (21.55%)
Closed apex	3 (1.29%)	3 (1.29%)	17 (7.33%)	23 (9.91%)
Total	180 (77.59%)	20 (8.62%)	32 (13.79%)	232 (100%)

TABLE 5 - Degree of lower first premolar formation and stages of ossification of the epiphysis of the proximal phalanx of the first finger (FP1).

FP1 / Premolar	Pre-capping	Capping	Fusion onset	Fusion in progress	Fusion	Total
0	74 (31.9%)	-	-	-	-	74 (31.9%)
1/3	57 (24.57%)	-	-	-	-	57 (24.57%)
1/2	24 (10.34%)	4 (1.72%)	-	-	-	28 (12.07%)
Open apex (3/4)	37 (15.95%)	9 (3.88%)	1 (0.43%)	1 (0.43%)	2 (0.86%)	50 (21.55%)
Closed apex	8 (3.45%)	4 (1.72%)	3 (1.29%)	1 (0.43%)	7 (3.02%)	23 (9.91%)
Total	200 (86.21%)	17 (7.33%)	4 (1.72%)	2 (0.86%)	9 (3.88%)	232 (100%)

TABLE 6 - Degree of lower first premolar formation and stages of ossification of the epiphysis of the radius.

Radius epiphysis/ Premolar	Smaller	Equal	Capping	Fusion onset	Fusion in progress	Total
0	73 (31.47%)	1 (0.43%)	-	-	-	74 (31.90%)
1/3	54 (23.28%)	3 (1.29%)	-	-	-	57 (24.57%)
1/2	24 (10.34%)	1 (0.43%)	3 (1.29%)	-	-	28 (12.07%)
Open apex (3/4)	27 (11.64%)	13 (5.60%)	3 (1.29%)	5 (2.16%)	2 (0.86%)	50 (21.55%)
Closed apex	3 (1.29%)	4 (1.72%)	2 (0.86%)	7 (3.02%)	7 (3.02%)	23 (9.91%)
Total	181 (78.02%)	22 (9.48%)	8 (3.45%)	12 (5.17%)	9 (3.88%)	232 (100%)

adequate time for the treatment of mandibular deficiency.^{21,26} Although the literature demonstrates that the lower canine has the greatest association with skeletal events,²³ the decision was made to assess the lower first premolar, as a recent study determined that this tooth also does not exhibit considerable variability when compared to bone age.¹⁷

No difference was found between genders in the progression of root formation of the first premolars. Analyzing the eruption chronology of the

permanent teeth, which is directly related to the degree of root formation, there is a difference between genders regarding the time in which these teeth erupt in the oral cavity in both the maxilla and mandible (Fig 10).^{27,30} In the present study, however, sexual dimorphism was found regarding the degree of root formation between the upper and lower first premolar. Thus, the lower first premolar was chosen for comparisons with skeletal events, although the upper first premolar could have been chosen as well.

The sesamoid bone undergoes ossification beginning from a cartilaginous center, which is seen at the beginning of adolescence between the distal portion of metacarpal 1 and the epiphysis of the proximal phalanx of the thumb. The onset of this ossification announces the beginning of the adolescent growth spurt.^{4,12,25} Peak of growth in adolescence is identified by the capping of the epiphysis of the proximal phalanx of the thumb.¹⁰ The final stages of adolescence can be determined on radiographs by indications of fusion or complete fusion of the epiphysis with the diaphysis in either the thumb or radius.^{5,6}

Dental age can be assessed radiographically by the degree of crown and root formation of the teeth²⁰ or clinically by non-erupted teeth.^{3,8} A tooth initiates its eruption after the root reaches 1/4 of its complete length.³⁰ Permanent teeth perforate the gingival tissue and appear in the oral cavity when the roots are approximately 3/4 formed.^{18,20} Eight to ten months elapse between the emergence of an incisor in the oral cavity and its complete eruption.⁹

The proposal of the present study is essentially clinical: The identification of adolescence through the assessment of dental age. For reasons of greater consistency and practicality from the methodological standpoint, dental age was inferred from the degree of root formation (Fig 9) assessed on panoramic radiographs obtained from archival records

(absence of root formation, root 1/3 complete, root 1/2 complete, root 3/4 complete and complete root). With 3/4 of the root formed, the tooth is already in the oral cavity and its complete eruption approximately coincides with its complete formation, though not necessarily with the apex closed.

Most of the patients in the present sample (n= 180) were in pre-adolescence, as identified by the lack of ossification of the sesamoid bone (Table 4), which restricts the analysis of the degree of root formation in adolescence itself. However, it was possible to determine that a larger portion of the patients in the stages prior to adolescence exhibited early degrees of premolar formation (absence of root formation or root 1/3 complete), indicating that these teeth had not yet erupted. Only 1.29% of the patients in pre-adolescence exhibited the R stage (closed apex), which is indicative of completely erupted teeth in occlusion. This result is in agreement with that described by Franchi et al,⁸ who found that the inter-transitory period of the mixed dentition coincides with pre-adolescence. Extrapolating these results to the clinical realm, the first premolars do not erupt in pre-adolescence and first premolars in occlusion announce adolescence. The presence of first premolars in occlusion has been the reference used to determine the proper time for orthopedic mandibular advancement for a Pattern II correction.²⁶

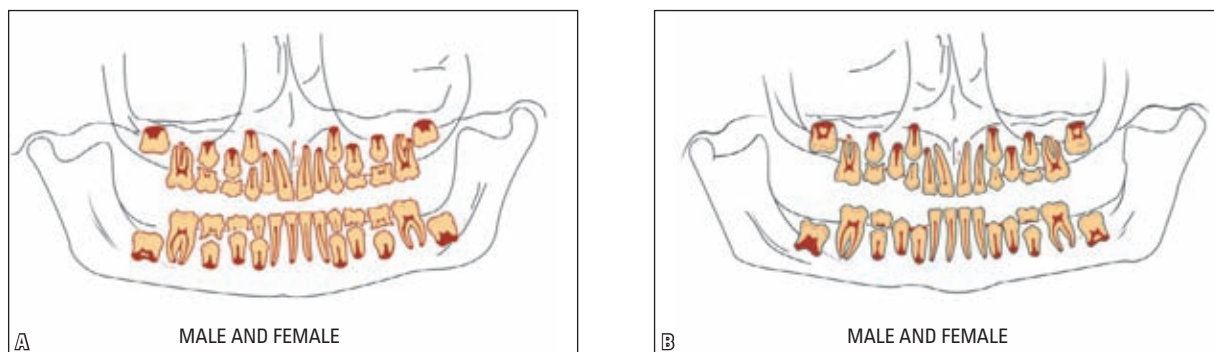


FIGURE 10 - Mean eruption sequence of permanent teeth in the final phase of mixed dentition (second transitory period) in panoramic radiographs (Source: Freitas, 1975), at mean age of 9 years and 3 months (A) and mean age of 10 years and 3 months (B).

Most of the patients who had initiated adolescence, as indicated by the onset of ossification of the sesamoid bone (only 8.6% of the sample) (Table 4), exhibited premolars with 3/4 of the root formed, which coincides with the eruption of these teeth. Patient in adolescence with the sesamoid bone defined (13.8%) exhibited premolars in either the stage of the onset of eruption or with a closed apex and therefore likely in occlusion with the antagonist. Franchi et al⁸ and Tassi et al²⁸ confirmed the end of the mixed dentition (second transitory period), with the exfoliation of the primary second molars and eruption of the premolars, to be an unreliable determinant of adolescence, as the results of these studies demonstrated that only one third of individuals with erupted premolars were in early adolescence and more than half had not left pre-adolescence.

Considering epiphyseal capping as an indicator of peak growth (7.3% of the sample), 1.7% exhibited a 1/2 formed root, 3.9% exhibited a 3/4 formed root and 1.7% had a closed apex. As there were few patients in this skeletal stage, one cannot draw reliable conclusions regarding the association between the degree of root for-

mation and growth peak. When the epiphysis of the radius was smaller than the diaphysis, the patients exhibited the initial degrees of root formation, with the first premolars further along the formation process when the fusion of the epiphysis with the diaphysis began to occur, corresponding to the final stages of adolescence. The few patients with indications of epiphyseal fusion of the radius (onset of fusion or fusion in progress, Table 6), corresponding to 9.05% of the sample, exhibited roots either 3/4 or completely formed.

The variability in the odontogenic stages in relation to bone maturation does not preclude the use of dental age as an initial development parameter in orthodontics or orthopedics, at least in the stages of mixed dentition and prior to the complete eruption of the permanent second molars (occlusal maturity). Surprisingly, due to its immediate clinical nature, dental age seems to suggest the remaining growth potential. Indeed, precise information is not expected.¹⁷ Dental age only reflects the passage to adolescence (Fig 11) and detailed information comes from skeletal age. Thus, dental age constitutes a

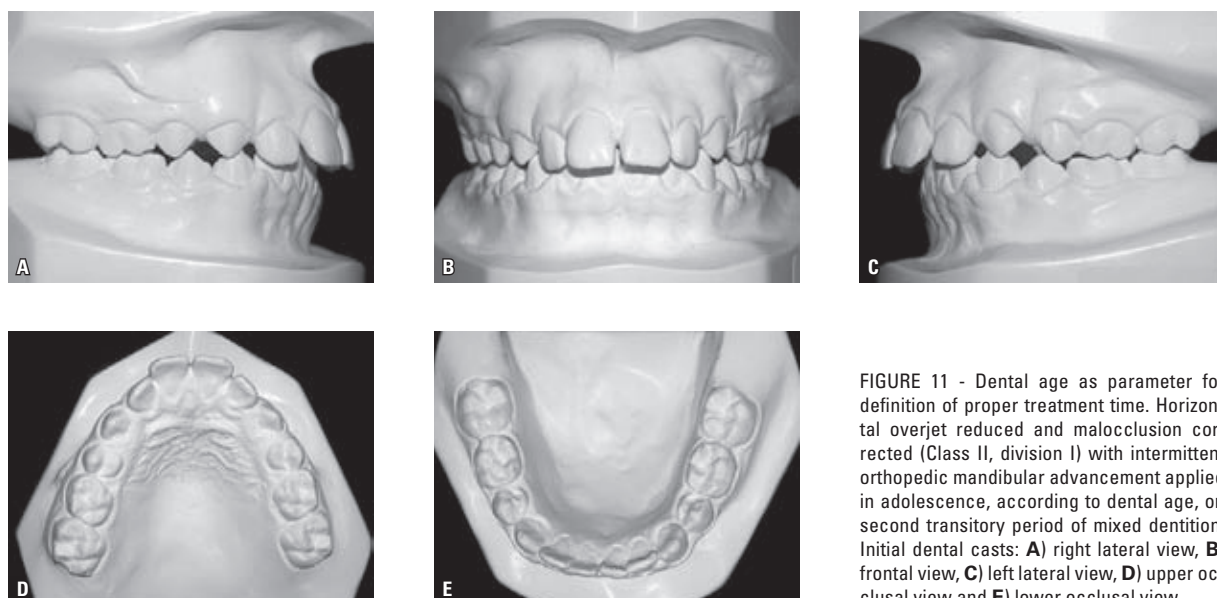


FIGURE 11 - Dental age as parameter for definition of proper treatment time. Horizontal overjet reduced and malocclusion corrected (Class II, division I) with intermittent orthopedic mandibular advancement applied in adolescence, according to dental age, on second transitory period of mixed dentition. Initial dental casts: **A)** right lateral view, **B)** frontal view, **C)** left lateral view, **D)** upper occlusal view and **E)** lower occlusal view.

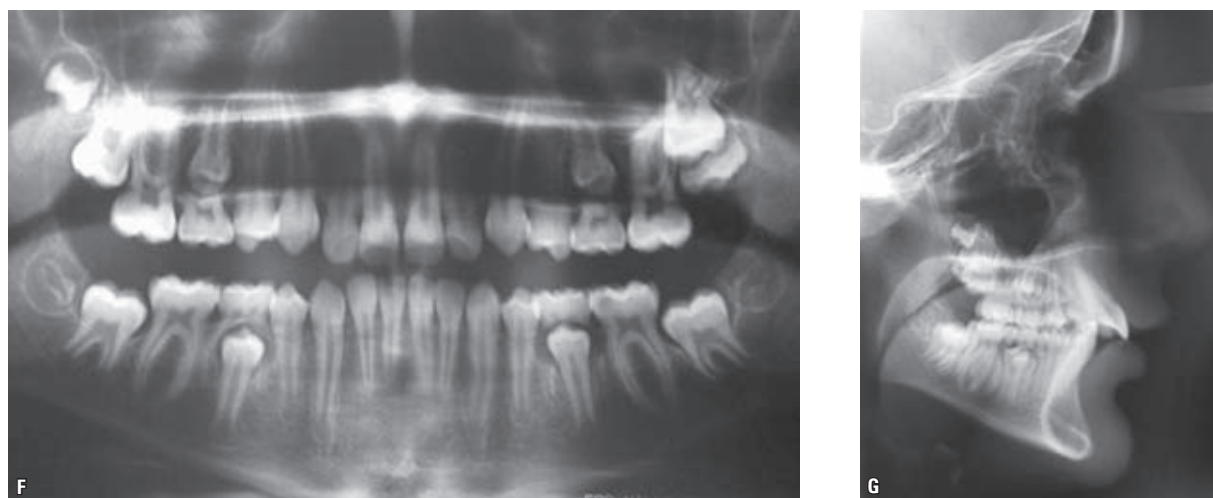


FIGURE 11 (continuation) - Initial panoramic radiograph (F) and lateral cephalometric radiograph (G).



FIGURE 11 (continuation) - Intermittent orthopedic mandibular advancement: H) right lateral view, I) frontal view and J) left lateral view.



FIGURE 11 (continuation) - K) Lateral cephalometric radiograph during corrective orthodontic treatment.



FIGURE 11 (continuation) - Final photographs after appliance removal: **L)** right lateral view, **M)** frontal view and **N)** left lateral view.

line of demarcation from which one may solicit skeletal age in order to locate the patient on the adolescence curve. Based on the present findings, skeletal age should be solicited at the beginning of premolars eruption and not before.

CONCLUSION

Based on the results of the present study, it appears valid to draw the following conclusions:

- 1) Lower premolars do not erupt in pre-adolescence.

- 2) Lower premolars can emerge in the oral cavity in the beginning of adolescence.
- 3) In adolescence, premolars vary from the clinical appearance all the way to full occlusion.
- 4) Intra-examiner agreement is high in the identification of dental age using panoramic radiographs and skeletal age using hand-wrist radiographs.
- 5) There is no sexual dimorphism in the development of the lower first premolars.

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Vertical growth control during maxillary expansion using a bonded Hyrax appliance

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Abstract

Introduction: Rapid maxillary expansion (RME) for the treatment of maxillary deficiency and posterior crossbite may induce changes in the vertical dimension. Expanders with occlusal splints have been developed to minimize unwanted vertical effects. **Objective:** This preliminary study used cephalometric radiographs to evaluate the vertical effects of RME using a Hyrax appliance in children with maxillary deficiency. **Method:** Twenty-six patients (11 boys; mean age = 8 years and 5 months) with maxillary deficiency and posterior crossbite were treated using a Hyrax appliance with an acrylic occlusal splint. Radiographs and cephalometric studies were performed before the beginning of the treatment (T1) and after RME active time (T2), at a mean interval of 7 months. Results were compared with normative values. **Results and Conclusions:** At the end of treatment, there were no statistically significant changes, and measurements were similar to the normative values. Data showed that there were no significant effects on vertical growth, which suggests that appliances with occlusal splints may be used to correct transverse deficiencies regardless of the patient's growth pattern.

Keywords: Palatal expansion techniques. Vertical dimension. Interceptive orthodontics.

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INTRODUCTION

Rapid maxillary expansion (RME) has been used to correct cases of maxillary deficiency and posterior crossbite in growing patients. The incidence of this type of malocclusion among children ranges from 7 to 23%, and RME has become a usual procedure in orthodontics.

Conventional RME results in midpalatal suture opening,^{16,29} increase of basal bone width and dental arch perimeter,^{1,13} and decrease of airflow resistance.^{10,15,19} However, treatment of transverse maxillary deficiencies using palatal expanders may have unwanted effects on the sagittal and vertical planes.⁵

Studies that evaluated radiographs and dental casts found that the maxilla moves forward and downward,^{10,12,16,29} the maxillary molars extrude,^{4,11,26,27} the mandibular plane angle^{4,12,13,26,29} and, consequently, the total facial height increases.^{4,10,14,27} However, other studies demonstrated that, although there were no statistical differences regarding the forward movement of the maxilla, the mandible and the palatal plane rotated clockwise.^{1,10,11,26} A systematic review of the long-term effects of RME¹⁸ concluded that there were no significant anteroposterior or vertical changes in the maxilla or mandible.

Several methods have been developed for RME,^{15,19,21,28} such as the bonded Hyrax developed by McNamara and Brudon¹⁹ (a Hyrax with an acrylic splint bonded to the occlusal surface of posterior teeth) to minimize the vertical effects of conventional expansion appliances.

The comparison of banded and bonded expanders revealed less forward and downward movement of the maxilla when the bonded appliance was used, which suggests that it should be used to minimize the unwanted vertical effects of RME.^{3,25} According to Garib et al,¹⁴ the side effects of RME with no vertical control are not significant in the long term, which do not contraindicate this treatment for patients with vertical growth pattern.

Despite the several studies in this area^{1,3,4,8,9,10,13,14,18,25,26,29}, there is still a controversy if bonded expanders provide vertical control. The aim of this preliminary study was to evaluate the cephalometric vertical effects of RME with a bonded Hyrax in children with transverse maxillary deficiency. Results were compared with normative follow-up values of dentofacial growth and development in untreated children.

MATERIAL AND METHODS

Sample selection

Twenty-six children (11 boys), with mean age of 8 years and 5 months (range = 6 years and 11 months to 10 years and 11 months) were included in this study. They all sought treatment in the Department of Orthodontics of the Ribeirão Preto Dental School, São Paulo University (FORP-USP). The inclusion criteria were good general and oral health, no caries or periodontal disease, erupted permanent maxillary and mandibular first molars, transverse maxillary deficiency and uni- or bilateral posterior crossbite. This study was approved by the Ethics Committee of the São Paulo University.

Occlusal radiographs were obtained to confirm the opening of the palatal suture after expansion, and lateral cephalograms were obtained before and after treatment for the analysis of vertical effects.

Modified Hyrax appliance

A bonded Hyrax (a rapid palatal expander with an acrylic occlusal splint) was used for RME, similar to the one described by McNamara and Brudon¹⁹ (Fig 1). The appliance was adjusted to the patient's mouth to obtain the highest possible number of occlusal contact points.

The enamel was etched with 37% phosphoric acid gel (Unitek/3M, St. Paul, MN, USA) on the buccal and lingual surfaces of the posterior teeth. After that, a primer (Single Bond, Unitek/3M, St. Paul, MN, USA) was used and light cured for



FIGURE 1 - Bonded Hyrax expander with acrylic occlusal splint used in this study.

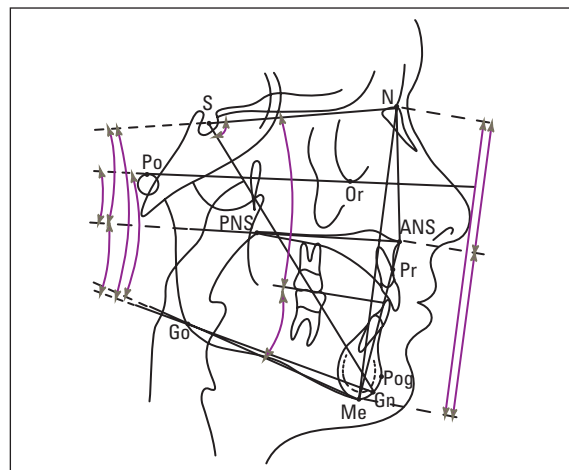


FIGURE 2 - Cephalogram showing the landmarks, lines, planes and cephalometric measurements used in this study.

15 seconds. A dual-cure resin cement (Rely X, Unitek/3M, St. Paul, MN, USA) was then applied on the internal surface of the acrylic splint and immediately placed in the patient's mouth. After removing the excess, the resin was light-cured for 40 seconds, as recommended by the manufacturer.

Patients and parents received hygiene and appliance activation instructions (2 turns per day). The expansion phase was weekly monitored up to the point of crossbite overcorrection. The opening of midpalatal suture was confirmed through occlusal radiographs. The appliance was then fixed using acrylic resin and remained as a retainer for 107 days.

Cephalometric analysis

The cephalograms were obtained and scanned by only one technician in the Laboratory of Dental Radiographic Analysis and Control (LACIRO) of FORP-USP at two time points: before treatment (T1) and immediately after the removal of the expansion appliance (T2). The mean time interval

between T1 to T2 was 7 months. All cephalograms were traced by the same examiner. Based on conventional cephalometric analysis (Steiner, Downs, Tweed, Ricketts, USP, Unicamp,) available in Radiocef software (Radio Memory, Belo Horizonte/BH, Brazil), we developed our own analytical method using 9 angles and 3 linear measurements (Fig 2) to evaluate the vertical bone changes and the facial height after the treatment.

Statistical analysis

To evaluate the error of method, 12 cephalograms were traced twice by the same examiner at an interval of at least 3 hours. The Pearson (r) correlation test and a t-test for r were used to statistically compare the values. Results were described and compared as means and standard deviations using a paired t-test. Statistical significance was tested at $p \leq 0.05$. To define whether treatment affected the vertical dimension in our experimental group, the values obtained for this sample were compared to a group of untreated patients.^{7,24}

RESULTS

There was a high correlation ($r \geq 0.99$) between repeated measurements to evaluate the error of method, with a great significance for r ($p < 0.001$).

Comparison of angular and linear cephalometric measurements in the vertical plane between T1 and T2 revealed that the changes were not statistically significant (Table 1), and that there was no change in vertical growth pattern. Although there was no significance, the greatest variation was found in the anterior facial height (AFH), with the mean difference between T1 and T2 of 0.5958 mm.

According to the Bolton's⁷ dentofacial growth and development standards, FMA and SN-GoGn values for children of 8 years of age are 26.2° and 31.6°, respectively, with a small reduction of these angles every year. The mandibular plane angle

(FMA) established by Ricketts²⁴ is about 28° at 3 years of age, with a 1° reduction every 3 years up to maturity. Therefore, at 8 years of age (a compatible phase with the mean initial age of this sample), FMA should be about 26°. The mean FMA angle in our sample was 26° at T1 and 26.2° at T2. Although there was an increase in the mean value of SN-GoGn angle when compared to the Bolton standards (37.06° at T1 and 36.80° at T2), there were no significant changes in this angle. Taken all together, the data suggested that there were no changes in the vertical growth of the mandible.

Moreover, the linear values used in this sample (AFH, UpAFH and LoAFH) were greater than the Bolton's⁷ standards. However, they were balanced between them, with a small but not statistically significant increase between T1 and T2, which is in agreement with the variations described by that author.

TABLE 1 - Descriptive statistics of cephalometric variables before and after treatment.

Measurements	Before treatment (T1)		After treatment (T2)		Difference (T2-T1)		Paired t test
	mean	SD	mean	SD	mean	SD	p values
SN0cl	20.0415	4.0931	20.1308	4.3207	0.0893	1.5746	0.775
SNGoMe	39.1738	5.2802	38.8958	5.2642	-0.2781	1.7458	0.424
GoGn0cl	17.0535	2.7608	16.7096	2.4922	-0.3439	1.7366	0.322
FMA	26.0965	4.4902	26.2550	4.5948	0.1585	1.4388	0.579
SNGn	69.0262	4.5551	68.7873	4.5124	-0.2389	1.1776	0.311
SNGoGn	37.0612	5.2509	36.8019	5.2126	-0.2593	1.7869	0.466
SNPP	6.8831	2.7199	6.7908	2.8008	-0.0923	1.7113	0.786
PPGoGn	30.1196	4.0914	30.0346	4.1125	-0.0850	2.1920	0.845
PPPoOr	4.1850	2.7565	3.8612	2.7186	-0.3238	1.4011	0.250
AFH	108.5315	4.8511	109.1273	5.1055	0.5958	1.8994	0.122
UpAFH	45.6777	2.8383	46.0577	3.0975	0.3800	1.2889	0.145
LoAFH	62.8527	3.7512	63.0704	3.9912	0.2177	1.5093	0.469

DISCUSSION

Different expanders with occlusal splints have been proposed^{19,21,28} to avoid changes in the vertical dimension when using banded appliances^{10,11,14,16,17,27,29} and the unfavorable effect on patient's facial height.^{3,11,19,25,28} The appliance described by McNamara and Brudon¹⁹ was chosen for this study because it is widely used in orthodontics, it is easy to manufacture and it is more hygienic.

The cephalometric measurements used in this study evaluated the vertical growth pattern of the patients. The focus was in the anterior facial height, and maxillary and occlusal plane tipping, relatively to the cranial base and the mandible, respectively. There was no control group in this study, and some of the results were compared with normative follow-up values for growth without orthodontic treatment.

The lack of statistical significance in the vertical measurements between T1 and T2 demonstrated the maintaining of the vertical pattern in the evaluated group. These results are in agreement with those reported by previous studies,^{3,19,23,25} which did not find any side effects on the vertical plane when bonded expanders were used, one of the great advantages of this type of treatment. These findings might be associated with the fact that appliances with an acrylic occlusal splint may prevent alveolar growth, excessive eruption of anchorage teeth, tilting of the alveolar processes and, consequently, buccal movement of maxillary posterior teeth.^{3,19,21,25,28} In contrast, clockwise mandibular rotation in response to RME was seen in other studies^{3,6} using banded and bonded appliances. In both cases, the explanation was in the buccal movement of the anchorage teeth. Such mandibular rotation was not confirmed in this study, and may be assigned to the skeletal resistance between the maxillary segments that did not allow a symmetrical expansion of the maxilla.^{3,8}

It can be suggested that the decrease of the palatal plane angle in relation to the cranial base (SN-PP) might be resulted from the downward displacement of the posterior region of the maxilla,^{3,10,25} rather than from the upward displacement of the anterior region. The downward and forward maxillary movement after RME, also reported by Haas,¹⁶ resulted from the fact that this procedure is traumatic and causes fractures along the maxillary tuberosity, which facilitated such movements.²⁰

Although several studies found statistically and clinically significant short-term changes in the vertical dimension of patients with banded expansion appliances,^{10,11,14,16,17,27,29} we believe that these changes are not significant in the long run, and the procedure should not be contraindicated for patients with a vertical growth pattern.¹⁴

The results of this study suggested that vertical changes after RME with occlusal splint also have no statistical and clinical significance. As the means found in this study were similar to normative values,^{7,24} we believe that the bonded Hyrax might be a good option for the correction of transverse maxillary deficiency, regardless of vertical dimension or facial pattern.

This is a preliminary study of the vertical effects of palatal expansion using an expander with occlusal splints. As it is a longitudinal study, other patients, as well as a control group, are still being followed up. This sample selection was based only on maxillary transverse dimension and did not take into consideration aspects associated with growth pattern. Further studies with a standardized sample should be conducted to clarify the benefits of expansion appliances with occlusal splints for patients with a vertical growth pattern.

CONCLUSIONS

The results of this study and their comparison with normative dentofacial growth and development values revealed that the

changes in the vertical plane are not statistically significant, which suggests that the vertical growth of patients that undergo this type of treatment does not change due to the use

of bonded Hyrax. Therefore, this type of appliance may be an alternative for the correction of posterior crossbite in individuals with a vertical growth pattern.

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Association between nonnutritive sucking habits and anterior open bite in the deciduous dentition of Japanese-Brazilians

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Abstract

Objective: Assess the association between nonnutritive sucking habits and anterior open bite in the deciduous dentition of Japanese-Brazilian children. **Methods:** 410 children of Japanese origin were assessed, 206 boys and 204 girls, between 2 and 6 years of age, in schools in São Paulo State, Brazil. Questionnaires concerning their nonnutritive sucking habits were sent to their legal guardians. Chi-square tests ($p < 0.05$) were applied to assess the association between nonnutritive sucking habits and anterior open bite, and the logistic regression test to obtain the relative risk. **Results:** The prevalence of sucking habits found in the sample was of 44.6% and for the anterior open bite, 4.4%. There was a statistically significant association between anterior open bite and sucking habits (O.R.=10.77), persistence of sucking habits from 2 to 4 years old (O.R.=22.06), and the persistence of sucking habits from 4 to 6 years old (O.R.=17.31). As for the interruption period of the habit, the group that had interrupted the habit for a period equal or inferior to six months showed an increased prevalence of open bite compared to the group without this habit or in which the habit was interrupted for more than six months. **Conclusion:** Japanese-Brazilian children that had sucking habits have greater chance of acquiring anterior open bite in the deciduous dentition.

Keywords: Deciduous dentition. Malocclusion. Preventive orthodontics.

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INTRODUCTION

Nonnutritive sucking habits must be seen as likely factors in the direct or indirect determination of dentoalveolar morphology disorder.

Specialized literature shows a cause-effect relation between sucking habits and anterior open bite in Caucasians. Various authors^{5,7,8,17} have already positively correlated the presence of these habits and the above mentioned malocclusion. Some surveys^{9,22} reported differences in the occlusal pattern, depending on the ethnical sample group. For this reason, it was considered appropriate to carry out a study with children from other ethnic groups to verify their occlusal features.

This epidemiological transverse study aimed to evaluate the finger and pacifier sucking habits in the deciduous dentition of Japanese-Brazilian children, as well as verify the associations of these habits and the presence of anterior open bite.

MATERIAL AND METHODS

This survey was developed in conformity with rules and standards under the Committee for Ethics in Scientific Researches of São Paulo University and before the beginning of the study a written consent form was obtained from the legal guardians.

Based on information from the Consulate of Japan, a list of Japanese-Brazilian preschools was put together in São Paulo State, Brazil. Thirty-six schools were picked out from this list to accomplish the minimal number estimated by the sample calculation for this randomized case-control study. The sample error was 4.9%, placed below the acceptable interval of 6% to 10%. Thus 410 Japanese-Brazilian children were assessed, 206 boys and 204 girls, from 2 to 6 years of age.

The children assessed in this study followed the criteria as described below:

- » They were born in Brazil with a minimum 50% direct Japanese origin, i.e., they should

have at least one of the parents, two grandparents and four great grand-parents, either on their mother's or their father's side, born in Japan.

- » Complete deciduous dentition,²¹ without presence of permanent teeth.
- » Absence of large caries or big crown damages.
- » Absence of dental disorders in shape, number, structure or eruption.
- » Absence of syndromes, or cleft lip and palate.
- » No previous orthodontic treatment or speech therapy.

The total sample (410 children) was subdivided into a Control Group (CG) and an Experimental Group (EG). The Control Group encompassed all the children who did not display any finger and/or pacifier sucking habit, which totalled 227 children. However, the Experimental Group was composed of 183 children that had one or more sucking habit, either at the moment of the clinical assessment or sometime in the past. The characterization of these groups can be observed in Table 1.

After, the Experimental Group was subdivided in three subgroups, concerning the length of time in which these habits persisted. In subgroup 1 (SG1) these habits were kept up to 2 years old. In subgroup 2 (SG2) they persisted in an interval between 2 and 4 years old. In subgroup 3 (SG3) those habits were active from 4 to 6 years old.

TABLE 1 - Distribution in number (n) and percentage (%) of the assessed sample according to gender in the Control and Experimental Groups.

Group	Gender				Total sample	
	male		female			
	n	%	n	%	n	%
Control (no habit)	125	55.1	102	44.9	227	100.0
Experimental (with habit)	81	44.3	102	55.7	183	100.0
Total	206	50.2	204	49.8	410	100.0

Concomitantly to the previous subdivision criteria, the time of the habit interruption was used, leading to the formation of two additional subgroups. In subgroup A (SGA) the children exhibited the habits at the moment of clinical assessment, or they had interrupted them in the last 6 months. However, in subgroup B (SGB) the habits had been interrupted more than 6 months ago.

Examiner's calibration

In order to promote the examiner's calibration, a training session was performed in one of the sample schools under the orientation of an experienced examiner. In the second phase, a fortnight afterwards, assessments were performed in order to evaluate the degree of intra-examiner agreement attained after the aforementioned calibration. The results were compared to the statistic Kappa test. The first and second clinical assessments presented a Kappa index of 0.94 for overbite, demonstrating an almost perfect agreement.

Criteria for the clinical assessment

The clinical assessment consisted of a visual inspection in the school itself. The child sat under clear light. For the identification of the presence or absence of anterior open bite the following criteria were used:

- » Absence of anterior open bite: The incisal borders of the upper central incisors overlapped or were in the same vertical level of the lower incisal borders
- » Presence of anterior open bite: Existence of a vertical opening between the incisal borders of the upper and lower incisors.

Assessment of the presence of oral habits

The presence of nonnutritive sucking habits was investigated through a questionnaire delivered to the guardian of each assessed child.

The information allowed determining the age in which the children interrupted the habit, as well as the interval between the interruption and the clinical assessment done for the survey.

Method for the analysis of the results

Initially the prevalence of the finger sucking and use of pacifier, as well as the identification of occlusal irregularity were calculated in the total sample. Then, univariate analysis was assessed through Pearson Chi-square tests ($p < 0.05$) to evaluate the association between the interruption of the habits and the prevalence of the investigated occlusal feature. For the identification of risk factors for the development of specific malocclusions, with $p < 0.05$, a stepwise multiple logistic regression analysis was performed. Variables that presented significant association with the malocclusion were selected. A logistic regression model was adjusted which estimated the odds ratio (O.R.) with confidence intervals at 95%.

RESULTS

According to Table 2, the prevalence of nonnutritive sucking habits was high. Out of the 410 studied children, 126 (30.7%) presented pacifier use habit, 45 (11%) finger sucking, 12 (2.9%) both habits and 227 (55.4%) didn't have any of those habits.

Tables 3 and 4 show data on the association between sucking habits and anterior open bite. Out of 183 children who displayed some kind of sucking habit, 8.7% presented anterior

TABLE 2 - Prevalence of sucking habits in the studied sample.

Habits	2 to 4 years		4 to 6 years		2 to 6 years	
	n	%	n	%	n	%
Pacifier	77	29.3	49	33.3	126	30.7
Finger	28	10.6	17	11.6	45	11.0
Pacifier + Finger	7	2.7	5	3.4	12	2.9
Without habit	151	57.4	76	51.7	227	55.4
Total	263	100.0	147	100.0	410	100.0

open bite and 91.3% absence of anterior open bite. However, out of the 227 children who didn't have a sucking habit, 0.9% presented anterior open bite and 99.1% absence of anterior open bite. The X^2 value for this association was equivalent to 14,92 ($p=0.000$). Therefore there were significant differences between the control and experimental groups related to the presence of anterior open bite (Table 4). The odds ratio was 10.77 ($p=0.002$).

On Tables 5 and 6, results of the association concerning the presence of anterior open bite related to the age of the sucking habits persistence are presented. It was verified that the anterior open bite presented a similar prevalence between the Control Group (CG) and Subgroup 1 (SG1), including the children who kept the sucking habit up to 2 years old. Nevertheless, the subgroups 2 and 3 revealed a considerably higher prevalence for anterior open bite. The statistical analysis of this association showed that the difference was significant among CG and SG2; CG and SG3; and between SG1 and SG2. Children with the persistence of the habit from 2 to 4 years old presented 22.06 times ($p=0.000$) more chances of acquiring anterior open bite than the children who didn't have these habits. The children whose habits persisted from 4 to 6 years old, presented 17.31 times ($p=0.000$) more chances of acquiring this malocclusion also when compared to CG. When SG1 and SG2 were analyzed, children in the latter had 5.04 more ($p=0.009$) chances of presenting anterior open bite (Table 6).

Tables 7 and 8 expose the results of the association between the prevalence of anterior open bite and the interruption time of the sucking habit. It was verified that the prevalence of the anterior open bite was higher in Subgroup A (25.9%), with present or interrupted habits in the last 6 months, while Subgroup B, with interrupted habit for more than 6 months, showed an accentuated reduction in the prevalence of this malocclusion (1.6%), almost similar to the frequency of CG (0.9%).

TABLE 3 - Prevalence of anterior open bite (AO) related to the presence or absence of nonnutritive sucking habits in Japanese-Brazilian children.

Groups	Presence of AO		Absence of AO		Total	
	n	%	n	%	n	%
Experimental (with habits)	16	8.7	167	91.3	183	100.0
Control (no habits)	2	0.9	225	99.1	227	100.0
Total	18	4.4	392	95.6	410	100.0

TABLE 4 - Statistic analysis according to Chi-square (X^2) test and the Logistic Regression (O.R.), for the comparison between control and experimental groups as to the prevalence of anterior open bite.

Comparisons	X^2	p	O.R.	P
Control/Experimental	14.92	0.000	10.77	0.002

TABLE 5 - Prevalence of anterior open bite (AO) according to the age of persistence of the nonnutritive oral sucking habit.

Age of persistence	Presence of AO		Absence of AO		Total	
	n	%	n	%	n	%
SG1 (<2 years)	4	3.7	103	96.3	107	100.0
SG2 (>2, <4 years)	10	16.4	51	83.6	61	100.0
SG3 (>4, <6 years)	2	13.3	13	86.7	15	100.0
CG (no habits)	2	0.9	225	99.1	227	100.0
Total	18	4.4	392	95.6	410	100.0

TABLE 6 - Analysis of the statistic significance according to Chi-square (X^2) and the logistic regression (O.R.), for the comparison among the subgroups 1, 2, 3 and control group as to the presence of anterior open bite related to the age of finger/pacifier sucking habit in children of both genders (total sample).

Comparisons	X^2	p	O.R.	P
CG x SG1	3.37	0.067	-	-
CG x SG2	28.97	0.000	22.06	0.000
CG x SG3	13.42	0.000	17.31	0.006
SG1 x SG2	8.15	0.004	5.04	0.009
SG1 x SG3	2.59	0.108	-	-
SG2 x SG3	0.08	0.771	-	-

TABLE 7 - Prevalence of anterior open bite according to interruption time of the nonnutritive sucking habit in Japanese-Brazilian children.

Group	Presence of AO		Absence of AO		Total	
	n	%	n	%	n	%
Subgroup A	14	25.9	40	74.1	54	100.0
Subgroup B	2	1.6	127	98.4	129	100.0
Control Group	2	0.9	225	99.1	227	100.0

Subgroup A: Present habit or interrupted in the last 6 months. Subgroup B: Interrupted habit for more than 6 months. Control Group: Children without sucking habits.

A significant statistic difference was found (Table 8) between Subgroup A and CG; and between Subgroup A and Subgroup B. The children in Subgroup A showed a risk 39.37 ($p = 0.000$) times higher than the children in CG and a risk 22.25 ($p = 0.000$) times higher than the children in Subgroup B of presenting anterior open bite.

DISCUSSION

The harmful influence of oral habits on the occurrence of malocclusions has been reported in epidemiological studies.^{5,16,20} In this study it was observed that 44.6% of children had a history of deleterious sucking habits (Table 2). Similar values are found in the literature.^{15,18} However there are reports of much higher frequencies such as 75.9%,² 78%,¹¹ 64%,¹⁶ 59%,²³ 65%.¹⁰ Low frequency, around 25% was also described¹³ and can be explained by the longitudinal character of the study, where mothers, from pregnancy, were oriented about the deleterious habits and about the benefits of breast-feeding. Another two studies^{8,22} with low prevalence were performed in Japan with results of 19.8% and 21.75%. These studies obtained lower frequencies because in that country the use of pacifier is not as widespread as finger suction.

Most of the studies focus on the prevalence of anterior open bite in Caucasian children and show prevalence over 16.50%.¹

TABLE 8 - Analysis of the statistic significance according to Chi-square (X^2) and the logistic regression (O.R.), for the comparison between the subgroups A and B and Control Group as to the prevalence of anterior open bite related to the period of finger/pacifier sucking habit in children of both genders (total sample).

Comparisons	X^2	p	O.R.	P
Control Group x Subgroup A	50.95	0.000	39.37	0.000
Control Group x Subgroup B	0.33	0.565	—	—
Subgroup A x Subgroup B	28.34	0.000	22.25	0.000

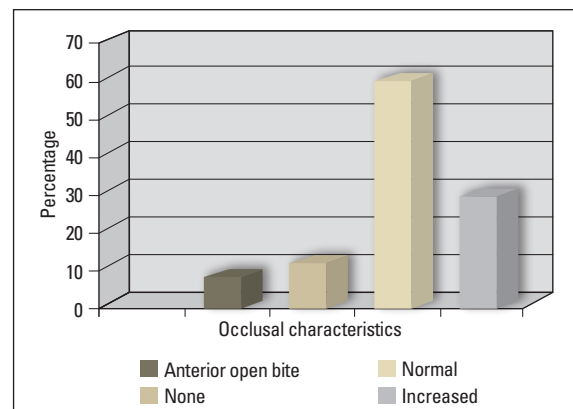


FIGURE 1 - Prevalence of the types of overbite in the sample.

Nevertheless, a study performed in a rural community in Finland¹² obtained a low prevalence (6.4%) close to the one found in this study (4.4%) (Fig 1). This can be explained by the restrict access to the pacifier in that location, one of the possible causes of the malocclusion. The only report in the literature using a Japanese-Brazilian sample¹⁹ showed a similar result (4.51%) to the present study. It didn't differ significantly from the prevalence of 7.7% found in another study performed in Japan.⁸ These lower prevalence should be attributed to the lower incidence of deleterious sucking habits in the Japanese ethnic group previously discussed, which some authors^{5,19,20} believe

to be the cause of this malocclusion. It should be highlighted that the Japanese facial pattern can also be a contributing factor for the low prevalence of anterior open bite in this ethnic group.

The results of the present study showed statistically significant association ($p=0.000$) between the finger/pacifier sucking and anterior open bite (Tables 3 and 4) corroborating previous studies.^{3,4,8,13,16,20,22} The relative risk observed for anterior open bite in children with deleterious sucking habits was 10 times higher ($p=10.77$) than those who did not have this behavior. Serra-Negra, Pordeus and Rocha Jr.¹⁶ found a risk close to that ($O.R.=14.1$). When assessing the association between the age of sucking habit persistence and the presence of anterior open bite, results point out that children who persisted on the habit after they were 2 years old presented a higher prevalence of malocclusion (Tables 5 and 6). Yonesu et al²² found statistically significant differences in the prevalence of anterior open bite when the habit persisted above 3 years of age. This statistic difference between the studies can be explained by the grouping done in the

sample, not by age, as in the Japanese study, but by age range, as the 3-year-old children were included in the 2 to 4 year-old range.

The period of habit interruption was studied and it was verified that children who interrupted the habit for more than 6 months did not present statistically significant differences compared to the group which never had the habit (CG) as for the presence of anterior open bite (Tables 7 and 8). This result suggests the occurrence of self-correction of this kind of malocclusion in children who interrupted the habit for more than 6 months, as previously described in the literature.¹⁴

CONCLUSIONS

The prevalence of deleterious sucking habits in Japanese-Brazilian children was equivalent to 30.7% for pacifier sucking, 11% for finger sucking, 2.9% for finger and pacifier sucking; 55.4% of the children did not have a sucking habit.

Children who present a sucking habit have more chance of having anterior open bite on their deciduous dentition than those who never displayed a sucking habit.

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Dahlberg formula – a novel approach for its evaluation

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Abstract

Introduction: The accurate evaluation of error of measurement (EM) is extremely important as in growth studies as in clinical research, since there are usually quantitatively small changes. In any study it is important to evaluate the EM to validate the results and, consequently, the conclusions. Because of its extreme simplicity, the Dahlberg formula is largely used worldwide, mainly in cephalometric studies. **Objectives:** (I) To elucidate the formula proposed by Dahlberg in 1940, evaluating it by comparison with linear regression analysis; (II) To propose a simple methodology to analyze the results, which provides statistical elements to assist researchers in obtaining a consistent evaluation of the EM. **Methods:** We applied linear regression analysis, hypothesis tests on its parameters and a formula involving the standard deviation of error of measurement and the measured values. **Results and Conclusion:** we introduced an error coefficient, which is a proportion related to the scale of observed values. This provides new parameters to facilitate the evaluation of the impact of random errors in the research final results.

Keywords: Biostatistics. Dahlberg error. Method error. Linear regression analysis.

INTRODUCTION

In biological research, it is not often possible to assess quantitative measurements directly from living beings. Therefore, indirect methods are used and it is necessary to evaluate their effectiveness when compared with other methods. It is not possible to state which one is more accurate, but it is feasible to compare

the agreement levels. The standard method is usually called “Gold Standard”, however, this does not mean that there is no error.¹ The randomized sample is one of the most important approaches to reduce bias. In another way, measure replications can be a good method to quantify and control random errors. The results of a trial might not be reliable if no

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satisfactory control of the error of measurements was performed.⁶

In dentistry, in order to interpret the results of a study, the author has to consider how imprecise it is to trace landmarks. In both studies of growth and in clinical trials, the changes are subtle, which makes the error of the method quite important.⁷ In order to evaluate the variance of error between researches, several authors^{4,6,7,8,10} suggested the formula proposed by Dahlberg⁶ in 1940. This method assumes that the sample has a normal distribution and, mainly, there is no bias (systematic error).⁶

Furthermore, the connections between error of measurement (EM) and misinterpretation of the results were not mentioned. In any research project, it is important to reduce the EM as much as possible, mainly when changes in measures were small comparing with the original scale of data. This wariness allows that the results, and consequently, the conclusions, can be validated.⁷

There is almost no reference to decide if some amount of error can be considered acceptable or not. In several papers the interpretation of the result is empirical or it is based on the personal experience of the investigator. According to Midtgard, Bjork, Linder-Aronson⁹ and Battagel,³ the error of variance should be ideally less than 3% of the total variance. However, Midtgard, Bjork and Linder-Aronson⁹ stated that it is almost impossible to have a variance of error less than 10% of the total variance. Baumrind and Frantz² reported that differences of measures derived from a patient should be at least the double of the standard deviation of the error of measurement. In this way, they can be considered as treatment results.

Although several studies reported few changes during a treatment, it is important to evaluate these changes properly. EM can be reduced but not totally eliminated. If therapeutic changes were small, EM can significantly

influence the inference of the evaluated differences. Therefore, there is a need to elaborate methodologies to analyze and interpret the effects of the EM in the changes observed during the treatment. Actually, there is no agreement about this subject in the literature.⁷

Regression analysis allows the assessment of systematic and random errors. It also permits a very intuitive visual evaluation of the results through a scatter plot chart and an optimum fitted line to these points. Further information about regression analysis can be found in the study of Wackerly, Mendenhall III and Scheaffer.¹¹

Due to its simplicity, the Dahlberg formula is frequently applied in dental research, in spite of other methods and different approaches to analyze the error, such as the one proposed by Martelli Filho et al.⁸ The aims of this paper were: To interpret the meaning of the Dahlberg⁶ formula proposed in 1940, to compare it to linear regression analysis and to propose a simple method to analyze the results of this formula.

MATERIAL AND METHODS

For the EM study, data sets of masters thesis in dentistry were kindly provided by their authors.

Data sets

1) From an initial sample of 20 orthodontic dental casts, the lingual shape of the arch was evaluated by using X and Y coordinates, resulting in 40 coordinates. Ten were re-measured to evaluate the EM.¹²

2) This study was based on 17 adult patients under orthodontic treatment, whom had magnetic resonance imaging taken in three different occasions. The tipping of anterior teeth (canine to canine) was measured using the author's own method.⁴ From these sample, 4 patients had these inclinations re-measured by the same researcher generating a set of 12 samples with duplicate measures for 5 different teeth.

Methods for error analysis

Dahlberg formula

The Dahlberg⁶ formula is defined as:

$$D = \sqrt{\sum_{i=1}^N \frac{d_i^2}{2N}}$$

d_i is the difference between the first and the second measure, and N is the sample size which was re-measured.

Assume the model $Z_{ij} = u_i + \varepsilon_{ij}$ where i is the sample index ($i=1,2,3,\dots,N$), j is the measure index (1st measure, 2nd measure), Z_{ij} is the observed measure, u_i is the actual measure and ε_{ij} the EM.

Regarding the EM, it is assumed that the expectation is $E(\varepsilon_{ij})=0$ and the variance $VAR(\varepsilon_{ij})=\delta_\varepsilon^2$. Thus, one probable quantification of the EM is its respective standard deviation ε_{ij} or, δ_ε . In other words, the smaller the standard deviation the smaller will be the error of method.

Observing the difference between the second and the first measure, we have:

$$d_i = Z_{i2} - Z_{i1}$$

so

$$Var(d_i) = Var(\varepsilon_{i2} - \varepsilon_{i1}) = 2\delta_\varepsilon^2$$

In this way, if we assume that there is no bias (systematic error), one intuitive estimator for $2\delta_\varepsilon^2$ could be:

$$2\hat{\delta}_\varepsilon^2 = \sum d_i^2 / N$$

and therefore,

$$\hat{\delta}_\varepsilon^2 = \sum d_i^2 / 2N$$

Thus, the quantity

$$\hat{\delta}_\varepsilon = \sqrt{\sum_{i=1}^N \frac{d_i^2}{2N}}$$

is exactly the formula Dahlberg proposed in 1940. This estimator of standard deviation of the EM is largely used in orthodontic research and gives us the root of the mean squared error (SSE), being equivalent to standard deviation of this error in case of no bias (systematic error),⁶ i.e., if the mean of errors is equal to zero.

Note that Dahlberg error is extremely sensitive to bias, since any mean deviation between the two measures will be incorporated. Besides, the Dahlberg formula presumes equality, not only between the means of the first and second measures but also of their variances. This second kind of systematic error, named “bias of slope”, will be more detailed in the next section. In summary, Dahlberg error does not distinguish between systematic and random errors, making it difficult to interpret the results.

Regression model

Several biological phenomena can be explained by mathematical models. Regression analysis describes a straight line as a relation function between two variables in a set of data. It is necessary to find the best line to fit this relation. The equation of the line is:

$$Y = \beta_0 + \beta_1 X$$

β_0 is the intercept (value of Y when the line crosses the X axis) and β_1 is the slope coefficient of the line.

For a linear regression model, it includes a random error, and thus, we have:

$$Y_i = \beta_0 + \beta_1 X_i + n_i$$

where n_i has mean zero and variance δ_n^2 . Details about the estimation process and test of hypothesis for parameters β_0 and β_1 can be found in the study of Wackerly, Mendenhall III and Scheaffer.¹¹

For dentistry, considering Y_i and X_i as the values for the i -th sample at first and second measures (i.e., $Y_i=Z_{i1}$ and $X_i=Z_{i2}$), the case without any bias or EM occurs if $\beta_0=0$, $\beta_1=1$ and $\delta_n^2=0$. One illustrative example of this case is in Figure 1A, in which a straight line has fitted perfectly to the points.

In Figure 1B, the points do not fit perfectly to the straight line. In this case there are scattered points along the line, indicating the presence of EM. In this case, the best fit in the least-squares criterion minimizes the sum of squared residuals. Residual is the vertical distance between the observed point and the fitted line.¹¹ Note also that the fitted line does not cross the origin, i.e., β_0 is different of zero, showing a bias in the mean of the error. It can be also noticed in Figure 1B that the inclination of the line is not 45°, which means that there is a slope bias, i.e., β_1 is different of 1. These two types of systematic errors can occur at the same time or not, and this Figure is only for illustrative purposes.

In practice, due to random fluctuations, the estimation of β_0 and β_1 coefficient will hardly be equal to one and zero, respectively. Thus, it is necessary to perform statistical tests to detect systematic errors. In these cases, t-statistics of estimators⁵ of β_0 and β_1 can be used, testing the null hypothesis for $\beta_0=0$ (mean bias) and $\beta_1=1$ (slope bias), respectively. These measures come from regression analysis and can be found in the study of Wackerly, Mendenhall III and Scheaffer.¹¹

If there is no systematic error, then Z_{i1} can be written as $Z_{i1}=Z_{i2}+n_i$.

Moreover, as $Z_{i2}=\mu_1+\varepsilon_{i2}$, we have $\mu_1+\varepsilon_{i2}+n_i=\mu_1+\varepsilon_{i1}$, then $\varepsilon_{i1}=\varepsilon_{i2}+n_i$ and, so, $n_i=\varepsilon_{i1}-\varepsilon_{i2}$, being ε_{i1} first measure error and ε_{i2} second measure error.

As,

$$\delta_n^2 = \text{Var}(n_i) = \text{Var}(\varepsilon_{i2}) + \text{Var}(\varepsilon_{i1}) = 2\delta_\varepsilon^2, \text{ then}$$

$$\delta_\varepsilon^2 = \frac{\delta_n^2}{2}$$

being δ_n^2 the error of variance of the regression analysis, which the estimator is denoted by $\hat{\delta}_n^2$.

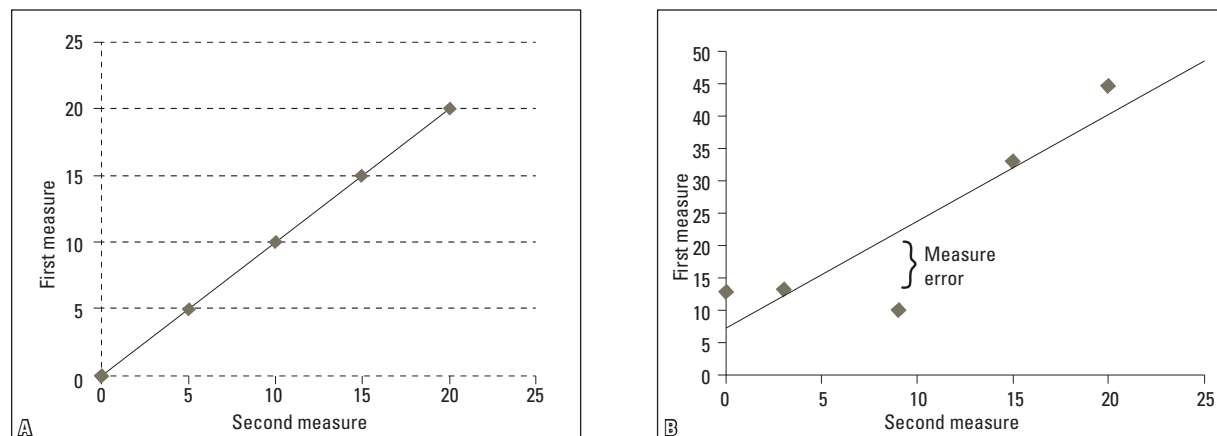


FIGURE 1 - **A)** 45 degree slope regression line fitted to the points. **B)** Regression line with mean bias, inclination and EM.

By calculating the square root of this coefficient, we have a measure equivalent to Dahlberg error, i.e.,

$$\delta_{\varepsilon} = \frac{\hat{\delta}_n}{\sqrt{2}}$$

Despite this, the formula will only be valid in case of no slope bias. One general formula in cases with systematic errors is given by:

$$\delta_{\varepsilon} = \frac{\hat{\delta}_n}{\sqrt{1 + \hat{\beta}_1^2}}.$$

Evaluation of found errors

If we assume that any distance can be described as the true distance plus an error, which has a Gaussian distribution, we have:

$$Z_{1i} = \mu_i + \varepsilon_{1i} \text{ and } Z_{2i} = \mu_i + \varepsilon_{2i} \text{ where } \varepsilon_i \sim N(0, \delta_{\varepsilon}^2).$$

From the statistics theory, we know that 95% of the data from one randomized sample with normal distribution have the mean between $\mu_i - 1,96 \delta_{\varepsilon}$ and $\mu_i + 1,96 \delta_{\varepsilon}$. Thus,

$$P = \frac{1}{2N} \left(\sum_{i=1}^N \frac{1,96 \hat{\delta}_{\varepsilon}}{|Z_{1i}|} + \sum_{i=1}^N \frac{1,96 \hat{\delta}_{\varepsilon}}{|Z_{2i}|} \right)$$

where N = is the number of data re-measured,
 δ_{ε} = standard deviation estimator of the EM.
 Z_{1i} = first measure,
 Z_{2i} = second measure.

This indicates that the ratio between EM and the observed measures is smaller than P in approximately 95% of the sample. Note that P is a proportion of the error related to the measured value, i.e., a percentage. This property makes it easier to interpret the results, since the reliability can be expressed in terms of a pro-

portion (i.e., 10%, 25%, etc). Note the original Dahlberg formula does not use this feature as it does not consider the total value of the original measures, but just the difference between them. The same absolute value of error in a sample with small measures has greater influence than in one with big measures.

RESULTS

The first set of data and their results are shown in Table 1 and 2 and Figure 2.

In approximately 95% of the cases the EM is in average less than 0.69% of the value from the observed measures. Note that under a significance level of 5% (Type I error) there is no mean (p-value=0.820) or slope (p-value=0.775) bias.

For the second set of data, the observed measures are shown in Table 3 and 4 and the results in Table 5 and Figure 3.

In this case, the error ratio (P) ranged from 9.38% to 125.88%. The biggest error ratio was found in tooth #11 and the smaller in tooth #22. Analyzing the systematic error test under a significance level of 5% ($\beta_0=0$ and $\beta_1=1$), it can be concluded that there were mean (p-value=0.029) and slope (p-value=0.043) bias for tooth #23.

DISCUSSION

The formula proposed by Dahlberg⁶ in 1940 assumes no systematic error in mean (β_0) or in slope (β_1). Nevertheless, the results obtained through regression analysis do not require these assumptions. Moreover, it also allows an intuitive analysis of the error using a scatter plot chart and a fitted line as shown in Figure 2. This scatter plot chart can be easily built with a Microsoft Excel® chart builder, which permits a visual analysis of the measures before sending the data to a more elaborated statistical analysis. In this chart, we can see that the straight line fitted almost perfectly to data set 1, which means that the errors are very small. The results confirm that the EM is extremely small

TABLE 1 - Dahlberg error formula⁶.

X1	X2	d	d2
37.44	37.36	-0.08	0.0064
35.5	35.79	0.29	0.0841
37.02	37.06	0.04	0.0016
40.47	40.3	-0.17	0.0289
36.82	36.82	0	0
36.01	35.98	-0.03	0.0009
34.61	34.32	-0.29	0.0841
39.44	39.39	-0.05	0.0025
37.17	36.84	-0.33	0.1089
39.29	39.13	-0.16	0.0256

TABLE 3 - Second set of data: first measure Z_{11} (# = tooth number).

Obs (i)	Measure	#12	#11	#21	#22	#23
1	0.2-in	6.8	4.5	6.2	8.2	-2.8
2	0.019 x 0.025-in	9.4	0	2.4	6.7	-1
3	0.021 x 0.025-in	9.6	2.8	3.3	6.9	-0.9
4	0.02-in	5.8	6	5	4.8	-5.6
5	0.019 x 0.025-in	6.6	8.9	5.9	4.4	-7.4
6	0.021 x 0.025-in	5.1	5	4.3	4.1	-7.5
7	0.02-in	7.5	4.2	4.4	4.9	-6.6
8	0.019 x 0.025-in	7.9	5.9	5.7	4.7	-8.2
9	0.021 x 0.025-in	10	7.8	5.3	5.6	-10
10	0.02-in	12.4	16.8	16.6	11	-0.9
11	0.019 x 0.025-in	18.1	18	15.1	13.2	-2.1
12	0.021 x 0.025-in	14	15.5	11.6	9.5	-3.1

TABLE 5 - Results using Dahlberg⁶ formula, Paired t-test, Regression Analysis and P ratio.

	#12	#11	#21	#22	#23
Dahlberg Error	0.692	1.141	0.856	0.304	0.880
EM (regression)	0.713	1.051	0.794	0.296	0.819
p-value paired t-test	0.230	0.064	0.303	0.146	0.329
Beta 0	-0.006	1.344	0.579	0.076	-1.195
p-value to mean bias	0.995	0.067	0.318	0.816	0.029
Beta 1	0.965	0.930	0.873	0.964	0.808
p-value to slope bias	0.663	0.353	0.065	0.401	0.043
Error ratio (P)	16.71%	125.88%	29.02%	9.38%	80.59%

TABLE 2 - Comparison between the results of the Dahlberg formula⁶ and Regression Analysis. P is the percentage of calculated error

	Error	Estimated β_0	p-value (1)	Estimated β_1	p-value (2)
Dahlberg	0.131	-	0.197 ^A	-	-
Regression	0.131	-0.299	0.820	1.01	0.775
P	0.691%				

Systematic Error Test: (1) = mean bias; (2) = slope bias;
A = paired t-test.

TABLE 4 - Second set of data: second measure Z_{21} (# = tooth number).

Obs (i)	Measure	#12	#11	#21	#22	#23
1	0.02-in	7.8	0.1	4.8	8.4	-1.1
2	0.019 x 0.025-in	11.4	0	3.2	6.7	-1.5
3	0.021 x 0.025-in	10.6	2.9	3.7	6.7	-0.6
4	0.02-in	5.2	4.1	3.9	4.2	-6.8
5	0.019 x 0.025-in	5.5	6.9	4.4	4.4	-7.9
6	0.021 x 0.025-in	4.8	6.1	4.1	4.2	-7.4
7	0.02-in	8.7	4	5.9	5.3	-7.1
8	0.019 x 0.025-in	8.8	5	5.9	5.1	-6.5
9	0.021 x 0.025-in	10.2	7.1	7.3	6.7	-10.2
10	0.02-in	12.6	17.1	18	11.2	1.8
11	0.019 x 0.025-in	17.1	17.6	16.6	13.6	-0.5
12	0.021 x 0.025-in	14.7	14.3	12.5	9.7	-3.9

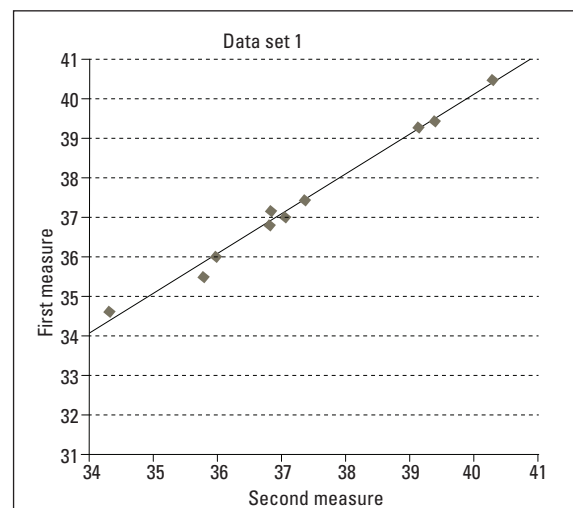


FIGURE 2 - Sample 1 – Regression line.

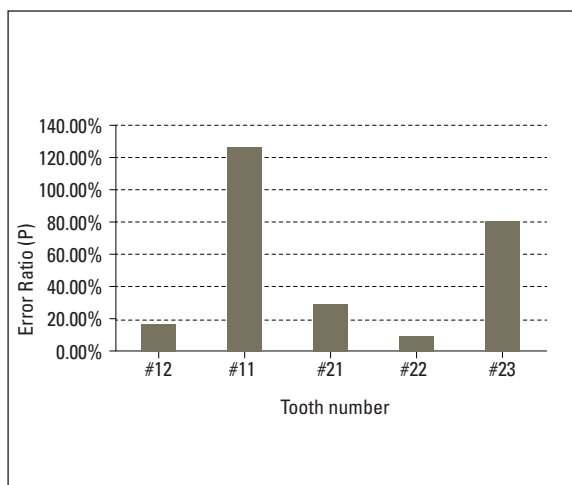


FIGURE 3 - P ratio for the second data set.

in comparison to the observation sizes ($P=0.69\%$). Moreover, using regression analysis we observed that β_0 is statistically equal to zero ($p\text{-value}=0.820$) and β_1 is equal to 1 ($p\text{-value}=0.775$). Therefore, we can conclude that there is no evidence of mean or slope biases and, when this happens, the EM estimated by the Dahlberg formula or regression analysis are very close, as shown in Table 2.

In sample 2, we analyzed the teeth with small measurement error (Fig 4) and those with the biggest error (Fig 5). We can visualize, by comparing the points in Figure 5, that the points did not fit the line as in Figure 4. The results of Trpkova et al¹⁰ demonstrated that there is a systematic error and a random error involving the tracing of the landmarks. There is a standard mean error and a confidence interval of 95% in repetition and reproduction of 15 landmarks regularly used in facial growth analysis. An average error of 0.59 mm on X axis and 0.56 mm on Y was considered acceptable accuracy, even though this criteria did not take into consideration the total scale of the measure. Other researchers proposed to evaluate the variance of error. Midtgard, Bjork, Linder-Aronson⁹ and Battagel³ stated that variance should be ideally less than 3% of the total variance.

But, in a later paper, Midtgard, Bjork, Linder-Aronson⁹ reported that it was almost impossible to have a variance of error of less than 10% of the total variance. The use of analysis of variance is quite complicated for researchers who are not familiar to the intricacies of statistics. Maybe this is why the Dahlberg formula is so broadly used, mainly in studies using cephalometric measures. The Dahlberg formula lacks bias analysis, which makes it hard for researchers to be secure if the error is acceptable or not. When we evaluated the values on Table 5, we can clearly notice that the analysis of the absolute value given by Dahlberg formula did not give us the parameters to evaluate the amount of error made. In tooth #21, the value provided by the formula was 0.856 and it corresponded to an error percentage of 29% (Fig 3). Meanwhile, in tooth #23, we had a very similar value of 0.880, which corresponded to a percentage error of 81% (Fig 3). Thus, it is necessary to analyze the Dahlberg formula using parameters that permits one evaluation of the amount of error made. By calculating the percentage of the error in relation to the magnitude of the original measure, we were establishing a probabilistic limit to the error with 95% of confidence. In the second set of data, using regression analysis, we could evaluate the existence of mean and slope biases. From the analysis of Table 5, we can notice there were no bias neither in the measure with the lowest error nor in the one with the highest error. In this case, we can also verify that Dahlberg formula was very similar to the result of regression analysis in the lowest error case (tooth #22), with a difference of 0.008 between this values. It is interesting to mention that there was a tendency of slope bias in tooth #11 ($p\text{-value}=0.065$) and there were mean and slope biases in tooth #23 (Fig 6). These two teeth were the ones who had the biggest difference between the EM given by the Dahlberg formula and the regression method,

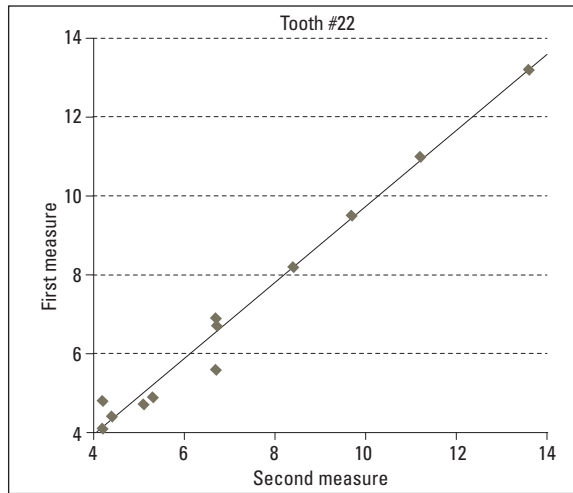


FIGURE 4 - Data set 2: Regression line adjusted to the data of tooth #22.

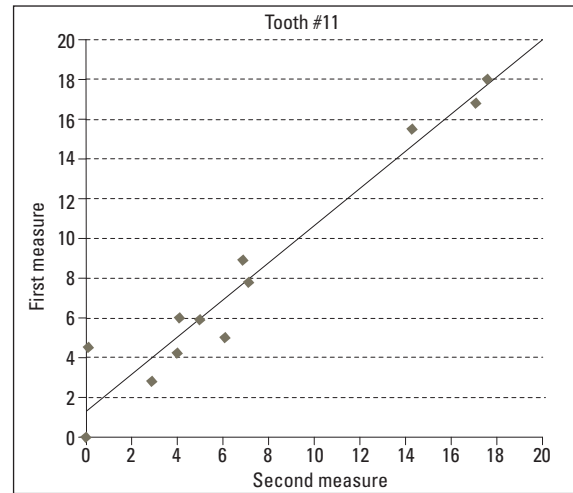


FIGURE 5 - Data set 2: Regression line adjusted to the data of tooth #11.

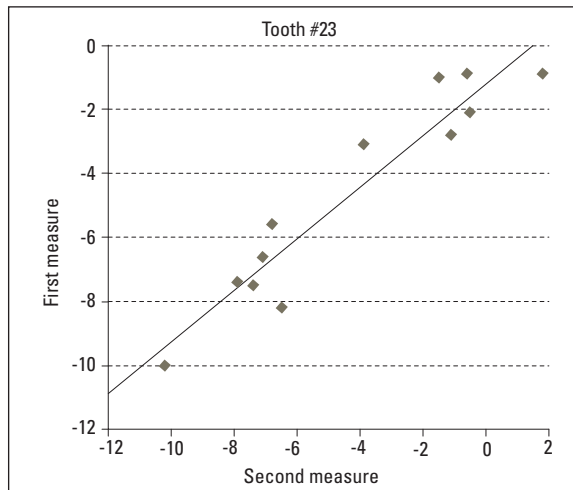


FIGURE 6 - Data set 2: Regression line adjusted to the data of tooth #23, which showed mean and slope biases.

showing that systematic error significantly influenced the Dahlberg formula. In these cases the Dahlberg formula differed from the regression analysis, mainly due to not making a difference between random and systematic error.

As the test for β_0 and β_1 referred to systematic error, these biases can be numerically rectified depending on the objective of the study. In several studies, the mean bias can be explained by equipment

calibration problems or operator subjectivity. Nevertheless, the cause of slope bias is not very clear and can be related to errors in data collection process. It is important to highlight that the estimator and test of hypothesis referring to β_1 had some limitations that were intrinsic to the estimation process. These procedures were suitable to a small set of observations and with EM reasonably low. In fact, this is what usually occurs, as the re-measures are made only in a few samples and elevated EM can be easily detected and these samples discarded.

Besides, paired t-test commonly used to detect mean bias showed to be ineffective. In tooth #23, the paired t-test did not reveal statistically significant differences between the mean of the first and second measures, which were detected by regression analysis as we can see in Table 5.

Baumrind and Frantz² mentioned that the differences observed in a patient must be at least two times the standard deviation of the estimated error, so it can be considered as therapeutic results. This proposition of evaluating the ratio of the error in relation to the measure lead to a less subjective parameter, which helps the researchers to determine what can be considered an acceptable error. However, the boundary value will depend on the accuracy level demanded by the research.

CONCLUSION

The use of regression models to evaluate EM have some advantages: 1) It distinguishes systematic error (mean and slope biases) from random error; 2) The results can be interpreted in a more objective and intuitive terms and permits a visual analysis using scattered plot charts and fitted line; 3) It supplies an estimation of EM integrated to the mathematical model.

The Dahlberg error is an estimator of standard deviation of the EM and correspond to the estimated error by regression analysis, when there is no systematic error. This fact is not highlighted very often in the literature. However, when there were biases, the Dahlberg error was different to the one obtained by our analysis as demonstrated by our results.

Although the Dahlberg formula can be a simple and efficient way to evaluate the EM, the analysis of quality of measure using standard deviation is quite hard. The transformation of the given value of this formula in a percentage of the amount measured provides parameters that makes it easier to evaluate the impact of the random error in the final result of the research.

Considering the aspects previously discussed, we concluded that the use of the regression model associated to the Dahlberg formula can be very useful to identify measurement and calibrating errors. These techniques, that can be used after a pilot plan to evaluate systematic and random error, increase the confidence of the results and avoid unexpected biases, regarding to procedure errors in gathering data.

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Evaluation of the dental arch asymmetry in natural normal occlusion and Class II malocclusion individuals

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Abstract

Objective: To verify the presence and degree of asymmetry of dental arches in Brazilian individuals with natural normal occlusion and Class II, Divisions 1 and 2 malocclusions. **Methods:** The study evaluated the symmetry of the maxillary and mandibular dental arches of 180 pairs of dental casts, divided into: Group I = 60 pairs of natural normal occlusion individuals; Group II = 60 pairs of Class II, Division 1 malocclusion individuals; and Group III = 60 pairs of Class II, Division 2 malocclusion individuals. A device was used to measure dental midline deviation and the canine tip in the dental arches (in degrees). It was also verified the distance of the upper canines from the palatal suture, intercanine distance, and anteroposterior upper and lower first molar position. **Results:** Dental arches of individuals from all groups presented asymmetry, regardless of the presence of malocclusion. Group I showed a lower asymmetry degree in relation to Groups II and III. The asymmetry in Groups II and III was similar. **Conclusion:** The dental arches of individuals with natural normal occlusion and with Class II, Division 1 and Division 2 malocclusions showed asymmetry. The asymmetry degree was higher in the mandibular dental arches than in the maxillary dental arches in all 3 evaluated groups.

Keywords: Dental arch. Abnormalities. Growth and development. Anatomy and histology. Malocclusion.

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INTRODUCTION

The study of form and transverse dimensions of dental arches is of great relevance to orthodontists. Correcting skeletal and dental midlines, as well as coordinating the position of teeth in each side of the arch, lead to maximum intercuspation, correct function, stability of achieved results, anterior and facial dental aesthetics and reduced potential for temporomandibular joint dysfunction.¹

The midpalatal suture and the center of the maxillary dental arch are almost coincident, validating the use of the suture as a symmetry axis.^{2,3} Dental arch asymmetry can be caused by a combination of genetic^{3,4} and environmental³ factors, with skeletal, dental or functional repercussions.⁴ In individuals with symmetric development, the slight differences between the right and left sides may be due to external environmental factors, such as: Thumb sucking, unilateral chewing, loss of contact due to cavities, extraction or trauma.³ Children can also feature asymmetric dental arches,⁵ and older individuals tend to have greater arch asymmetry, resulting from lifelong external environmental factors.⁶

Even symmetrical faces feature skeletal asymmetry, suggesting that soft tissues minimize the existing asymmetry. Dentoalveolar regions feature symmetry between the right and left sides, probably due to muscle balance of lingual and labial forces.⁷

It is rare to find a totally symmetric individual. Therefore, small asymmetries are regarded as normal.⁸ Most individuals with normal occlusion may show almost coinciding midlines (deviation smaller than 1 mm), and many can have molar asymmetry greater than 1 mm in transversal and anteroposterior directions.⁹ Dental midline deviations greater than 2 mm are easily detected by lay persons, and should therefore be considered when planning orthodontic treatments.¹⁰

Dental asymmetries and a variety of functional deviations can be treated with orthodontics, but significant asymmetries of facial structures may

require orthopedic correction during growth period and/or later surgical treatment.⁴

Some authors have observed skeletal asymmetries both in normal occlusion and malocclusion groups,^{2,11} with pre-orthodontic treatment patients showing more symmetrical arches.² Conversely, other authors revealed a tendency for posterior crossbite in individuals with malocclusion,¹² and a greater tendency towards dental arch asymmetries in individuals with Angle Class II and/or Class III malocclusions.^{13,14} Other studies showed asymmetries in the dental arches of individuals with normal occlusion, in the passage from adolescence to adult age, further questioning the possibility of achieving post-treatment stability.⁵

The verification of dental arch asymmetries during diagnosis makes it possible to choose the appropriate mechanics for orthodontic treatment—for instance, whether to recommend extractions. When opting for tooth extractions, arch symmetry should be controlled throughout orthodontic movement.

In cases of dental arch asymmetry, therapy with asymmetric extractions can reduce complications resulting from patient compliance to the use of elastic bands, as well as reducing the length of orthodontic treatment. Atypical extractions can also benefit pre-surgery orthodontic preparation.¹⁶

Caution must be taken when planning orthodontic treatments, as there are cases when transversal asymmetry of dental arches is not corrected after orthodontic treatment, and orthodontic cases originate dental arches that are larger than those without extraction.¹⁷

There is great ethnic diversity among the Brazilian population, raising questions on the applicability of standards and measurements previously established in more homogenous populations. Based on that premise, the objective of this study was to evaluate the presence and degree of asymmetry of the maxillary and mandibular dental arches in Brazilian individuals with normal occlusion or Angle Class II, Divisions 1 and 2 malocclusion.

MATERIAL AND METHODS

Material

The experimental group consisted of plaster cast models of mandibular and maxillary dental arches from 80 patients with ages varying between 12 and 21 years. The experimental group was composed using the following selection criteria: a) Permanent dentition, with exception of third molars; b) Brazilian ethnicity; c) Not subjected to any orthodontic intervention. They were then divided into three groups:

- » Group 1: 60 pairs of models from individuals with natural normal occlusion, featuring at least 4 of Andrews' 6 keys to occlusion.
- » Group 2: 60 pairs of models from individuals with Angle Class II, Division 1 malocclusion.
- » Group 3: 60 pairs of models from individuals with Angle Class II, Division 2 malocclusion.

The plaster models are part of the collection belonging to the Orthodontics Graduate Program of the Methodist University of São Paulo (UMESP), São Bernardo do Campo/SP, Brazil.

Methods

Model measurements were obtained from an original device, developed specifically to analyze dental arch asymmetries. It was conceived and designed at UMESp, in the Orthodontics Department, manufactured in steel and aluminum. A millimeter ruler and metallic protractor were adapted to obtain measurements. The models were positioned in a delineator base (used in the manufacture of removable partial prostheses) fixed in the base of the appliance using a screw manufactured specifically for that purpose (Fig 1).

The maxillary model midline was determined by marking points over the midpalatal suture, from the incisive papilla to the most visible posterior landmark.^{5,18} By connecting these points, the symmetry axis is obtained, which if prolonged anteriorly up to the incisal

edge of the maxillary incisor determined point As (anterior-superior), and posteriorly, up to the posterior surface of the maxillary model, determining point Ps (posterior-superior), as shown in Figure 2.

To determine the mandibular midline, the midline projection obtained in the maxillary dental arch was used, according to Alavi.¹⁹ The maxillary midline was transferred to the mandibular model, using the As and Ps reference points.

The models, properly cropped, were placed in occlusion, so that their posterior surfaces coincided in the same place. Landmark Ps of the maxillary model was transferred onto the mandibular model using a squared ruler, positioned perpendicular to the base of the mandibular model. This defined landmark Pi (posterior-inferior) in the mandibular model (Fig 3).

Next, using the squared ruler equally positioned anteriorly to the models, coinciding with point As of the maxillary model, landmark Ai (anterior-inferior) was marked in the mandibular model (Fig 4). The assessment of points Ai and Pi made it possible to determine the mandibular midline (Fig 5). Thus, two angular measurements and three linear measurements were made in each of the plaster cast models.

To assess the reliability of the obtained measurements, they were repeated in 20 pairs of models selected at random. These measurements were made 15 days after obtaining the initial data.

Angular measurements performed

- » Midline deviation, in degrees (MD): The reference used to position the models on the device was the midpalatal suture. The positioning, in degrees, of the maxillary and mandibular midline in relation to the midpalatal suture was measured using the protractor in the device, as shown in Figures 6 and 7.
- » Positioning of canines in the dental arches, in degrees (PC): The reference point in the



FIGURE 1 - Measuring device with models in position: frontal view (A), posterior view (B).



FIGURE 2 - Determining the maxillary midline (points As and Ps).

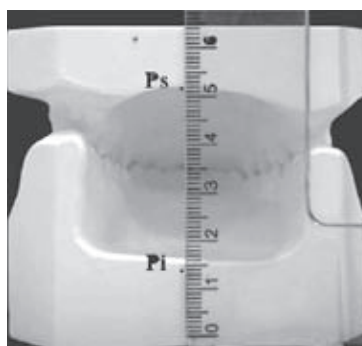


FIGURE 3 - Transferring point Ps to the mandibular model (obtaining point Pi).

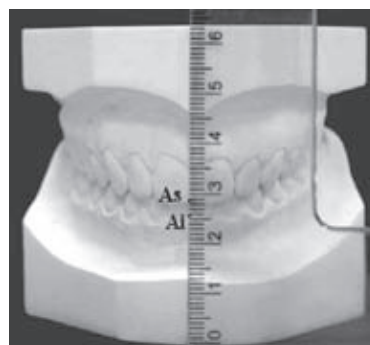


FIGURE 4 - Transferring point As to the mandibular model (obtaining point Ai).



FIGURE 5 - Determining the mandibular midline (points Ai e Pi).

canines was the cusp tip. The positioning, in degrees, of right and left maxillary and mandibular canines in relation to the midpalatal suture, was measured using the protractor in the device (Fig 8).

Linear measurements performed

- » Distance of right and left canines in relation to the midpalatal suture (DC): The cusp tip was used as reference to measure the distance from the maxillary and mandibular

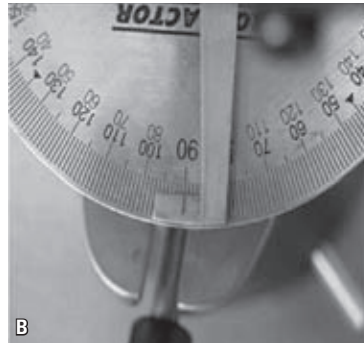
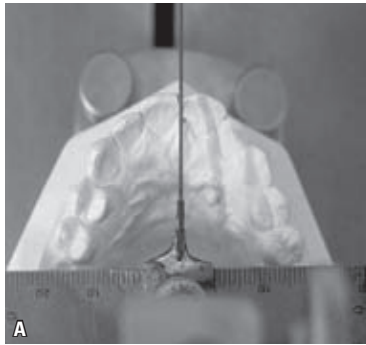


FIGURE 6 - Model positioned with the protractor in the zero position over the palatine raphe (A); protractor in the 90° position – initial position (B).

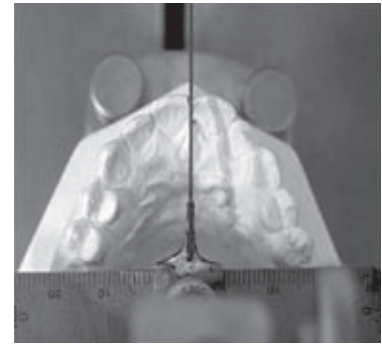


FIGURE 7 - Model positioned with the hand over the dental midline.

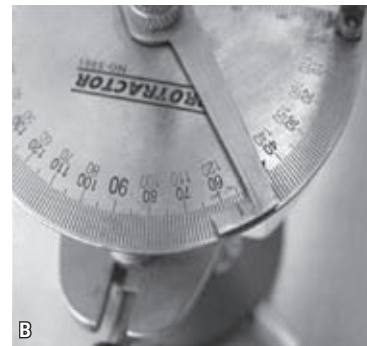
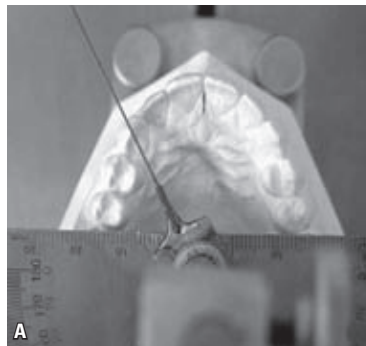


FIGURE 8 - Model positioned with the hand over the cusp of the right maxillary canine (A); protractor pointing the position of the right maxillary canine at 33.5° (B).

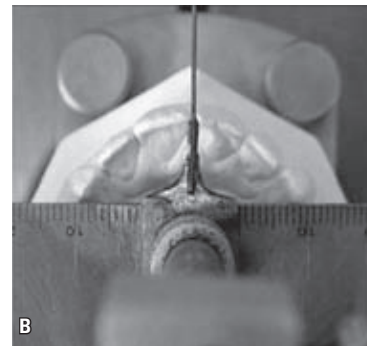
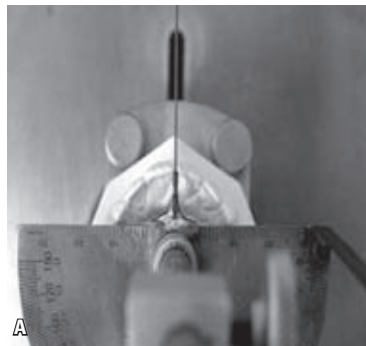


FIGURE 9 - Model positioned for measurement of DC (right and left) and ICD (A); close-up view of the model and ruler used to measure DC and IDC (B).

canines to the midpalatal suture (Fig 9).

- » Intercanine distance (ICD): The cusp tip of canines was used as reference point to measure intercanine distance, in the maxillary and mandibular models (Fig 9).
- » Position of the maxillary and mandibular

first molars, in anteroposterior direction (PM): The distance was measured longitudinally from the mesial marginal crest of the molar positioned more distally to the mesial marginal crest of opposite side molar, as shown in Figures 10 and 11.

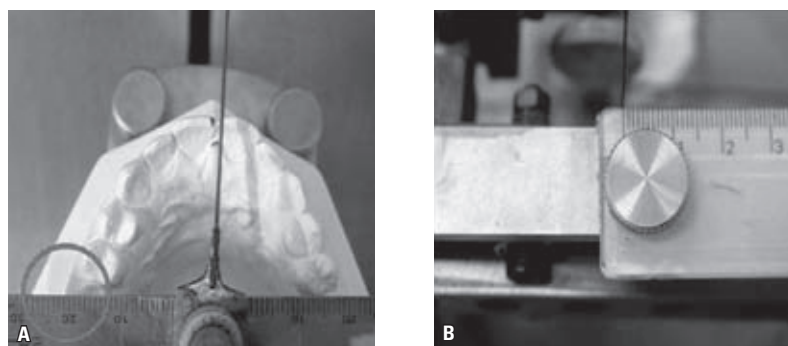


FIGURE 10 - Model positioned evidencing a more mesial positioning of the right-side maxillary first molar, in relation to its left-side counterpart (A); ruler recording the positioning of the right-side maxillary first molar at the zero position (B).

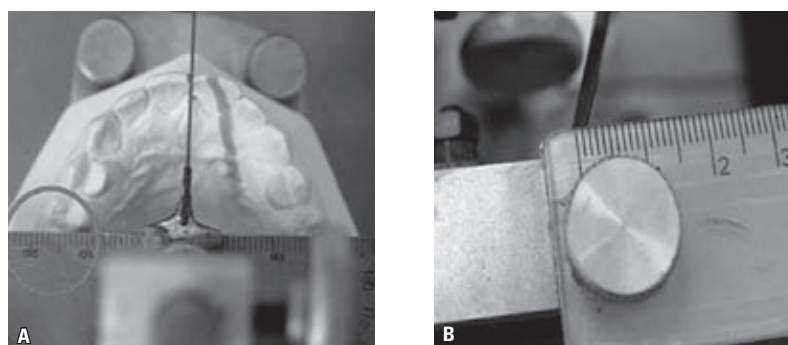


FIGURE 11 - Device positioned at the level of the mesial marginal crest of the right-side maxillary first molar (A); ruler recording a more mesial positioning of the right-side maxillary first molar by 1.5 mm, in relation to its left-side counterpart (B).

RESULTS

In order to verify intra-examiner systematic error, the paired t-test was used; to determine casual error, Dahlberg's error formula was applied. The comparison of studied measurements among groups was done using ANOVA. Whenever it indicated a statistically significant difference, Tukey's test was applied for multiple comparisons. For statistical calculations of measurements MD and PM, left-side deviations were recorded as negative and right-side deviations as positive. The measurements marked as “_dif” refer to the difference between right and left sides. Measurements marked as “_abs” refer to the absolute value (positive) of measurements, which can oscillate between negative and positive, in order to analyze the level of deviation, regardless of direction (Tables 1 to 4).

To verify the correlations between measurement MD and PC_dif, DC_dif and PM, Pearson's correlation coefficient was used (Table 5). Tests were executed in Statistica for Windows 5.1 software, with significance level of 5%.

DISCUSSION

In evaluating dental midline deviation on the maxillary arch, a lower value was observed for group 1, followed by groups 2 and 3. There was a statistically significant difference between groups 1 x 2 and 2 x 3 for MD; and 1 x 3 for MD_abs. In the mandibular arch, group 1 continued to show lower values, but group 2 showed higher values than group 3. There was a statistically significant difference between groups 1 x 2 and 1 x 3 for MD_abs, with no statistically significant difference be-

TABLE 1 - Mean, standard deviation and Analysis of Variance, for comparison of measurements among the three groups, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-1		Class II-2		F	p
		mean	SD	mean	SD	mean	SD		
Maxillary	MD	-0.24	0.88	-0.28	1.49	0.53	1.70	6.46	0.002*
	MD_abs	0.43	0.80	0.92	1.21	1.10	1.40	5.40	0.005*
	PC_right	34.11	1.48	32.26	2.15	33.61	2.15	14.46	0.000*
	PC_left	34.57	1.49	33.07	2.43	33.91	2.13	8.03	0.000*
	PC_dif	-0.46	1.67	-0.81	2.42	-0.30	2.99	0.69	0.502
	PC_dif_abs	1.01	1.40	1.99	1.58	1.92	2.31	5.51	0.005*
	DC_right	17.54	1.09	17.13	1.61	17.91	1.80	3.94	0.021*
	DC_left	17.19	1.04	16.64	1.50	16.82	1.24	2.99	0.053
	DC_dif	0.35	1.20	0.49	1.62	1.09	1.95	3.57	0.030*
	DC_dif_abs	0.78	0.97	1.07	1.30	1.41	1.73	3.14	0.046*
	ICD	34.73	1.76	33.76	2.65	34.72	2.40	3.55	0.031*
	PM	-0.20	1.18	-0.27	1.14	-0.18	1.86	0.06	0.945
Mandibular	PM_abs	0.87	0.81	0.78	0.87	1.32	1.32	4.70	0.010*
	MD	-0.13	1.38	0.81	2.55	0.32	2.47	2.70	0.070
	MD_abs	0.96	0.99	1.94	1.82	1.70	1.81	6.23	0.002*
	PC_right	28.66	1.57	28.63	4.14	28.98	2.75	0.25	0.781
	PC_left	28.49	1.87	27.37	2.67	27.71	2.02	4.07	0.019*
	PC_dif	0.17	2.30	1.26	5.30	1.27	3.80	1.51	0.225
	PC_dif_abs	1.77 a	1.46	4.24 b	3.38	3.12 c	2.49	13.98	0.000*
	DC_right	12.88	0.80	13.05	1.81	12.73	1.38	0.78	0.462
	DC_left	13.50	0.97	13.27	1.52	13.25	1.45	0.64	0.529
	DC_dif	-0.62	1.11	-0.22	2.58	-0.52	2.01	0.63	0.536
	DC_dif_abs	1.00	0.78	1.89	1.75	1.52	1.40	6.40	0.002*
	ICD	26.38	1.39	26.33	2.12	25.98	1.99	0.81	0.448
	PM	-0.02	1.38	-0.20	1.84	0.20	1.97	0.79	0.456
	PM_abs	1.12	0.79	1.37	1.23	1.57	1.19	2.57	0.080

* statistically significant difference (p<0.05).

tween MD averages. With regard to MD_abs, it was noticed that dental midline deviation values were higher for the left side in groups 1 and 2, represented by the negative sign, and higher for the right side in group 3, represented without any sign for positive value. In the mandibular arch, the average of values for the left side was higher only in group 1. These negative values for MD mean that the average for left-side midline deviation values was higher than the average deviation val-

ues for the right side, which in the final average show as negative, representing a greater frequency of deviation to the left side.

With regard to the positioning of canines, in degrees, group 1 showed a smaller difference between the right and left sides than the other groups, representing a lower degree of asymmetry in both arches. In the maxillary arch, group 2 showed higher values for PC_dif and PC_dif_abs; statistically significant values were found only for

TABLE 2 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 1 and 2, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-1		p
		mean	SD	mean	SD	
Maxillary	MD	-0.24	0.88	-0.28	1.49	>0.05
	MD_abs	0.43	0.80	0.92	1.21	>0.05
	PC_right	34.11	1.48	32.26	2.15	<0.05*
	PC_left	34.57	1.49	33.07	2.43	<0.05*
	PC_dif	-0.46	1.67	-0.81	2.42	>0.05
	PC_dif_abs	1.01	1.40	1.99	1.58	<0.05*
	DC_right	17.54	1.09	17.13	1.61	>0.05
	DC_left	17.19	1.04	16.64	1.50	>0.05
	DC_dif	0.35	1.20	0.49	1.62	>0.05
	DC_dif_abs	0.78	0.97	1.07	1.30	>0.05
	ICD	34.73	1.76	33.76	2.65	<0.05*
	PM	-0.20	1.18	-0.27	1.14	>0.05
	PM_abs	0.87	0.81	0.78	0.87	>0.05
Mandibular	MD	-0.13	1.38	0.81	2.55	>0.05
	MD_abs	0.96	0.99	1.94	1.82	<0.05*
	PC_right	28.66	1.57	28.63	4.14	>0.05
	PC_left	28.49	1.87	27.37	2.67	>0.05
	PC_dif	0.17	2.30	1.26	5.30	>0.05
	PC_dif_abs	1.77	1.46	4.24	3.38	<0.05*
	DC_right	12.88	0.80	13.05	1.81	>0.05
	DC_left	13.50	0.97	13.27	1.52	>0.05
	DC_dif	-0.62	1.11	-0.22	2.58	>0.05
	DC_dif_abs	1.00	0.78	1.89	1.75	<0.05*
	ICD	26.38	1.39	26.33	2.12	>0.05
	PM	-0.02	1.38	-0.20	1.84	>0.05
	PM_abs	1.12	0.79	1.37	1.23	>0.05

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

PC_dif_abs between groups 1 x 2 and 1 x 3. The average of PC_dif values was higher for the left side than for the right. In the mandibular arch, groups 2 and 3 showed almost similar values for PC_dif. For PC_dif_abs, however, group 2 showed higher values; statistically significant values among the three groups were found only for PC_dif_abs. The average for PC_dif values was higher for the right side than for the left. Regardless of malocclusion, the values for differences between the

positioning of right- and left-side canines were higher in the mandibular than in the maxillary arch, with exception of PC_dif for group 1. As with the analysis of midline deviation, the mandibular arch showed a higher degree of asymmetry than its maxillary counterpart.

The distances from the right and left canines to the palatine raphe, in millimeters, were measured as well. Group 1 showed lower values for that difference, between the right and left sides,

TABLE 3 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 1 and 3, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-2		p
		mean	SD	mean	SD	
Maxillary	MD	-0.24	0.88	0.53	1.70	<0.05*
	MD_abs	0.43	0.80	1.10	1.40	<0.05*
	PC_right	34.11	1.48	33.61	2.15	>0.05
	PC_left	34.57	1.49	33.91	2.13	>0.05
	PC_dif	-0.46	1.67	-0.30	2.99	>0.05
	PC_dif_abs	1.01	1.40	1.92	2.31	<0.05*
	DC_right	17.54	1.09	17.91	1.80	>0.05
	DC_left	17.19	1.04	16.82	1.24	>0.05
	DC_dif	0.35	1.20	1.09	1.95	<0.05*
	DC_dif_abs	0.78	0.97	1.41	1.73	<0.05*
	ICD	34.73	1.76	34.72	2.40	>0.05
	PM	-0.20	1.18	-0.18	1.86	>0.05
	PM_abs	0.87	0.81	1.32	1.32	<0.05*
Mandibular	MD	-0.13	1.38	0.32	2.47	>0.05
	MD_abs	0.96	0.99	1.70	1.81	<0.05*
	PC_right	28.66	1.57	28.98	2.75	>0.05
	PC_left	28.49	1.87	27.71	2.02	>0.05
	PC_dif	0.17	2.30	1.27	3.80	>0.05
	PC_dif_abs	1.77	1.46	3.12	2.49	<0.05*
	DC_right	12.88	0.80	12.73	1.38	>0.05
	DC_left	13.50	0.97	13.25	1.45	>0.05
	DC_dif	-0.62	1.11	-0.52	2.01	>0.05
	DC_dif_abs	1.00	0.78	1.52	1.40	>0.05
	ICD	26.38	1.39	25.98	1.99	>0.05
	PM	-0.02	1.38	0.20	1.97	>0.05
	PM_abs	1.12	0.79	1.57	1.19	>0.05

* statistically significant difference (p<0.05).

than the other groups, with exception of DC_dif, which represented the highest value for the average of group 1. Even so, this group again showed a lesser degree of asymmetry of dental arches. In the maxillary arch, group 3 featured higher averages for both DC_dif and DC_dif_abs, with statistically significant values between groups 1 x 3 and 2 x 3 for both variables. And, contrary to PC_dif, the values of averages for DC_dif were higher for the right side as compared to the left in this arch.

In the mandibular arch, group 1 showed higher values for DC_dif, followed by group 3, with group 2 featuring the lowest averages, with no statistically significant difference among groups for this variable. Averages were higher for the left side than for the right in this arch. For DC_dif_abs, the highest values were obtained by group 2, and the lowest by group 1; statistically significant differences were found only between groups 1 x 2, in this arch.

TABLE 4 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 2 and 3, regardless of gender (n=180).

Arch	Measurement	Class II-1		Class II-2		p
		mean	SD	mean	SD	
Maxillary	MD	-0.28	1.49	0.53	1.70	<0.05*
	MD_abs	0.92	1.21	1.10	1.40	>0.05
	PC_right	32.26	2.15	33.61	2.15	<0.05*
	PC_left	33.07	2.43	33.91	2.13	>0.05
	PC_dif	-0.81	2.42	-0.30	2.99	>0.05
	PC_dif_abs	1.99	1.58	1.92	2.31	>0.05
	DC_right	17.13	1.61	17.91	1.80	<0.05*
	DC_left	16.64	1.50	16.82	1.24	>0.05
	DC_dif	0.49	1.62	1.09	1.95	>0.05
	DC_dif_abs	1.07	1.30	1.41	1.73	>0.05
	ICD	33.76	2.65	34.72	2.40	>0.05
	PM	-0.27	1.14	-0.18	1.86	>0.05
	PM_abs	0.78	0.87	1.32	1.32	<0.05*
Mandibular	MD	0.81	2.55	0.32	2.47	>0.05
	MD_abs	1.94	1.82	1.70	1.81	>0.05
	PC_right	28.63	4.14	28.98	2.75	>0.05
	PC_left	27.37	2.67	27.71	2.02	>0.05
	PC_dif	1.26	5.30	1.27	3.80	>0.05
	PC_dif_abs	4.24	3.38	3.12	2.49	<0.05*
	DC_right	13.05	1.81	12.73	1.38	>0.05
	DC_left	13.27	1.52	13.25	1.45	>0.05
	DC_dif	-0.22	2.58	-0.52	2.01	>0.05
	DC_dif_abs	1.89	1.75	1.52	1.40	>0.05
	ICD	26.33	2.12	25.98	1.99	>0.05
	PM	-0.20	1.84	0.20	1.97	>0.05
	PM_abs	1.37	1.23	1.57	1.19	>0.05

* statistically significant difference (p<0.05).

With regard to intercanine distance, a statistically significant difference was observed only in the maxillary arch, between groups 1 x 2. This difference is not relevant from a clinical standpoint. As shown in another work,¹² intercanine distance in the maxillary arch showed higher values in group 1 than in the other groups, while in the mandibular arch the groups showed similar values.

Molar position, in the anteroposterior direction, was evaluated comparing the molar from one side to its opposite side counterpart. In the maxillary arch, the averages of variation in position of these teeth were higher for left-side molars in the three groups, and there was no statistically significant difference in PM among the groups. For PM_abs, there were statistically significant differences among groups 1 x 3 and 2 x 3. In the mandibular arch, there was

TABLE 5 - Pearson's correlation coefficient between MD and measurements PC_dif, DC_dif and PM.

Group	Arch	Measurement	r	p
Normal	Maxillary	PC_dif	0.58	0.000*
		DC_dif	0.35	0.006*
		PM	-0.29	0.022*
	Mandibular	PC_dif	0.71	0.000*
		DC_dif	0.78	0.000*
		PM	-0.60	0.000*
Class II-1	Maxillary	PC_dif	0.46	0.000*
		DC_dif	0.43	0.001*
		PM	0.13	0.328
	Mandibular	PC_dif	0.84	0.000*
		DC_dif	0.67	0.000*
		PM	-0.55	0.000*
Class II-2	Maxillary	PC_dif	0.27	0.037*
		DC_dif	0.54	0.000*
		PM	-0.34	0.008*
	Mandibular	PC_dif	0.82	0.000*
		DC_dif	0.77	0.000*
		PM	-0.61	0.000*

* statistically significant correlation ($p < 0.05$).

no statistically significant difference among the three groups, either for PM or PM_abs. In groups 1 and 2, PM values were higher for left-side molars, while in group 3 they were higher for the right side.

Corroborating the works of other authors,^{2-5,8,9} individuals with natural normal occlusion (group 1) showed dental arch asymmetry, even if in a lesser degree than individuals with Angle Class II, Division 1 malocclusion (group 2) and Angle Class II, Division 2 malocclusion (group 3).

Although group 1 showed a smaller degree of asymmetry than the other two groups, a small difference was noticed between the degrees of asymmetry shown by groups 2 and 3; in other words, the results do not show an expressive difference, clinically speaking, among the measured variables, when comparing only groups 2 and 3. This indicates a greater degree of asymmetry for groups with malocclusion, in agreement with other authors.¹³

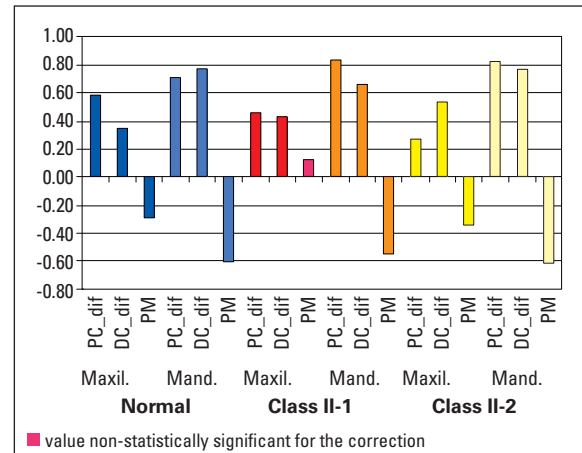


FIGURE 12 - Pearson's correlation between MD and measurements PC_dif, DC_dif and PM, in all three studied groups.

As in other research studies,^{9,11,13,14} the degree of asymmetry of the mandibular dental arch was greater than its maxillary counterpart, for all three groups, regardless of the presence or not of malocclusion.¹²

To facilitate the interpretation of the analysis of asymmetry degree of dental arches, Pearson's correlation test was also performed to evaluate the MD ratio and measurements for PC_dif, DC_dif and PM.

Pearson's correlation was statistically significant among the 3 measurements (PC_dif, DC_dif and PM) and MD in all groups and arches, except for measurement PM in Angle Class II, Division 1 malocclusion for the maxillary arch (Fig 12).

The significant correlations were directly proportional for measurements PC_dif and DC_dif and inversely proportional for measurement PM. A higher correlation value could also be observed in the mandibular arch, when compared to the correlation in the maxillary arch.

The results of Pearson's correlation analysis revealed that the occurrences of MD, PC_dif and DC_dif were in the same direction, whereas for MD and PM, they were in opposite directions. This means that whenever the midline deviation

was towards the right side, the left-side molar was more mesial in relation to the right-side molar and vice-versa, in both arches.

With regard to the maxillary arch of group 2, factors such as tooth rotation and more severe crowding, found in the entire group, can explain the fact that this correlation is different than the other groups only in this arch of this group.

Dental arch asymmetry is a widely discussed subject in orthodontic literature, from its possible causes (such as heredity,³ chewing^{3,6,7} and posture^{3,6} habits, early tooth loss and agenesis with resulting movement of adjacent teeth^{3,4,17}) to the several different diagnostic resources^{4,10,16,17} and treatment possibilities^{1,10,16,17} in the first phases of orthodontic mechanics, aiming for a successful orthodontic treatment resulting in an occlusion with better post-treatment stability. This stability also deserves special attention, because it is questioned over time, as individuals reach adult age.^{1,2,6,15,16,17}

This study introduced a new methodology, with measurements in plaster cast models, to analyze the asymmetry of dental arches. The obtained results will provide important data that can be used by clinical professionals and researchers in orthodontics, both in the diagnosis and planning or new cases to be treated, as in devising new research studies.

CONCLUSIONS

After a judicious analysis of the applied methodology and the results obtained in this study, it can be concluded that:

- 1) Asymmetry in the dental arches was found in all individuals, regardless of the presence of malocclusion.
- 2) Individuals with natural normal occlusion showed a smaller degree of asymmetry than individuals with Angle Class II, Division 1 and Angle Class II, Division 2 malocclusions, and the latter two featured similar degrees of asymmetry.
- 3) The degree of asymmetry in mandibular dental arches was greater than in maxillary dental arches for all 3 evaluated groups.
- 4) The direction of midline deviation showed a correlation directly proportional to the difference in position of the canines and to the difference in the distances from the canines to the palatine raphe.
- 5) The direction of midline deviation showed a correlation inversely proportional to the side of the molar positioned most mesially, in both arches of all three groups, with exception of the maxillary arch in group 2 (Angle Class II, Division 1).

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Study of the number of occlusal contacts in maximum intercuspation before orthodontic treatment in subjects with Angle Class I and Class II Division 1 malocclusion

Gustavo Adolfo Watanabe-Kanno*, Jorge Abrão**

Abstract

Objective: Define and compare numbers and types of occlusal contacts in maximum intercuspation. **Methods:** The study consisted of clinical and photographic analysis of occlusal contacts in maximum intercuspation. Twenty-six Caucasian Brazilian subjects were selected before orthodontic treatment, 20 males and 6 females, with ages ranging between 12 and 18 years. The subjects were diagnosed and grouped as follows: 13 with Angle Class I malocclusion and 13 with Angle Class II Division 1 malocclusion. After analysis, the occlusal contacts were classified according to the established criteria as: tripodism, bipodism, monopodism (respectively, three, two or one contact point with the slope of the fossa); cuspid to a marginal ridge; cuspid to two marginal ridges; cuspid tip to opposite inclined plane; surface to surface; and edge to edge. **Results:** The mean number of occlusal contacts per subject in Class I malocclusion was 43.38 and for Class II Division 1 malocclusion it was 44.38, this difference was not statistically significant ($p>0.05$). **Conclusions:** There is a variety of factors that influence the number of occlusal contacts between a Class I and a Class II, Division 1 malocclusion. There is no standardization of occlusal contact type according to the studied malocclusions. A proper selection of occlusal contact types such as cuspid to fossa or cuspid to marginal ridge and its location in the teeth should be individually defined according to the demands of each case. The existence of an adequate occlusal contact leads to a correct distribution of forces, promoting periodontal health.

Keywords: Dental occlusion. Malocclusion. Orthodontics.

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INTRODUCTION

For a long time the basis for evaluation of success for an orthodontic treatment has been the establishment of a normal mesiodistal relation of posterior teeth, ideal overbite and overjet evaluated in a static manner. Along time, the orthodontics has assumed that only such factors are not sufficient to achieve a satisfactory functional balance. Therefore, there is a trend among orthodontists to emphasize the importance in occlusal functional analysis before orthodontic treatment. The success of orthodontic treatment is based on an optimal balance between dental and skeletal components, and requires careful evaluation of occlusal contacts to have an efficient masticatory function.³

Maximum intercuspation (MI) is the most reproducible reference position. The teeth occlude in a position where there is maximum activity of the muscles.²¹ The MI position is morphologically determined by the shape and position of the teeth, periodontal proprioceptors, muscle memory and occlusal contacts. The nerve impulses enable the mandible to open and close, quickly and repeatedly in the same position. Most of the mandibular movements are functional (chewing) or parafunctional (bruxism), and occur in MI¹⁹, hence the importance of studying the occlusal contacts in that mandibular position. Also, it is important to locate the occlusal contacts in MI for maintaining the alignment of the teeth and the occlusal stability.¹⁰

On completion of orthodontic treatment, Andrews six keys of occlusion is one of the main purposes or a Class I malocclusion. Many times orthodontic treatments finish in Class II molar relationship, especially in Class II cases where molar distalizations are not part of the treatment plan. The clinician should be able to recognize and interpret the behavior of occlusal contacts in different malocclusions to obtain stability and function of the stomatognathic system, at the

beginning and most especially during the end of orthodontic treatment in cases that present therapeutic limitations. There is a great variety of studies on occlusal contacts in individuals with normal occlusion. Knowing that to understand what is a malocclusion one should understand a normal occlusion, these studies are used as reference to establish means of comparison.

With the purpose of contributing for a better understanding of this subject, the aim of this study was to define and compare the number and types of occlusal contacts in maximum intercuspation in subjects with Angle Class I and Class II Division 1 malocclusions before orthodontic treatment.

MATERIAL AND METHODS

The study sample consisted of 26 untreated subjects, 20 males and 6 females, Caucasians, with ages between 12 and 18 years, at beginning of orthodontic treatment. The patients were diagnosed and grouped into 13 with Angle Class I malocclusion and 13 with Angle Class II Division 1 malocclusion, from the Orthodontic Clinic of the Dental School of São Paulo University, following these criteria: Complete permanent dentition with erupted second molars, no caries lesions, no interproximal wear, no extractions nor previous orthodontic treatment, healthy periodontal status and absence of temporomandibular joint dysfunction symptoms. This research project was approved by the Ethics Committee on Research of the University of São Paulo, report number 74/07.

Occlusal contact points were determined clinically on patients with the aid of articulated dental casts. The patient was put in a vertical position, with the back and head on a reclined dental chair, approximately 45 degrees to the floor. The patient was asked to open and close his mouth until MI was reached. After prophylaxis and drying of all teeth, the patient was asked to open and close his mouth

in MI and the occlusal contacts were assessed using 12 μm articulating film (Accu film II, Parkell™, Farmingdale, New York, USA). In this way, when in occlusion, the contacts were marked in black on the upper teeth and the lower teeth were marked in red. Using mouth retractors and an intraoral mirror, both arches were photographed (Fig 1).

Then polyvinyl siloxane-based occlusal registrations (Re'CORD®, Bosworth, Illinois, USA) of the posterior occlusion were obtained bi-

laterally with the subjects in maximum intercuspation. Previously the subject was asked to swallow and then to close into maximum intercuspation. The bite registration material was applied to the occlusal surfaces of all lower canines, premolars, and molars both sides with a silicone gun. The subject was required to apply moderate pressure (Fig 2), comparable with the one employed for natural swallowing and chewing, to ensure that teeth were in contact, for 30 seconds. The reproducibility of this



FIGURE 1 - Intraoral photograph of MI contacts in the upper arch (A) and in the lower arch (B).



FIGURE 2 - Occlusal registration in MI.

TABLE 1 - Types of occlusal contacts definitions.

Types of Occlusal Contacts	Definition
Tripodism	Centric retention cusp contacts the perimeter of the slopes of the opponent fossa in three points. ^{3,22}
Bipodism	Centric retention cusp contacts the perimeter of the slopes of the opponent fossa in two points. ⁴
Monopodism	Centric retention cusp contacts the fossa in one individual point. ²³
Cusp to marginal ridge	Contact between the cusp tip and the opposite marginal ridge. ²³
Cusp to two marginal ridges	Two contacts between the cusp tip and two opposite marginal ridges. ²²
Cusp to opposite inclined plane	Individual contact of the cusp tip and the internal slope, external slope, mesial or distal slope on the opposite side. ⁸
Surface to surface	Individual contact between two opposing slopes. ⁸
Edge to edge	Individual contact between cusp tip and cusp tip on the opposite side. ⁸

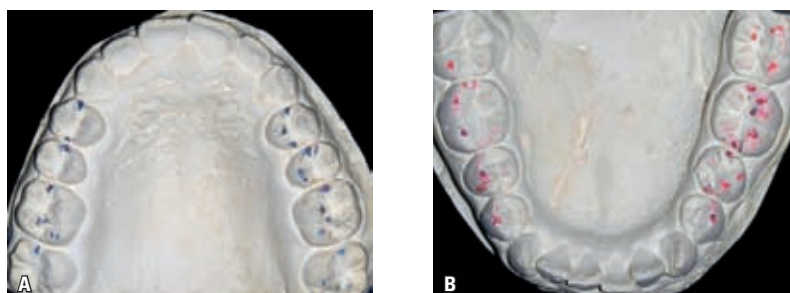


FIGURE 3 - Occlusal contacts in articulated study casts: **A)** upper and **B)** lower.

procedure was checked with the polyvinyl siloxane bite record in maximum intercuspation position; the perforations of the record had to coincide with the occlusal contacts clinically marked with the articulating film. In addition, dental casts were mounted on semi-adjustable articulator (Bio-Art® 4000) in MI. This procedure was performed to facilitate the determination of the occlusal contacts types (Table 1), using Arti-Fol 8 µm articulating film (Bausch, Köln, Germany) (Fig 3).

STATISTICAL ANALYSIS

Data was analyzed using the statistical software SPSS version 16.0 for Windows (SPSS Inc., Chicago, USA) and graphs were constructed using Microsoft Excel 2007. Sample normality and homogeneity of variances were determined using Kolmogorov-Smirnov Z test. Student t-test was used to determine any statistically significant differences in the observed number and location of occlusal contacts between the different types of malocclusions (level of significance at 5%).

RESULTS

The Kolmogorov-Smirnov test demonstrated that values had a normal distribution ($p > 0.05$), therefore comparisons between malocclusion values were performed with parametric tests based on the sample distribution.

Number of occlusal contacts in maximum intercuspation (MI)

The comparison between the mean occlusal contacts in MI on the upper and lower arches, according to the malocclusion is described in Table 2, and demonstrated that:

- » The mean number of total occlusal contacts in Angle Class I malocclusion was 43.38 contacts and in Class II Division 1 it was 44.38. According to the paired t-test there was no statistical difference ($p = 0.79$).
- » The mean of occlusal contacts on the right side was 10.20 (range 7 to 22) and on the left side it was 11.5 (range 6 to 17) for Class I malocclusions. For the Angle Class II Division 1 malocclusion the mean of occlusal contacts was 11.8 (range 8 to 15) on the right side and 10.39 (range 5 to 15) on the left side. No significant difference was observed between the two types of malocclusion.
- » The means of occlusal contacts on lower premolars in Class I and Class II Division 1 malocclusions were 2.62 and 3.92, respectively. This difference was statistically significant ($p = 0.03$).

Distribution of occlusal contacts

Class I malocclusion had a total of 237 contacts of the evaluated types and Class II

Division 1 a total of 246 contacts (Table 3). The highest concentration of the contacts was for the upper and lower first molars in both the Class I malocclusion and Class II Division 1, which had, respectively, an average of 39.12% and 38.87% of all contacts recorded (Fig 4). The second molars had an average of 25.03% and 22.9% of total contacts accounted, respectively. The first lower premolar presented the smallest number of contacts both in Angle Class I and Class II Division 1, reaching

10.87% and 16.60%, respectively. Analyzing the distribution of occlusal contacts in the cuspids, fossa and marginal ridges in Figure 5, we can conclude that from the totality of the contacts made by the centric contention cuspid, 45.07% corresponded to the cuspids of upper teeth and 54.93% to the cuspids of lower teeth in the Class I malocclusion; and 48.34% corresponded to the cuspids of upper teeth and 51.66% to the cuspids of lower teeth in Angle Class II Division 1 malocclusion.

TABLE 2 - Comparison between means of occlusal contacts in MI on the upper and lower arches.

Variables	Class I malocclusion				Class II Division 1 malocclusion				Paired t test
	Mean	SD	Range		Mean	SD	Range		p-value
			Minimum	Maximum			Minimum	Maximum	
Upper first premolars occlusal contacts	3.38	2.29	0.00	9.00	4.38	0.87	3.00	6.00	0.16
Upper second premolars occlusal contacts	4.85	1.91	2.00	8.00	4.54	0.88	3.00	6.00	0.60
Upper first molars occlusal contacts	8.08	2.56	4.00	14.00	8.00	1.68	6.00	11.00	0.93
Upper second molars occlusal contacts	5.31	2.63	2.00	13.00	5.31	3.04	2.00	11.00	0.99
Lower first premolars occlusal contacts	2.62	1.80	0.00	6.00	3.92	0.76	3.00	5.00	0.03*
Lower second premolars occlusal contacts	5.00	1.58	3.00	9.00	4.77	1.36	2.00	7.00	0.69
Lower first molars occlusal contacts	8.15	2.34	5.00	14.00	8.23	1.69	6.00	12.00	0.92
Lower second molars occlusal contacts	6.00	2.74	2.00	13.00	5.23	2.68	2.00	10.00	0.48
Upper right side occlusal contacts	10.08	3.38	7.00	20.00	12.00	1.83	9.00	15.00	0.08
Upper left side occlusal contacts	11.54	3.26	6.00	17.00	10.23	2.42	5.00	14.00	0.26
Lower right side occlusal contacts	11.46	2.79	7.00	16.00	10.54	3.07	5.00	15.00	0.43
Lower left side occlusal contacts	10.31	3.97	7.00	22.00	11.62	1.56	8.00	14.00	0.28
Total occlusal contacts	43.38	11.63	27.00	75.00	44.38	6.02	32.00	53.00	0.79

* Level of significance $p < 0.05$.

TABLE 3 - General distribution of the types of occlusal contacts in absolute numbers.

Class I malocclusion									
Types of occlusal contacts	A	B	C	D	E	F	G	H	Total number
Number of occlusal contacts according to type	6	32	36	49	33	27	51	3	237
Total number of occlusal contacts	18	64	36	49	66	27	51	3	314
Class II Division 1 malocclusion									
Types of occlusal contacts	A	B	C	D	E	F	G	H	Total number
Number of occlusal contacts according to type	9	27	46	34	31	24	74	1	246
Total number of occlusal contacts	27	54	46	34	62	24	74	1	322

A = Tripodism, B = Bipodism, C = Monopodism, D = Cusp to one marginal ridge, E = cusp to two marginal ridges, F = cusp tip to opposite slope, G = surface to surface, H = edge to edge.

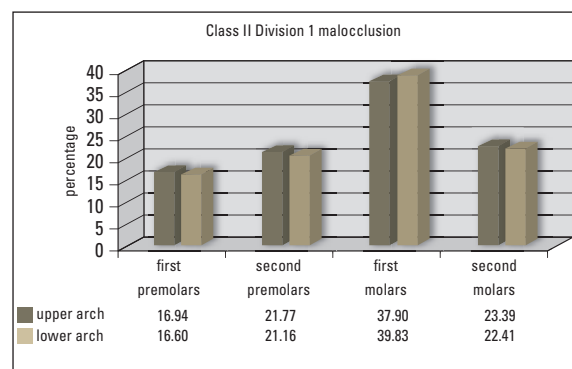
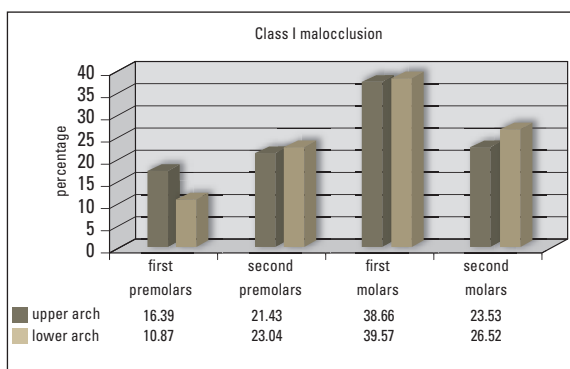


FIGURE 4 - Distribution of occlusal contacts on the upper and lower arches, in percentage, according to the malocclusion.

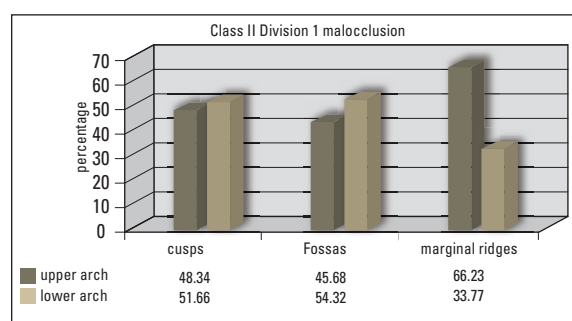
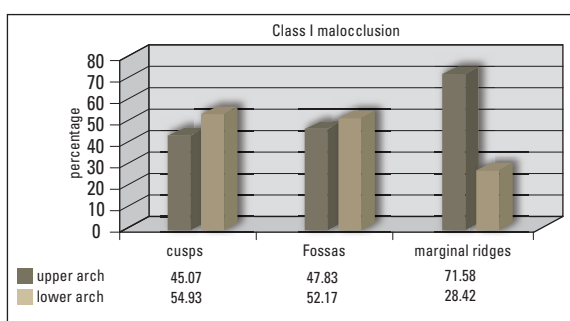


FIGURE 5 - Distribution of occlusal contacts on the cusps, fossas and marginal ridges, in percentage, according to the malocclusion.

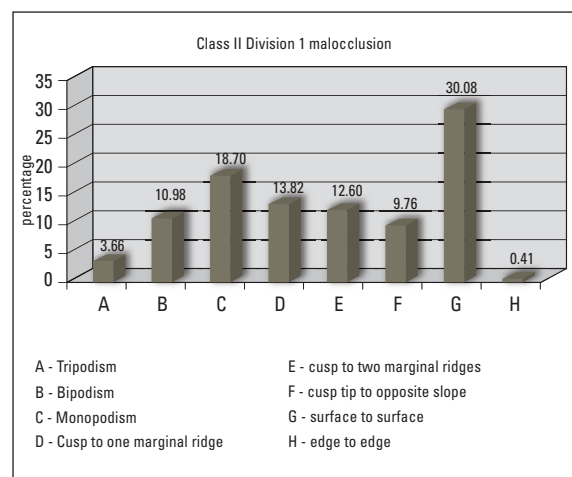
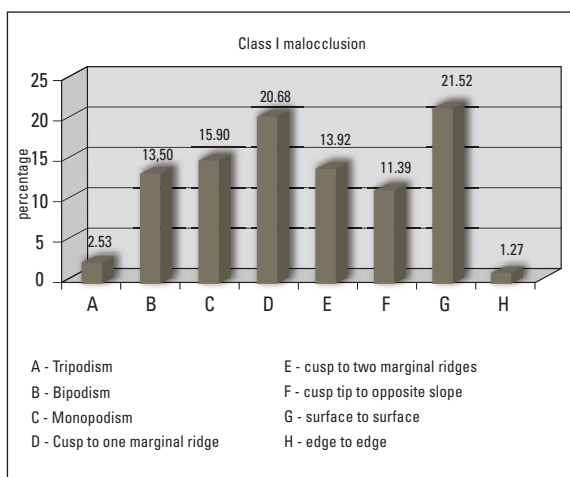


FIGURE 6 - Distribution of types of occlusal contacts, in percentage, according to the malocclusion.

On the other hand, the marginal ridges of the upper teeth had the most contacts in both Class I and Class II Division 1 malocclusions, totaling 71.58% and 66.23%, respectively.

Types of occlusal contacts

In Class I malocclusion (Fig 6), from a total of 237 registered contacts, the higher frequency of occlusal contact types corresponded

to the surface to surface and a cuspid to marginal ridge in 21.52% and 20.68%, respectively. Thus, the tripodism and edge to edge occlusal contacts registered the smallest percentage of total, with 2.53% and 1.27% respectively. On the other hand, in Angle Class II Division 1, from a total of 246 occlusal contacts, the most frequent contact types corresponded to the surface to surface (30.08%) and monopodism (18.70%). The lower frequency was shown by tripodism (3.66%) and edge to edge (0.41%).

DISCUSSION

Comparing the occlusal contacts in maximum intercuspation, between both malocclusions, there were no significant differences. There were no significant differences in most of the variables with the exception of the occlusal contacts on first mandibular premolars. Especially the Class II Division 1 malocclusion showed a higher average of contacts in that tooth, because of the skeletal and dental distal relationship typical characteristic of this malocclusion when compared to Class I malocclusion.

These results are also related to the shape and function of the lower first premolar during mastication. The lower first premolar is the only posterior tooth with a lingual inclination in relation to the occlusal plane, it also has a larger buccal cusp in comparison to the lingual cusp. This shape variation is due to the primary function of the buccal cusp during mastication. This cusp is responsible for perforating food, establishing a primary contact, then the lingual cusp performs the second function which is to grind the food without contacting its antagonist tooth in MI.^{5,18}

In our study, the shape of the lower premolar lingual cusp in Class I malocclusions was mostly smaller than in the Class II Division 1 malocclusion. This finding explains why the Class I malocclusion presented lower number of contacts in this tooth.

The total average of occlusal contacts in Class I malocclusion was 43.38 and in Class II Division 1 malocclusion was 44.38. Considering the mean number of contacts per arch, it was observed that patients with Class I malocclusion had 21.69 contacts and in Class II Division 1, 22.19. This agrees with Gondim et al¹⁴ that registered an average of 23.20 contacts per arch and Oliveira²² with 20.5 contacts, 22 maxillary contacts and 19 mandible contacts in patients with natural normal occlusions. Athanasiou et al⁶ established an average of 23.8 contacts per arch in subjects with normal occlusion using the technique of photo-occlusion. Thus, Ricketts²⁵ also recorded an average of 24 occlusal contacts for patients with normal occlusions. However, as for the number of dental occlusal contacts, Velmovitsky²⁹ found in his study an average of 24.89 contacts in all patients—in disagreement with Hellman,¹⁶ which found 138 possible contacts in a normal occlusion, ranging from 90 to 103 for 28 teeth, and Anderson and Myers² with 565 occlusal contacts evaluated on 32 subjects with an average of 17.7 contacts.

Considering that this research was performed in patients with Class I and Class II Division 1 malocclusions, it can be inferred therefore that small changes in individual and dental positions seem not to produce severe changes in the quantitative behavior of dental occlusal contacts in subjects with complete dentition, but does produce changes regarding their distribution and localization. This fact also explains that no significant differences were found between the mean contact points between the studied malocclusions.

In Class II Division 1 there are no contact between anterior teeth (canine to canine), so only posterior contacts were considered, 246 contacts of the 13 subjects with Class II Division 1 showed an average of 22.19 occlusal contacts, similar to the findings of McNamara and Henry²⁰ with an average of 19.7, Riise and Ericsson²⁶ with

an average of 18.15, and Taicher and Ehrlich¹⁰ with an average of 39.5, Garrido et al¹² with an average of 19.43, and Gondim et al¹⁴ with an average of 18.9. This average was relatively higher in comparison to other studies: Aoki et al⁴ with an average of 7.14, Gazit and Lieberman¹³ with an average of 9.30 (normal occlusion) and 7.60 (malocclusion), Koriath¹⁷ with an average of 14.0, McDevitt and Warreth¹⁹ with an average of 11.5, and Ferrario et al¹¹ with an average of 13.0. Considering that these studies were developed in conditions of normal occlusion and using different methodologies as indirect determination of the occlusal contacts using interocclusal records, T-Scan or using different types of articulation papers, even so this research has reported results without significant differences when compared with other studies mentioned above.

In this study the occlusal contact types such as monopodism, bipodism and tripodism, in their majority concentrates on the first molars in descending order, both in Angle Class I and Class II Division 1 malocclusions. However, in Class I malocclusion, the monopodism occlusal contact type was located on distobuccal cuspid and the central fossa of the first mandibular molar, and the central fossa and the palatal mesial cuspid of the first maxillary molar. In prosthodontics there is no established occlusal pattern and the occlusal types of contacts could be modified individually.⁷

Thus, the relationship cuspid-fossa is the most stable because it tends to direct the forces on the long axis of the teeth and with almost no lateral pressures and the relationship cuspid to one marginal ridge tends to separate the contact points and create an unstable occlusion.²³ The first molars have greater physiological limit, to withstand an amount of load without damaging the periodontal ligament.¹⁵ When occlusal forces are applied to the long axis of the tooth it absorbs certain loads without raising the proprioceptive sensors.

The contact type cuspid to two marginal ridges was located mainly in the second premolar, with similar distribution between upper and lower arches. This type of occlusal relationship can also be considered according to the literature as physiological, because it tends to distribute the occlusal load close to the long axis of the teeth, with the disadvantage of promoting in some cases interproximal separation.¹

According to the types of occlusal contacts in both malocclusions, Class I and Class II Division 1, the type of occlusal contact surface to surface had the greater frequency. This type of occlusal contact does not promote stabilization of the mandible, creating tangential or horizontal forces on the supporting structures of the teeth, maintaining the muscles next to a very high level of activity. The anterior teeth that had occlusal contact occluded on an inclined plane, considered clinically normal and stable. In anterior and posterior teeth with this type of occlusal contact there should be a balance in physiological forces of the tongue, lips, cheeks and occlusion, to maintain its relative position.² Posterior teeth are dependent on this same balance of forces for their physiological stability position. Through continuous eruption or modification in buccal forces, the posterior teeth can slide down on inclined planes to a new position, thus establishing its final occlusal stop. The vertical forces are more easily tolerated because they are directed to the apical region where there is a bone density, for example, cuspid-fossa contacts.²⁷ Lateral forces are more destructive because they are directed against a buccal and lingual alveolar wall, which are fragile and very thin.

In this research, there was a high incidence of these types of occlusal contacts mainly in Angle Class II Division 1 malocclusion, basically due to altered anteroposterior and transverse relationship of dental arches, a skeletal characteristic of this malocclusion.

CONCLUSIONS

1. The average number of occlusal contacts per patient in Class I malocclusion was 43.38 and in Class II Division 1 malocclusion was 44.38, and this difference was not statistically significant. There is a variety of factors that influence the number of occlusal contacts, such as small changes in individual tooth positions (rotations, infraocclusion, extrusion, linguoversions, buccal, mesial and distal displacements) and the anteroposterior and transverse relationship

between jaws and the occlusal morphology of teeth related to the mastication.

2. There is no standardization of the types of occlusal contacts in relation to the studied malocclusions, even when compared with studies in normal occlusal conditions, which shows the same variability. A proper selection of a cuspid-fossa or cuspid-marginal ridge contact and its location in teeth can be individually changed according to the requirements of each case.

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Transverse malocclusion, posterior crossbite and severe discrepancy*

Roberto Carlos Bodart Brandão**

Abstract

This article reports the orthodontic treatment of a 14 years and 2 months old female patient, presenting both anterior and posterior unilateral left crossbite, related to a transverse atrophy of the maxilla and a severe negative tooth-arch discrepancy in the upper arch. A maxillary expansion with a modified Haas appliance was the first therapeutic attempt. Then, fixed appliances were used in both arches, and the second left premolar was extracted. The space for the upper left lateral incisor was achieved with compressed springs and tooth movement was accomplished with double archwires. The final result showed a good intercuspation, considering that the left molar relation remained as a Class II, which demanded special occlusal adjustments. This case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics, representing category 5, as a partial requirement for the BBO certificate.

Keywords: Crossbite. Ectopic. Corrective orthodontics.

HISTORY AND ETIOLOGY

An orthodontic evaluation was first performed when the patient was 13 years old, but treatment only began when she was 14 years and 2 months old according to her parents' decision. Tooth crowding on the upper arch, with aesthetic consequences to her smile, was the chief complaint. She presented favorable con-

ditions for treatment, free of caries and restorations, reasonably good oral hygiene, even on the upper left lateral incisor, rotated towards the palate. Good general health conditions were observed. She had good general health and it was also reported that her mother was submitted to an orthodontic treatment that required extraction of four premolars.

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* Clinical case report, category 5, approved by the Brazilian Board Orthodontics and Facial Orthopedics.

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DIAGNOSIS

The greatest problems were seen in dental analysis. Molars and premolars were edge to edge bilaterally. There was a severe upper crowding, that resulted in the ectopic eruption of tooth #22, palatally rotated and in crossbite. Upper canines were in infraocclusion, with the left side presenting semi-impaction and buccal rotation. Other than that, a moderate buccal inclination of the lower incisors was also observed (Fig 1).

The upper arch asymmetry deserved special attention. The midline was deviated 3 mm to the

left, with a severe distal inclination of tooth #21, further compromising her smile aesthetics (Fig 1). Using the Schmutz's plate, it was clear that the whole upper left side was 3 mm mesial in relation to the right side. An upper lip frenum fibrous attachment was also detected.

Patient presented a good lower arch regarding shape and symmetry, with the lower right first molar revealing an increased buccal root torque, that indicated some sort of constriction on the lower right side (Fig 2). The patient also presented a severe overbite, with the incisal edges of the



FIGURE 1 - Initial facial and intraoral photographs.

lower incisors touching the cervical third of the lingual surface of the upper incisors.

Clinical assessment of the smile revealed a wide buccal corridor, confirmed with the occlusal dental casts analysis, with a moderate transverse constriction of the maxillary arch. This transverse problem was an important cause of the posterior left crossbite (Figs 1, 2 and 3).

Skeletal analysis revealed good maxillomandibular relationship at the anteroposterior aspect ($ANB=2^\circ$). For the vertical aspect, the patient was considered brachyfacial defined by the angles $SN-GoGn=24^\circ$ and $FMA=18^\circ$ (Fig 4).

The concave facial profile represented a challenge both due to a high nasal prominence and a significant soft tissue thickness at the chin level.⁹ The chief complaint was eminently aesthetic, described as a “canted smile”, strictly linked to the space collapse at the anterior part of the upper left side. In this case, the smile line inclination was mainly due to: 1) the inclination of the

upper left central incisor; and 2) to the infraocclusion of the upper left canine, semi-impacted, rather than to the midline deviation.

TREATMENT GOALS

The treatment had as a primary goal the establishment of a better transverse dimension of the maxillary arch by means of skeletal expansion and, consequently to obtain the correction of the posterior crossbite.⁴ For the aesthetic improvement it would be necessary to open space for the alignment of the upper left lateral incisor, together with the uprighiting of all upper anterior teeth in relation to the maxillary skeletal base. The smile line inclination would be finally reached by the extrusion of the upper left canine, provided the dominance of the upper central incisors was still preserved.⁶ Gaining canine disocclusion would be the main occlusal objective, as to reach effective occlusal determinants and anterior occlusal guidance, with immediate

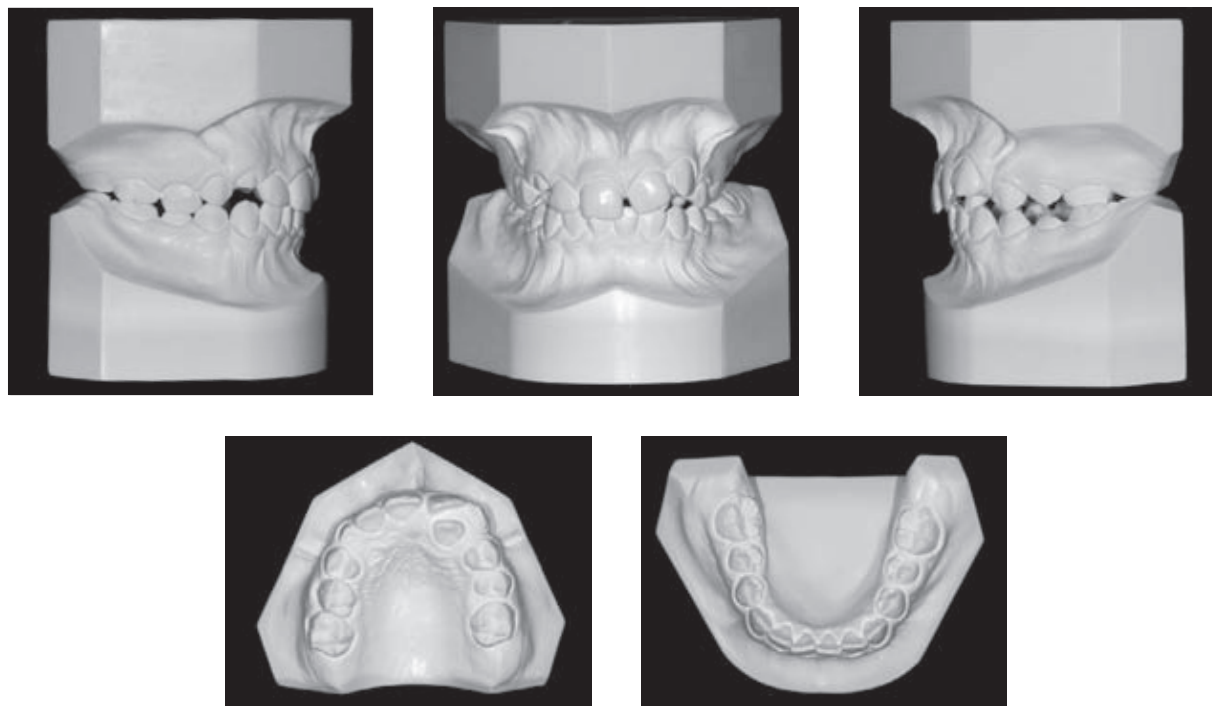


FIGURE 2 - Initial dental casts.

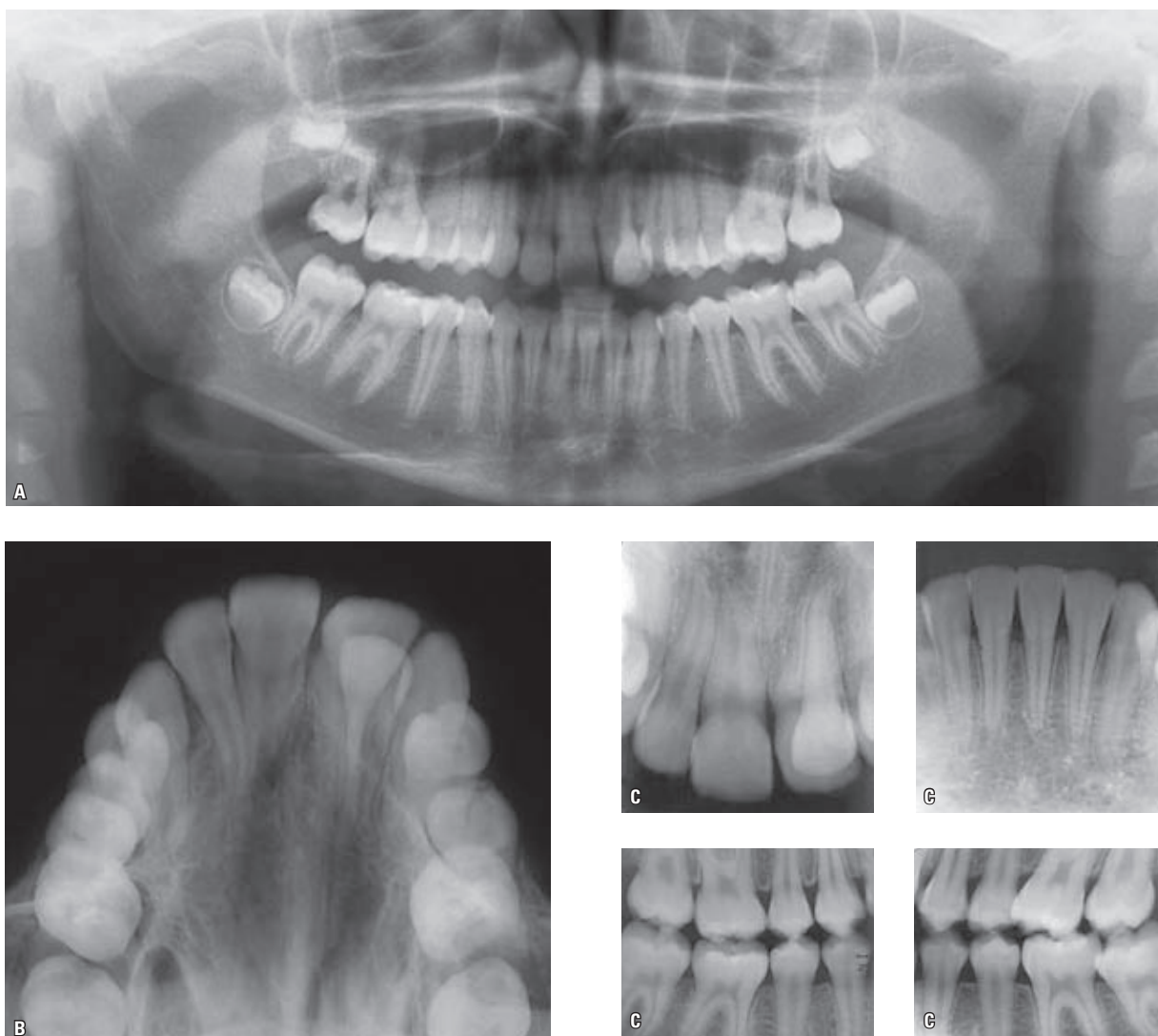


FIGURE 3 - Panoramic (A), upper occlusal (B), anterior region periapicals and posterior region interproximal (C) radiographs.

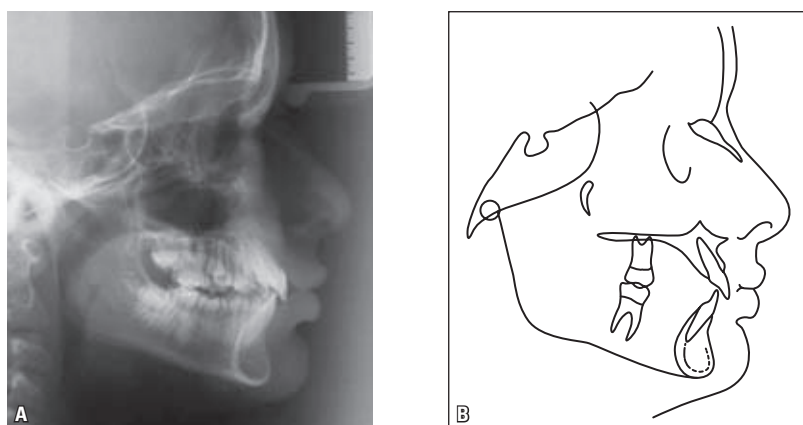


FIGURE 4 - Initial profile cephalometric radiograph (A) and cephalometric tracing (B).

disocclusion in mandibular movements.³ The best posterior intercuspation, with simultaneous and equivalent bilateral contacts should also be present, despite the asymmetric molar relation, with occlusal contacts on the right side and disocclusion on the left side.

TREATMENT PLAN

The treatment plan involved palatal expansion, with an overcorrection of the posterior crossbite—contacts edge to edge of the upper palatal cusps and lower buccal cusps.⁴ Subsequently, an upper removable appliance with an anterior plateau, simultaneously to a lower fixed appliance, including the second molars, would be used in order to accomplish more effective dental leveling and alignment. Upper fixed appliance would be finally included and the request for extraction of the upper left second premolar would be made.

After upper arch leveling, the upper left canine would be distalized using a compression coil spring. The eventual need for an upper frenectomy was also included in the treatment plan. After the 0.019 x 0.025-in stainless steel upper and lower archwires, the upper left lateral incisor had its orthodontic traction planned with an

overlapped TMA 0.017 x 0.025-in wire section. By then, Class II intermaxillary elastics would be attached to the right side.

Manipulation in centric relation at every appointment would be an important reference and to avoid dual bite.¹ Posterior intercuspation and anterior guidance would be finally established with 0.019 x 0.025-in delta loop stainless steel wires in both arches, closing remaining spaces. At the finishing stage priority would be given to control the torque of the upper left lateral incisor. Upper wraparound and lower lingual arch retentions were planned, bonded to the canines by a 0.028-in stainless steel wire.

TREATMENT EVOLUTION

A modified Haas appliance was installed for palatal expansion, fixed to teeth #16 and #26 by wires welded to bands, and to teeth #14 and #24 with wires bonded to the buccal surface by composite resin and with a 7-mm screw, activated twice a day and stabilized after the planned overcorrection was reached (Fig 5).

After four months, the Haas appliance was replaced by a removable appliance with an anterior plateau, creating a posterior disocclusion to accelerate the effects of the fixed appliance on

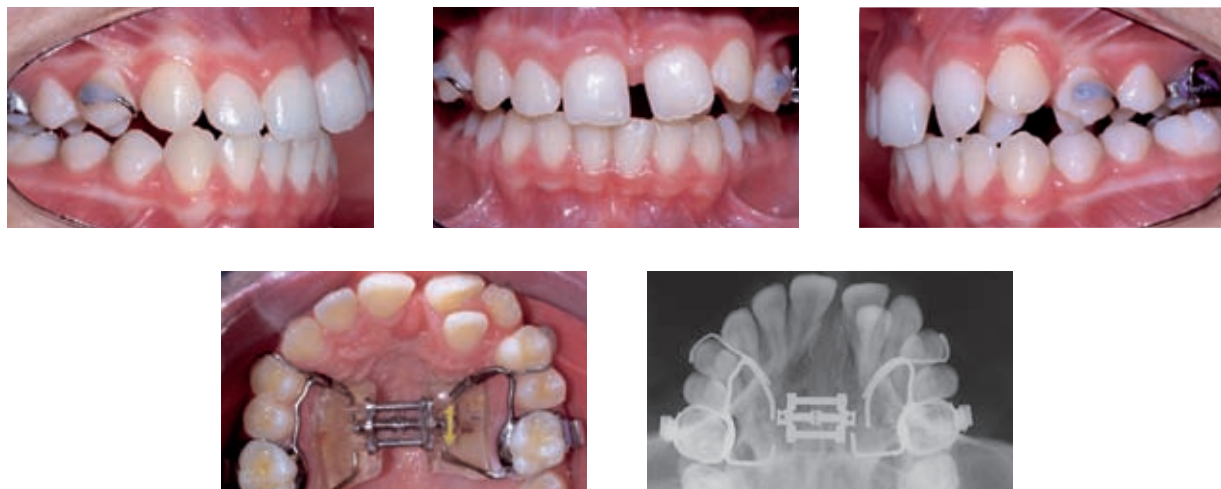


FIGURE 5 - Photographs and occlusal radiograph after palatal expansion.

the lower arch for correction of the severe overbite. In this case, the lower second molars were included in the appliance, with leveling from 0.014-in through 0.020-in archwires.

Extraction of the upper left second premolar was requested in the upper arch. The decision for the extraction of a single premolar was directly linked to the facial profile of the patient. The intention was to avoid retraction of anterior teeth, keeping the lips from retruding. It should be taken into account that the nose and chin would have become more prominent in the face due to the normal ageing pattern of brachyfacial patients.⁹ The fibrous upper lip frenum was also removed.

From 0.018-in upper archwire onwards, chain elastics were used for the distal movement of the upper left premolar and a NiTi open coil spring was incorporated between upper left central incisor and canine, in order to correct both midline deviation and canine distalization (Fig 6). For the alignment of the upper left lateral incisor, a titanium-molybdenum alloy (TMA) 0.017 x 0.025-in

archwire segment was used with a cantilever rectangular loop as a means to achieve root control since the beginning of the movement.

A 0.019 x 0.025-in archwire was initially attached to the lower arch in order to function as anchorage for the Class II intermaxillary elastics on the right side. Subsequently, a rectangular 0.019 x 0.025-in delta loop archwire was attached to the upper arch to close remaining spaces and for root control during finishing stage. The wraparound retention appliance was used on the upper arch and a fixed retainer bonded to canines on the lower arch.

For a better intercuspation on the left side, where there was a molar distoclusion relation, a mesial rotation on the upper left first molar was established.^{1,2}

TREATMENT RESULTS

Considering the patient's final records, an improvement of the transverse dimension of the maxillary arch was noticed, which was crucial for the left side crossbite correction.

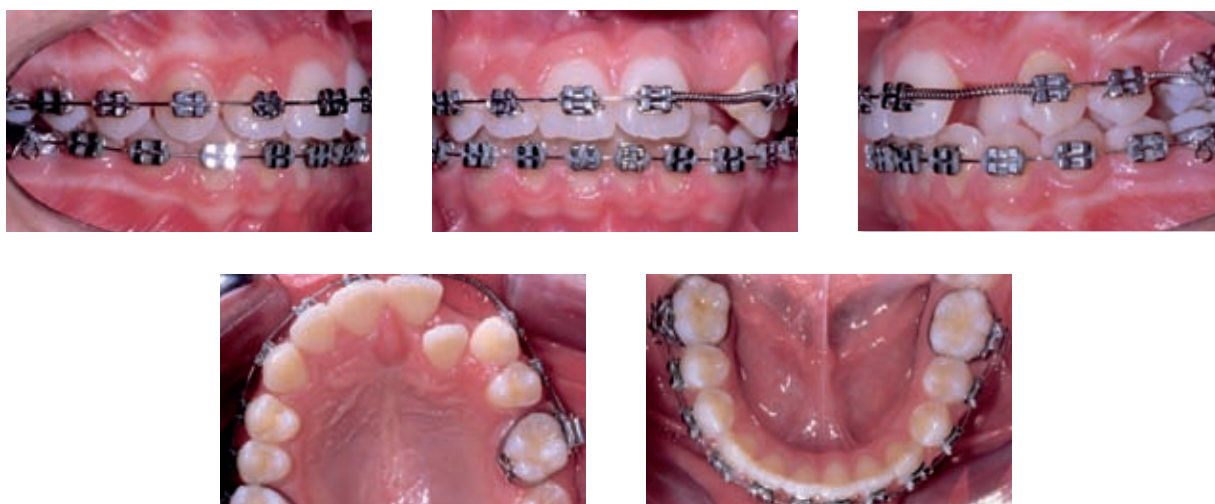


FIGURE 6 - Photographs of the space opening with the compressing coil spring, making upper left lateral incisor movement possible.

The skeletal effect of expansion obtained with the Haas appliance is widely demonstrated throughout the literature.^{4,5} The stability of results is easily explained by the position of teeth over the bony base and by the placement of muscle attachments away from teeth crowns.⁵ On top of that, there is the aesthetic effect of the increased width of the dental arch, reaching up to 6 mm in this case, decreasing the buccal corridor and creating a wider and more pleasant smile.⁹ Inter canine width was maintained on the lower arch with a slight increase in the intermolar width, resulting from lower right first molar torque adjustment (Fig 7).

Left intercuspation had to be adapted to the upper second premolar extraction option on this side. In this case, the molar relation was in distoclusion, which required special adjustments: 1– The upper first molar was finished with a mesial rotation so that the mesiobuccal cusp would touch the distal slope of the buccal cusp of the lower left second premolar, given the smaller dimension of the latter (Fig 8); 2– In order to compensate the larger mesiodistal width of the molar, some stripping was needed on both canine and first molar; and 3– Enameloplasty on the occlusal slope of the mesiobuccal cusp of the first molar, as prescribed by Brandão and Brandão.¹



FIGURE 7 - Final facial and intraoral photographs.

On the right side, a normal occlusion relation was established between molars, as well as the proper relation of the mesiodistal inclined planes of the cusps of other teeth. On both sides, normal occlusion was obtained between canines, which led to ideal overjet and overbite, plus the immediate disocclusion during mandible excursion movements.^{1,3}

Radiographic records revealed parallel roots and integrity of almost all teeth and alveolar bone ridges. The slight round shape of root apices is compatible to the orthodontic treatment. A larger root resorption was observed on the mesial root of tooth #26, due to the proximity with the maxillary sinus cortical plates associated to dental movement (Fig 9).

Cephalometric measurements and superimpositions demonstrate a significant mandibular growth, as expected according to the facial profile presented by the patient. The decision for extracting a single second premolar was shown to

be efficient in avoiding the retraction of anterior teeth and worsening of the facial profile (Fig 11 and Table 1).⁹

But the better effect of the biomechanics applied was seen in the smile. Midline correction, associated to the improvement on upper anterior teeth has set harmony to the smile (Fig 12). The symmetry obtained when exhibiting anterior teeth as well as the dominance of central incisors were also noticeable.⁸ On the other hand, there was an increase in the concavity of the facial profile due to expressive mandibular and nasal growth, greater than the one presented by the nasomaxillary complex (Fig 10). Upper incisor projection to compensate this lack of proportion between maxillary and mandibular structures did not alter this tendency. A good gingival contour was obtained and, together with the smile curve that delineates the lower lip curvature, they define a pleasant smile presenting dominance of upper central incisors.^{6,7}

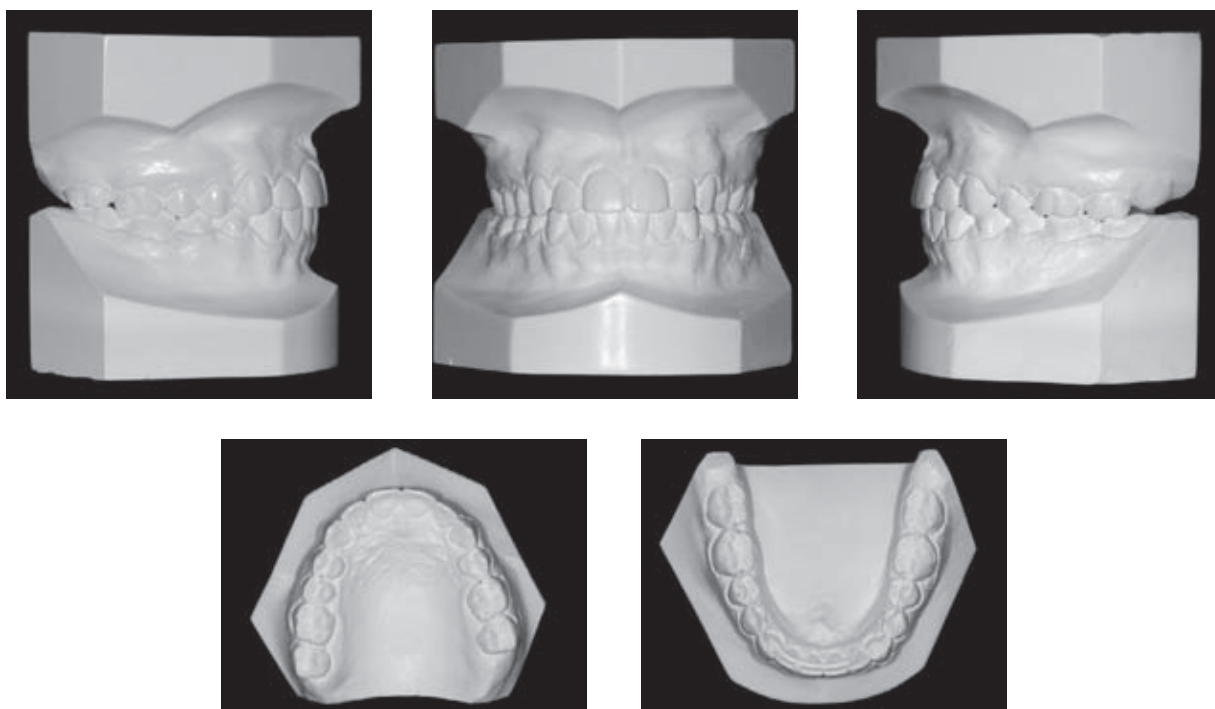


FIGURE 8 - Final dental casts.

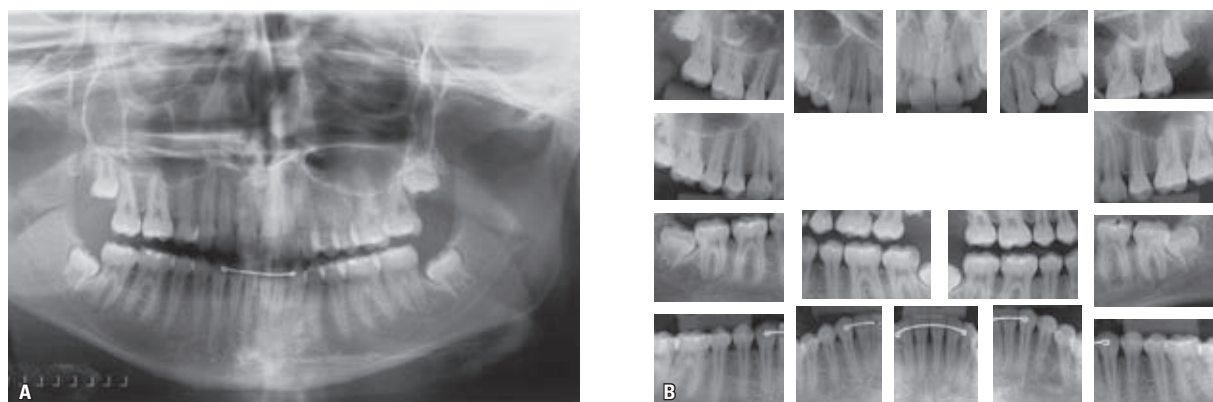


FIGURE 9 - Final radiographs: panoramic (A) and periapical (B).

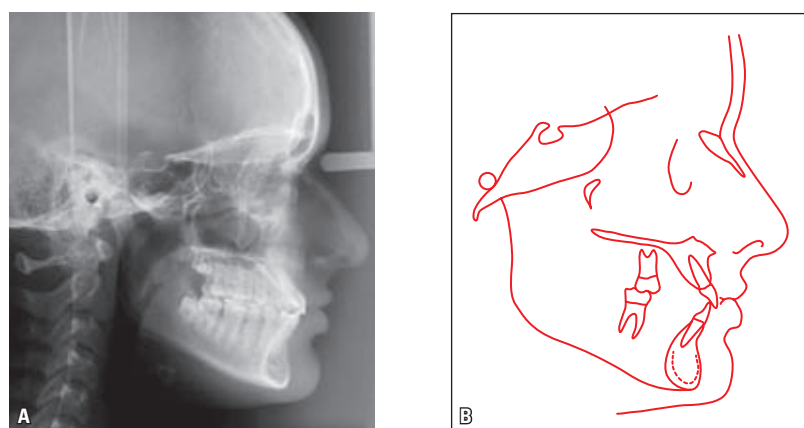


FIGURE 10 - Final lateral cephalometric radiograph (A) and tracing (B).

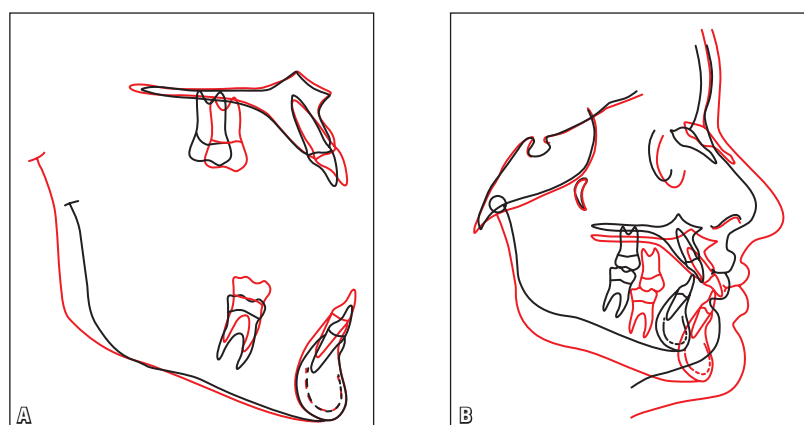


FIGURE 11 - Total superimposition (A) and partial superimposition (B) of both initial (black) and final (red) cephalometric tracings.

TABLE 1 - Summary of cephalometric measurements.

	MEASURES	Normal	A	B	A/B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	83°	83°	0
	SNB (Steiner)	80°	81°	83°	2
	ANB (Steiner)	2°	2°	0°	2
	Convexity angle (Downs)	0°	3°	-2°	5
	Y axis angle (Downs)	59°	58°	56°	2
	Facial angle (Downs)	87°	86°	91°	5
	SN-GoGn (Steiner)	32°	24°	23°	1
	FMA (Tweed)	25°	18°	17°	1
Dental pattern	IMPA (Tweed)	90°	105°	100°	5
	$\underline{1}$ – NA (degrees) (Steiner)	22°	24°	32°	8
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	5 mm	6 mm	1
	$\bar{1}$ – NB (degrees) (Steiner)	25°	30°	25°	5
	$\bar{1}$ – NB (mm) (Steiner)	4 mm	4 mm	4 mm	0
	$\frac{1}{1}$ – Interincisal angle (Downs)	130°	125°	121°	4
	$\bar{1}$ – APo (mm) (Ricketts)	1 mm	2 mm	3 mm	1
Profile	Upper lip – S line (Steiner)	0 mm	0 mm	-4 mm	4
	Lower lip – S line (Steiner)	0 mm	0 mm	-3 mm	3



FIGURE 12 - Initial (A) and final (B) smile photographs with the aesthetic results obtained, showing a broader smile and a smaller buccal corridor.

FINAL REMARKS

In this case, skeletal approach and growth use occurred in the transverse aspect. There was significant space gain and simplification of the problem since the maxillary constriction was corrected. What escaped the skeletal action did happen as a consequence of the dental movement, especially after molar dentoalveolar corrections and compensations. The projection of upper incisors was needed in order to offset a smaller anteroposterior growth of the maxilla

in relation to the mandible. On the other hand, the strategy of fewer extractions, maintaining the posterior asymmetry and upper incisor proclination seem to have been the best option when compared to a greater number of extractions or distalizing appliances that could have caused even further lip retraction, compromising facial aesthetics.⁹ The stability expected for this treatment is directly linked to the palatal expansion, of utmost importance for the successful management of this case.⁵

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Orthosurgical treatment of patients in the growth period: At what cost?

Jonas Capelli Junior*, Rhita Cristina Cunha Almeida**

Abstract

Awaiting growth to end prior to starting orthosurgical treatment is sometimes extremely difficult for patients suffering from severe facial deformities. In cases of substantial skeletal disharmonies surgery may be indicated during active growth phase when the patient is psychosocially, aesthetically and/or functionally compromised. To indicate this therapy, orthodontic criteria, such as mild intramaxillary discrepancy and the possibility of preoperative preparation without major dental repositioning, must be met. A second orthosurgical treatment will probably prove necessary after growth has ended. This treatment should not be considered as routine, but rather as a therapeutic option in carefully selected cases.

Keywords: Orthodontics. Orthognathic surgery. Psychosocial impact.

INTRODUCTION

Awaiting the end of growth before subjecting a patient to an orthosurgical procedure always proves exhausting for both the professional and the patient. The professional feels pressured by the patient, who expresses his/her dissatisfaction with his/her face and occlusion. Moreover, issues emerge regarding the best moment for surgery and about the possible effects of early surgery on the residual facial growth.

Approximately 98% of all facial growth ceases by the age of 15 years in girls and 17 or 18 years in boys.^{1,2} However, in Class III skeletal disharmonies, mandibular growth sometimes even exceeds these ages.³ The data show that orthosurgical patients spend much of adolescence and even early adulthood living with a facial deformity. Appearance is a crucial factor in social relations. Adolescents with significant dentofacial deformities are considered less attractive and so end up as a target of discrimination.³

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Thus, early orthognathic surgery can in some cases prevent future psychosocial problems.

In addition, postponing surgery until adulthood in very severe cases may exacerbate problems related to pain, speech, breathing, occlusion, articulation and masticatory function.³

According to Medeiros and Medeiros⁴ there are two situations in which orthognathic surgery in a growing patient becomes desirable: In the event of a progressive deformity which, if untreated, threatens to reach serious proportions; and when the dentofacial deformity is severe and is causing substantial psychosocial damage to the patient.

Some factors must be evaluated before subjecting patients to orthognathic surgery. One of these is the temporomandibular joint (TMJ). If the TMJ is not stable and healthy, surgical results may also be unstable, causing dysfunction and joint pain.⁵ Studies showed that the number of patients who reported joint pain or discomfort rose from 36% prior to surgery to 88% two years after surgery.⁶ Furthermore, condylar resorption was detected in 30% of patients, resulting in facial deformity and malocclusion relapse.⁶ Other pathological joint conditions that can influence surgery are condylar hyperplasia, condylar hypoplasia, idiopathic condylar resorption, osteochondroma, rheumatoid arthritis and even systemic lupus erythematosus.³

The tongue is also an important factor in the growth and development of the jaws. Microglossia can result in underdeveloped jaws and macroglossia can result in their overdevelopment. The tongue usually reaches its maximum size by eight years of age.⁷ One should assess whether it interferes with the patient's speech, chewing, breathing and treatment stability. Surgical reduction of the tongue can increase the stability and predictability of surgical outcomes.³

Although difficult to predict, determining vectors and amount of growth is important for planning.³ The differential growth of the jaws

can occur in 3 dimensions. A comprehensive understanding of growth trends in each facial type provides clinicians with relevant information regarding what to expect from sequential growth.³

MANDIBULAR DEFORMITIES

Mandibular hypoplasia

Mandibular retrusion that results in a skeletal Class II malocclusion may display either a normal or deficient mandibular growth.⁸ When there is normal mandibular growth the disharmony may be caused by a mandibular size smaller than the maxilla or the mandible may be in a more retruded position relative to the position of the maxilla, but with similar growth patterns. Thus, the same skeletal and occlusal Class II relationship is maintained throughout the growth period.⁸ This deformity could therefore be corrected during growth, yielding fairly stable results. Surgical results are expected to last with a healthy TMJ and with no disruption of growth direction by means of a surgical procedure.³

When mandibular growth deficiency is present, malocclusion tends to worsen with growth, since the maxilla outgrows the mandible.⁹ Should one opt for surgical correction during growth it is likely that the residual growth will result in a new skeletal and dental Class II malocclusion as an uneven growth pattern will remain between the maxilla and the mandible.⁹ In these cases, early surgery is indicated in the presence of severe deformities that can affect patient function or cause him/her to experience psychosocial problems.³ Early surgery in these circumstances can improve the quality of life of the patient, but it is important to warn him/her that a second surgery will probably be required.

Mandibular hyperplasia

Mandibular hyperplasia is defined as a protruded mandibular position resulting in a skeletal and dental Class III malocclusion.³

In this type of malocclusion, the size and posi-

tion of the tongue must be evaluated since mandibular retrusion surgery decreases oral cavity space whereas macroglossia or tongue thrusting can result in surgical relapse.¹⁰

Mandibular hyperplasia cases can also exhibit a normal growth pattern between the maxilla and mandible, with the mandible positioned more anteriorly relative to the maxilla. Moreover, the mandible may be larger than the maxilla, or the two may present unequal growth patterns, with the mandible growing more rapidly than the maxilla.³

When the growth pattern of the jaws is similar, virtually the same Class III relationship is maintained during growth. Thus, the early correction of this disharmony enhances the chance of result stability.³

In patients with accelerated mandibular growth, facial deformity becomes increasingly severe. An increase in mandibular growth rates usually results from condylar hyperplasia, often begins at the peak of pubertal growth and can continue beyond the normal growth period until the beginning of the twentieth year of age. This growth can be uni- or bilateral, with vertical or horizontal prevalence.³

In this type of malocclusion one may decide to postpone surgery until growth is complete, which can lead to functional problems, facial deformity, joint pains and psychosocial problems.¹¹ In addition, allowing the deformity to be fully expressed can preclude an ideal treatment in the future. The possible consequences of an excessive mandibular growth are mandibular deformation and compensatory changes in the maxilla, dentoalveolar structure and soft tissue, thereby hindering surgical outcome prognosis. Cases of unilateral growth can also present with severe asymmetries and joint dysfunctions.³

Another treatment option could be early surgery of the mandible, positioning it posteriorly with an overcorrection.³ A second surgery will probably be required, but the patient will at

least enjoy some improvement in function and aesthetics. When one decides to perform early surgery, preoperative preparation should be carried out as fast as possible, just enough to allow the patient to be operated on. Furthermore, extending the postoperative orthodontic treatment period is not recommended. Thus, when growth ceases and the need arises for further orthodontic preparation, the patient will not be exhausted from the first orthodontic treatment and the two treatment periods will not take place sequentially. Besides, it is important to avoid time-consuming dental movements, which are normally associated with root resorption and which can render the second orthodontic treatment unfeasible.

Some authors will indicate a third treatment option, i.e., eliminating any residual mandibular growth with a high condylectomy and correcting the skeletal deformity. A high condylectomy will remove the active growth center, preventing future mandibular growth.^{3,12}

MAXILLARY DEFORMITIES

Maxillary hypoplasia

Maxillary hypoplasia is defined as poor maxillary development in the anteroposterior, transverse or vertical direction.¹³ Once established that the cause of the deformity is a deficiency in maxillary growth, even assuming that surgery is performed early, normal growth after surgery is compromised. Therefore, the correction of deficiencies in the anteroposterior or vertical direction during growth will probably result in a new Class III skeletal disharmony due to a continued normal mandibular growth pattern. Early surgery is only indicated in the presence of significant functional, aesthetic or psychosocial issues. Wolford et al¹³ recommend that the maxilla be overcorrected to allow mandibular growth and that the patient be forewarned that a second surgery will be necessary.¹³ However, since quantifying this overcorrection can prove daunting, it seems safer to correct the deformity

as optimally as possible, thus averting the replacement of an unfavorable Class III condition by an unfavorable Class II condition. Growth prognosis is necessarily uncertain.

Vertical maxillary hyperplasia

Maxillary vertical hyperplasia or maxillary vertical excess is defined as excess in the vertical growth of the maxilla which may or may not result in an anterior open bite.¹³ This deformity can be corrected during the growth period with fairly predictable results. The vertical growth of the maxilla will continue after surgery in the same proportion as before the surgery,¹⁴ but the postoperative occlusal outcome will probably be preserved. The facial growth vector will continue downwards and backwards. Le Fort I osteotomy is not recommended as it may compromise the anteroposterior growth of the maxilla.³

CLINICAL CASES

Surgeries performed at an early age are indicated in a number of cases presenting with facial deformities such as cleft lip/palate, facial microsomia, condylar ankylosis, among other conditions.

Thus, clinicians tend to agree that patients with severe facial deformities, which render the patient's social coexistence unbearable, should be subjected to early surgery. However, the indication of early surgery for Class III cases is controversial. Professionals should bear in mind that patients react differently to the same malocclusion and a facial pattern lacking in harmony can be well tolerated by some, but can cause severe psychosocial disorders in others. Surgical patients should therefore be assessed individually to decide whether or not it would be convenient to perform surgery before the end of the growth period.

One should assess the patient's chief complaint, i.e., whether he or she has a clear notion of what is wrong with his/her face, how long he/she has been aware of this problem, what they expect from the treatment, to what extent the

problem interferes with their daily routine and if someone is compelling them to seek treatment. Patients who have a precise idea of the problem and realistic expectations about the treatment are better indicated for early surgery.¹⁵ One should exercise caution with patients who are unable to identify where exactly the skeletal disharmony is located and hold very high expectations regarding the treatment as they may not be psychologically prepared for the treatment and are therefore highly likely to be disappointed.

Case 1

A female patient with severe facial deformity caused by condylar ankylosis.¹⁶ She presented with facial asymmetry and a deficient lower facial third, lip incompetence, limited mouth opening and mandibular deviation during mouth closing (Fig 1A). There were functional problems both in speech and chewing. From a dental standpoint, there was impaction of the canine and second left premolar, agenesis of left upper first molar, widespread lack of space and unfavorable root inclinations.

When the patient was 11 years old a costochondral graft was placed between the mandibular body and an ankylosed joint, in addition to an arthroplasty and a sagittal osteotomy to move the lower-right side anteriorly (Fig 1B). The mandibular deviation was corrected, the retrognathic mandible was greatly reduced and the right side of the face showed a significant aesthetic gain. A 25 mm mouth opening and better lip positioning were achieved.

When she was 15 years old, four years after the first surgery, there was ankylosis relapse and graft resorption. A new arthroplasty was carried out and the lower left canine, which was impacted, was removed.

At age 16 a new costochondral graft was placed, but facial growth remained unfavorable during follow-up. The patient was therefore referred for orthodontic treatment to start preparing for orthognathic surgery (Figs 1C and 2).

Functional analysis showed mouth opening limitation, difficulty in swallowing and speaking, tongue protrusion, mandibular deviation to the left during mouth opening and left condylar ankylosis with an abnormal mandibular ramus. One could also observe an increase in the lower third of the face, high smile line and lip incompetence.

Preoperative preparation required extraction of the first upper premolars and mandibular right first premolar. The mandibular first premolar substituted the canine, which had previously been extracted. Combined maxillary and mandibular surgery was performed, substantially improving the patient's facial aesthetics (Figs 1E, 1F and 3).



FIGURE 1 - Patient's facial photographs: **A)** Initial facial photographs, **B)** At 11 years of age, after the first surgical procedure, **C)** At the beginning of orthodontic treatment, **D)** Photographs prior to orthognathic surgery, **E)** Photographs following post-orthognathic surgery, **F)** Final facial photographs. Surgery performed by Dr. Paulo José Medeiros.



FIGURE 2 - Initial intraoral photographs.



FIGURE 3 - Intraoral photographs at the end of the orthosurgical treatment.

Case 2

A female patient aged 14 years, presenting with a skeletal Class III malocclusion, Class III dental relationship, mandibular excess interfering with facial aesthetics, and maxillary atresia. The patient was still going through her growth period and reported extreme dissatisfaction

with her face, which negatively impacted on her normal social interaction (Fig 4).

The patient was forewarned of all surgical risks and about the need for a second surgery after the end of the growth period. It was decided then to perform a quick preoperative preparation (Fig 5) and vertical osteotomy to



FIGURE 4 - Initial facial and intraoral photographs.



FIGURE 5 - Preoperative orthodontic preparation.

achieve a 9 mm mandibular setback (Fig 6). The orthodontic appliance was removed after the surgery until it was time for the second treatment. The patient was monitored and at age 18 once again a skeletal Class III relationship, end-on bite and concave profile were observed (Fig 7).

It was then proposed to the patient to start a second orthosurgical preparation, which she rejected. At 21 years old, with a stable Class III relationship, the patient was once again advised to undergo a second orthosurgical preparation, to which she reported being satisfied with the outcome, refusing a new treatment (Fig 8).



FIGURE 6 - Facial and intraoral postoperative photographs.



FIGURE 7 - Facial and intraoral photographs at age 18 showing again a skeletal disharmony caused by postoperative growth.

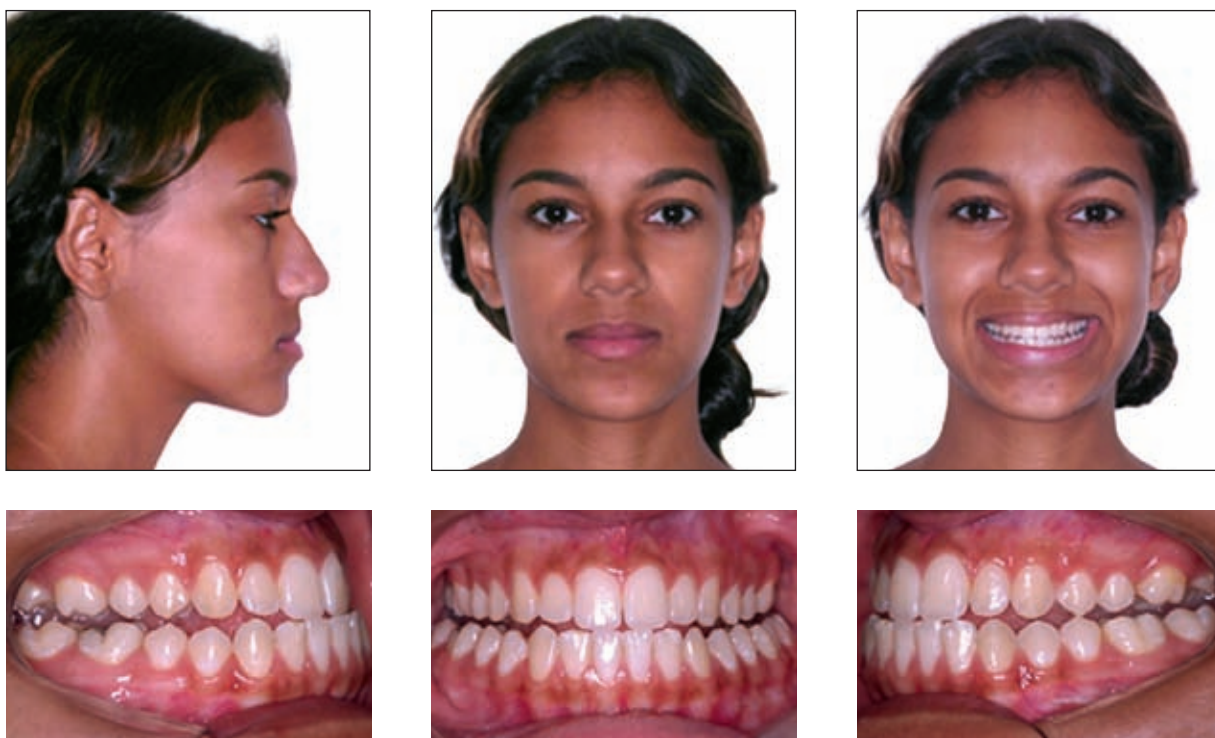


FIGURE 8 - Facial and intraoral photographs at age 21 showing a stable Class III malocclusion.

Case 3

A female patient, aged 14 years with a dental and skeletal Class III relationship and concave profile. The patient had a maxillary deficiency in the transverse and anteroposterior direction, and mandibular excess in the anteroposterior direction (Fig 9).

The patient's mother reported that the patient was very shy and was encountering serious psychosocial problems as a result of her face, which did not meet socially acceptable aesthetic standard. The patient was informed about the future need of another surgical procedure due to the fact that she was still experiencing active growth.

The complexity index¹⁷ for the case, according

to the standards of the Brazilian Board of Orthodontics, was 61, significantly above 25, which is already considered a high degree of complexity.

Preoperative preparation was then performed (Fig 10) followed by combined 3 mm maxillary advancement surgery and 2 mm lowering of the maxilla, in addition to 6 mm mandibular setback (Fig 11).

When she reached age 20, the patient once again presented with a dental and skeletal Class III relationship and concave profile (Fig 12). The Class III, however, was moderate, with a complexity index¹⁷ equivalent to 13, considered intermediate. The second orthosurgical treatment was then initiated in the traditional manner.



FIGURE 9 - Initial facial and intraoral photographs.



FIGURE 10 - Facial and intraoral preoperative photographs.



FIGURE 11 - Facial and intraoral postoperative photographs. Surgery performed by Dr Henrique Martins.



FIGURE 12 - Facial and intraoral photographs at the beginning of the second orthosurgical treatment.

Case 4

A male patient, 13 years of age, dental and skeletal Class III relationship, presenting with maxillary atresia and mandibular anteroposterior excess, facial asymmetry and insufficient space for the eruption of impacted teeth (Fig 13).

A slightly more time-consuming preoperative preparation was carried out since it was necessary to create space and orthodontically erupt the im-

pacted teeth (Fig 14). Additionally, a combined surgery comprising a 7 mm maxillary advancement and 8 mm mandibular setback was performed (Figs 15 and 16).

The patient's growth was monitored and by age 18 the dental relationship had been restored to a Class III condition, with incisors in an end-on relationship. Nevertheless, the patient reported that she was pleased with the outcome (Fig 17).

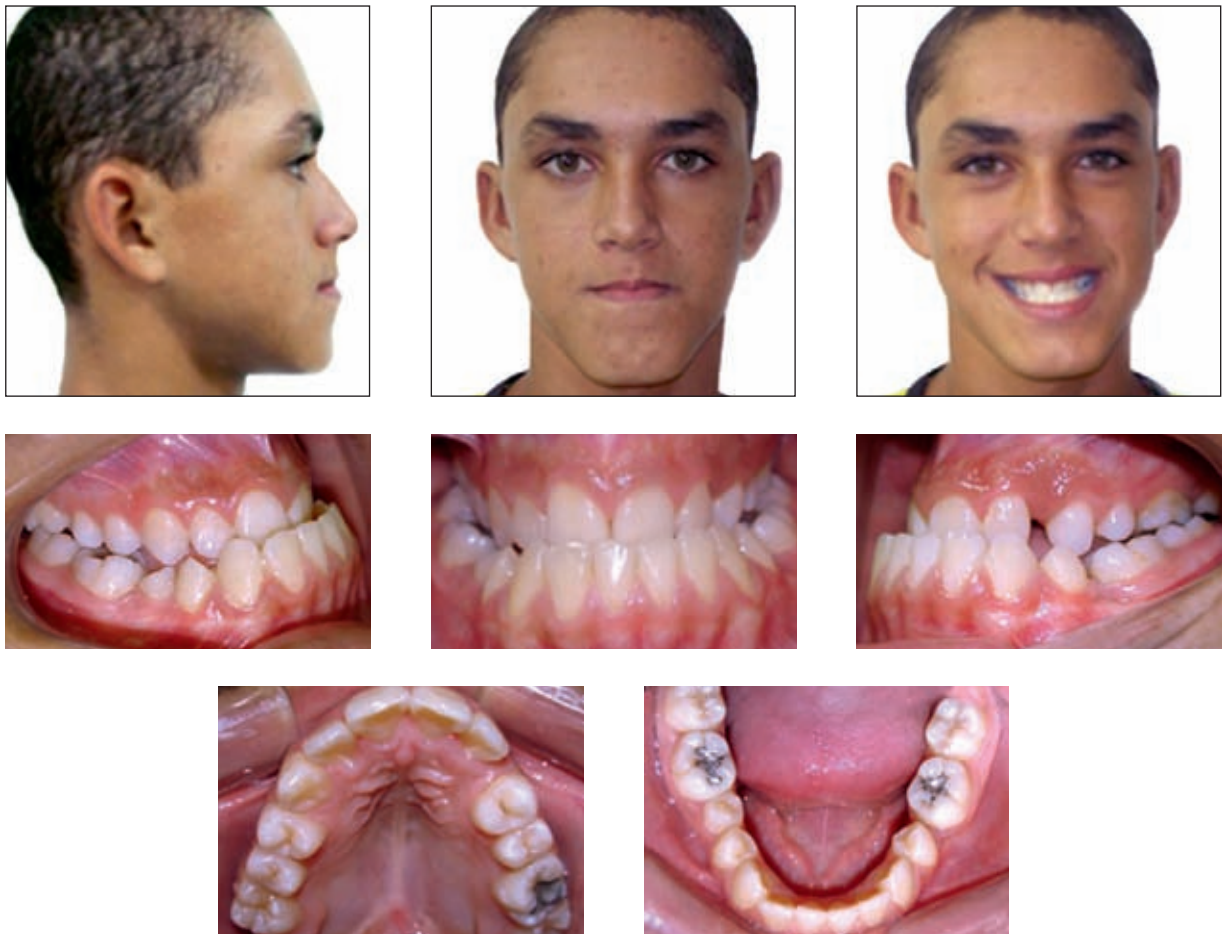


FIGURE 13 - Initial facial and intraoral photographs.



FIGURE 14 - Facial and intraoral preoperative photographs.



FIGURE 15 - Intraoral postoperative photographs.

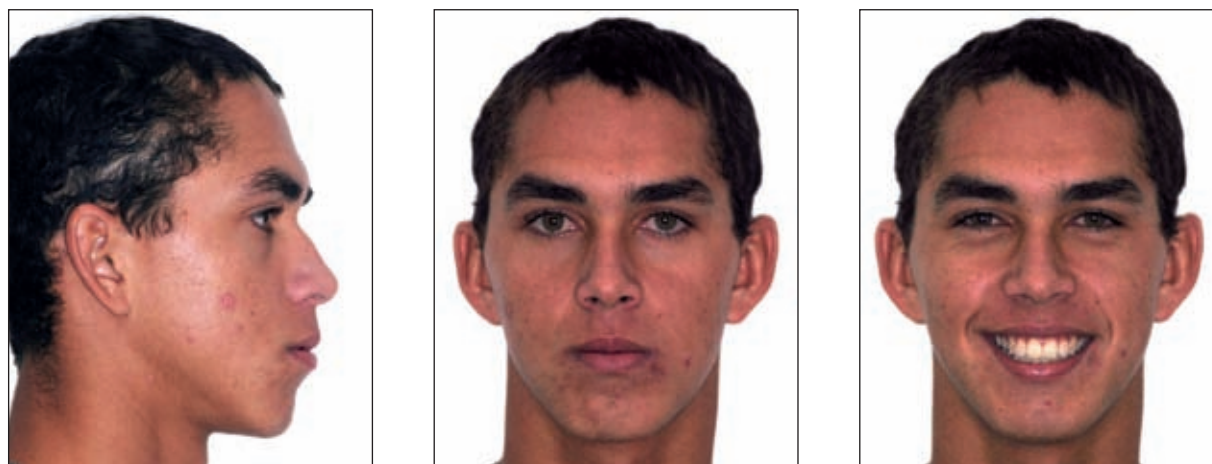


FIGURE 16 - Final facial photographs.



FIGURE 17 - Facial and intraoral photographs at age 18 showing a new Class III skeletal disharmony due to continued treatment.

Case 5

A 14-year-old female patient presenting with a dental and skeletal Class III, anteroposterior and vertical mandibular excess and maxillary atresia, as well as over-retained primary teeth (Fig 18). The complexity index¹⁷ for the

case was extremely high, i.e., 87. Preoperative preparation was performed and then combined maxilla and mandible surgery, providing the patient with a pleasant looking face along with considerable aesthetic and functional improvement (Figs 19 and 20).



FIGURE 18 - Initial facial and intraoral photographs.



FIGURE 19 - Final intraoral photographs.



FIGURE 20 - Facial photographs showing the patient's aesthetic gain: **A)** Before, **B)** During and **C)** After orthosurgical treatment.

Case 6

A female patient, aged 12 and presenting with a Class III dental and skeletal pattern, concave profile with a sharply protruded mandible (Fig 21). The patient also presented with anterior and posterior crossbite, torsion of tooth #15, spaces in the lower arch and retroclined lower incisors. Maxillary expansion was performed with the aid of a Hyrax palatal separator and brief preoperative preparation, disregarding the closure of existing spaces (Fig 22).

The patient was subsequently subjected to maxillary advancement and mandibular setback orthognathic surgery. Two miniplates were then inserted in the anterior region of the mandible as anchorage for the closure of posterior spaces (Fig 23).

After space closure, the appliance and miniplates were removed, disclosing a rather significant aesthetic and functional gain after these few months of treatment (Fig 24).

The patient reported complete satisfaction with the treatment outcome despite the need for further intervention in the future. According to her, this surgery completely changed her teenage years since she saw herself as an ugly person, the target of demeaning nicknames related to her facial deformity, which hurt her self-esteem and undermined her relations with other people. She further reiterated that the procedure really worked for her and she would not hesitate to undergo the same treatment again.



FIGURE 21 - Initial facial and intraoral photographs.



FIGURE 22 - Preoperative orthodontic preparation.



FIGURE 23 - Postoperative photographs showing anterior miniplates as an aid in closing spaces in the lower arch.



FIGURE 24 - Final facial and intraoral photographs.

CONCLUSIONS

The patient's type of facial deformity and growth vector should be carefully studied, as they will affect the surgical outcome. Patient and family must be aware of the expected results of early surgery as well as the risks and potential complications of a non-traditional approach. Professionals should understand the uniqueness of each individual case and be aware that some patients with facial deformities need to be subjected to surgery during growth in order to ensure for such patients

function, aesthetics and a psychological attitude in line with their normal development. Difficulties in persuading these patients to undergo a second orthosurgical treatment have been observed. Most patients' complaints are not sufficient to justify a second procedure. If, on the one hand, this may frustrate professionals when they realize that the case would indeed require a second procedure, on the other hand it becomes clear that early surgery was beneficial and added to the well being and satisfaction of the patient.

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1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (<http://www.who.int/ictrp/network/en/index.html>), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and

<http://isrctn.org> (International Standard Randomized Controlled Trial Number Register (ISRCTN)). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
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Yours sincerely,

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Influence of the banded Herbst appliance on dental changes in mixed dentition

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Abstract

Objective: This prospective clinical study was conducted with the purpose of evaluating the influence of the banded Herbst appliance on dental changes during the early treatment of Class II malocclusion. **Method:** The sample consisted of 15 prepubertal subjects (12 boys and 3 girls, initial age: 9 years and 6 months) who were treated with the Herbst appliance. Treatment effects were compared with those of a Class II Division 1 group of 15 subjects (8 boys and 7 girls, mean initial age 9 years and 1 month), not treated orthodontically. Statistical analysis was performed using Student t-test with 5% significance level. **Results:** The results showed that treatment with the banded Herbst appliance in the mixed dentition stage tended to upright maxillary incisors (mean: 4.14°). The maxillary molars were distalized and intruded significantly (mean 2.65 mm and 1.24 mm, respectively), the lower incisors slightly protruded anteriorly (mean 1.64 mm) and the molars showed no significant changes in the horizontal and vertical directions. Furthermore, significant improvements were noted in overbite (1.26 mm), overjet (4.8 mm) and molar relationship (12.08 mm). **Conclusions:** Changes in the upper dental arch were found to be greater than changes in the lower arch. Furthermore, mandibular anchorage loss was reduced due to the anchorage system used in the study.

Keywords: Herbst appliance. Anchorage system. Mixed dentition. Orthodontics. Cephalometry.

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INTRODUCTION

Class II malocclusion is a maxillomandibular discrepancy that not only affects a significant percentage of the population²⁶ but is also considered one of the most frequent problems in orthodontic practice as it triggers a wide range of aesthetic and functional problems. During correction of this malocclusion, a variety of alterations may occur in the antero-posterior relationship, including distalization of maxillary teeth, mesialization of mandibular teeth, growth and/or orthopedic changes in the apical bases. Within this context, the Herbst appliance, developed by Emil Herbst in 1905,¹⁸ has been used in an attempt to change the amount and direction of growth of the maxilla and mandible.

Having as its main goal to stimulate mandibular growth and correct Class II malocclusion, it is reasonable to assume that tooth movement during treatment with the Herbst appliance is not desirable. However, it is difficult to avoid anchorage loss in both upper and lower teeth,¹⁵ which therefore renders anchorage with the Herbst appliance a daunting task.

Thus, throughout all these years the Herbst appliance has prompted researchers to develop different types of anchorage that are comfortable for the patient while reducing side effects to a great extent. Fixed anchorage, as proposed by Pancherz,¹⁸ has been significantly modified in an attempt to enhance treatment effectiveness. For example, bands have been replaced by steel crowns on the anchorage teeth.¹¹ The use of metal¹⁵ or acrylic⁶ splints has also been suggested in order to enhance anchorage and reduce breakage in regions where attachments are welded to bands. Mayes¹² recommended that anchorage be achieved with the aid of a cantilever if treatment is performed early, prior to the eruption of first premolars. Therefore, this prospective clinical study was conducted in order to evaluate the influence of the banded

Herbst appliance on dental changes during the early treatment of Class II malocclusion.

MATERIAL AND METHODS

Sample characterization

The treatment group comprised 15 Caucasian children (12 boys and 3 girls), aged 8-10 years (mean initial age of 9.4 ± 0.64 years, mean final age of 10.1 ± 0.64 years). Subjects were selected according to the following criteria:

- » Class II, Division 1 facial pattern associated with mandibular retrusion.
- » Class II, Division 1 dental relationship.
- » Central and lateral permanent maxillary and mandibular incisors either erupted or erupting.
- » Mixed dentition.
- » Absence of severe crowding in the lower arch and absence of transversal issues.

To determine Class II facial pattern and Class II dental relationship a clinical analysis of the face and occlusion was performed. Thus, a certain amount of subjectivity was present, as no measurable data obtained from lateral cephalograms were used. Facial analysis disclosed some features that helped to determine the Class II facial pattern, such as: Morphological evaluation of the nasolabial angle (straight, acute and obtuse) and length of the chin-neck line. Thus, individuals who had a convex profile, a straight or slightly acute angle, and a short chin-neck line, were classified as Class II facial pattern. Dental Class II, Division 1 relationship was determined by the sagittal position of the first permanent molars and deciduous or permanent canines, and overjet. Subjects with molar Class II equal to or greater than half a cusp, and overjet equal to or greater than 4 mm, were included in the sample.

Facial morphological pattern was determined by Jarabak's Facial Index. In this study, 60% of the subjects had mesofacial pattern, 33.33%, brachyfacial and 6.66%, dolichofacial pattern.

Patients were treated with a modified Herbst appliance, where the first permanent molars were

banded and bound together by a transpalatal arch welded to the bands and 2 mm away from the palate⁶ (Fig 1A). A modified Nance lingual arch made with 1.2 mm steel wire welded to the bands of the first permanent molars was used for anchorage. A cantilever extending to the region of primary or permanent canines was welded to the buccal side of mandibular first molar bands. The cantilever was attached to the lingual arch in the region of primary canines and first molars or permanent canines and first premolars, using 0.9 mm wire in order to avoid occlusal interference²² (Fig 1B). The anterior protrusion of the mandible with the Herbst appliance was performed as recommended by Pancherz¹⁶, i.e., single mandibular advancement to an extent that an incisor end-to-end bite was achieved (Fig 1C). The appliance was used for a period of 7 months.

The control group was selected among the patient records of the Burlington Growth Centre, located at the University of Toronto, and comprised 15 children (7 girls and 8 boys). The criteria for selection of the control group were:

- » Class II, Division 1 facial pattern associated with mandibular retrusion.
- » Class II, Division 1 dental relationship.
- » Erupted maxillary and mandibular permanent central incisors.
- » No prior orthodontic treatment.

The mean initial age in the control group was

9 years and 1 month (SD=0.09) and mean final age was 10 years (SD=0.05). Regarding facial morphology in the control group, 73% of the subjects had mesofacial pattern, 20 % brachyfacial and 7% dolichofacial patterns.

Skeletal age in both groups was assessed by means of lateral cephalometric radiography, using cervical vertebrae indicators of skeletal maturity. Bone age was determined by the same operator and in the form of a blind study (without identifying the patient being assessed), which reduces the subjectivity effect in the evaluation. The subjects of this study were in maturation stages 1 and 2, i.e., before the period of pubertal growth spurt, according to Baccetti et al² and O'Reilly and Yanniello.¹⁴

Methods

For each subject in the experimental group two lateral cephalograms were obtained at maximum intercuspation. They were named T1 (Beginning of treatment) and T2 (Seven months after treatment). Radiographs were obtained using an X-ray machine (model MR05 Rotograph Plus) set at 85 kVp and 10 mA and exposure time of 0.5 seconds. For the control group two lateral cephalograms were obtained at maximum intercuspation.

They were named T1, at 9 years of age, and T2 at age 10. The radiographs were taken in a Keleket device set to 120 kVp, 25 mA and exposure time of 0.3 seconds.



FIGURE 1 - **A)** Maxillary anchorage system with bands and palatal bar. **B)** Mandibular anchorage system with bands and cantilever. **C)** Herbst appliance telescope system after placement.

Although these radiographs were obtained by different X-ray machines, image magnification was not corrected. Image magnification, i.e., the percentage of magnification of the experimental sample, was 10%, equivalent to an increase of 0.1000 cm (1.000 mm), according to Sakima.²³ In the control group, a 9.84% magnification was reported, according to the records provided by the Burlington Growth Centre, as reported by Popovich and Thompson.²¹ Since the percentage difference in magnification between the samples was 0.16%, it would not affect the comparison of variables obtained by radiographs taken with different X-ray machines. This difference in magnification corresponds to a difference of 0.0016 cm (0.016 mm) between the radiographs. All radiographs were traced manually by one operator and then the cephalometric points (landmarks) were entered into a Numonics AccuGrid tablet and evaluated through computer software Dentofacial Planner Plus 1.2 to obtain the cephalometric measurements (Fig 2 and Table 1).

Statistical planning

To assess the potential occurrence of errors in measurements attributable to the observer or the measurement process all tracings were once again digitized and measured by the same operator with an interval of 2 weeks between the first and second evaluation. Intraclass correlation coefficient (ICC) was used to evaluate method error (reproducibility).

To compare the changes that occurred in the cephalometric measures, with and without treatment, it was necessary to eliminate the effect of the difference in time between measurements performed in the experimental and control groups. To this end, changes in measures were annualized.

To evaluate the data the following statistical tests were conducted:

a) Student t-test for equality of means of two independent populations: To examine the hypothesis that the mean of each cephalometric measure is equal to the experimental group at baseline (Table 2).

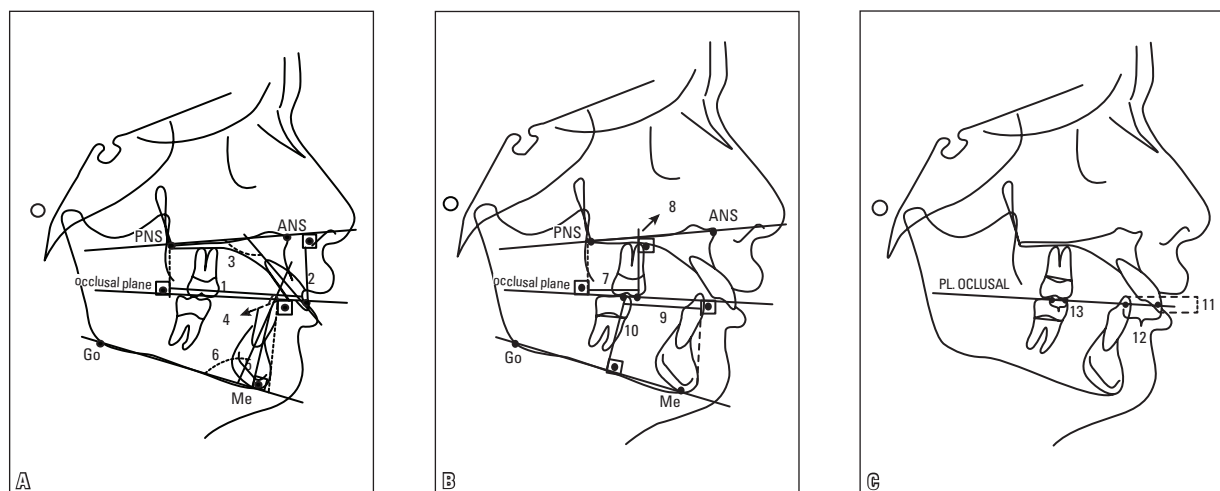


FIGURE 2 - Dental cephalometric measures: **A)** 1= IIs-PNS, 2= IIs-PP, 3= IIs.PP, 4= Ili-Pog, 5= Ili-MP, 6= Ili.MP; **B)** 7= CMs-PNS, 8= CMs-PP, 9= CMi-Pog, 10= CMi-MP; **C)** 11= overbite, 12= overjet, 13= molar relationship.

TABLE 1 - Linear and angular cephalometric measures.

Cephalometric measure	Definition
1) IIs-PNS	Linear distance from points IIs and PNS reflected perpendicularly in the occlusal plane. Represents the anteroposterior relationship between incisors and PNS
2) IIs-PP	Linear distance from the edge of the maxillary incisor perpendicularly to the palatal plane. Represents the vertical position of the incisors relative to PP
3) IIs-PP	Angle formed by the long axis of the maxillary incisors relative to the palatal plane. Represents incisor inclination with PP
4) Ili-Pog	Linear distance from points Ili and Pog reflected perpendicularly in the occlusal plane. Represents the anteroposterior relationship between incisor and pogonion
5) Ili-MP	Linear distance from the edge of the mandibular incisor perpendicularly to the mandibular plane. Represents the vertical position of the incisor relative to MP
6) Ili-MP	Angle formed by the long axis of the mandibular incisor and the mandibular plane. Represents incisor inclination relative to the mandibular plane
7) CMs-PNS	Linear distance from points CMs and PNS reflected perpendicularly in the occlusal plane. Represents the anteroposterior relationship between first molar and PNS
8) CMs-PP	Linear distance from the tip of the mesiobuccal cusp of the first permanent maxillary molar perpendicularly to the palatal plane. Represents the vertical position of the first molar relative to PP
9) CMi-Pog	Linear distance from points CMi and Pog reflected perpendicularly in the occlusal plane. Represents the anteroposterior relationship between molar and pogonion
10) CMi-MP	Linear distance from the tip of the mesiobuccal cusp of the first permanent mandibular molar perpendicularly to the mandibular plane. Represents the vertical position of first molar relative to MP
11) Overbite	Linear measurement which represents the vertical relationship between the edges of the maxillary and mandibular central incisors relative to the occlusal plane
12) Overjet	Linear measurement which represents the horizontal relationship between the edges of the maxillary and mandibular central incisors relative to the occlusal plane
13) Molar relationship	Linear distance from points CMs and CMi reflected perpendicularly in the occlusal plane. Represents the horizontal relationship between maxillary and mandibular molars

TABLE 2 - Mean and standard deviation of cephalometric measurements in experimental and control groups and mean differences between distances, before treatment, and Student t-test for differences in cephalometric measures.

Cephalometric measure	Experimental Group		Control group		Mean difference	t-test		
	Mean	SD	Mean	SD		t	df	p
Overbite	5.46	1.96	2.56	1.78	2.90	4.24	28	0.000*
Molar relationship	1.11	0.87	0.90	0.62	0.20	0.74	28	0.466
IIs-PP	115.69	7.90	112.53	6.62	3.16	1.19	28	0.245
Ili-MP	96.23	4.51	99.67	6.05	-3.45	-1.77	28	0.088
IIs-PP	29.30	1.97	25.32	2.29	3.98	5.11	28	0.000*
Ili-MP	39.41	3.20	36.47	2.58	2.94	2.77	28	0.010*
CMs-PP	20.48	2.21	18.78	1.43	1.70	2.51	28	0.018*
CMi-MP	28.66	2.99	27.68	2.02	0.98	1.05	28	0.302
CMs-PNS	18.36	3.09	16.50	1.98	1.86	1.97	28	0.059
IIs-PNS	58.06	4.63	50.45	2.21	7.61	5.75	20.1	0.000*
Ili-Pog	0.58	3.71	-1.54	3.53	2.12	1.60	28	0.121
CMi-Pog	28.71	4.09	27.00	3.77	1.71	1.19	28	0.245
Overjet	8.65	2.60	5.33	1.68	3.32	4.16	28	0.000*

* Statistically significant at 5% significance level.

Source: SPSS software package (Statistical Package for the Social Sciences, for Windows, version 10.0, SPSS Inc., Chicago, IL, USA).

b) Student t-test for equality of means of two populations with independent samples: To examine the hypothesis that the observed changes in a given cephalometric measure between times 1 and 2 are identical, on average, in the control and experimental groups (Table 3).

RESULTS

The results indicated that the measurement process was highly accurate since the expected ICC value was at least 0.983 and, for most variables, the ICC was above 0.99. Given the high degree of agreement between the two measurements, it was decided that the mean obtained in both measurements would be used for each variable at each time.

Assessment of equivalence between the experimental and control groups regarding the variables of interest at baseline (Table 2) showed that the experimental group had greater overjet and overbite.

TABLE 3 - Means and results of Student t-tests of equality of means in the experimental group and control group, for each of the variables under study.

Cephalometric measures	Means		t-test		
	Experimental Group	Control group	t	gl	p
Overbite	-1.26	0.62	-2.98	28	0.006*
Molar relationship	-12.08	0.23	-13.41	14.8	0.000*
IIs.PP	-4.14	-0.32	-2.01	28	0.054
Ili.MP	1.37	0.46	0.61	28	0.550
IIs-PP	0.76	0.64	0.27	28	0.787
Ili-MP	1.05	0.70	0.91	28	0.369
CMs-PP	-1.24	0.29	-5.12	28	0.000*
CMi-MP	0.72	0.29	1.04	28	0.306
CMs-PNS	-2.65	1.20	-4.37	21.0	0.000*
IIs-PNS	0.34	1.28	-1.30	28	0.205
Ili-Pog	-1.64	0.60	-2.82	28	0.009*
CMi-Pog	-1.11	-0.24	-1.27	28	0.214
Overjet	-4.80	0.17	-7.37	20.1	0.000*

(*) Statistically significant at 5% significance level.

Source: SPSS software package (Statistical Package for the Social Sciences, for Windows, version 10.0, SPSS Inc., Chicago, IL, USA).

According to Table 3, it can be seen that in 6 (overbite, molar relationship, CMs-PP, CMs-PNS, Ili-Pog, overjet) of the 13 variables studied, the mean changes that occurred in the treated population is statistically different from the mean changes which occurred in the untreated population.

DISCUSSION

Orthopedic appliances are meant to provide maximum orthopedic effect, so it is reasonable to assume that tooth movement during treatment is not desirable. However, no matter how good the performance of the appliance, it is difficult to avoid anchorage loss in both maxillary and mandibular teeth.¹⁵ This limitation in the skeletal effect of orthopedic devices is due in part to what is referred to as “distance” anchorage, i.e., including both the upper and lower dental arches.²⁵ Therefore, when the telescoping system of the Herbst appliance is fitted, it produces a force in the superior and posterior direction in maxillary teeth, and a force in the anterior and inferior direction in mandibular teeth.⁸

Therefore, when analyzing the changes occurred in maxillary incisors, it was found that while in the control group variable IIs-PNS increased significantly (1.28 mm/year) in the experimental group the change was not significant in the same direction (0.34 mm), although much smaller than in the untreated group. This finding suggests that since in the untreated group the upper incisors tended to follow maxillary growth, the experimental group tended to show inhibited anterior drift of these teeth. By observing variable IIs.PP, it was found that in the experimental group it showed a significant -4.14°/year decrease, whereas in the control group it showed no significant alteration. This finding confirms that in this study maxillary incisors were uprighted during treatment. This outcome stood out due to the fact that the maxillary incisors were not incorporated in the anchorage

system. It is believed that this uprighting was caused by vertical mandibular postural change toward the anterior region, thereby yielding improved lip competence. Rego²² found in their study that maxillary incisors were uprighted by about 6° in patients subjected to early treatment with the Herbst appliance. Several studies^{1,3,7,16,20,29,30} have reported a similar movement in maxillary incisors. However, other authors observed no changes in the position of these teeth during treatment with the Herbst appliance.^{17,27}

As regards the vertical behavior of maxillary incisors, it was observed that while in the control group variable IIs-PP increased significantly (0.64 mm/year), in the experimental group it experienced no significant change during the treatment period. Lai and McNamara⁹ also observed no change in upper incisors in the vertical plane in subjects treated with the Herbst appliance. Likewise, Valant and Sinclair²⁷ found that maxillary incisors did not change position during treatment.

Regarding changes in maxillary molars, it was observed that in the experimental group there was a significant change in the sagittal position of these teeth when variable CMs-PNS was measured (-2.65 mm/year). This alteration in the treated group occurred in opposite direction of the untreated group (1.2 mm/year). This reversal in the direction of the change showed that in the experimental group maxillary molars were distalized during treatment with the Herbst appliance while in the control group these teeth followed maxillary growth, thus worsening the Class II. This finding was also reported by Franchi et al,⁵ who found an upper molar distalization of -1.71 mm during treatment with the Herbst appliance. Konik et al⁷ also noted a distalization of -2.6 mm in patients undergoing early treatment with the Herbst appliance, and Pancherz¹⁶ found a -2.8 mm distalization of maxillary molars during treatment with the Herbst appliance. In most studies, upper molar distalization contributes significantly to the correction of molar

relationship. There is, however, substantial variation in the amount of distalization between studies, ranging from 1.8 mm⁵ to 2.8 mm.¹⁶ When using the Herbst appliance with bands, distalization is responsible for 25% to 40% of molar correction.^{7,20} On the other hand, when using the Herbst appliance combined with an acrylic splint, distalization is responsible for 20% to 25% of molar correction.^{5,9,30}

Regarding the behavior of upper molars in the vertical plane, a significant decrease (-1.24 mm/year) was observed in the CMs-PP measure, while the control group showed that a non-significant change took place in this measure, but in the opposite direction. It is therefore reasonable to conclude that the Herbst appliance acted by restricting molar eruption. Almeida et al¹ also found that the Herbst appliance produced greater inhibition of upper molar eruption (-0.7 mm) in subjects undergoing treatment with mixed dentition. Likewise, Pancherz¹⁷ found that molar eruption was inhibited by -1.0 mm during treatment, and Flores-Mir et al⁴ identified a change of -0.9 mm in the vertical plane of maxillary molars during treatment with the Herbst appliance. These effects, which were observed in molars in this study, may be explained by the fact that the telescopic mechanism of the Herbst appliance, once installed, produces a force in the posterior and superior direction in the upper dental arch, thus simulating the effect of a high-pull hegear.^{5,13,17,30}

As regards the sagittal changes that occurred in mandibular incisors, these teeth tended to procline, although not significantly, when measure Ili.MP was examined (1.37°/year). The change observed in the treated group occurred in the same direction as in the control group, but with greater impact. Major changes in the sagittal position of mandibular incisors can be found by comparing variable Ili-Pog (-1.64 mm/year) in the experimental

group and the control group (0.60 mm/year), showing that the lower incisors moved anteriorly relative to the pogonion. Anterior mandibular incisor inclination occurred as a result of anchorage loss due to the anterior force exerted by the telescoping system in mandibular teeth.^{18,20} These data are consistent with other studies.^{1,4,7,9,13,16,19,20,22,24,29,30} In these studies, the degree of inclination of mandibular incisors was very high and extremely variable (ranging from 2.0° to 8.4°). In this study, we found a smaller amount of flaring, an outcome similar to that recorded by Valant, Sinclair²⁷ and Croft et al.³ This slight flaring of lower incisors is probably due to the mandibular anchorage structure that was used. This mandibular structure consisted of a lingual arch placed 3 mm away from the anterior mandibular teeth, i.e., there was no direct contact between the anchorage system and these teeth, thereby reducing the force produced by the telescoping system in this region.

As regards the vertical behavior of mandibular incisors, it was observed that variable Iii-MP showed a significant change both in the experimental group (1.05 mm/year) and in the control group (0.70 mm/year). However, a comparison between the experimental and control groups showed that there was no statistically significant change between them. According to this finding, it was noted that the Herbst appliance does not influence the process of mandibular incisor eruption. Rego²² concluded that mandibular incisors did not suffer any change in the vertical direction after 12 months of treatment with the Herbst appliance. Similarly, McNamara et al¹³ and Pancherz^{16,17} found no vertical changes in these teeth.

In assessing the molar, a significant change was identified in variable CMi-Pog (-1.11 mm/year), indicating that the molar was mesialized during treatment. Comparing this outcome with that of the control group, a change in the same direction was identified, although more intense in the treated group. However, no statistically

significant difference was found between the groups. Konik et al⁷ found that the mandibular molar was mesialized by 1.3 mm in patients subjected to an early treatment. Franchi et al⁵ also found a 1.44 mm movement in the anterior direction in the lower molar, while Pancherz and Hägg¹⁹ found a change of 1.5 mm in these same teeth in patients treated with the Herbst appliance. Mesialization of mandibular molars also contributes to the correction of Class II molar relationship, ranging from 0.8 mm⁵ to 2.2 mm.³⁰ In studies that use the banded Herbst appliance, mesialization of mandibular molars is usually smaller than maxillary molar distalization, and contributes about 20 to 30% to the correction of malocclusion as a whole. In studies using the Herbst appliance with an acrylic splint these changes are similar and contribute 25% to correcting molar relationship.^{5,9,30}

In analyzing measure CMi-MP, it was found that there was no significant vertical change in the mandibular molar in both groups. This finding is consistent with the findings of Flores-Mir et al,⁴ Valant and Sinclair.²⁷ However, the results of this study disagreed with those of Almeida et al;¹ Lai, McNamara⁹; Pancherz¹⁷ and Rego,²² who found significant molar eruption during treatment with the Herbst appliance.

In assessing the effects caused by the use of the Herbst appliance on the horizontal relationship of incisors, it was observed that while the control group tended to increase this variable, but not significantly, in the experimental group there was a statistically significant decrease of -4.8 mm/year in this measure. Pancherz and Hansen²⁰ observed a reduction of 6.9 mm in overjet in patients treated with the banded Herbst appliance.

In assessing the vertical distance between the incisors, it was found that in the control group there was a significant increase in this variable. This result suggests that overbite was severe in patients who received no treatment, since in the experimental group a significant decrease of

-1.26 mm was observed in this measure. This result is in agreement with Croft et al,³ who found a decrease of -2.0 mm in the treated group. Pancherz¹⁷ also reported a -2.5 mm decrease in overbite during treatment with the Herbst appliance.

An analysis of molar relationship showed that there was a statistically significant change for this measure, equivalent to -12.08 mm/year. By comparing these changes with those observed in the control group, which had been in the opposite direction to this group (0.23 mm/year), it can be argued that the Herbst appliance caused a positive change in the correction of molar relationship in the present study.

According to the results, it was noted that dental changes did occur, and therefore to avoid such changes, it is recommended that more teeth be incorporated in the anchorage system. However, no anchorage system exists

today which is capable of preventing dental changes. Weschler and Pancherz²⁸ evaluated the effects of three different anchorage systems and concluded that anchorage loss was inevitable, regardless of the type of anchorage used. They further argued that anchorage loss in Class II treatment with the Herbst appliance always occurs, and orthodontists should therefore learn to cope with this reality.

CONCLUSIONS

The use of the banded Herbst appliance in the mixed dentition stage induced changes in both dental arches which contributed to the correction of Class II malocclusion. Such changes were most evident in the upper dental arch. Furthermore, mandibular anchorage loss was adequately reduced thanks to the anchorage system used in the present study.

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Study of tension in the periodontal ligament using the finite elements method

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Abstract

Orthodontic movement is process of transformation of a physical stimulation into a force applied to a tooth, with a biological response identified as bone remodelling. Although it is possible to measure the force applied on a tooth, its distribution around the root is irregular forming areas of higher concentration of tensions, which do not correspond to the force initially applied. To evaluate the behavior of the periodontal ligament after the application of an external action and to prove which would be the areas of higher tension generated in the periodontium, the Finite Elements Method (FEM) was used in comparison to the results obtained *in vivo* on experimental models in rat. To test the error susceptibility of the technique used in the experimental model, the force application was simulated in three different heights on the mesial surface of the molar. The resulting histological analysis was compared with the result obtained for the computational code and disclosed that the greater focus of osteoclasts in activity had coincided with the compressed areas of the periodontal ligament. The alteration of points of force application generated areas of more extensive deformations in the periodontal ligament, as the point of application was more distant of the initial point, the horizontal force vector became bigger. These results demonstrate that the FEM is an adequate tool to study the distribution of orthodontic forces. The sensitivity of the experimental model used was also observed in relation to the installation of the dental movement device, which should be considered depending on the objective of the research.

Keywords: Method of the Finite Elements. Orthodontics. Tensions.

INTRODUCTION

Dental movement occurs through a transduction process, that is, the transformation of a physical stimulus, which consists of a biologic load applied to the tooth, and the final result is identified by bone remodeling around it.

The moment the tooth is submitted to mechanical action and the periodontal ligament is forced, some compressed areas are formed and others are tensioned according to the force dissipation around the dental root. On the compressed areas, resorption cells (osteoclasts) activity is

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observed, whose function is to remove bone, favoring the equilibrium of the periodontal space; and on the tension areas, the action of the osteoblasts occurs in slower speed and start bone neoformation. The force magnitude applied on the dental crown can be easily measured, but the way it is applied must be interpreted by the stress generated all over the periodontal surface. The stress can be interpreted as tension (defined as force per area unit) developed on the adjacent tissues. When a tooth is stimulated, tension distribution over the periodontal area is not equal; there is a higher compression on the cervical and apical areas, and lower tension on the middle third of the root. The magnitude of generated tension, identified here as stress, varies inversely with the area in which the load is applied.¹²

There is some difficulty in clinical studies which relate the load magnitude with the intensity of dental movement, due to three main factors. First, the researchers are unable to control the type of movement, that is, inclination or translation, induced by the devices. Second, as dental movement is non linear and time-dependent, after the activation of the device, the measurement of movement, which is not coordinated by the activation, may systematically influence the results. Third, there are some mistakes concerning measurements, as well as a great variation on the pattern of dental movement both among the patients or the quadrants of an individual patient, being difficult to reach statistically significant data.¹²

Up to now, the technical literature does not provide information about the intensity of force induction or the ideal points for its application, and throughout practice, these parameters are determined exclusively by the experience of orthodontists. Definition about these parameters is very important, because low magnitude load causes deformation of the periodontal ligament and originates cellular activity responsible for bone remodeling. On the other hand, high

intensity forces may cause ischemia, cellular death, or in a lower scale, impairs bone resorption, not reaching the aimed results.

According to Toms and Ebrhardt,¹⁵ the tensions developed in the ligament and alveolar bone provide indications of a favorable or unfavorable tooth movement. Thus, aiming to define parameters for orthodontics practice, researches are performed considering two aspects: the first refers to the experiments comprising humans or animals; and the second refers to the numerical analyses elaborated, based on the Finite Element Method (FEM). Concerning the first aspect, the ethical criteria for *in vivo* researches are extremely rigorous and the costs for this type of research are high. Besides, sample control represents an additional obstacle, because damage of the orthodontics appliances may occur, patient may miss control appointments, discontinuance of some patients and death of animals. Other additional problems consist in keeping the samples until the end of the experiment, and the sensitivity of the tissues submitted to storing medium, which interfere in its physical properties, requiring accurate evaluation. Regarding the employment of FEM, it has been an excellent computational resource, used for the evaluation of the dental structures concerning several areas of dentistry,⁷ as orthodontics,^{1,4,10} periodontology¹¹ and prosthesis.^{8,9} It also represents a cheaper and practical alternative for testing materials and techniques of various specialties cited above.

Jones et al⁴ tested the physical properties of the periodontal ligament of a tooth under extreme load, through an experiment in humans and by the analysis of a 3D computational model. The results demonstrated the efficacy of the FEM for this purpose. Kawarizadeh et al,⁵ employing the mathematical methodology and the histological interpretation, evaluated the force concentration around the moved teeth of rats and its relationship to the cellular events, concluding that the results were coincident demonstrating

that FEM can be safely employed for research concerning movement of teeth.

However, it is important to note that the variability on the physical characteristics of the different tissues, added to their interactivity on the response to a stimulus from several origins, constitute a limiting factor for the definition of a more appropriate mathematical model, for analysis via FEM. The mechanical properties of the periodontal ligament are, nowadays, subject of research, for presenting variable conducts according to different animal species, being influenced by the storage methods and experimental research methodologies.⁶

This study comprises researches in the areas of engineering and dentistry aiming to provide to the clinician and the researcher, with an additional way to evaluate planning and biomechanics options, before application on a patient. This research aimed to testify, by numerical experimentation, the results obtained through *in vivo* experiments and to test the sensitivity of the technique employed for tooth movement, concerning the specific site where the load is applied. From the experiment with rats, the cellular events which occurred from the applied mechanical forces were analyzed and, consequently, compared to the results obtained from FEM, which is being employed in the biomechanical analysis.

MATERIAL AND METHODS

Analysis of the experimental model

The experiment consisted in identifying, through a histological analysis, the presence of cellular elements which represented compressed and stretched areas of the periodontal ligament, demonstrating the load distribution around the root extension. These areas were obtained from a modified model described by Heller and Nanda,³ in which the tooth movement was performed on the first upper left molar of rats, employing a pre-manufactured nickel-titanium closed coil spring (Morelli-SP, Brazil) 7 mm long, fixed on that tooth and anchored on the incisor of the same arch, with a load corresponding to 0.25 N. The force was calibrated employing a digital dynamometer and transferred to the mouth with a caliper (Fig 1). The sample consisted of six female Wistar rats, 70 days old, proceeding from Potiguar University, under authorization of the Ethics Committee. All the procedures were performed under general anesthesia. During the experimental period, the animals stayed in appropriate cages, with temperature ranging from 23 to 25 °C, with an inverted light cycle and they were fed with pasty food and water *ad libitum*. After 7 days, the animals were sacrificed in CO₂ chambers and their heads were fixed in 10% formalin for 48 h. After fixation, the pieces were decalcified with nitric acid at 7.5%,

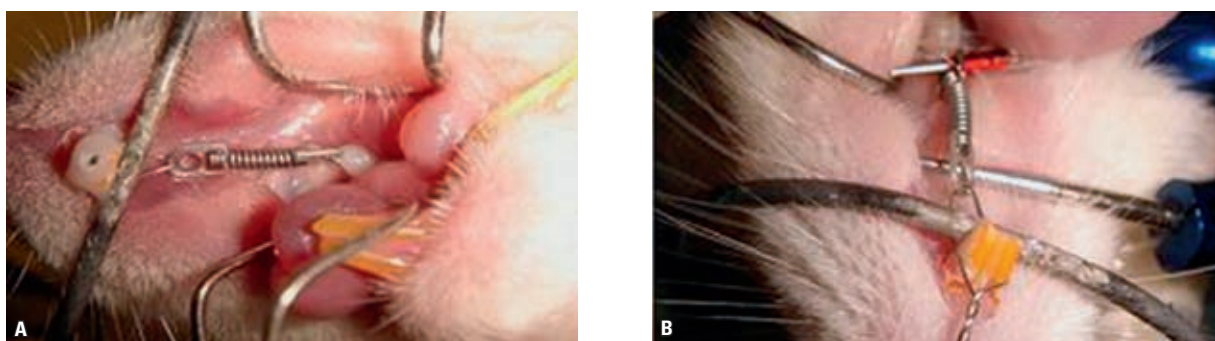


FIGURE 1 - **A)** Spring system to apply the load on the molar; **(B)** transferring the load with caliper opening.

for 5 days, maximum. Afterwards, the left maxillary hemiarches were cleaved; the samples were immersed in paraffin and sectioned 4 μm thick, until the root pulp was observed. They were stained with hematoxylin and eosin (HE).

In the histological evaluation, the compression areas could be identified by the presence of resorption cells (osteoclasts), by the absence of any type of cells (hyalinization areas) or by root resorption, which occurs due to excessive compression. Those situations can be seen in Figure 2. The strain areas were related to the absence of osteoclasts.

Analysis by FEM

Description of the mathematical model

In order to determine tooth geometry for dental structure analysis employing FEM, the removal of the upper molar of a rat was necessary as well as to photograph it in a stereomicroscope, without the central roots, to facilitate its modeling (Fig 3). The photograph printed on graph paper enabled the establishment of the coordinates of interest.

Nine-nodes quadrilateral finite elements, for the Stress Plan of the computational code ADINA (Automatic Dynamic Incremental Nonlinear Analysis) – version 8.3, comprised the discretization mesh presented in Figure 4. In the same Figure, there are three dental structures: Tooth, bone and periodontal ligament, admitted as homogeneous and isotropic media.

The physical properties were extracted from the research of Kavarizadeh et al⁵ and are presented in Table 1.

The elastic bilinear behavior of the ligament is highlighted, which on the initial phase of the movement presents great mobility with elasticity module E_1 similar to 0.15 MPa and, when reaching deformation limit of 6.3%, changes to module E_2 equal to 0.60 MPa with reduced mobility.

The load of 0.25 N given by a coil spring had its direction defined from its decomposition towards the mesial and occlusal directions, as illustrated in Figure 5 and towards lingual and mesial directions, as illustrated in Figure 6.

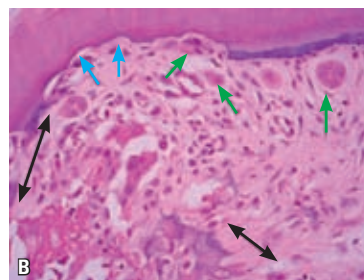
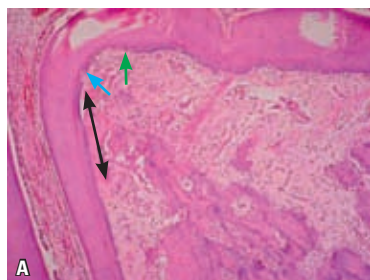


FIGURE 2 - Compression regions in the periodontal ligament: moderate hyalinization (black arrow), osteoclasts (green arrows) and root resorption (blue arrows). HE: **A)** 100X and **B)** 400X.



FIGURE 3 - Stereophotography of the upper molar.



FIGURE 4 - Finite elements mesh.

TABLE 1 - Physical properties of the tissues.

Tissue	Elasticity modulus (Pa)	Poisson coefficient
Tooth	20,000.00	0.30
Periodontal ligament	Elastic bilinear	0.45
Bone	2,000.00	0.30

Alteration of the point of force application

In order to evaluate the influence of the applied force height and the error susceptibility of the technique employed on the experimental model, related to tooth movement, concerning small deviation on the spring position in relation to the occlusal aspect of the tooth, the force was applied at 0.38 mm high, from the cervical margin of the tooth (point highlighted in Fig 4), 0.64 mm and 0.83 mm, keeping the same anchorage for the three situations.

RESULTS

Experimental model

As shown in Figure 2, 100% of the sample presented greater concentration of osteoclasts, root resorption and hyalinization on the furcation area, starting from the center towards distal direction, and along the distal root in its mesial aspect, especially from the middle third of the root to the furcation. According to the proposed interpretation, these areas were considered as regions of higher compression of the periodontal ligament, corresponding to the areas of bone resorption.

Numerical model

When the load was applied 0.38 mm from the cervical margin, the numerical simulation employing Finite Elements produced the deformations and effective tensions, presented in Figures 7 and 8, respectively.

The highlighted area in Figure 7 indicates the compressed region, reference for validation of the

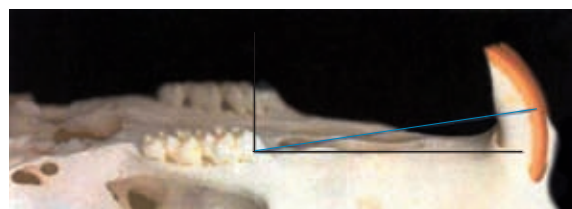


FIGURE 5 - Occlusal and mesial force components.

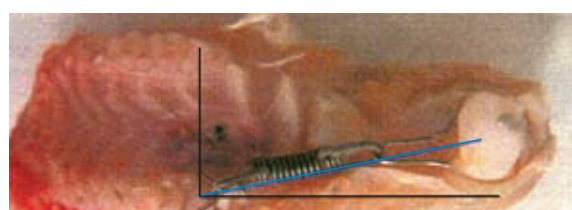


FIGURE 6 - Lingual and mesial force components.

numerical procedure. The maximum horizontal strains obtained from the numerical analysis on the ligament region was 0.03198%, inferior to its strain limit, indicating that the force applied presented low intensity, favoring cellular activity for bone resorption. In Figure 8, it was possible to observe higher stresses around the smaller root and the occurrence of maximum stress in the alveolar bone, originating regions of bone neoformation.

The distribution of deformations obtained from heights at 0.64 mm and 0.83 mm from the cervical margin demonstrated to be similar between them and to the previous (Figs 9 and 10), differing on the propagation of areas, which were amplified. The deformations, as well as the effective tensions, increased in intensity with the greater of point of force application height. Table 2 presents the maximum values obtained from the analyses.

The effective stresses values on the periodontal ligament indicate that the experiment produced results on the elastic linear regimen in which the tension limit is equivalent to 9450 N/m².

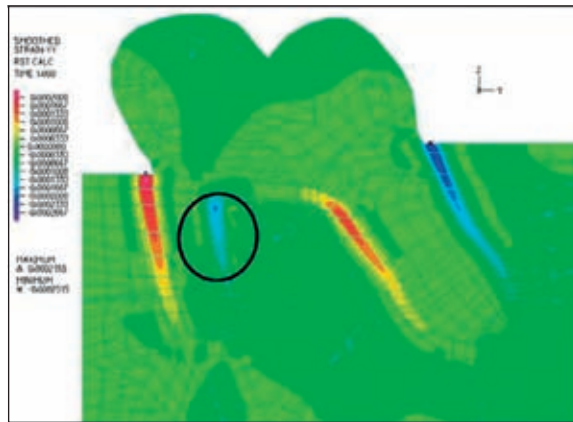


FIGURE 7 - Strains due to load application at 0.38 mm from the cervical margin.

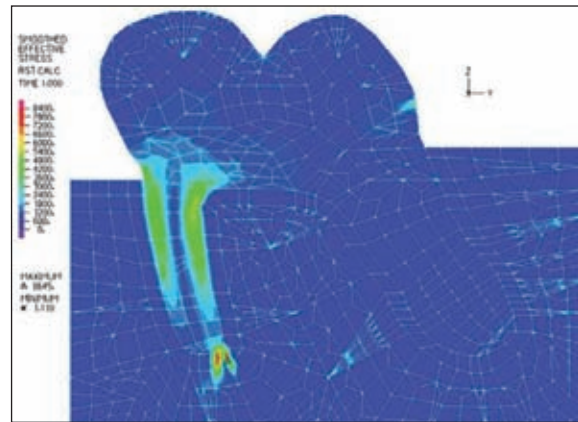


FIGURE 8 - Effective stress due to force application at 0.38 mm from the cervical margin.

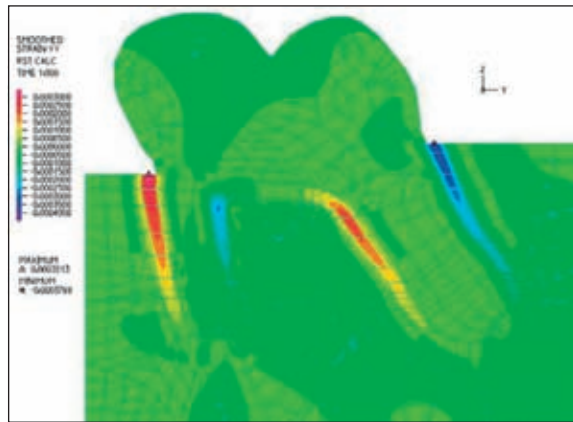


FIGURE 9 - Horizontal strain for load at 0.64 mm from the cervical margin.

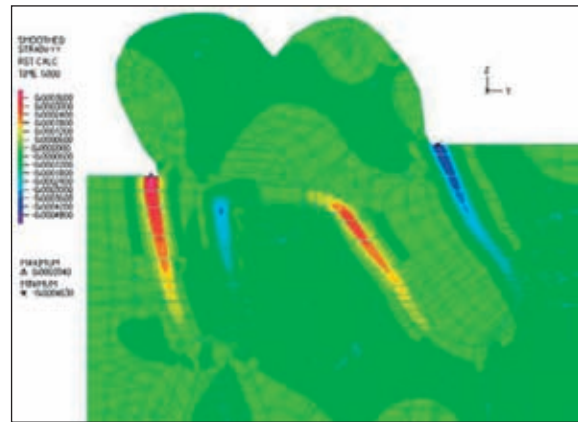


FIGURE 10 - Horizontal strain for load at 0.83 mm from the cervical margin.

TABLE 2 - Stresses and strains for load applied at 0.38 mm, 0.64 mm and 0.83 mm.

		0.38 mm	0.64 mm	0.83 mm
Periodontal ligament	Strains (%)	0.0319821	0.0481154	0.0597829
	Effective stresses (N/m ²)	7.04292×10^{-1}	1.09042×10^{-2}	1.35718×10^{-2}
Bone	Effective stresses (N/m ²)	1.32567×10^{-4}	2.03861×10^{-4}	2.55899×10^{-4}

DISCUSSION

The presented results aim to confirm the efficiency of employing FEM for qualitative evaluation of dental movement. For this reason, the two dimension model for the Stress Plan and the bi-linear elastic behavior of the periodontal ligament were chosen. It is important to highlight that the mechanical behavior of the ligament, due to its

variability among samples, is a topic for research nowadays. Models which consider the linearity or non-linearity, viscous elastic behavior, anisotropy of the medium, have been presented, but the results have generated some controversy.⁶

The elastic model used for the ligament, produced the results showed in Figure 7, which in confrontation to Figure 2A, demonstrated that FEM

provides results in accordance to the ones truly obtained. This fact indicates the possibility of adjusting load levels to be applied to the teeth and the resulting movements, avoiding high intensity load and its resultant problems.

In relation to the study concerning force application height, it can be observed in Table 2 that the described values are progressively higher with the elevation of the point of force application, identified in Figure 4. This fact happened because the direction of the inclined force was altered for each situation of analysis, placing it more horizontal as the height of force application was more distant from the cervical margin, maintaining the anchorage point on the incisors. The anchorage was defined on the mathematical model as the origin of the force vector, indicated in Figure 6. It is evident that during the experiment the real direction could not be established, due to the difficulty in making the measurements, but as the aim of this work consisted on the qualitative evaluation of the heightening of the point of force application, it was considered pertinent, for the numerical analysis, to keep as reference the origin of the force vector. Thus, the magnitude of the horizontal force projection, responsible for a more significant movement of the tooth, was higher

in each analysis, producing, consequently, small expansions on the stressed and strained areas.

Among the necessary studies to confirm the adequacy of FEM for quantitative analyses, additional researches on the mechanical behavior of the periodontal ligament are mandatory. In such case, tridimensional analyses will need to be done aiming to consider all the parameters involved in tooth movement.

For the orthodontists, there is a new option for planning and research, employing a tool which allows a previous simulation of force mechanisms versus dental movement.

CONCLUSIONS

The results obtained show a satisfactory correlation between experimental and numerical data, justifying the efficiency of the Finite Element Method to analyze problems related to tooth movement, especially when studying orthodontic force distribution.

Small variation towards force application height, mathematically tested, demonstrated the existence of sensitivity of the technique employed on the experimental model, in relation to the installation of the device for tooth movement. Depending on the objective of the research, these variations should be taken into consideration.

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The influence of asthma onset and severity on malocclusion prevalence in children and adolescents

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Abstract

Objective: The influence of asthma, its severity levels and onset time on malocclusion occurrence were investigated. **Methods:** The sample was composed by 176 children/adolescents, of both genders, aged 3 to 15 years, that were divided in two groups. The asthma group (AG) enrolled 88 children/adolescents that were seen at the Breathe Londrina Program. The asthma-free group (AFG) enrolled 88 preschool and school children recruited in 2 public schools. Malocclusion diagnosis was made according to WHO criteria (OMS, 1999). **Results:** A higher prevalence in malocclusions in asthmatic patients in mixed dentition was observed when compared to controls ($p < 0.05$). On the other hand, these results were not observed for deciduous ($p > 0.05$) and permanent dentition ($p > 0.05$). A significant association was seen between asthma onset time and marked maxillary overjet ($p < 0.05$), and open bite ($p < 0.05$) in the mixed dentition, being both conditions more common among those that have presented the symptoms of asthma prior to 12 months of age. **Conclusion:** The results of this study indicate that the early manifestation of asthma at first year of life can cause dentofacial changes. Therefore, the prompt diagnostic of the illness, as well as the establishment of a proper therapy could improve the symptoms and chronic complications of asthma and also reduce its impact on craniofacial development.

Keywords: Asthma. Malocclusion. Child. Adolescent.

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INTRODUCTION

Asthma is a chronic disease that affects millions of people around the world from different ethnic and social background.¹² Its incidence has increased in recent decades, and according to an estimate by the World Health Organization, in 2005, the costs of asthma medication outstrip the costs for AIDS treatment.⁵ In Brazil, it affects about 20% of infantile population.²³

Asthma affects lower airway and it causes narrowing in bronchial tubes resulting in air flow limitation, which can be reversed spontaneously or after treatment. Its symptoms vary from the form of simple coughing episode up to recurrent severe dyspnea, and may even cause death.⁸ As it is a respiratory disorder, asthma may be associated with mouth breathing, which can cause changes in functional posture of oral muscles and as a consequence, changes in craniofacial development, dental position and occlusion can be observed.^{9,21}

Dental literature shows contrasting results among respiratory disorders and malocclusion occurrence, especially concerning bronchial asthma. Therefore, this study aimed to evaluate the influence of asthma severity and onset in malocclusion prevalence, and in this way, provide information so that suitable dental preventive programs and therapeutic approaches can be proposed in order to reduce possible orofacial deformities related to asthma.

MATERIAL AND METHODS

Experimental design and study population

The University of Northern Paraná Ethical Committee (Londrina-PR, Brazil) approved this study. This cross-sectional comparative study evaluated relation between asthma severity and onset on the prevalence of malocclusion in 3 to 15 years-old children. The study population was composed by two groups: Asthma group and control group (both were divided according to the dentition phase in deciduous, mixed and permanent).

One hundred children and adolescents from Breathe Londrina Program were invited to join the research. However, two patients were excluded because they were using orthodontic appliances and 10 patients missed the dental appointment scheduled for clinical exam. Therefore, the sample from asthma group (AG) was composed by 88 asthmatic children and adolescents.

The asthma-free group (AFG) was also composed by 88 children and adolescents of age, gender and social background similar to the AG group, randomly selected from two public schools, one in the west region and other in the south of the municipality.

Data gathering

Data gathering was performed from February to October 2007 by two dentists, one was responsible for the interview and the other for the nasal breathing test and clinical examination. Before any methodological procedure, the parents/legal guardians were informed about the risks and benefits of the study and only after a written informed consent was obtained, the patient was included in the research, as demanded by Brazilian CNS 196/96 resolution.

The parents were interviewed on medical and dental history of their children, with special regard to bronchial asthma history (disease onset and its pharmacological treatment). These data were used to classify asthma severity (Table 1), which was confirmed through patients' medical records. Moreover, retrospective data concerning non-nutritive sucking (such as digital sucking and pacifier's use) and the presence of allergic rhinitis were also assessed by the questionnaire.

The data obtained for asthma severity classification were also compared to those in the patients medical records. For those cases in which the severity classification based on the parents/legal guardians interview did not coincide with the medical records, the latter was used.

FIGURE 1 - Classification of asthma severity (adapted from Shulman et al,¹⁷ 2001).

Category	Occurrence at last year
Severe	2 hospitalizations or 4 acute events
Moderate	1 hospitalization or 2 acute events or 3 events of respiratory difficulties
Mild	No hospitalization or 1 acute event or 2 events of respiratory difficulties

The test described by Menezes et al¹³ was performed to evaluate the nasal breathing. In this test, the patient must put water into the mouth and keep the lips closed without swallowing water during 3 minutes. The patients who open the lips or swallow the water are considered mouth breathers.

Clinical examination was performed by one previously calibrated orthodontist ($\kappa = 0.96$) according to the criteria described by World Health Organization¹⁴ for diagnosis of crowding and spacing in the anterior segments; maxillary and mandibular overjet; overbite; anterior open bite; posterior crossbite. The molar relation was based on Angle's classification¹ for permanent teeth and Tomita, Bijella, Franco²⁰ criteria for deciduous ones.

Statistical analysis

A multivariate logistic regression (Forward Stepwise Likelihood Ratio) was performed, with the following variables included in the model: Asthma, allergic rhinitis, digital suction, impaired nasal breathing and pacifier use after 2 years of age.

Chi Square test (X^2) was used, with 95% confidence interval and 5% significance level, to ascertain the associations between malocclusions and asthma (severity and onset). To allow bivariate analysis, the variables that presented more than one category were grouped and converted to di-

chotomous variables. When the cells showed reduced numbers, G-test with Yate's correction was applied instead of Chi Square test.

Statistical analysis was performed at the Statistical Package for Social Sciences 15.0 (SPSS) software.

RESULTS

One hundred seventy six children and adolescents were recruited for this research, being 88 in the asthma group (AG) and 88 in the asthma-free group (AFG). The patients were split into three groups: Deciduous dentition ($n=30$), mixed dentition ($n=109$) and permanent dentition ($n=37$). Regarding gender, 103 patients were female while 73 were male (Table 1). The mean age of children from AG was similar to the mean age of those from AFG, except in the mixed dentition group, whereas AFG age was higher than AG (Table 2).

No statistical differences were observed between the groups concerning the following variables: molar relation (Chi Square= 0.390 and $p>0.05$), spacing in anterior region (Chi Square= 0.846 and $p>0.05$), crowding (Chi Square= 0.834 and $p>0.05$), crossbite (Chi Square= 1.10 and $p>0.05$), maxillary overjet (Chi Square= 0.112 and $p>0.05$) and open bite (Chi Square= 0.226 and $p>0.05$). Despite the prevalence of malocclusion seems to be higher in the asthma group, no statistical differences were observed between the groups (Chi Square= 2.79 and $p>0.05$).

However, an increased malocclusion prevalence in the asthma group was observed in the mixed dentition when compared to asthma-free group (Chi Square= 4.54 and $p<0.05$). On the other hand, no differences were observed for the deciduous (G test= 0.44 and $p>0.05$) and permanent dentitions (G test= 0.01 and $p>0.05$).

Considering that malocclusion occurrence was higher in asthma group and that other variables such as impaired nasal breathing and non-nutritive sucking habits are involved in malocclusion etiology, a multivariate analysis was performed in order to control these variables.

Asthma and impaired nasal breathing were related to malocclusion occurrence through logistic regression. However, no association was observed between allergic rhinitis or non-nutritive sucking habits and malocclusion (Table 3). Indeed, asthma was not related to functional changes in stomatognathic system, such as nasal breathing and tongue position. Asthma severity did not seem to influence neither the molar relation nor the presence of crossbite, overjet and open bite in the studied population.

Symptoms onset was correlated to the presence of an increased maxillary overjet in the mixed dentition (Table 4), usually in patients whose asthma started at one year of age. Moreover, a significant association between symptoms

onset and the presence of open bite was also observed in mixed dentition. In this subgroup, all the patients showing open bite had asthma onset at one year of age (Table 5).

DISCUSSION

The present study is part of a project designed to evaluate asthma's impact on oral health whereas the following variables were studied: dental caries, oral hygiene, dental enamel defects (enamel opacities and dental fluorosis), salivary levels of cariogenic bacteria (*S. mutans* and *Lactobacillus* spp) as well as *Candida* spp; salivary properties and malocclusion prevalence. The children and adolescents enrolled in this research are assisted by Breathe Londrina Program. This program started in 2003 aiming to improve the quality of health assistance provided to asthmatic patients. It aims to integrate the activities of primary, specialized and hospital care, as well as to qualify measures to control home environment and use the most appropriate drug therapy for each clinical situation. Drug therapy is based on the use of beclometasone in powder form, inhalation or spray, and albuterol in the form of an inhaled spray.

TABLE 1 - Distribution of the studied population according to group, dentition and gender.

Dentition	Gender	Group			
		AFG		AG	
		n	%	n	%
Deciduous	Male	4	36.36	9	47.37
	Female	7	63.64	10	52.63
Mixed	Male	23	37.10	20	42.55
	Female	39	62.90	27	57.45
Permanent	Male	3	20.00	14	63.64
	Female	12	80.00	8	36.36

TABLE 2 - Comparison of mean age according to group and dentition.

Dentition	Group	n	Age		t	p
			mean	SD		
Deciduous	AFG	11	4.55	1.44	0.04	0.97
	AG	19	4.53	0.84		
Mixed	AFG	62	9.16	1.43	2.26	0.03
	AG	47	8.40	2.06		
Permanent	AFG	15	12.40	1.45	0.18	0.87
	AG	22	12.32	1.25		

TABLE 3 - P value, odds ratio and confidence intervals of malocclusion prevalence according to the presence of asthma, allergic rhinitis, pacifier use after 2 years of age, digital suction and impaired nasal breathing

Variable	P value	OR	CI 95%
Asthma	0.02	2.47	1.14 - 5.37
Allergic rhinitis	0.11	0.47	0.18 - 1.20
Pacifier use	0.45	0.75	0.36 - 1.58
Digital suction	0.72	1.24	0.38 - 4.00
Impaired nasal breathing	0.00	6.24	2.08 - 18.73

TABLE 4 - Relation between maxillary overjet and asthma onset symptoms, according to dentition phase.

Dentition	Maxillary overjet	Symptoms onset				X²	p
		After 12 months		Before 12 months			
		n	%	n	%		
Deciduous	Normal	6	50.00	6	50.00	0.03	0.86
	Increased	3	42.86	4	57.14		
Mixed	Normal	21	67.74	10	32.26	7.74	0.01
	Increased	4	25.00	12	75.00		
Permanent	Normal	13	68.42	6	31.58	0.27	0.60
	Increased	1	33.33	2	66.67		

TABLE 5 - Relation between the presence of open bite and asthma onset symptoms, according to dentition phase.

Dentition	Maxillary overjet	Symptoms onset				X ²	p
		After 12 months		Before 12 months			
		n	%	n	%		
Deciduous	Absent	6	40.00	9	60.00	0.47	0.49
	Present	3	75.00	1	25.00		
Mixed	Absent	25	59.52	17	40.48	4.66	0.03
	Present	0	0.00	5	100.00		
Permanent	Absent	14	63.64	8	36.36	**	**
	Present	0	0.00	0	0.00		

Those enrolled in the program have monthly meetings and lectures with health professionals, where they receive information about the disease. The assessment of its impact was very positive because there was reduced number of crises and hospitalizations, which resulted in less suffering for patients and savings for the health system.⁴

There are many reports about the association between malocclusion and upper airway tract diseases. However, there is a lack of information about lower airway tract disorders, such as asthma, and malocclusion development. Upper and lower airway disorders have the same pathogenesis^{6,19} and they are usually present at the same patient. Epidemiological studies showed that nearly 74% to 81% of asthmatic patients have also allergic

rhinitis.^{7,11,19} It is important to point out that patients with allergic rhinitis or asthma as well as patients with nasal septum deviation, enlarged adenoids or nasal polyp generally present mouth breathing,^{3,16} which is often related to malocclusion etiology.¹⁸ Barros et al,² in a cross-sectional study, observed a positive correlation between allergic rhinitis and mouth breathing. Venetikidou²¹ also reported a higher prevalence of mouth breathing in asthmatic patients. On the other hand, no association between asthma and impaired nasal breathing was observed in this study, even in patients with moderate or severe asthma. However, through multivariate analysis, it was observed that patients with an impaired nasal breathing showed a higher occurrence of malocclusion.

The contrasting results of this study in comparison to Barros et al² and Venetikidou²¹ could be explained considering the fact that asthmatic patients enrolled in this study take part of a program whereas the treatment is based on use of inhaled corticosteroid,⁴ powerful anti-inflammatory drugs¹⁵ which reduce the inflammation on upper and lower airway tract and, consequently, improve nasal breathing.¹⁰ Wenzel et al²² reported that inhaled budesonide can reduce nasal obstruction in allergic children and, therefore, normalize possible changes in craniocervical angulations observed. However, cohort studies are necessary to evaluate if pharmacological treatment of asthma can effectively improve nasal breathing, preventing the establishment of malocclusion.

Bivariate and multivariate analysis showed higher prevalence of malocclusion and consequent facial changes in asthmatic children and adolescents when compared to control ones. These changes in occlusal features (increased maxillary overjet and open bite) are more common in patients with an early disease onset, when the disease started at the first year of age, especially in mixed dentition group. Faria et al⁹ also reported an association between asthma onset and dento-facial changes observed in adults. Actually, the authors verified that crossbite and crowding are often observed in asthmatic adults in whom the

disease begun before 14 years of age. However, Venetikidou²¹ showed no statistically differences among overbite and overjet prevalence in asthma group when compared to control one.

Dental crowding can be influenced by functional changes, such as impairment of nasal breathing and presence of lower airway tract diseases (asthma).⁹ On the other hand, no association between asthma and dental crowding was observed at this study.

No differences were observed among asthma and control group concerning the crossbite incidence, even when asthma severity and the disease onset are considered in the analysis. Nevertheless, Venetikidou²¹ and Faria et al⁹ reported a positive correlation between asthma and crossbite prevalence.

In this study, there were no association between asthma severity and the presence of any change in occlusal features related to malocclusion, such as modified molar relation, presence of spacing in the anterior regions, increased maxillary overjet or open bite. These results are in agreement with Faria et al⁹ who found no association between asthma severity and malocclusion in adults, despite other study have previously reported this correlation in children.²²

The findings of this study showed that early asthma onset, especially at the first year of age can

evoke dentofacial changes. Therefore, the prompt diagnosis of asthma, as well as the correct pharmacological treatment, could improve not only its symptoms and chronic complications, but also it could reduce its impact on craniofacial development. Special oral health attention should be provided to asthmatic children and adolescents as well as it can be recommended that dentists should be included at the multidisciplinary team involved in asthma assistance.

CONCLUSIONS

According to the present results, it can be concluded that:

- » Asthma is associated to malocclusion prevalence.
- » There is no correlation between asthma severity and malocclusion.
- » Asthma onset can influence malocclusion's establishment, especially when the disease started at the first year of age.

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Assessment of the orthodontic knowledge demonstrated by dental school undergraduates: recognizing the key features of Angle Class II, Division 1 malocclusion

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Abstract

Objective: To investigate the ability of undergraduate students in diagnosing Angle Class II malocclusion and evaluate the clinical approach of these students toward a patient displaying this condition. **Methods:** The sample consisted of 138 students attending the last semester of 10 dental schools in the State of Rio de Janeiro/Brazil assessed by questionnaires with closed questions. They were presented with photographs and dental casts of a patient in the mixed dentition, with Angle Class II malocclusion, increased overjet and overbite, deviated dental midlines and anterior diastemas in the upper arch. **Results:** It was found that students easily identified increased overjet (92% of students), followed by the presence of diastemas (89%), midline deviation (84.7%) and increased overbite (77.3%). Conversely, approximately half the sample (n=70 or 51% of the students) were able to identify bilateral Angle Class II malocclusion. Nearly all agreed on the need for treatment and that it should be provided by a specialist (n=131 or 95%), but found it difficult to determine the ideal moment to start orthodontic treatment: 48.9% of the sample would begin treatment at the end of the mixed dentition, 41.7% would indicate treatment during deciduous dentition and 7.9% during permanent dentition. **Conclusions:** On completion of their undergraduate courses, students encounter difficulties in diagnosing Class II and even find it hard to articulate ideas about a basic treatment protocol to correct this malocclusion.

Keywords: Interceptive orthodontics. Angle Class II malocclusion. Diagnosis.

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INTRODUCTION

Diagnosing Class II malocclusion is a complex and critical task as it may occur as a result of diverse skeletal structures involved in combination with dentoalveolar problems. Furthermore, the identification of changes in the maxillomandibular sagittal and vertical components, be it in isolation or in combination,²² requires an orthodontists' abilities to choose the best therapeutic solution.

Orthodontic planning for these patients requires knowledge on the growth of facial bones^{2,19} and determining the stage of skeletal maturation of the individual. Chronological age and dental eruption are often seen as important factors for determining skeletal maturation. These methods, however, are considered inaccurate since they usually do not coincide with the patient's skeletal age.^{4,6} The best ways to assess skeletal development is through hand and wrist X-rays^{6,27} and lateral cephalometric radiographs with visualization of the cervical vertebrae.²¹ Pubertal growth spurt usually occurs in girls between 9 and 12 years old and boys aged 11 to 13 years.²⁰

Thus, orthodontists can treat this malocclusion at three different development stages: (a) Pre-pubertal; (b) During pubertal growth spurt, in order to produce both dentoalveolar and skeletal changes; or (c) Adulthood, when growth has ceased. It is crucial that clinicians learn to distinguish between these stages as it has a bearing on the choice of therapy to which the patient will be subjected, when referred to an expert.

For patients with changes in maxillary development, headgears, such as the Kloehn and Thurow types, are best suited to control growth.¹⁶ Depending on facial pattern, patients experiencing growth may be subjected to different procedures. The Kloehn cervical headgear is recommended for cases of maxillary protrusion and reduced vertical dimension, producing effects such as: Distalization and

extrusion of upper molars, maxillary growth restriction, increased vertical dimension, clockwise mandibular rotation and anterior inclination of the palatal plane.¹⁶ Maxillary splints or Thurow headgear, on the other hand, act on the maxilla due to an increased area of force application, thereby providing control over direction and location of the applied force, restricting the anteroinferior displacement of the maxilla and clockwise rotation of the mandible.²⁴

For patients with Class II malocclusion due to a deficiency in anterior mandibular growth, the proposed therapies are often associated with functional appliances with the purpose of stimulating its anterior development in order to correct sagittal discrepancies between the jaws.³⁰ These appliances may assist in treating these malocclusions by remodeling the condyle and glenoid fossa, thus interfering with facial development and growth. However, the increments to mandibular growth during the active treatment phase using these appliances and the stability of these changes are still important issues that need to be addressed.²⁹

Therefore, the therapeutic intervention choice for Class II malocclusion correction is made from a wide range of approaches and types of treatment, resting on the orthodontist the task of carefully assessing them, insuring that it meets the patient's actual needs.²³

Moreover, two orthodontic treatment protocols are recommended for Class II patients undergoing growth. The first one, known as two-phase treatment, is initiated when the patient is in pre-adolescence (pre-pubertal growth spurt stage). The first phase aims to correct skeletal discrepancies and molar relationship²⁵ and is performed using orthopedic-functional appliances or headgears. Next, during pubertal growth spurt, the second phase is engaged during which a fixed orthodontic treatment improves occlusion. The second protocol comprises a single-phase treatment in which the professional only

initiates correction at the beginning of pubertal growth spurt, when skeletal and dental corrections can be performed simultaneously.⁹

In attempting to assess the efficacy of these two Class II treatment protocols, major studies were conducted with large clinical samples focusing on comparative results yielded by two-phase and one-phase orthodontic treatment.^{8,14,22,25,30} Overall, these studies compared three groups—two treated groups and one control group—to assess the effect of treatment and growth. The treatment groups underwent a first phase with an extraoral appliance (high pull, Kloehe or Thurow) and a functional appliance (Fränkel, Bionator or plateau retainer) followed by a second phase with fixed orthodontics. A control group, not subjected to the first phase, was treated only in one single phase with fixed orthodontics during pubertal growth spurt. These studies revealed that the treated groups exhibited significant improvement in their maxillomandibular relationship with the greatest maxillary effects being linked to the headgears, and mandibular effects linked to the functional appliances.^{8,14,22,25,30} When compared with the other groups at the end of treatment, the control group showed no clinical differences (PAR index). It was also observed that the total treatment time was greater in the groups that experienced the first phase.

Regarding the advantages of a two-phase treatment some authors believe that the approach would favor early growth modification, decreasing the duration and complexity of the second phase of treatment, improving patient self-esteem and decreasing the incidence of injuries in anterior teeth. Also, it would be carried out in pre-adolescence when there is adequate patient compliance and reduce the need for extractions, since there would be greater skeletal changes and consequently a reduced need for dental compensation.^{5,10,28} Currently, however, these benefits are the subject

of much controversy. On the issue of reducing trauma frequency to the upper incisors, for example, recent research has shown that prevention can be achieved only when treatment is started excessively early, increasing orthodontic treatment time.^{15,25}

Thus, those who advocate single-phase treatment also argue that the low growth activity that occurs before pubertal growth spurt would increase the length and cost of treatment, reducing patient compliance since there is no evidence to support the idea that results achieved through early intervention are potentially superior.^{13,22,25}

Cost-effectiveness analysis of two-phase treatment showed that at least 90% of all growing patients could be successfully treated in one-single phase, which should begin during the late mixed dentition, characterized by exfoliation of all deciduous teeth, with the exception of the second molars. These findings reinforce the fact that early treatment (pre-pubertal growth spurt) does not necessarily show favorable differences in the outcomes of orthodontic treatment for Class II when compared to the indication for treatment during pubertal growth spurt.⁹

This study aimed to assess the level of orthodontic knowledge held by undergraduate students attending the last semester of dentistry in educational institutions in the State of Rio de Janeiro. To this end, a questionnaire was applied to assess diagnostic skills, identification of the typical features of a patient presenting with Angle Class II, as well as clinical conduct and ideal moment to provide orthodontic treatment.

MATERIAL AND METHODS

The sample consisted of 138 undergraduate students randomly selected from those attending the last semester of 10 dental schools in the State of Rio de Janeiro, namely, Campos School of Dentistry, Rio de Janeiro State University, Fluminense Federal University, Rio de Janeiro

Federal University, Gama Filho University, Estácio de Sá University, Volta Redonda University, Nova Iguaçu University, Rio Grande University and Veiga de Almeida University.

A standard data collection technique was used consisting of a questionnaire, which was

attached to the case report (Figs 1 and 2). These were individually presented to all undergraduate students attending the last semester who were present on the visit day. No time limit was set to answer the questions. The material consisted of a header characterizing patients in terms of age



FIGURE 1 - Side profile and front photographs of the patient whose case records were presented to the students.

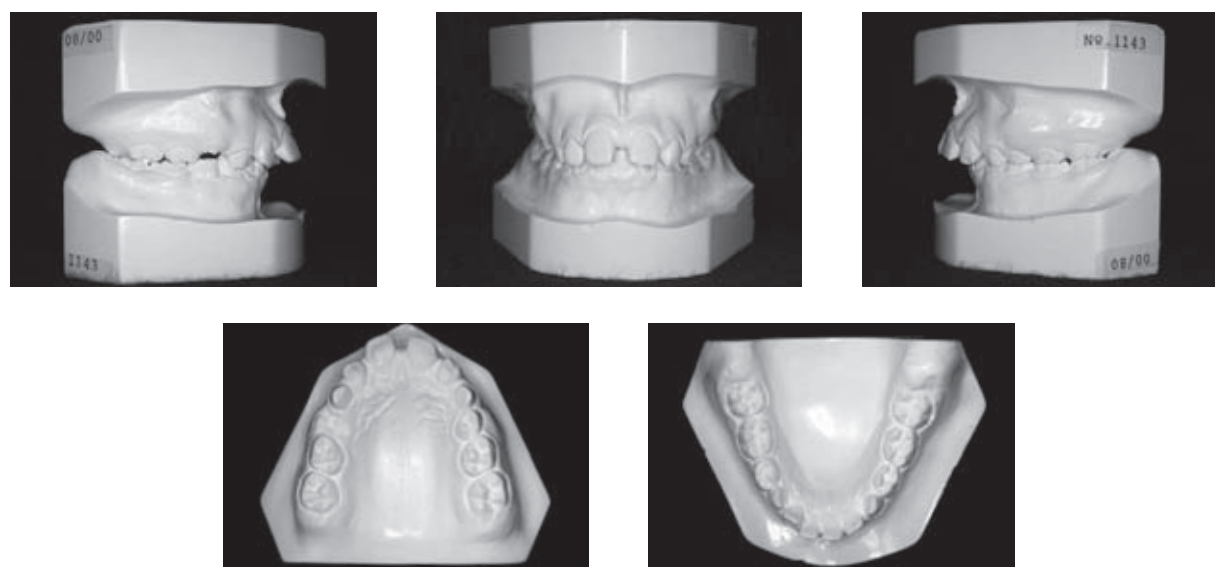


FIGURE 2 - Occlusal, front and side views of the dental casts presented to the students.

and gender, front and profile photographs of the face and dental casts of a patient displaying Angle Class II, Division 1, with the following dental features: Increased overjet and overbite, deviated upper and lower midlines, diastemas between maxillary anterior teeth and mixed dentition. No cephalometric, panoramic or hand and wrist radiographs were provided intending to simulate a routine clinical consultation, where patients could only provide them with their clinical features. After analyzing the material, students were asked, by means of closed questions about Angle classification, existence of dental problems, the

ideal stage for initiating treatment and the possible referral of their patient to an expert. Questionnaire responses were kept confidential to preserve student identity.

The collected data were processed and analyzed with the aid of EpiInfo software v. 6.04, and the charts were generated using Microsoft Excel 2004. Since the aim of this study was to assess the orthodontic knowledge of undergraduate students, the analysis was descriptive and comparative.

RESULTS

According to the sample configuration there was a noticeable lack of knowledge reflected in the difficulty encountered by students to accurately detect bilateral Class II, Division 1 malocclusion, since only about half of them reached a correct diagnosis ($n=70$ or 51%). Thirty-two percent ($n=44$) identified Class II subdivision, i.e., the posterior relationship was identified, however on one side only. The remaining students ($n=24$ or 17%) failed to diagnose the problem presented to them (Fig 3).

Figure 4 illustrates the characteristics more readily recognized by respondents, with increased overjet appearing as the most easily identifiable feature (92% of students), followed by the presence of diastemas (89% of students), deviated midlines (84.7% of students) and the least perceptible feature was increased overbite (77.3% of students).

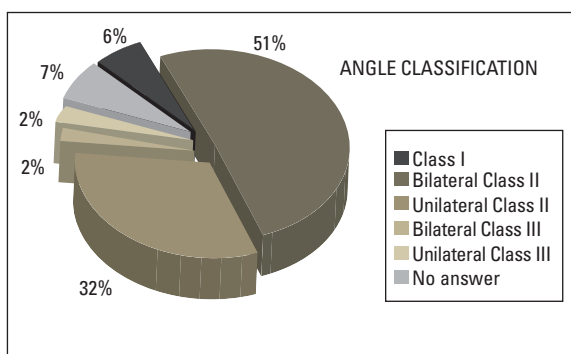


FIGURE 3 - Angle classification according to the sample of undergraduate dental students in the State of Rio de Janeiro.

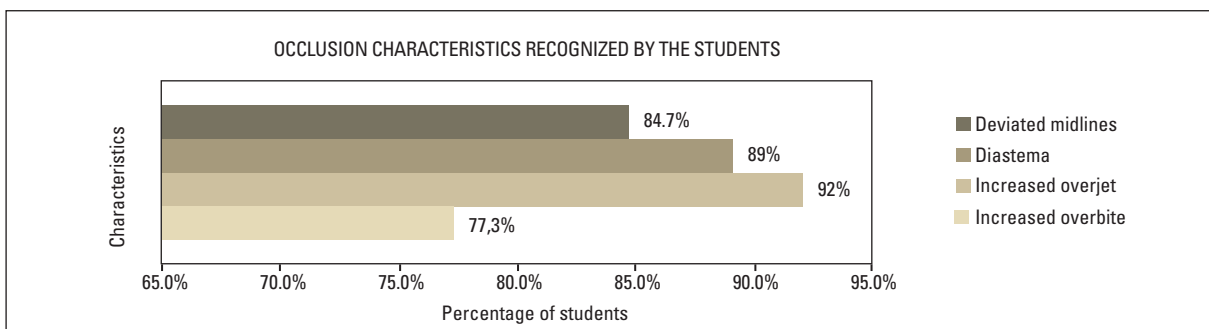


FIGURE 4 - Occlusal characteristics of the presented case as identified by a sample of undergraduate dental students in the State of Rio de Janeiro.

Regarding the need for orthodontic treatment, the vast majority of the sample answered that there was the need to refer treatment and that it should be performed by a specialist (n=131 or 95%), compared to only 2.1% (n=3), who replied that there would be no need for treatment (Fig 5).

Figure 6 shows the results of the questionnaire applied to the students regarding the ideal stage to start orthodontic treatment considering the dental age. It was found that 48.9% of the sample indicated treatment at the end of the mixed dentition, but 41.7% opted for deciduous dentition, and 7.9% believed that permanent dentition was the right stage to begin orthodontic therapy. As shown in Figure 7, most students (54%) were able to understand that pubertal growth spurt may be an important ally in the treatment of patients with Angle Class II malocclusion.

DISCUSSION

The intent of the questionnaire applied to undergraduate students, who had already attended the course in orthodontics, was to check whether or not some basic diagnostic concepts had been absorbed. These future dental professionals, during their clinical career, should be capable of identifying dental occlusion problems in their patients and referring them for orthodontic treatment. In Class II, where facial bone growth and development must be redirected by orthodontic therapy, it is critical that the clinical characteristics of this malocclusion, as well as the beginning of patients' skeletal maturation process, are properly identified to achieve a successful treatment.

It is notorious, however, that the curricula adopted for the orthodontics undergraduate course in dental schools across Brazil employ different teaching methods and therefore offer varied undergraduate orthodontic training. These schools should primarily focus on

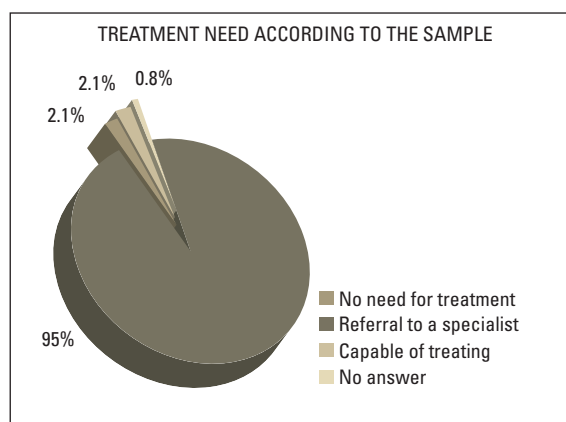


FIGURE 5 - Need for treatment of the case presented, as determined by a sample of undergraduate dental students in the State of Rio de Janeiro.

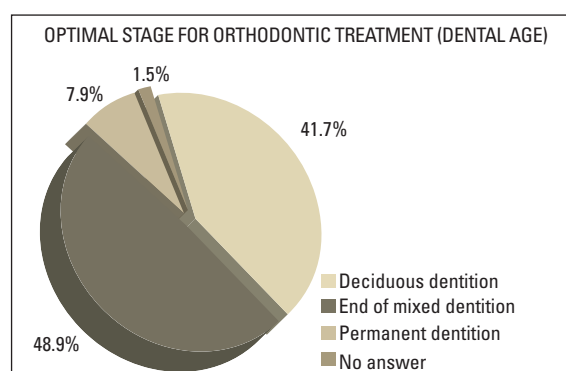


FIGURE 6 - Ideal stage for orthodontic treatment for the Class II patient taking into account dental age, as determined by a sample of undergraduate dental students in the State of Rio de Janeiro.

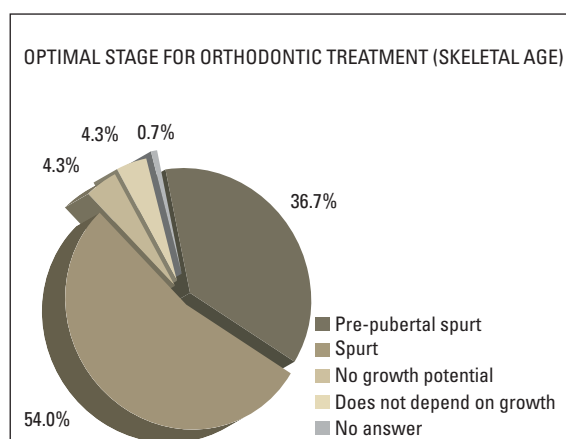


FIGURE 7 - Ideal stage for orthodontic treatment for patients with Angle Class II malocclusion taking into account skeletal age, as determined by a sample of undergraduate dental students in the State of Rio de Janeiro.

teaching the development of normal occlusion and facial bones growth, thereby providing the foundation necessary to diagnose dentition abnormalities and deviations from the normal growth pattern.

As regards to Class II malocclusion it is important that clinicians possess an understanding of the optimal treatment time. Identifying specific dentoalveolar characteristics and, mainly, the beginning of patient's growth spurt is essential, if dentists are to refer the patient to an orthodontist at the most suitable time for treatment. Puberty signs, such as the development of physical and sexual features, are excellent indicators of this spurt. The authors deliberately refrained from providing students with cephalometric, panoramic and hand and wrist radiographs that could better identify the patient's development stage. Actually, the purpose was to simulate an initial consultation for Class II patients providing clinical information only.

In this study students were not identified, but their schools of origin were recorded in order to make comparisons and establish potential trends according to the dental schools. The undergraduate core curriculum includes lessons on the classification of malocclusions. However, after the classes, not all courses provide practical activities with dental casts, teaching how to recognize and classify malocclusions. Therefore, curricula may vary in content, and some schools only provide theoretical lessons and laboratory activities, while others also offer specific orthodontic clinics. Some schools provide this training in conjunction with the Pediatric or General Clinic, which not always are performed by the orthodontic faculty. However, surprisingly, no significant differences were found in students' responses when they were grouped by schools of origin.

Given the concern of educators and dentists in other countries, the American Association of Dental Schools, in 1980, developed a Cur-

ricular Guide for Orthodontics with the aim of establishing the content of orthodontic education programs, including enough information to enable students to recognize and take action in the presence of malocclusions by differentiating cases of interceptive orthodontics from other cases which require referral to specialists.¹

Deficiencies in the training of general practitioners are observed not only in diagnosing orthodontic problems but also in identifying the optimal time for treatment of various malocclusions and referral to specialists.¹²

Other studies used the same sample as this study (students attending the last semester of undergraduate dental courses in the Rio de Janeiro State) for Angle Class I malocclusions in the so-called "ugly duckling" stage (phase of normal occlusion development) and Angle Class III malocclusions. Both questionnaires showed that most students did not have adequate knowledge to determine the optimal stage to begin treatment. Although students were able to identify Class I malocclusion ($n=120$ or 79.6%) and deviations from normality such as the existence of diastemas (81.7%) and excessive overbite (29.9%), they failed to understand that in the "ugly duckling" stage these features are inherent to normal development and referred these patients to a specialist, which might lead to indicating undesirable treatment. Regarding Angle Class III malocclusion, more than half (53.3%) took skeletal age into consideration when referring for orthodontic treatment, which is an important factor to start treatment since its orthodontic approach should be initiated prior to the pubertal growth spurt. Results from both questionnaires revealed major deficiencies in the correlation between students' identification of occlusal features and proper referral of these patients to an orthodontist.^{12,17}

Similarly, the present study found that students had difficulty in properly identifying

Angle Class II, Division 1 malocclusion (Fig 3), since only half of the sample subjects did so correctly. It became clear that students displayed some doubt regarding the concept of Angle Class II relationship since 32% of them (Fig 4) identified the problem in only one side of the dental arch (unilateral Class II).

The vast majority of respondents could easily perceive the existence of dental midline deviation, presence of increased overjet, diastemas and overbite (Fig 4) since all these features are visible in the anterior region of the dental arches. They also determined that the existing problem should be treated by a specialist, since 95% of the students (Fig 5) referred the patient to an orthodontist.

In analyzing Figure 6, showing that 41.7% of the sample indicated treatment still in the deciduous dentition, one is led to the conclusion that students failed to grasp the concept of optimal treatment time for Class II. Starting orthodontic treatment at this stage would not allow the orthodontist to effectively solve the patient's main problem: Redirecting growth and development of the jaws, subjecting the patient to an excessively long treatment time. The same reasoning applies to the 7.9% who indicated treatment during permanent dentition, considering that this patient's skeletal problem could no longer be corrected, what in this case could be treated with extraction of the upper first premolars for orthodontic camouflage.

Although indications for the early treatment of Class II patients, in two phases, is highly frequent,³ treatment planning for growing patients should be performed in a more critical manner, assessing not just the outcomes, but also weighing all psychological, biological and financial costs underlying the decision. Disagreements regarding early treatment can be easily found in the literature and it is therefore important to discuss specific topics related to their validity.¹⁶ Indication of early treatment should be narrowed to cases with severe skeletal disharmony, since

growth observed during growth spurt would not be sufficient to achieve optimal results, avoiding all the skeletal correction to be followed up during comprehensive orthodontic treatment.

It should be emphasized that patients with this kind of problem will be first seen by a general and/or pediatric dentist and therefore they are the ones who refer patients to an orthodontist for further explanations about the condition to the patient or their legal guardian. For that reason, these professionals should be aware of the most suitable stage to initiate treatment, which is ideally during pubertal growth spurt, when correction can be accomplished with greater effectiveness and efficiency. Despite this evidence, what actually takes place is that many experts still suggest early correction of this malocclusion.^{3,26} A recent systematic review published in the Cochrane Library¹¹ further strengthens the argument that orthodontists should not perform early Class II correction, since little can be done to influence on prediction or changes in the skeletal components of the face by means of orthodontic treatment. Moreover, the best outcomes are achieved by changes in dentoalveolar components performed during growth. Therefore, the best age to start Class II treatment is between 9 to 13 years, or more specifically when the patient is experiencing the beginning of pubertal growth spurt. This emphasizes the need for professionals to detect and identify the clinical and individual features of their patients, so they can be referred to an orthodontist at the most suitable time for correcting the problem.

As regards problems related to Angle Class II malocclusion, students and future clinicians should be emphatically informed that orthodontic correction is closely linked to the patient's pubertal growth spurt stage. They should be empowered with information on indicators of skeletal maturation, which can be clinically assessed. It is important that clinicians are capable of differentiating between dental age and

skeletal age, as studies show that there is no correspondence between these two indicators.⁶

In light of the results, it is suggested that more comprehensive studies be carried out in order to verify the need to alter the content of undergraduate orthodontics courses in the Brazilian State of Rio de Janeiro. Educating on diagnosis, discussion and development of treatment plans should take precedence over teaching orthodontic appliances fabrication techniques.

CONCLUSIONS

After analyzing the data obtained from the questionnaires answered by undergraduate students of dental schools in Rio de Janeiro State, Brazil, a deficiency was detected in their identification of the morphological features of

Angle Class II, Division 1 malocclusion despite the presence of striking characteristics of this malocclusion in the presented case. Additionally, the vast majority of students were unable to identify the ideal time for intervention and referral of the patient to an orthodontist.

A deficiency was therefore observed in the training of students at the end of undergraduate courses with respect to the identification of Class II malocclusion and the ideal stage for initiating orthodontic intervention.

These findings lead to a reflection about curriculum content and teaching methodology of undergraduate orthodontic courses at dental schools given their inability to qualify future clinicians to identify a malocclusion frequently found in dental practice.

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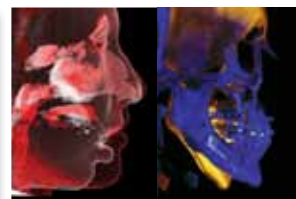
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