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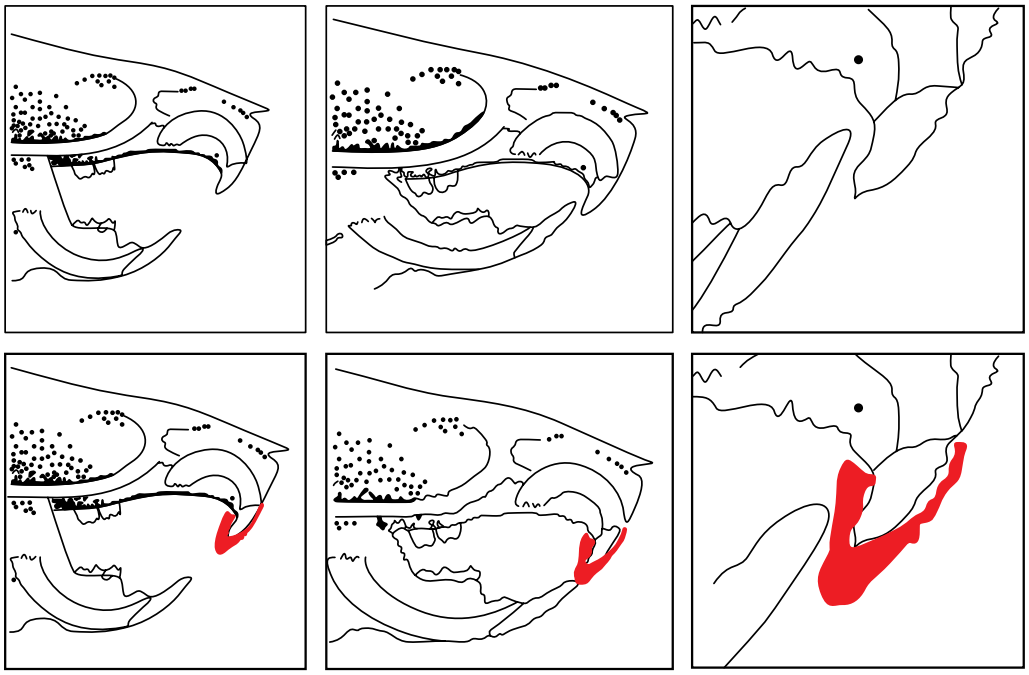
Volume 18, Number 4, July / August



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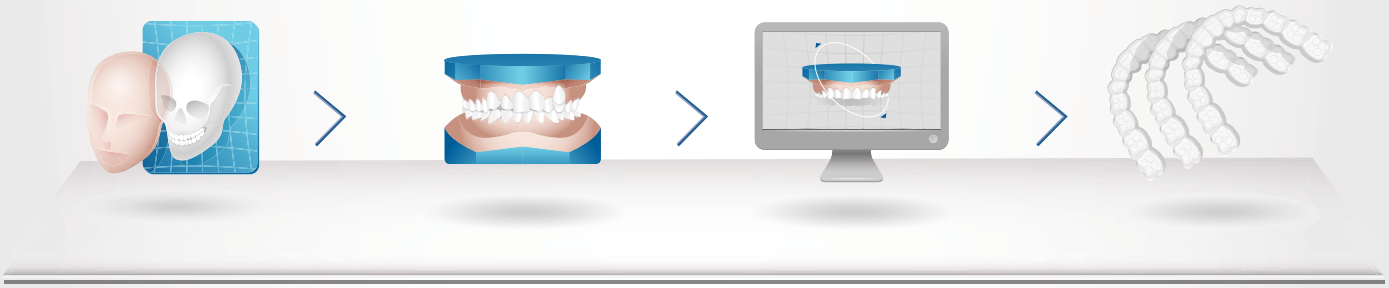

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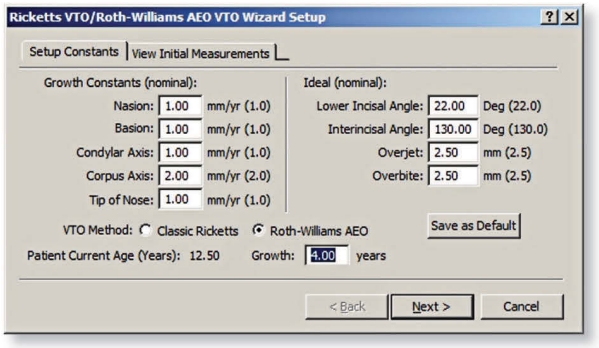

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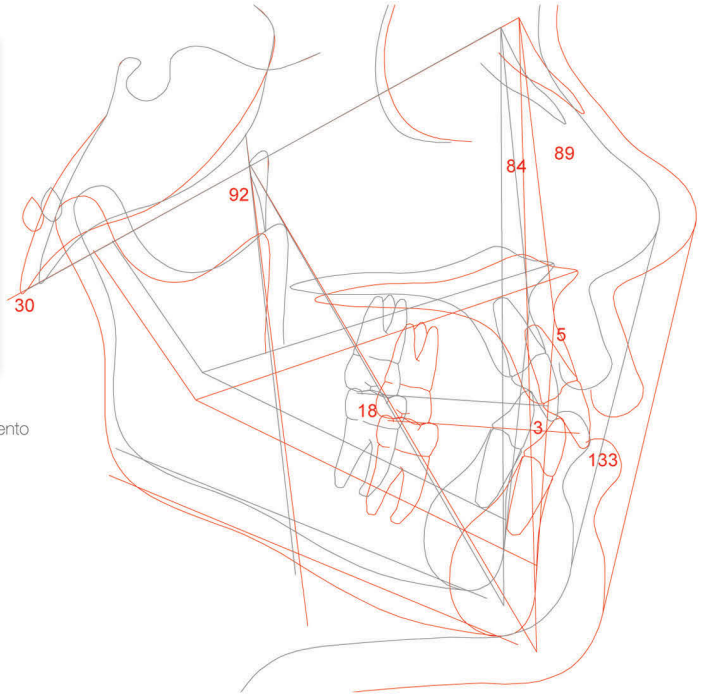

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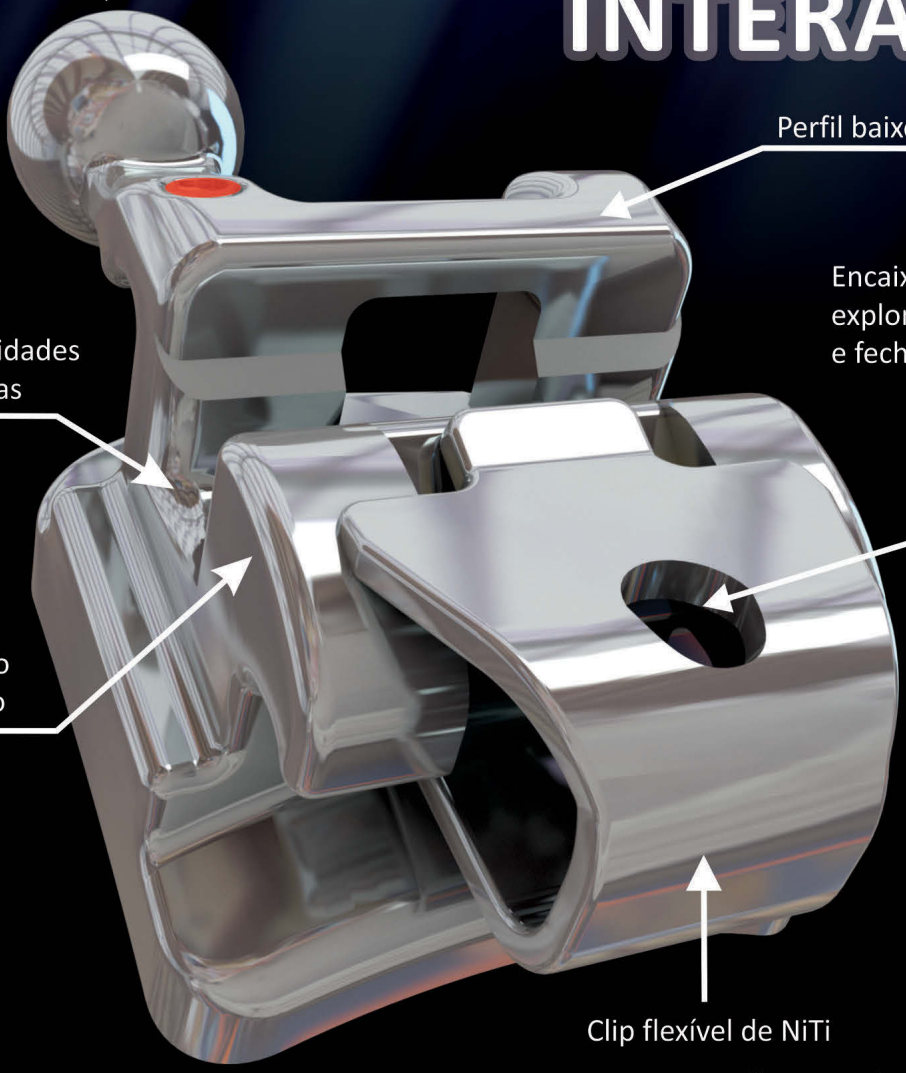

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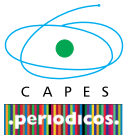

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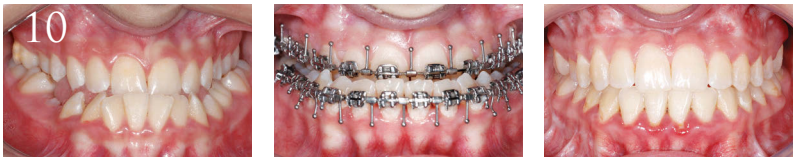

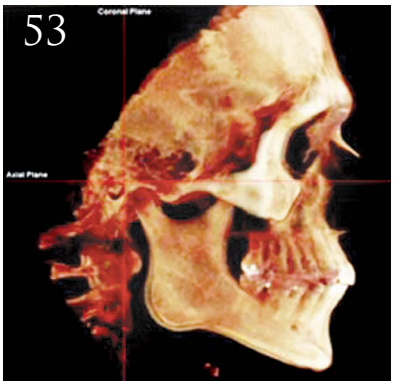

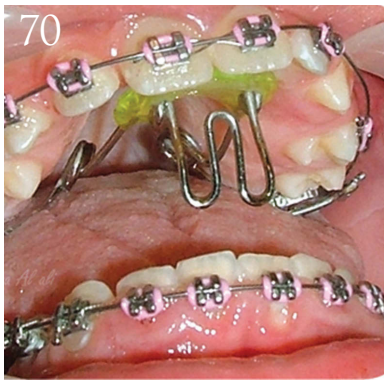

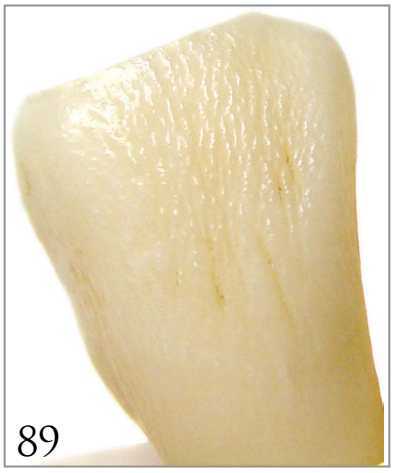

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MEDLINE — International recognition of the development of Brazilian Orthodontic science

Because all I need is free steps, hand in hand, and eyes wide open.
(Guimarães Rosa)

Increase in scientific production requires that periodicals be indexed in databases, in order to make information available quickly and systematically to clinical and scientific communities. The main purpose of an indexing service is to ensure prompt access to information and documents of any kind whenever one searches for a specific subject in information systems or databases.

Having a journal indexed in a database not only means merit recognition, but also corroborates the quality of published articles. Therefore, all scientific periodicals must comprise, among other features, visibility and accessibility, both of which are facilitated by indexation.

We have all witnessed the development of Brazilian Orthodontics in the last decades. We are no longer seen as mere knowledge consumers once we have become one of the countries with the greatest scientific production in Orthodontics in the world. Numerous clinical and scientific awards permeate our daily routine, ratifying our ongoing path. Despite the volcanic eruption of the specialty, our editorial production process has always been discredited. Would we be really capable of producing and maintaining an orthodontic journal with as much quality as the international periodicals used as means to ascend to our scientific success?

Dental Press Journal of Orthodontics team always believed so. We have been restlessly working for 18 years in order to achieve the same success as our Brazilian Orthodontics has achieved. Thus, we are happy to announce* that the *Dental Press Journal of Orthodontics* is indexed in the MEDLINE/ PubMed, the most important database providing references to health sciences information. It is a National Library of Medicine (NLM) journal citation database which has been providing over 22 million bibliographic citations since 1960. The *Dental Press Journal of Orthodontics* can be accessed through the following link:

http://www.ncbi.nlm.nih.gov/nlmcatalog/101532240.

Dental Press editors have known, since the publication of its first issue, in 1996, that the aim of scientific journals is to communicate and disclose scientific discussion and development, playing a leading role in breaking paradigms and being responsible for spreading knowledge about new clinical practices. This has been the case since the first publications, initially in the *Journal dês Sçavans*, a French journal published since 1665, and the *Philosophical Transactions of the Royal Society of London,* firstly published a few years later.

We must bear in mind that databases often carry out evaluations; therefore, we must keep quality standards, at risk of exclusion. Thus, to refine our criteria for manuscript acceptance and strictly monitor our ethical principles is surely an essential task. For this reason, Brazilian periodicals are little represented in international databases. It is important to highlight that only a small number of these journals have been indexed in MEDLINE/ PubMed and ISI. The indexed ones have been internationally recognized, publishing more and better articles as a reward. Additionally, science is like an iceberg of which visible portion, above the water level, represents scientific production indexed in international databases.

Hence, I sign this editorial with free steps, eyes wide open and many hands interlaced, in the attempt of expressing my gratitude to all assistant editors, former editors, authors, reviewers as well as other members of Dental Press publishing company, who have assiduously contributed not only for accomplishing the objectives of the *Dental Press Journal of Orthodontics,* but also for its international indexation. Undoubtedly, one more victory of Brazilian Orthodontics competency.

David Normando – editor-in-chief
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Orthodontic movement of endodontically treated teeth

Alberto Consolaro[1], Renata Bianco Consolaro[2]

Often there is the need of moving teeth endodontically treated or teeth still in endodontic treatment. In order to collaborate with the comprehension and substantiation of the following subjects will be discussed: 1) Orthodontic movement in endodontically treated teeth without periapical lesion, 2) Orthodontic movement in endodontically treated teeth with inflammatory periapical lesion, and 3) Orthodontic movement in teeth endodontically treated due to aseptic pulp necrosis by dental trauma. In practically all situations, endodontically treated teeth to be orthodontically moved must be subjected to a careful evaluation by the endodontist about the conditions, adequate or not, of the endodontic treatment. Then, in this paper it was sought to induce an insight for new clinical researches about the theme that may definitely prove the information obtained by interrelations of information in parallel to clinical practice.

Keywords: Orthodontics-endodontics. Endodontic treatment-orthodontics. Periapical diseases-orthodontics. Orthodontics-dental trauma.

It is frequent the need of moving endodontically treated teeth or teeth still in endodontic treatment. What underlies the clinical decisions and biological orientations routinely applied is based on the interrelation of information pertinent to inflammation, tissue repair, tooth movement biology and of associated resorptions, pulp diseases and periapical disease. To collaborate with the comprehension and substantiation of this subject, it will be discussed together with these interrelations and experiences obtained over time. It was also sought to induce in this insight new clinical researches about the theme.

1. ORTHODONTIC MOVEMENT IN ENDODONTICALLY TREATED TEETH WITHOUT PERIAPICAL LESION

During many decades, until 1990, there was practically no movement of teeth that were endodontically treated. There was almost a consensus, not methodologically substantiated, that these teeth would present greater risk of root resorption during orthodontic movement.

From the 90s on, after the publication by Spurrier et al,[4] it was emphasized that teeth properly endodontically treated, if orthodontically moved, would not increase the risk of root resorption, nor reduce this risk.

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In the current context of Dentistry, there are more and more healthy teeth, and the required endodontic treatment comes from needs related to dental trauma. However, there is still many teeth endodontically treated because of dental cavity, specially clinical cases in which the necessity or not of endodontic retreatments is questioned. The improvement in economic and social conditions leads many adults to undergo orthodontic treatments and among older adults previously performed endodontically treatments are still very common.

There was marked reduction of endodontic treatment due to caries, which was gradually substituted by those due to dental trauma, considering the several ways and the greater opportunity to leisure and sports, and to the greater mobility by the several transportation means to which men submit with greater chances of accidents, especially in the large cities.

Orthodontic movement is done due to the periodontal ligament.[2] Cementoblasts have no receptors for bone turnover mediators, but the osteoblasts located 0.25 mm from the tooth have them. The application of an orthodontic force:

1. Compresses the cells, deforming its cytoskeleton, promoting a mechanical stress.

2. And, at the same time, reduces the lumens of blood vessels with hypoxia in the area establishing a metabolic stress.

The stressed cells of the periodontal ligament release many mediators that alternately stimulate the resorption and the bone position on the ligament surface of the alveolar process, promoting local bone remodeling, fixating the tooth in a new position. The root resorption induced during orthodontic treatment will only occur if the applied forces also cause the death of cementoblasts with subsequent exposition of the root surface. The death of cementoblasts is necessarily associated to more intense forces that compress the vessels in certain areas of the periodontal ligament.

The pulp tissues, on the other hand, do not suffer morphological and functional alterations during orthodontic movement,[1,3] regardless of the type and intensity of the applied force. Thus, in the same way, if the canal is filled by endodontic material, it will also not cause any modification on the periodontal tissues before orthodontic movement. In other words, if a tooth properly endodontically treated is orthodontically moved and presents less or more root resorptions, this response is not directly related to the present orthodontic treatment.

In practically all situations, endodontically treated teeth to be orthodontically moved must be subjected to a careful evaluation about the adequate conditions or not of the endodontic treatment by the endodontist. In cases in which these conditions are considered inadequate or inappropriate an endodontic retreatment must be performed.

Possible consequences

Reactivation of previous periapical lesions — the apical resorptions due to applied forces, a common and acceptable event from the clinical point of view — may "open" canaliculi, tubules and accessory canals of apical deltas that still had bacterial components. These products may, temporarily, promote the relapse of chronic periapical lesions such as chronic apical pericementitis and/or periapical granuloma.

The local microbiota in these conditions have its pathogenic limits since there is no nutritional source for an exuberant microbial proliferation due to the lack of communication with the oral environment. When ceasing orthodontic treatment, the process tends to regress; if the regression doesn't happen, the tooth must be endodontically retreated. This situation is quite rare, but theoretically can occur in sporadic cases.

Pseudo-overfilling – apical resorptions due to applied forces round and shorten the tooth, but the gutta-percha cones and some sealers are not phagocytable by the macrophages and/or by the clasts. After orthodontic treatment, the appearance will be of a gutta-percha cone surpassing the most apical limit of the tooth.[2] This situation is relatively common.

How long to wait and explanations

If the orthodontic movement does not change the pulp biology from the morphologic point of view, nor age it, the endodontic treatment, in the same way, does not interfere on the cellular and tissue phenomena of tooth movement. Strictly speaking, from the biological point of view and correlating the information about pulp biology and orthodontic movement, the application of forces can be done after a few days of the conclusion of endodontic treatment. Between 15 and 30 days, the exudate (liquids) and the inflammatory infiltrate (cells) were absorbed and migrated from the site.

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In cases of orthodontic movement of endodontically treated teeth in which a failure of months or years was detected, this fact must not be assigned to the performed tooth movement. The applied forces do not interfere on the pathogenicity and on the virulence of the associated microbiota, as well as in the biology of microbial biofilms and chronic inflammatory periapical lesions. The failure must be justified from the limitations inherent to the endodontic treatment.

2. ORTHODONTIC MOVEMENT IN ENDODONTICALLY TREATED TEETH WITH INFLAMMATORY PERIAPICAL LESION

The periapical lesions are exclusive of the periapex; eventually, some other lesions may be locate in this region and not be considered true periapical diseases. The periapical diseases are the most common maxillary intrabony lesions.

The periapical lesions or periapical diseases are predominantly inflammatory and associated to the microbiota present in the canals in which the dental pulp is necrotic, or yet associated to pulp aseptic necrosis due to dental trauma.

The non-inflammatory periapical diseases are, relatively, much less frequent and can be:

1) Cemental dysplasia or periapical cemento-osseous dysplasia: An osteofibrous dysplasia of the periapical bone of lower incisors;

2) Benign cementoblastoma: An odontogenic neoplasia, almost exclusive of the periapex of lower first molars.

Among the non-inflammatory periapical diseases, the periapical cemento-osseous dysplasia requires secure diagnosis and only monitoring, without any treatment and consequence for the patient; the benign cementoblastoma must be surgically removed with a good prognosis.

The inflammatory periapical diseases may be associated to two basic conditions: pulp necrosis associated to a rich and mixed microbiota and to pulp aseptic necrosis due to trauma.

Every inflammatory periapical lesion begins as acute apical pericementitis which may evolve to:

1) Acute dentoalveolar abscess, and then chronic, characterized by the fistula.

2) Chronic apical pericementitis and then periapical granuloma which may remain for months or years, or yet, evolve eventually to apical periodontal cyst.

In the case of the acute inflammatory periapical diseases — acute pericementitis and dentoalveolar abscess in its several phases — endodontic treatment has an excellent prognosis if considering that there is no time or local conditions to occur significant and minimum areas of apical resorption. The bacteria will have a shorter period and more regular root surface, which complicates its permanence in the root structure after the adequate endodontic treatment.

On the chronic inflammatory periapical diseases — chronic apical pericementitis and periapical granuloma — the permanence period of the microbiota is much longer than in the acute, allowing bacteria to colonize the dental tubules and the irregular areas of apical absorption. At the same time, many bacteria colonize the external part of the apical surface forming microbial biofilms. These conditions allow a good prognosis, but with reservation, because the endodontic technique, even being evolved, still does not guarantee complete elimination of this microbial component. There is still a percentage rate to be considered on failures in cases of endodontic treatment of teeth with chronic periapical lesion, around 10 and 35%, according to analyzed cases.

The periapical granuloma consists of an agglomerate somewhat organized of inflammatory cells, specially macrophages, lymphocytes and plasma cells. These cells are nourished by numerous vessels and physically supported by the exudate and by an extracellular matrix with fibroblasts and eventual collagen fibers. Dimensionally and by analogy, the periapical granuloma can be compared to a pillow of soft tissue accommodated and wrapping the most apical part of the tooth root.

When referring to chronic inflammatory periapical disease it is often related to the periapical granuloma, because in apical periodontal cysts still small and located on the context of a periapical granuloma, the endodontic treatment is also efficient.

What keeps the periapical granuloma active is the constant leave of bacterial products and of the bacteria itself to the periapical region, especially in the cemental canal. The elimination of the microbial source by an adequate endodontic treatment implies in eliminating the stimulus. Immediately after the endodontic treatment, the macrophages and other cells from the periapical granuloma eliminate the last bacteria and its products and, in hours, eliminate them.

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They also did that before, but the leave of bacteria was constant. In a few hours or a couple of days, the periapical granuloma gives way to a tissue free of bacteria and its products thanks to the macrophage activity. The space of the periapical granuloma becomes occupied by a granulation tissue rich in vessels and with osteoblast cells invading it for the bone repair to occur.

The repair initiates in hours, as soon as the microbial agents are eliminated. However, the local bone repair will take long to generate a radiographic image of a normal periapical bone. The generation of these images depends on a higher degree of tissue maturity and mineral density that might take weeks and even months to be achieved.

Possible consequences

Besides the pseudo-overfilling by the end of the orthodontic treatment, other consequences are independent from the orthodontic movement, such as the persistence of the lesion or its partial regression, or even its increase. In these cases, the endodontic treatment must be evaluated regarding its capacity of completely eliminating the microbiota, closing the spaces occupied by it and the possibility of the involved tooth having a different morphology that would complicate the elimination of the microbiota by the endodontic treatment, such as apical delta, dilacerations, developmental groove and others. To assign the failure to the fact that the tooth was orthodontically moved is not pertinent.

How long to wait and explanations

It must be emphasized that the forces applied in a certain tissue do not modify or potentiate the action of settled microbiotas. The application of orthodontic forces in chronic periapical lesions of teeth properly endodontically treated would not interfere on the microbiota nor on the repair.

The first thought would be: But wouldn't the forces compress the vessels of the region in repair and complicate cellular proliferation and the synthesis of new tissue components? No, because the apical and periapical region is filled by soft tissue from the old periapical granuloma or from the granulation tissue of the ongoing repair. The application of forces in this area cannot compress the vessels, the walls are not hard and limited by a periodontal space of 0.25 mm. In fact, there is a large area of soft tissue in reconstruction. The force necessary to compress a fragile structure such as the periodontal ligament will not have effect on a soft tissue in a wider area, like where the repair is in an area previously occupied by a chronic periapical lesion.

Strictly speaking, from the biological point of view, by what is known and conceived as orthodontic force, there wouldn't be a way for it to interfere on the repair of chronic periapical lesions after an adequate orthodontic treatment. Again, the movement of a tooth with chronic periapical lesion endodontically treated can be done after a few days. A period between 15 and 30 days would be more than enough for the exudate and inflammatory infiltrate to be respectively absorbed and migrate from the area, remaining only the macrophages and other cells that were participating of the granulation tissue in the repair of the area.

In cases of orthodontic movement of endodontically treated teeth in which a failure over months or years was detected, this fact must not be assigned to the performed tooth movement. The applied forces do not interfere on the pathogenicity and on the virulence of the associated microbiota, as well as on the biology of microbial biofilms and chronic inflammatory periapical lesions.

The failure in these cases must be justified by the limitations inherent to the endodontic treatment and not by the fact that the tooth was subjected to orthodontic movement. In teeth with chronic periapical lesions the frequency of irregular areas due to apical resorptions associated to it is very high, increasing the possibility of persistence of microbial biofilms. The occurrence of failures on the hermetic closure of the apical opening due to natural anatomical irregularities can also justify these failures, as well as the presence of apical deltas, the used material and many other factors that affect the final results. The possibility of failure in endodontically treated teeth with chronic periapical lesion is greater than in other situations.

3. ORTHODONTIC MOVEMENT IN ENDODONTICALLY TREATED TEETH FROM ASEPTIC PULP NECROSIS BY DENTAL TRAUMA

The aseptic pulp necrosis can be treated right after its occurrence, but it can also be clinically ignored and, only months or years later, be detected — by coronary darken-

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ing or in routine radiographic exams, as those performed for orthodontic planning. When diagnosed too much later, the aseptic necrosis may present chronic apical pericementitis and/or even a small periapical granuloma.

After one year, half of the aseptic pulp necrosis tend to present microbiota, by hematogenous retrograde invasion of the root canal. In general, it represents a microbiota of low aggressiveness and with low metabolic activity, since the involved teeth did not present periodontal involvement or dentin and pulp exposure to the oral environment.

With or without periapical lesion, endodontically treated teeth for aseptic pulp necrosis due to dental trauma, if orthodontically moved could have the same behavior expected from those teeth endodontically treated for pulp necrosis with infected canals. However, this situation must be faced in a different way by the following rule: Every tooth previously traumatized, if moved, may present earlier and more intense root resorptions by the end of the orthodontic treatment.

This rule is regardless if the tooth was endodontically treated by aseptic necrosis or not. In dental trauma there is a greater chance of repair of the cementoblastic layer be, focally and in eventual spots, done with cells of osteoblastic lineage that have receptors for bone turnover mediators. In dental trauma the lesions of the cementoblastic layers are more extensive than the ones induced on orthodontic treatment.

Despite behaving — morphological and physiologically — like cementoblast or cementoblast-like cells, with the usual mediator accumulation on the ligament, by the compression of orthodontic forces, it is led to periodontal bone resorption as expected; but now also to root resorption which in normal conditions is protected by the true cementoblast cells without receptors for such mediators. This is because the cementoblast-like cells, true osteoblasts, soon take on the management of the bone remodeling units after a few hours of force application, resorbing the root.

The previously traumatized teeth, with or without aseptic pulp necrosis and endodontic treatment properly performed, can be orthodontically moved, but the professional must scale the forces, evenly distributing them as much as possible on the dental structure and perform periapical radiographic control every three months to verify the degree of root resorption, if happening. Within possibility, these teeth must be avoided as point of anchorage or subjected to extensive movements and intrusive mechanics; if there is no other option, they can be subjected, but will present a higher degree of root resorption.

Possible consequences

The inconvenient consequences of orthodontic movement of teeth endodontically treated from aseptic pulp necrosis due to dental trauma are related, mainly, to the fact that the tooth was previously traumatized: the root resorptions may be greater by the end of the orthodontic treatment. As for being an endodontically treated tooth, there would be no contraindication especially because it refers to teeth with aseptic pulp necrosis that, when retrograde and secondarily contaminated via blood, the microbiota has low virulence.

How long to wait and explanations

Every tooth previously traumatized, if moved, may present earlier and more intense root resorptions by the end of the orthodontic treatment. This possibility justifies the rule of waiting a period of time for this type of tooth to be subjected to orthodontic movement which is almost universally accepted and followed.[2] The period varies with the classification of the trauma in mild, moderate and severe.

In mild trauma, as concussion and discrete subluxation, it must wait 3 to 4 months to provide a new periapical radiograph or tomograph and evaluate if the periodontal tissues and structures went back to normal. If so, the traumatized tooth can be moved.

Moderate dental trauma characterized by more severe subluxation, luxation, displacement and even extrusion without total avulsion of the tooth on the alveolus, must wait one year. If new periapical radiographs and/or tomographs after this period reveal structural and organizational normality, absence of dental alveolar ankylosis, resorption by substitution and/or inflammatory resorption, the tooth can be orthodontically moved.

In more severe cases, as total avulsion followed by reimplantation until 30 to 60 minutes out of the alveolus and in cases of root fracture, it must wait 2 years. After this period, if new periapical radiographs and/or tomographs reveal structural and

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organizational normality, without dental alveolar ankylosis, without resorption by substitution and or without inflammatory resorption, the tooth can be orthodontically moved. Always considering the rule that they may present greater root resorption by the end of the orthodontic treatment.

4. FINAL CONSIDERATIONS: THE "INSIGHT"

The statements of the previous topics are based on the interrelation of information pertinent to inflammation, tissue repair, biology of the dental movement and of the associated resorptions, pulp and periapical diseases. There is still no work in the literature in which significant number of cases of endodontically treated teeth have been moved in the context of orthodontic treatment. There is a lack of methodologically adequate and comparative studies where there were:

1) A group of endodontically treated teeth for pulp necrosis with infected canals, without chronic periapical lesion and, then, orthodontically moved; with the final result evaluated by the end of treatment, regarding the severity of the associated resorption, when it happen and/or other consequences such as pseudo-overfilling, reactivation of previous lesions, endodontic failure index and other phenomena.

2) Another group of teeth endodontically treated for pulp necrosis with infected canal, with chronic periapical lesion and, then, orthodontically moved; with the final result evaluated by the end of treatment, regarding the severity of the associated resorption, when it happened and/or other consequences such as pseudo-overfilling, increase or partial/total regression of the previous lesions, endodontic failure index and other phenomena.

3) A third group of teeth endodontically treated from aseptic pulp necrosis induced by dental trauma and, then, orthodontically moved; with the final result evaluated by the end of treatment regarding the severity of the associated resorption when it happened and/or other consequences such as pseudo-overfilling, reactivation of previous lesions, endodontic failure index and other phenomena.

4) The fourth group of patients with teeth with pulp vitality and moved similarly to the other three groups, a control group. A special care on the performance of these researches is regarding the maximum standardization possible of the orthodontic treatment performed in each patient in all four groups, especially regarding the type and extension of the movement, intensity and distribution of applied forces. In the same way, the period in which the endodontic treatment was initiated should be standardized.

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Matheus Melo Pithon*

ELECTRIC TOOTHBRUSH PROMOTES BETTER CLEANING FOR PATIENTS WITH FIXED ORTHODONTIC APPLIANCE

Patients with fixed orthodontic appliance find it much more difficult to clean their teeth. The presence of brackets, wires, elastics, buttons and other accessories promote greater plaque retention, favoring the appearance of white spot lesions, dental caries and periodontal disease. Daily, orthodontists see patients with dirty teeth. What must be done in these situations? There are various devices and resources available for cleaning these patients' teeth. Among these, manual and electric toothbrushes are very important. Would electric toothbrushes be more effective in cleaning compared with the manual type? To answer these questions, German and American researchers conducted a clinical study[1] in which they evaluated the effectiveness of manual, conventional electric, and orthodontic electric toothbrushes (Fig 1) in cleaning the teeth of patients using fixed orthodontic appliances. The authors were able to verify that electric brushes performed better cleaning when compared with the manual type. In the comparison between electric brushes, the specific type for orthodontic use, promoted greater cleanliness. The findings of this study are relevant and important, because orthodontists have gained proof of a new ally in the maintenance of their patients' oral health.

Figure 1 - Brushes evaluated in the study conducted by Erbe et al[1]: **A**) electric with orthodontic head; **B**) electric with conventional head; **C**) manual.

SEALANT REDUCES THE APPEARANCE OF WHITE SPOT LESIONS IN ORTHODONTIC PATIENTS

As mentioned in the previous article, there is constant concern about the hygiene of orthodontic patients all over the world. Development of a material that reduces the appearance of caries lesions in these patients is a dream we all share. Day by day, material industries launch new products for this purpose, including sealants. These material are indicated for application on the enamel around brackets, with the intention of preventing the appearance and progression of caries lesions during the period the fixed orthodontic appliance is in use. However, there has been little scientific proof reported regarding these materials. The industry that develops these products is frequently satisfied only with launching them on the market, backed by laboratory studies, without conducting clinical trials. With the purpose of obtaining these clinical results, Porto Rican and American researchers developed a multi-centric study evaluating the effectiveness of these sealants in patients using orthodontic appliances.[2] The results found in this study demonstrated that the studied sealant presented the capacity of preventing the appearance of white spot lesions. However, the authors pointed out that the sealant does not prevent all lesions, nor does it provide protection throughout the period of experimentation. Nevertheless, the results present good future perspectives.

TOOTH EXTRACTIONS DO NOT COMPROMISE THE NASOPHARYNGEAL AIRSPACE

Over the years, orthodontics has increasingly adopted a multidisciplinary approach for patient treatment. For a long time, occlusion remained the main focus of the

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orthodontic world, sharing space with facial analysis and the inter-relations with the airways. Would orthodontic treatment be related to changes in these structures? Nowadays, it is known that improvements are achieved when orthodontic treatment is accompanied by surgical procedures, such as mandibular advancement for the correction of Class II malocclusion. However, little is known with respect to what the behavior of these structures would be in the face of the simplest and most common procedures for the orthodontist, such as for example, the extraction of permanent teeth. To elucidate this question, researchers of Turkish and American universities evaluated the effect of tooth extractions on the nasopharyngeal airspace.[3] Tomographic images were obtained from patients who underwent extraction of the four first premolars. The results proved there was no reduction in the airway space with the extractions (Fig 2). These results demystified the idea that extractions influence the tongue by positioning it posteriorly, making air passage difficult, as a consequence of reduction in arch length.

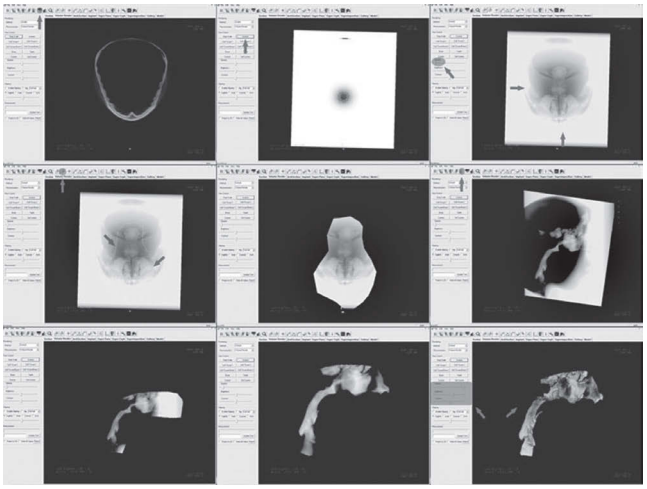

Figure 2 - Obtaining the image of the pharyngeal airway space (Source: Stefanovic et al,[3] 2013).

OVERWEIGHT PATIENTS ARE LESS COOPERATIVE WITH ORTHODONTIC TREATMENT

As a severe public health problem, obesity figures among one of the greatest epidemics of the century. Excess weight compromises the individual socially and physically (cardiac, metabolic and osteoarticular alterations), frequently generating irreversible problems in patients. But, how could our orthodontic treatment be affected by this problem? German researchers developed a study seeking answers to these questions.[4] They evaluated the cooperation, oral hygiene, care of orthodontic devices and time of treatment among patients with a normal body mass index (BMI) and individuals with increased BMI. The authors concluded that patients with an increase in body mass index did not cooperate as well during treatment, leading to the total treatment time of these individuals being longer than that of adolescents with normal BMI. The authors themselves pointed out that new studies need to be conducted to evaluate the reason for this association. Would it be due to social alterations? Or as a result of physical alterations?

FEMALE ADOLESCENTS REPORT MORE PAIN DURING ORTHODONTIC TREATMENT

A frequent complaint among patients, after orthodontic appointments, is post-activation pain. Without any doubt, this is one of the reasons that affects the most the patient motivation to begin with an orthodontic treatment. We all believe that orthodontic movement functions by means of a mechanism of inflammation, a process that always involves pain. Identifying the group of patients most sensitive to pain is important, in order to adjust measures that minimize this process. Starting with this premise, in the present study the authors' proposal was to evaluate, with the use of questionnaires, the interaction between orthodontic post-activation pain and the adolescents gender.[5] It was concluded that girls in the 14 to 17 year age group presented higher levels of pain compared with boys. The results showed the need to perform activations with lighter forces in this group of patients, thereby avoiding greater complaints with respect to the treatment being performed, and obtain better cooperation.

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An interview with

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» Peer-reviewer of the following journals: *Archives of Oral Biology, Dental Press Journal of Orthodontics, European Journal of Orthodontics, Journal of Biomechanics, Journal of the World Federation of Orthodontists* and *The Angle Orthodontist*.

All young people have an idol to follow, which can be a rock star or a great professor. Many people, including the greatest professors, do not realize their positive influence in their students' education. When I started the specialization course in Orthodontics at the Rio de Janeiro State University (UERJ), I knew nothing about this specialty, dentist's offices or teaching, and I needed orientation. Having good-hearted and altruist professors determined the path I should follow. Among such professors, I would like to highlight Prof. Jonas Capelli Jr. — the expert I present in this interview. Being from the first class of the course, he has always been a model to us. Dr. Capelli Jr. is the Director of the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) and has received many awards, such as the CDABO Case Report of the Year, for the best case report published during 2007 in the AJO-DO. In addition, he has had more than 60 articles published in scientific journals. Therefore, coordinating this interview could not be more rewarding and satisfactory to me. I proudly claim that it will provide us with a wide range of expertise concerning our clinical and scientific practice within our beloved field. In addition, this interview will allow us to know more about the professor who has been considered a positive and inspiring milestone in his students' lives as well as in the history of Brazilian Orthodontics.

Sissy Maria Mendes Machado

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

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Is there any clinical difference in the quality of smile esthetics diagnosis performed by photographs and filming? Carlos Alexandre Câmara

In Orthodontics, three methods are commonly suggested when studying the smile, namely: Qualitative, semi-quantitative and quantitative methods. The qualitative method is strictly visual; the orthodontist looks at the patient's smile and assesses, for instance, the smile line height. In the semi-quantitative method, analysis of the smile is performed by means of photographs, while in the quantitative method, the smile line height is determined with the aid of measurement instruments and may vary from the simplest to the most sophisticated approaches.[1]

Capturing the smile image through photography presents many drawbacks. Photograph standardization is difficult due to differences in camera positioning, distance control between the patient and the focal point, head angle and the impossibility of reproducing the same smile in different photography sessions.[2]

Capturing an image through filming, creating a video for subsequent analysis with computer software seems to be a very efficient method for the dynamic analysis of speech and smile.[3]

Clinically speaking, I believe that the quality of esthetic diagnosis may be well established through photography. Moreover, the orthodontist is in contact with the patient during the first appointment, which gives the specialist the opportunity to observe all variables involved in the process of diagnosis. On the other hand, with regard to researches involving smile analysis at different time intervals, in which different measures are carried out, recording video images seems to be a valuable tool. Our studies with videos in which patients are encouraged to say a sentence and then smile seem to be highly efficient for analyzing the exposure of teeth and soft tissues at different time intervals.[4,5]

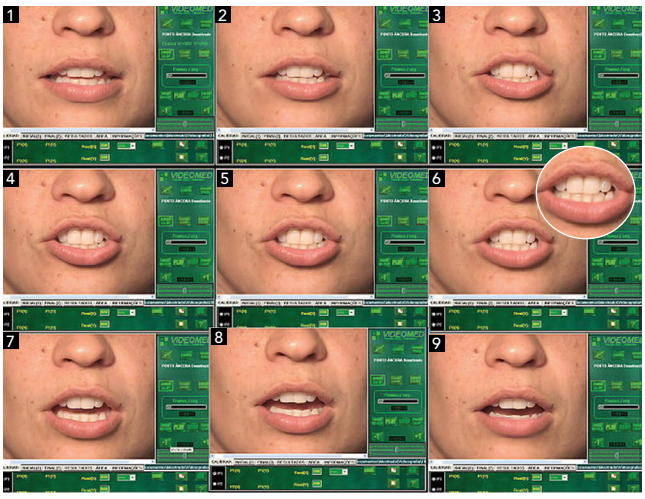

Figure 1 - Video split up into static frames. Frame number 6 (amplified) shows the maximum incisor exposure when patients pronounced the sound "Czech", as in Czechoslovakia.

These videos last for about 12 seconds, comprising a total of 360 frames per video. They are analyzed and split up – at rest, during speech and smile — in order to produce four static frames (corresponding to a photograph) for analysis of the least and the greatest exposure of the incisor, for example. Figure 1 demonstrates an example of this method.

What are the main esthetic parameters that guide your orthodontic treatment plan? Carlos Alexandre Câmara

Our main parameters are listed below and illustrated in Figures 2 to 7:

1) Incisor exposure (Fig 2): Taking into account the length and elevation of the lip as well as the vertical height of the maxilla.

2) Negative lateral space or buccal corridor (Fig 3): There are many publications, comprising studies developed with digital image manipulation, which present different options of buccal corridor exposure. It seems to be common sense that minimal corridors are more attractive.[2,3,5]

3) Smile arc (Fig 4): Taking into account that, in an ideal smile arc, the curvature of the incisal edge of the maxillary incisors coincides with the margin of the lower lip when smiling ("consonant"). The lower lip may touch, not touch or slightly cover the incisal edge of the maxillary incisors.

4) Upper lip curvature (Fig 5) — Three options: upward, when the commissure is higher than the center of the lip; straight, when the commissure and the center of the lip are leveled; downward, when the commissure is lower than the center of the lip. Upward and straight curvatures are considered more esthetic than the downward curvature. The upper lip curvature is guided by the facial muscles; therefore, it cannot be changed through orthodontic treatment.

5) Smile symmetry (Fig 6): Commissures move upward and laterally when smiling, but there may be some difference in amount and direction of movement

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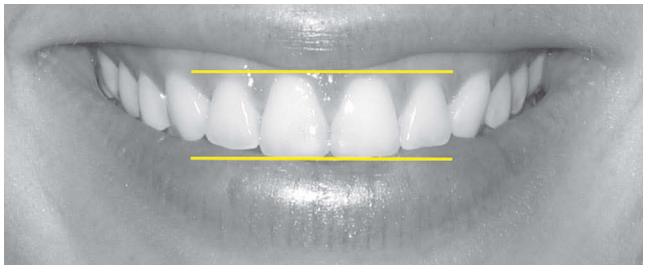


Figure 2 - Upper incisor exposure directly associated with both length and elevation of the upper lip.

Figure 3 - Examples of negative lateral space or buccal corridor.

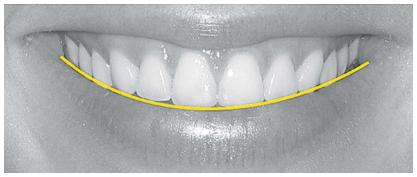
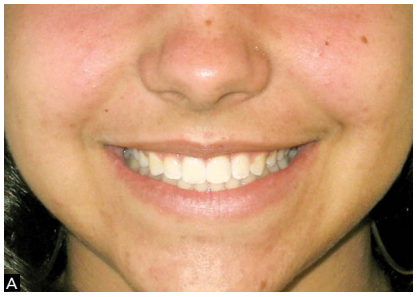
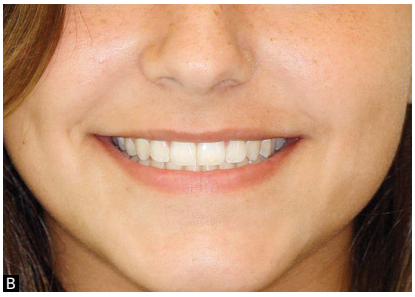


Figure 4 - Examples of consonant smile arcs.





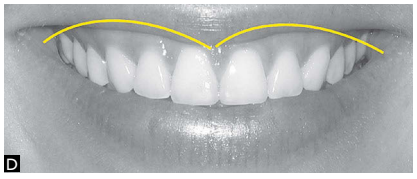


Figure 5 - Upper lip curvature (**D**).Examples of the three types of curvature: Upward (**A**), straight (**B**) and downward (**C**).

between the right and the left sides. Should there be any significant difference, it may be due to deficiency of muscular tonus in one of the sides of the face.

6) Frontal occlusal plane (Fig 7): Represented by a line that goes from the incisal edge of the upper right canine to the incisal edge of the upper left canine. Transversal inclination may be caused by a difference in eruption time or due to skeletal asymmetry. Clinical examinations are essential to perform a differential diagnosis to distinguish between smile asymmetry, occlusal plane inclination and facial asymmetry. The influence of the lower teeth on the smile cannot be seen in dental cast models.

7) Dental components: taking into account the size, shape, color, alignment, angulation and midline. There are great studies which comprise such content.[9]

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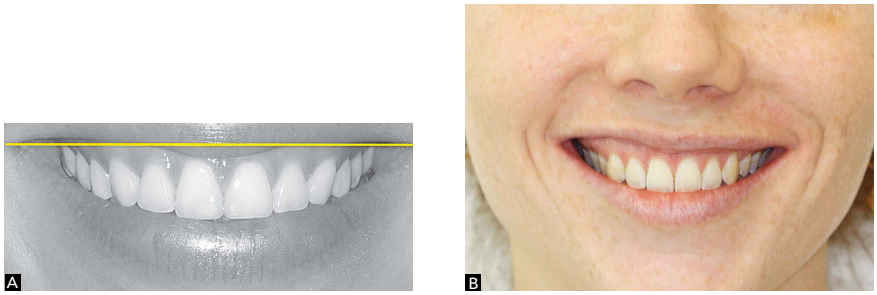

Figure 6 - In a symmetric smile (**A**), commissures move upward harmoniously. In **B**, asymmetry is remarkable, due to right commissure elevation being higher than the left one — such conditions cannot be changed through orthodontic therapy.

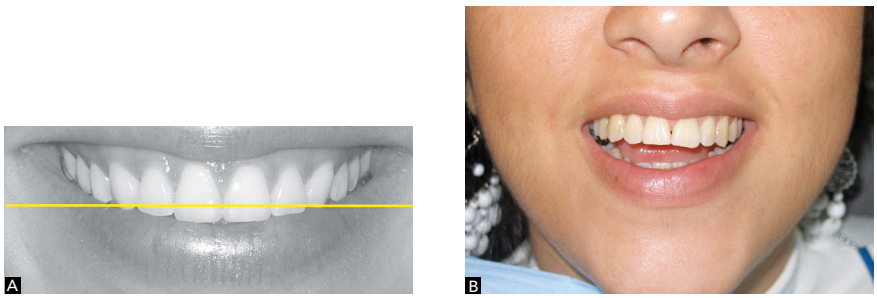

Figure 7 - Frontal occlusal plane represented by a line that goes from the right canine to the left canine (**A**).Transversal inclination may be caused by a difference between the time of eruption or skeletal asymmetry. In **B**, example of frontal occlusal plane inclination.

Patient's age is another esthetic parameter which I consider essential for treatment plan. Over time, men and women present less exposure of maxillary incisors and greater exposure of mandibular incisors, due to the fact that the length of the upper lip increases, while the length of the lower lip decreases with age. It has been proven that the amount of exposure of mandibular incisors after 60 years of age is equivalent to the amount of exposure of maxillary incisors before 30 years of age.[10]

With aging, the lips go through many changes which affect the exposure of teeth. For example, muscle atrophy that implies in decreased lip volume, changes in lip shape and increased length of the lips. Such changes highlight the importance of normative values according to age, allowing older patients to have their treatment plan objectively and precisely carried out.[11]

After the age of 40, there is a 2 mm mean loss of muscle capacity to lift up the upper lip. This contributes to age one's appearance, since upper anterior teeth are hidden by the upper lip at smile.[11]

When a patient of such age comes to me complaining about dissatisfaction concerning crowding of mandibular incisors, claiming that he/she is dissatisfied with his/her appearance in photographs and that he/she has recently noticed this situation, I suppose that such crowding had already been there for a long time, but has been recently noticed.

Deepening of the nasolabial angle is another consequence of aging, causing great esthetic impact. As time goes by, there is loss of cheek prominence due to atrophy, making the skin loose. As the cheek becomes flaccid, the elevator muscles of the upper lip pull the nasolabial folds upward, resulting in a deep nasolabial angle.

When preparing the orthodontic treatment plan, the orthodontist should consider the patient's age, due to the fact that with aging, many changes concerning the exposure of incisors occur. Generally speaking, it is better to rejuvenate the patient's appearance than aging it. In severe overbite cases, especially in adult patients, it is more advisable to intrude mandibular incisors than maxillary incisors, in order to ensure a young and esthetic smile by the end of the treatment. Should it be necessary to intrude maxillary incisors, the orthodontist must assess not only the exposure of the incisors at rest and speech, but also the patient's age and sex, quantifying how much intrusion will be possible without compromising esthetics. With regard to excessive gingival display, it is generally better to treat gingival smile in a less aggressive way, due to the fact that aging will naturally reduce this feature.[12]

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Figure 8 - Exposure of upper incisor is greater in younger individuals (**A, B, C**) while exposure of lower incisor is greater in elder individuals (**D, E, F**).

Our researches carried out at the Rio de Janeiro State University/Brazil (UERJ) also suggest that men are more likely to suffer the effects of aging than women. A comparative example regarding these differences is demonstrated in photographs of young and older men, as shown in Figure 8. Many factors may turn a young skin into a precociously aged skin, namely: sun exposure, smoking, stress, hormonal changes, medicines and unhealthy eating habits. The main villain has always been excessive sun exposure. Therefore, excessive sun exposure, due to sports practice or outdoor activities, without proper protection from UV radiation, may be one of the factors that influence the fact that men are more affected by the effects of aging. However, it is important to consider that smoking has been the main cause of early aging, as it directly acts upon the epithelium elastic fibers and collagen matrix.[5]

In the last few years, some authors have questioned how valid is to use a simple photograph to assess esthetics and determine the patient's treatment plan. They have suggested the use of dynamic images recorded in video. In your opinion, capturing dynamic images through filming, in order to use them for the diagnosis and treatment plan in Orthodontics, is a valid method?
Sissy Mendes Machado

Smile analysis performed through standardized photographs may be used as a subsidiary method for diagnosing and planning orthodontic and surgical treatments, allowing assessments before and after the treatment. Additionally, it may be considered a reliable instrument for comparing pre and posttreatment phases. However, it is important to highlight that this technique may be considered dubious, as it does not represent a smile apex. Video recording may provide larger information for facial esthetic assessment.[4,5]

Dynamic analysis of speech and smile has been made possible because of technology. Current low prices and popularization of digital cameras have facilitated access to this type of equipment. Photo editing programs are available in most computers. This facilitated the identification of both positive and negative aspects of facial esthetics, enabling, for example, observation of the effects of aging in the perioral soft tissues. Videography may be used in orthodontic practice with many purposes, such as diagnosis and treatment plan, communication between specialist and patient during appointments and communication between specialists.[4]

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There has been increasing awareness among professors, researchers and clinicians about the importance of biology for orthodontic practice and this has been reflected in the curriculum of the main Orthodontics programs in the world. Why is it important for the orthodontist's formal education to be familiar with the biology of tooth movement? Ildeu Andrade Jr.

The postgraduate programs in Orthodontics have always favored formal education and training based on orthodontic mechanics, as all credit hours are spent with studies performed with typodont simulator. However, Orthodontic clinical practice is based in both mechanical and biological parameters. The mechanical approach is enough for treatments performed on the typodont, however, in clinical practice, knowledge of biology involved in the process is necessary. I am a die-hard fan of the mechanotransduction definition: Mechanical forces applied to teeth do not result in mechanical movement only, they also produce biological stimuli capable of promoting desirable tissue reactions in order to achieve a stable and long-lasting change in tooth position.[13] The clinical practice of this definition lead us to question the claims concerning the types of brackets or techniques offering drastic reduction in treatment duration. Whenever I see an advertisement or a presentation stating this type of offer, I begin to think: Is this capable of promoting a differentiated biological stimulus? If not, what explains the hypothesis of reducing treatment duration?

The main orthodontic journals in the world have provided more opportunities for the publication of researches into biology of tooth movement. In your opinion, what are the benefits — for us, orthodontists and for our patients — of the increasing interaction between biological and clinical researches in Orthodontics? Ildeu Andrade Jr.

We have conducted a survey at PubMed, in March 2013, which reveals an increase in the number of publications available in the literature,when the keywords "orthodontic tooth movement" were used (data is shown in Fig 9).

There are many reasons for this increasing number of publications. First, the total amount of scientific journals has significantly increased, providing the opportunity for the publication of scientific findings. We are currently facing the dilemma of what we should read due to the great amount of information that is available. However, I believe that the main reason for this increasing number of publications is the development of researches that have as final outcome the publication of their results. Researches carried out with biomarkers aim at studying not only orthodontic tooth movement in many different situations, but also root resorption as well as accelerated and decelerated tooth movement. Such researches, which frequently involve molecular biology analysis, have contributed for a significant increase in the number of publications in the 2000s, especially in the last five years.[14,15] Our studies involving the quantification of different markers present in the gingival crevicular fluid while moving teeth aim at understanding what happens when we apply forces to induce tooth movement.[16] As a researcher, I aim at understanding the cascade of biological events involved in tooth movement. The main benefit for the orthodontist is to understand why his patients react differently to the same mechanics, same appliances and same activations. Why do patients react differently towards the gains and sequelae of orthodontic treatment? Force modulation being the only variable used to answer that seems to be a simplistic approach towards a more complex issue.

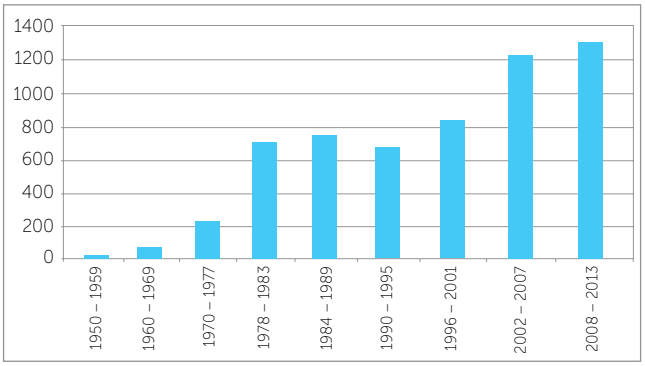

Figure 9 - Total number of publications available in the literature using "orthodontic tooth movement" as keywords.
Source: www.ncbi.nlm.nih.gov/pubmed.

In your opinion, what are the future prospects and the potential clinical impacts of researches on the cellular and molecular mechanisms involved in biology of tooth movement? Ildeu Andrade Jr.

Our initial studies on gingival crevicular fluid (GCF) were based on Periodontology researches which claim that the GCF flow may increase by 30 times in periodontitis, when compared to healthy sulcus.[17] As orthodontic tooth movement has inflam-

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mation-dependent characteristics, we believe that the GCF volume would increase during this movement. However, we have observed that such data are not consistently expressed. The GCF volume does not seem to be a reliable biomarker used for the analysis of tissue remodeling during orthodontic treatment.[18-21]

With regard to periodontal patients, we based our studies upon previous evidence which claim that clinically healthy sites of patients with periodontitis have greater levels of GCF and periodontal pathogen biomarkers than clinically healthy sites of patients without periodontitis.[22] In other words, periodontal patients would be considered as high-risk patients for orthodontic treatment, as pro-inflammatory markers originated from periodontal diseases have been superposed onto those markers activated by tooth movement. It is a chaotic scenario! However, a study carried out with periodontal patients undergoing tooth movement reveals that orthodontic movement of periodontally compromised teeth does not result in significant changes of matrix metalloproteinase in the GCF.[23] Clinically speaking, this is a great finding as it assures us that moving periodontally compromised teeth, yet healthy, is possible.

With regard to future prospects, it is necessary to have a better understanding concerning the molecular constituents of the gingival crevicular fluid which are more sensitive to orthodontic tooth movement, the meaning of GCF as well as its biological function. Studies on GCF have enabled non-invasive monitoring of tissue remodeling and may serve as a good tool for researches on tooth movement, root resorption or dental ankylosis. The more we know about the biological mechanisms of orthodontic tooth movement, the earlier we shall develop local administration methods of medication. Local application of bioactive agents associated with conventional biomechanics may be used to facilitate or hinder tooth movement.

In clinical practice, orthodontic treatment performed in adults is different from treatment performed in adolescents, as adults are more likely to have compromised dentitions. Based on your experience with biological studies on tooth movement, what would be the most appropriate treatment plan for adult patients with bone loss and clinical attachment loss caused by jeopardizing the biological space or by previous periodontal diseases, taking into account biomechanical and functional properties? Sissy Mendes Machado

Orthodontic treatment of patients with periodontal disease may not be faced as a common treatment. All orthodontic cases require effective diagnosis and planning. However, this practice is more difficult in periodontal patients. We must bear in mind that all types of treatment must benefit the patient. When the periodontium is compromised and the orthodontic plan is defective, the chances of harming the patient, due to an improperly performed treatment, are high. Therefore, such cases require integration between specialists. The patient should not start orthodontic tooth movement without his periodontist's approval, and the periodontist must follow-up the periodontal situation during orthodontic treatment.[25,26] Figures 10, 11 and 12 show a good example of tooth movement in a patient with little periodontal attachment.

Tooth movement should not be performed in patients with periodontal diseases for many reasons, namely: 1) It may cause periodontal abscess, especially in deep periodontal pockets; 2) After periodontal therapy, edema is eliminated and gingival collagen fibers consolidate, leading to tooth accommodation which may be favorable to tooth alignment and, thus, reduce the duration of a subsequent orthodontic treatment; 3) At the beginning of orthodontic treatment, it is important to know the height as well as the density of the bone surrounding the teeth. Such information may be observed by the periodontist during surgery and provided later on to the orthodontist.[25,26]

The orthodontic treatment of patients with controlled periodontal diseases is usually shorter and direct. Reduction in the periodontium generates important implications for orthodontic tooth movement. There is a direct linear relationship between the alveolar support and the localization of the center of resistance. As the alveolar bone support reduces, the center of resistance moves apically. Both the intensity and the point of force application during orthodontic treatment must be adapted in such situations. The applied forces must be lower than those applied to healthy periodontium. In order to control tooth movement — due to the fact that the center of resistance is apically located — all accessories must be bonded closer to the gingiva.

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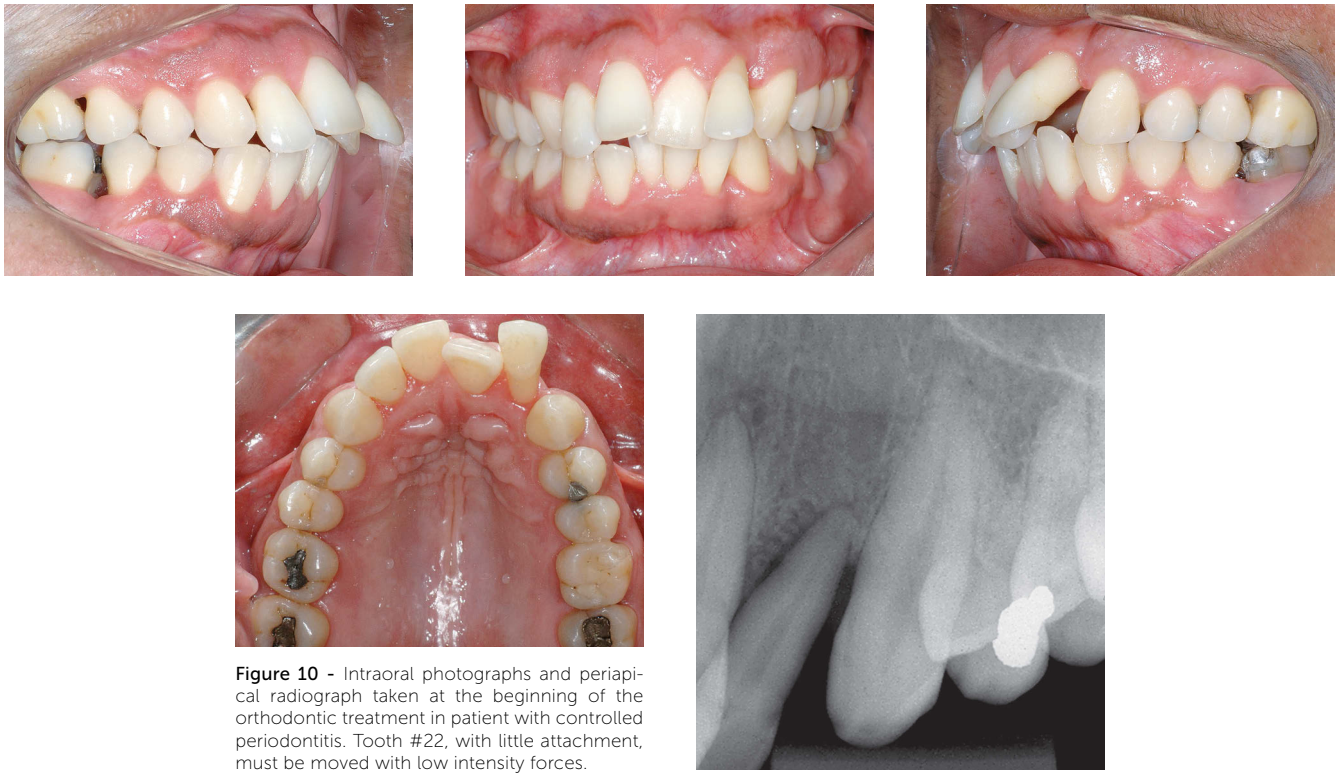

Figure 10 - Intraoral photographs and periapical radiograph taken at the beginning of the orthodontic treatment in patient with controlled periodontitis. Tooth #22, with little attachment, must be moved with low intensity forces.

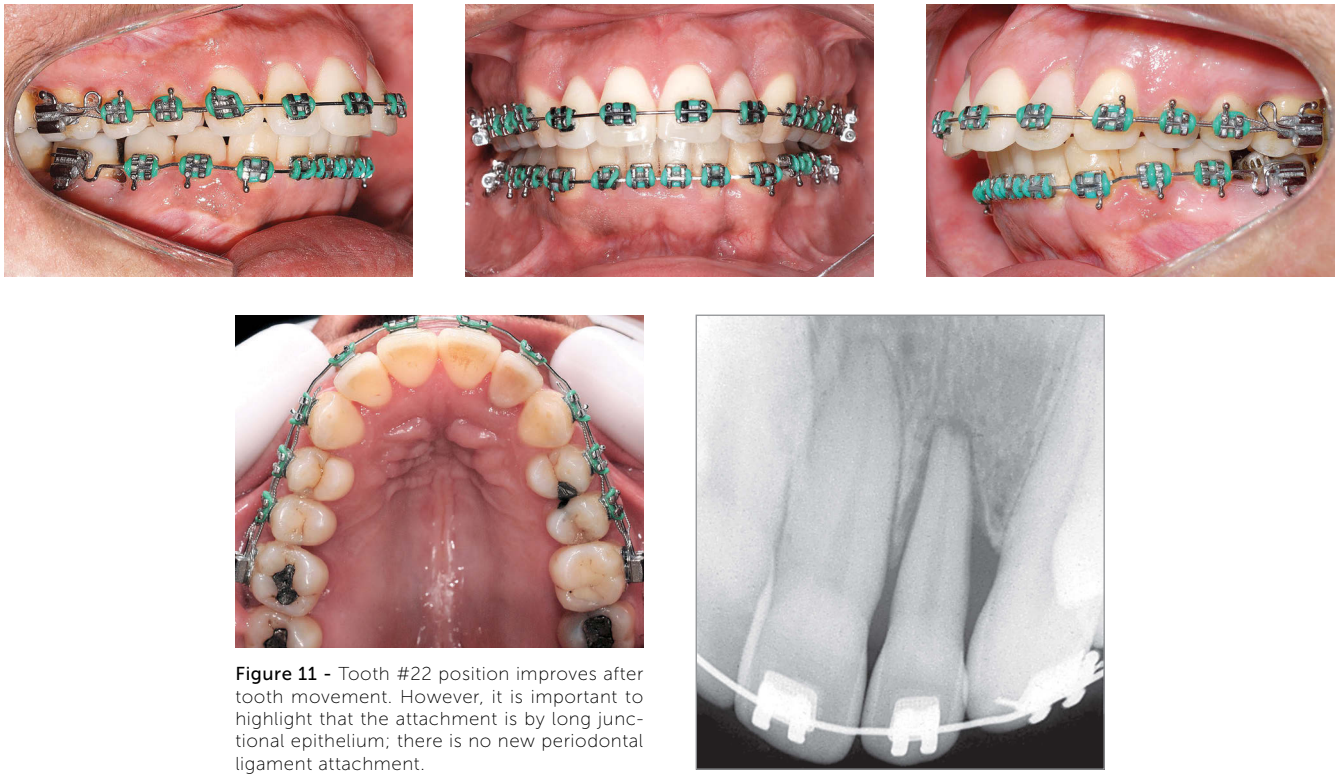

Figure 11 - Tooth #22 position improves after tooth movement. However, it is important to highlight that the attachment is by long junctional epithelium; there is no new periodontal ligament attachment.

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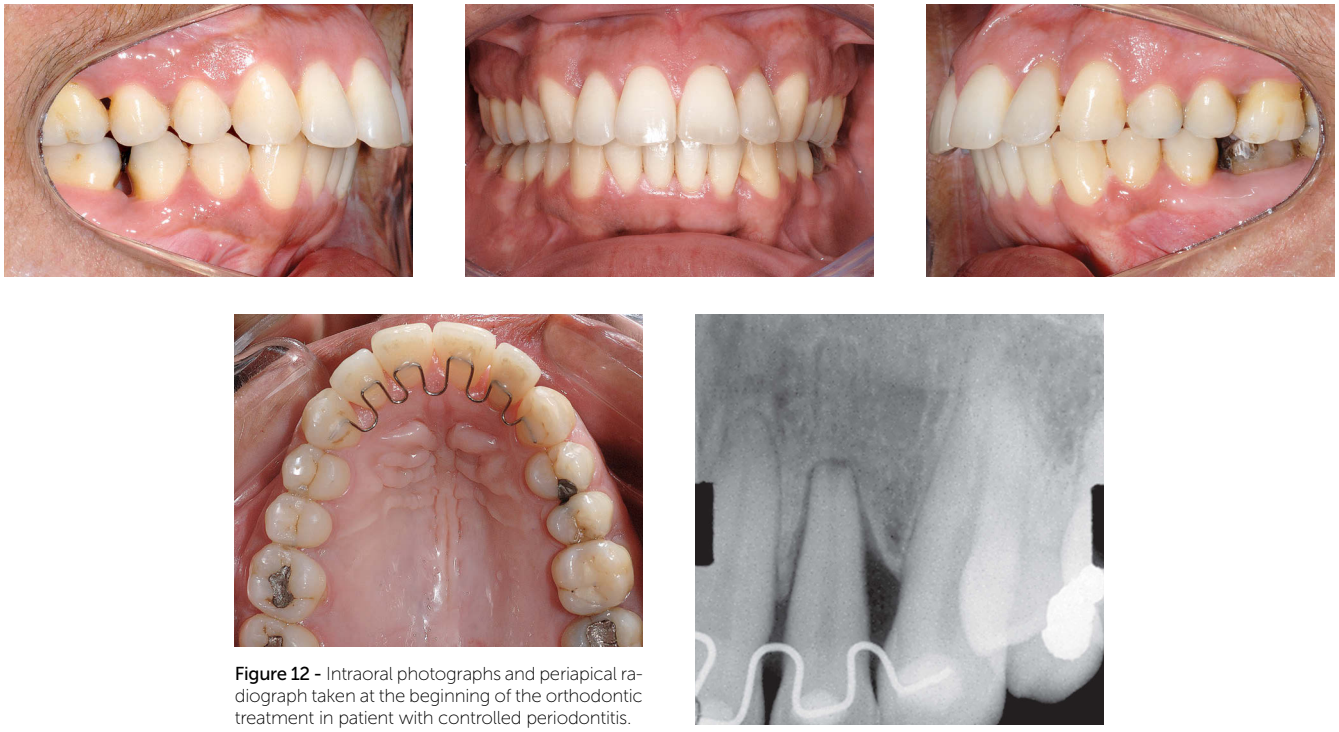

Figure 12 - Intraoral photographs and periapical radiograph taken at the beginning of the orthodontic treatment in patient with controlled periodontitis.

For adult patients, the orthodontic plan with ideal objectives must be reconsidered when the periodontium is compromised, when there is great tooth loss or other limiting conditions. Such patients need an objective and directed treatment in order to have their problem quickly and efficiently solved. Three factors must be taken into account at this moment, namely: 1) Simplification — seek mechanics to favor patient's oral hygiene. 2) Goals — ponder which would be the best result taking esthetics, stability and functional occlusion into account. Patients usually seek improvements in esthetics, which does not always provide stable results. Therefore, the specialist must discuss with the patient in order to reach a

Figure 13 - Example of an objective and directed treatment. Need for intrusion of right mandibular molars to place the crowns over the implants in the antagonist area.

Figure 14 - Placement of miniplate (buccal) and mini-implant (palatal) for anchorage; NiTi spring for intrusion.

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mutual agreement on the final outcome. 3) Risk-cost/benefit — talk to the patient about the benefits of the treatment. The costs involve not only the financial value, but also pain, discomfort and tooth mobility. Risks are seen as the possibility of creating problems which did not exist in the first place, such as decalcification, root resorption, mucogingival problems and even tooth loss. At this moment, the orthodontist must also notify the patient about the risks of not taking the treatment.[25] Figures 13 to 16 illustrate a case with a realistic objective: the need for intrusion of left mandibular molars for prosthetic restoration of antagonist teeth.

Figure 15 - After intrusion and placement of crowns over the implants.

Figure 16 - Study models demonstrating the performed treatment: Initial (**A**); after intrusion of teeth #26 and #27 (**B**); crowns placed over implants in the mandibular arch (**C**).

What is your opinion about early orthosurgical treatment with esthetic and psychosocial purposes? Carlos Alexandre Câmara

When treating Class III, we have good results in patients from 7 to 10 years old with mild to moderate malocclusion and in patients from 17 to 19 years old undergoing the renowned orthosurgical treatment, or in cases with little maxillomandibular discrepancies in which we have the option of orthodontic camouflage.[6] In clinical practice, I have always noticed a gap concerning the treatment of Class III patients from 12 to 14 years old with dental and facial deformities: it is too late for an interceptive approach and too early for surgery. Awaiting growth to end prior to starting orthosurgical treatment is sometimes extremely difficult for patients suffering from severe facial deformities. It is difficult to explain to them and their guardians that treatment will happen after 4 or 5 years, only. Therefore, orthosurgical treatment may be performed during the active growth phase, in cases of severe skeletal disharmonies in which patients present significant functional, esthetic or psychosocial issues[7] — as shown in Figures 17 to 21. 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.[7,8]

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Figure 17 - Facial and intraoral photographs taken at the beginning of the orthodontic treatment in patient aged 13, with Class III dental and skeletal relationship.

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Figure 18 - Facial and intraoral photographs after orthodontic preparation for orthognathic surgery.

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Figure 19 - Facial and intraoral photographs taken at the end of treatment (surgery performed by Dr. Henrique Martins).

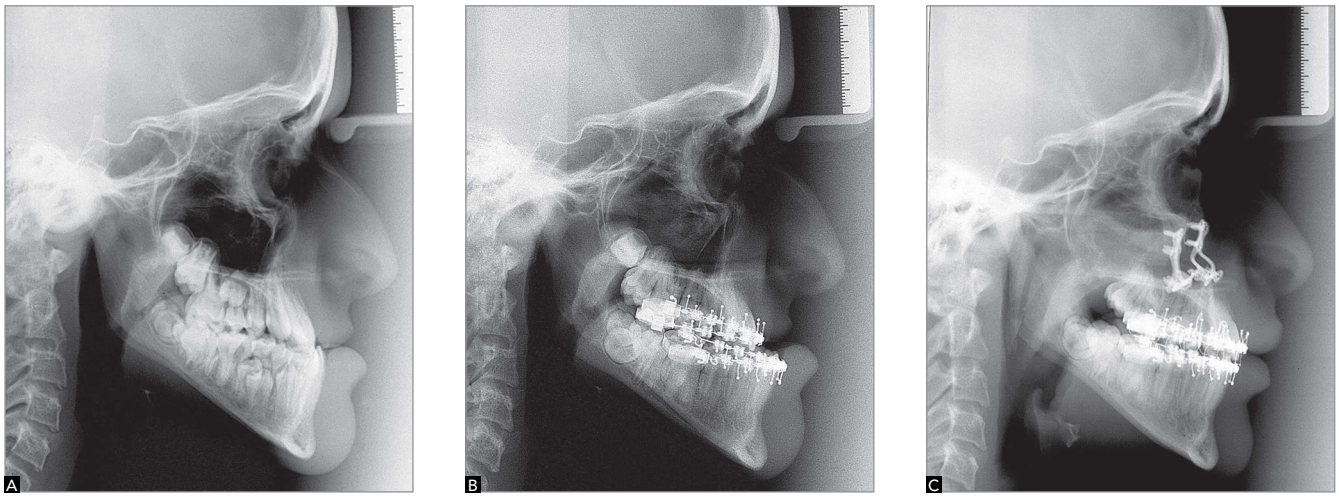

Figure 20 - Cephalometric radiographs at initial (A), presurgical (B) and postsurgical (C) phases.

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Figure 21 - Facial and intraoral photographs of patient aged 18. Five years after the surgery, we notice good facial esthetics and, again, dental compensation in the anteroinferior segment. Potential need for a new surgery shall be assessed at the age of 21.

Is there a minimum age required to indicate orthognathic surgery for growing patients? If so, what would it be concerning the different types of deformities? Carlos Jorge Vogel

The minimum age required to indicate orthognathic surgery for growing patients is directly associated with the development of dentition. Therefore, the dental development stage is decisive for surgical procedures involving all kinds of facial deformities in which early surgery is recommended — mandibular hyperplasia or hypoplasia, maxillary hypoplasia or maxillary vertical hyperplasia. The development degree of maxillary canines is important to assess the viability of maxillary surgery with no harm to the dental structure.

Mandibular advancement surgery is recommended after mandibular second molar eruption. However, the ideal would be to have the surgery performed after all permanent teeth have erupted, except for the third molars. We sometimes have to wait to perform the surgery in order to assure a greater dental development. Figures 22 to 26 show an example of a patient treated at age 12 when dental development allows all necessary surgical procedures. It is not advisable to recommend, for this or any other reason, the surgery for a Class III patient aged between 15 or 16. This does not seem to be a sensible approach. It would be correct to wait until the patient turns 18 to perform the Class III traditional orthosurgical treatment.

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Figure 22 - Facial and intraoral photographs taken at the beginning of the orthodontic treatment in patient aged 12, with Class III dental and skeletal relationship.

Is surgical treatment indicated for mandibular asymmetry cases during growth?

Carlos Jorge Vogel

The mandibular asymmetry cases in which surgery is indicated during growth are, mainly, the condylar hyperplasia ones. In this asymmetric growth process, accentuated by the age of 13, the hypothesis of high condylectomy procedure must be taken into account. Some surgical maneuvers that section the upper part of the mandibular condyle, which grows increasingly, have presented good results for a subsequent balanced mandibular growth process.

Which surgery cases are more likely to succeed: Correction of hypoplasia or hyperplasia?

Carlos Jorge Vogel

The cases of Class III patients with severe anteroposterior deformities are commonly composed of maxillary hypoplasia and mandibular hyperplasia. One may predominate over the other; however, we have always found a combination of both. Maxillary advancement surgeries have presented stable results. In addition, significant mandibular setback surgeries can cause some damage, such as narrowing of the upper airways. Although we started treating cases in which the mandibular setback surgery

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Figure 23 - Facial and intraoral photographs after orthodontic preparation for orthognathic surgery.

alone was considered satisfactory, currently many Class III cases that are treated with an early surgical approach undergo more maxillary advancement surgeries than mandibular setback surgeries.[7,24]

The Anticipated Benefit orthognathic surgery has presented many advantages, such as the reduction of about 40 to 50% in conventional treatment estimated total time. Based on your experience, do you also see such advantage? If so, what are the causes of this reduction in time?

Sissy Maria Mendes Machado

The expression "Anticipated Benefit" was created by my colleague Dr. Jorge Faber.[27] It refers to an approach towards orthosurgical treatment in which there is an inversion of stages: From Orthodontics prior to Surgery to Surgery prior to Orthodontics.

The "surgery-first" approach refers to a process in which orthognathic surgery is performed prior to orthodontic treatment, while the "Orthodontics-first" approach refers to a process in which orthodontic treatment is implemented prior to orthognathic surgery. Presurgical orthodontic treatment aims at aligning both upper and lower dental arches in order to coordinate their respective skeletal bases, eliminating dental compensations. Orthodontic treatment performed at the presurgical phase is proved very important to yield the best results with the least relapse.[6,28]

The surgery-first approach treats facial esthetics prior to occlusion, while the traditional approach treats occlu-

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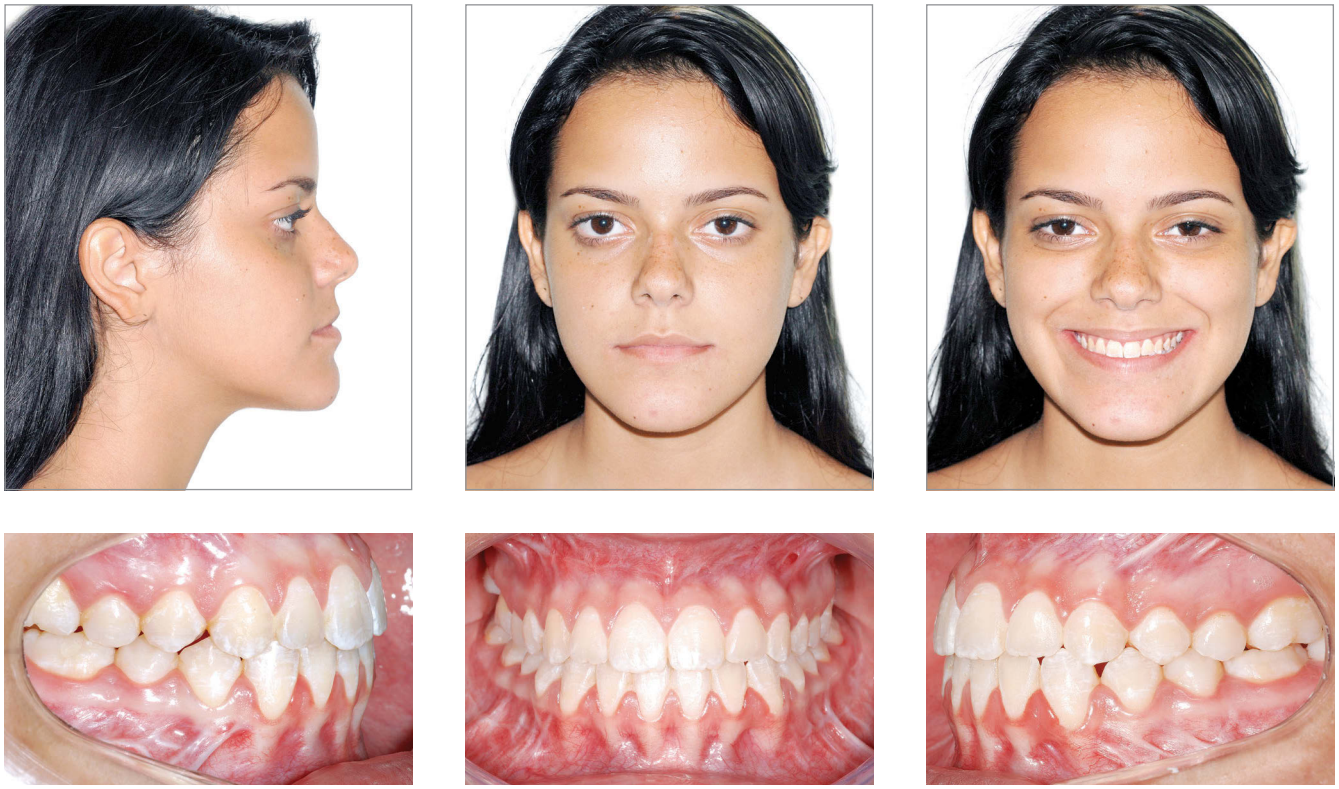

Figure 24 - Facial and intraoral photographs taken at the end of treatment. Combined surgery was performed,with 5 mm of maxillary advancement and 2 mm of mandibular setback (surgery performed by Dr. Henrique Martins).

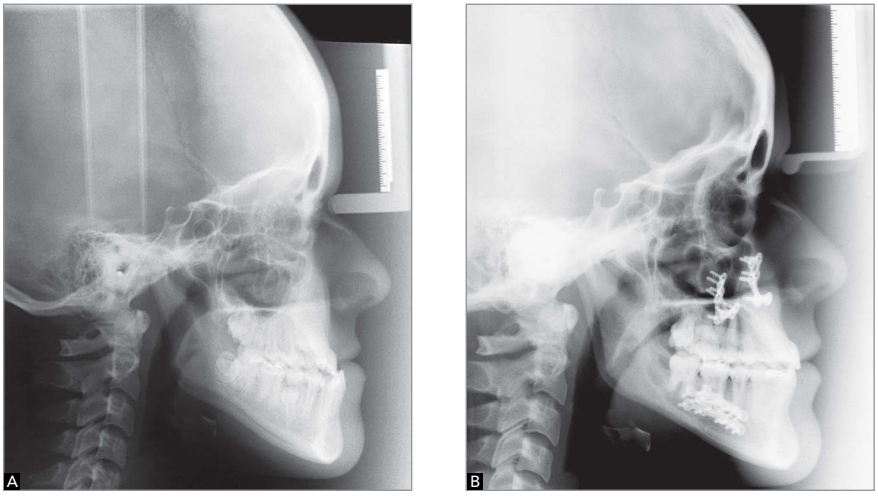

Figure 25 - Cephalometric radiographs at initial (**A**) and final (**B**) phases.

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Figure 26 - Patient's photographs taken during a photo shoot, demonstrating patient's great self-esteem by the end of adolescence.

sion prior to facial esthetics. The surgery-first approach solves, at the same time, skeletal problems despite occasional dental compensations, and a transitional occlusion is corrected after surgery. The surgery-first approach is recommended for cases with no need of significant decompensation or presurgical orthodontic alignment. Such cases include: 1) properly aligned or slightly crowded teeth; 2) mild curve of Spee and 3) incisor inclination ranging from normal to slightly buccal or retroclined.[28]

The main reported advantages are: 1) improvement in patient's chief complaint (dental function) and facial esthetics right at the beginning of treatment; 2) reduction in treatment total time, depending on the complexity of the orthodontic treatment; 3) reduction in complexity and duration of orthodontic treatment due to accelerated orthodontic tooth movement at the presurgical phase.[28]

Answering your question, we presume that reduction in total treatment time can be associated with recommending the surgery-first approach for less complex cases. When comparing the average total time of the surgery-first approach with the average total time of the traditional approach, which includes all types of orthosurgical treatments, we found that the average time for the former is shorter.

However, we should also pay attention to the fact that tooth movement was faster immediately after surgery. An increase in osteoclastic activity and metabolic changes in the dentoalveolar region, with higher expression of bone activity markers — such as alkaline phosphatase (ALP) and C-terminal telopeptide (CTX-1) — are valid reasons for such accelerated bone remodeling.[29] It is as if orthognathic surgery worked as the injury caused by the selective alveolar corticotomy. This is an interesting finding which requires further research.

During the ABOR (Brazilian Association of Orthodontics and Facial Orthopedics) congress, held in the city of Belo Horizonte/MG, the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) promoted the pilot project for the certification process of recent graduates and students in the last year of the post-graduation course in Orthodontics. What are your expectations towards those participating in this activity? What are the plans for the future?

Carlos Jorge Vogel

The participants in this activity should follow criteria such as: 1) minimum 12-month graduate from a post-graduation course in Orthodontics with a minimum of 2,000 credit hours; 2) student attending the last year of a post-graduation course in Orthodontics with a minimum of 2,000 credit hours; 3) member of a state-owned entity affiliated with the ABOR.

The chairman of the ABOR invited the coordinators of the courses with a minimum of 2,000 credit hours to take part in this pilot project.

The 47 candidates who applied passed the pilot project examination (equivalent to Phase I). Once they have passed the examination, they have up to 10 years to sit in for Phase II of the certification exam. Should they pass it, they will become a BBO Diplomate, being approved in the "Clinical Excellence" examination.

It is highly likely that a similar exam will be held in Natal/RN (Brazil), during the next ABOR Congress.

As for the BBO, our expectations obligatorily lay on our young colleagues: They shall decide the future of our specialty.

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Effects of surface treatment of provisional crowns on the shear bond strength of brackets

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Objective: To assess the adhesive resistance of metallic brackets bonded to temporary crowns made of acrylic resin after different surface treatments.

Methods: 180 specimens were made of Duralay and randomly divided into 6 groups (n = 30) according to surface treatment and bonding material: G1 – surface roughening with Soflex and bonding with Duralay; G2 – roughening with aluminum oxide blasting and bonding with Duralay; G3 – application of monomer and bonding with Duralay; G4 – roughening with Soflex and bonding with Transbond XT; G5 – roughening with aluminum oxide blasting and bonding with Transbond XT and G6: application of monomer and bonding with Transbond. The results were statistically assessed by ANOVA/Games-Howell.

Results: The means (MPa) were: G1= 18.04, G2= 22.64, G3= 22.4, G4= 9.71, G5= 11.23, G6= 9.67. The Adhesive Remnant Index (ARI) ranged between 2 and 3 on G1, G2 and G3 whereas in G4, G5 and G6 it ranged from 0 to 1, showing that only the material affects the pattern of adhesive flaw.

Conclusion: The surface treatment and the material influenced adhesive resistance of brackets bonded to temporary crowns. Roughening by aluminum blasting increased bond strength when compared to Soflex, in the group bonded with Duralay. The bond strength of Duralay acrylic resin was superior to that of Transbond XT composite resin.

Keywords: Acrylic resins. Orthodontic brackets. Shear bond strength.

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INTRODUCTION

The technique of directly bonding orthodontic appliances by means of acid conditioning and composite resin became universal in the 90s.[8] Since then, many researches have been developed with the aim of verifying the resistance of metallic brackets on dental enamel.[2] Bonding in Orthodontics, although temporary, must be resistant enough to withstand orthodontic and occlusal forces.[18]

As a result of developments in technology regarding continuing education and communication in orthodontics, there has been an increase in the demand of adult patients seeking orthodontic treatment in the last few years, and it is not unusual to find amalgam restorations, incrustations in gold, ceramic crowns and fixed prosthesis in these patients.[20]

Orthodontics is oftentimes an intermediate stage to oral rehab. Thus, it becomes necessary to perform bracket bonding in temporary crowns which are generally made of self-etching acrylic resin. Newman[11] asserted that the materials and techniques available are capable of effectively bonding accessories to the surface of materials other than enamel.

According to Zachrisson,[21] acrylic resin is recommended for bonding on acrylic surfaces because its bonding strength is greater than that obtained with other bonding agents.

Some works in the literature focus on bracket bonding on surfaces of gold, amalgam, resin and porcelain, however, there are a few references about bonding on acrylic resin present in temporary crowns.[3,12] Therefore, this work aims at assessing bond strength between brackets and acrylic resin after different surface treatments using two distinct bonding materials.

MATERIAL AND METHODS

The specimens were made of self-etching acrylic resin (Duralay/Reliance, Worth, USA). Polymethylmethacrylate and methylmethacrylate were mixed in the proportions recommended by the manufacturer (3 powder:1 fluid) in a glass recipient with lid until the mixture reached the plastic phase. Afterwards, resin was poured into standardized aluminum rings (20 x 20 mm). With resin polymerization, the specimens were removed and regularized under refrigeration in 400, 600 and 1200 wet sandpaper. After the use of sandpapers, the specimens were polished with felt disc and calcium carbonate in a bench vise.

The 180 specimens were randomly divided into 6 groups (G1 to G6), according to the surface treatment and material used for bonding (Table 1).

G1 and G4 samples had their surface roughened with coarse sandpaper disc (Soflex) during 2 minutes, rinsed with air/water blasting for 15 seconds and dried with air blasting for another 15 seconds.

G2 and G5 samples had their surface roughened with 45-μm aluminum oxide blasting during 45 seconds, rinsed with air/water blasting for 15 seconds and dried with air blasting for another 15 seconds.

As for G3 and G6 samples, monomer was applied to the surface of specimens central region. To this end, monomer was dropped on a disposable brush which remained in contact with the acrylic surface for 5 seconds.

Thereafter, excess was removed with air blasting and orthodontic bonding was performed by a single operator, as follows.

On groups G1, G2 and G3, Duralay® acrylic resin (Reliance) was the material used for bonding. It was inserted in the base of the brackets by means of the brush technique, with accessories positioned and subjected to 400 gF of pressure measured by a dynamometer (ETM). In order to maintain the proportion recommended by the manufacturer, 1g of powder was mixed with 0.5 ml of fluid in a Dappen dish. This measure was used for the bonding of two specimens. Excess was removed with the aid of a probe. After bracket bonding, the specimens were immediately stored in distilled water at 37°C for 24 hours.[9,13]

Conditioning was performed with phosphoric acid at 37% (Dentalville, Joinville, Brazil) for 15 seconds on the specimens of G4, G5 and G6. After that, the surfaces were rinsed with air/water blasting for 15 seconds

Table 1 - Division of groups according to surface preparation and bonding resin.

Group	Surface preparation	Bonding resin
G1	Soflex sandpaper disc	Duralay
G2	Aluminum oxide	Duralay
G3	Monomer	Duralay
G4	Soflex sandpaper	Transbond XT
G5	Aluminum oxide	Transbond XT
G6	Monomer	Transbond XT

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and dried with air blasting for another 15 seconds, followed by the application of Transbond adhesive (3M/Unitek®). Transbond XT® (3M/Unitek®) light-activated resin was inserted in the base of the brackets (3M/Unitek®) according to the manufacturer's instructions. It was positioned and subjected to 400 gF of pressure measured by a dynamometer (ETM) (Fig 1). Excess was removed with the aid of a probe and the resin was light-activated for 40 seconds, 10 seconds in each face. Once bracket bonding had been finished, the specimens were stored in distilled water at 37°C for 24 hours.[9,13]

The specimens were subjected to shear test with guillotine system at a speed of 0.5 mm/min in a Universal Testing Machine (EMIC DL500, São José dos Pinhais, Paraná, Brazil) connected to a computer (Fig 2). Strength value was obtained at the moment of bond rupture. Then, it was recorded and converted into MPa by means of specific calculations.

Bond failure was observed by a single operator through a stereomicroscope with magnification of 40X. The Adhesive Remnant Index (ARI) was analyzed as suggested by Årtun and Bergland,[1] where 0 indicates no adhesive remnant in the dental structure; 1, less than half of remnant in the dental structure; 2, more than a half of remnant in the dental structure and 3, all the adhesive remnant adhered to the bracket base.

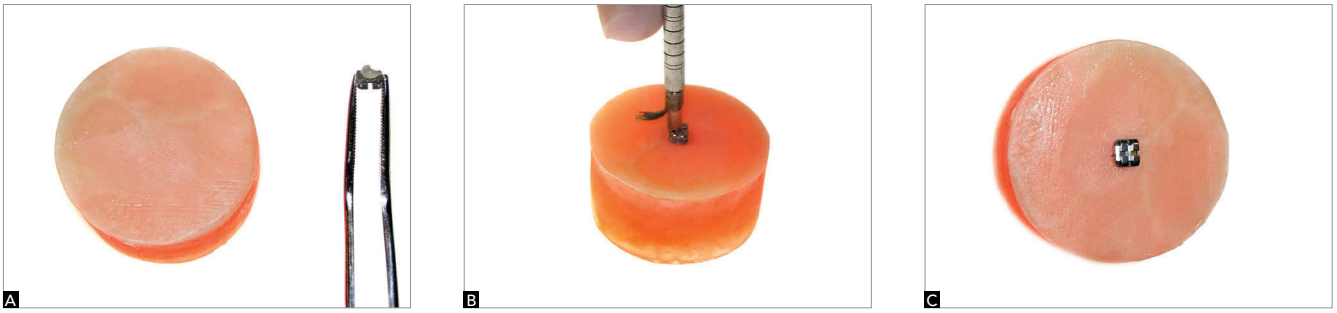

Figure 1 - Sequence of bonding, **A**) bonding material applied to the base of the bracket, **B**) pressure of 400 gF applied at the moment of bonding to standardize the material thickness, **C**) specimen.

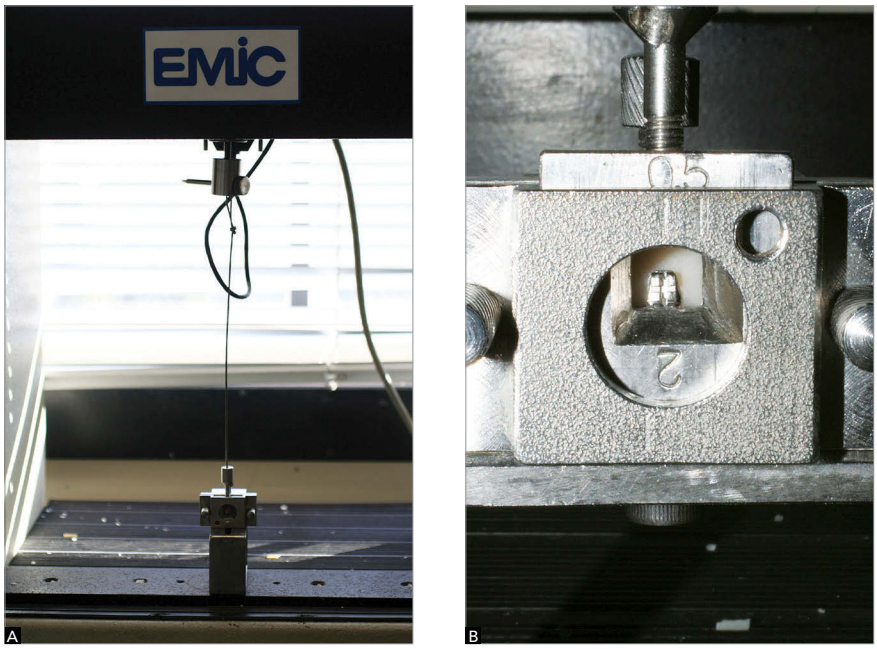

Figure 2 - **A**) shear bond strength test, **B**) specimen positioned in the testing machine

RESULTS

Kolmogorov-Smirnov static test revealed that variables related to bond strength presented normal distribution, except for G1. Comparison of mean values was performed through two-way ANOVA.

The yielded results showed that the value of F was statistically significant ($p < 0.05$) for the variables "material" and "treatment". Thus, Games-Howell test of multiple comparison was used to identify the differences, since the measures did not present homogeneous distribution (Levene test) (Table 2).

The Adhesive Remnant Index (ARI) in G1, G2 and G3 ranged between 2 and 3, whereas in G4, G5 and G6 it ranged between 0 and 1. As distribution was not normal, Kruskal Wallis test was used. No significant difference ($p > 0.05$) was found for surface treatment. Mann-Whitney U test showed significant difference ($p < 0.05$) with regard to the material used for bonding. Duralay had bond strength increased (Table 3).

The Spearman coefficient of linear correlation was 0.5, which shows a regular correlation between bond strength and ARI.

Table 2 - Mean, standard deviation and p value for adhesive resistance of groups..

Group	Mean ± standard deviation	Statistics
G1	18.04 ± 3.46	A
G2	22.64 ± 4.04	B
G3	22.41 ± 3.95	A, B
G4	9.71 ± 2.11	C
G5	11.23 ± 2.75	C
G6	9.67 ± 1.95	C

Different letters indicate statistically significant difference for the Games-Howell test ($p < 0.05$).

Table 3 - Mean, standard deviation and p value for the Adhesive Remnant Index (ARI) of groups.

Group	Mean ± standard deviation	Statistics
G1	2.84 ± 0.46	A
G2	2.94 ± 0.09	A
G3	2.70 ± 0.95	A
G4	0.71 ± 0.09	B
G5	0.03 ± 0.05	B
G6	0.77 ± 0.15	B

Different letters indicate statistically significant difference for Mann-Whitney U test ($p < 0.05$).

DISCUSSION

After acid conditioning was discovered,[3] the processes of adhesion to dental surfaces have improved. Adhering brackets to enamel or other structures depends on some factors such as preparation of the surface, adhesive and material used for bonding, among others.[19]

In this study, it was observed that pre-treating the acrylic resin surface affects bond strength. In the group in which the surface was roughened by aluminum oxide blasting, the adhesive resistance was statistically superior ($p < 0.05$) to the surface treated with Soflex, when bonding was performed with Duralay. It is probable that aluminum oxide was capable of creating deeper slots that caused the bonding material to adhere to the acrylic resin, making the bond between bracket and bonding material the weak link of the adhesive process.[5]

Surface preparation by chemical variation was performed in accordance with Cunningham and Benington[8] and Takahashi et al,[17] who recommended the use of dichloromethane solvent to increase acrylic resin bond strength. Thus, in this research, the prior application of monomer generated an adhesive resistance similar to that obtained after roughening with Soflex, a fact that disagrees with Spratley[16] and Chung et al,[7] who asserted that wetting the surface with monomer alone would not increase adhesive resistance in denture base. Additionally, they indicated the necessity of rugosities on the surface of prosthesis in order to obtain an acceptable adhesive resistance. This difference is probably due to the level of strength to which it will be subjected because, in previous works, the prosthesis were subjected to masticatory loads, different from the present research in which the level of applied strength was lower.

The surface treatment did not change the adhesive resistance when the composite resin was used as bracket bonding material. This can be explained by the short-term storage of the temporary crown made of acrylic resin before bracket bonding. According to Gegauff and Wilkerson,[10] 24 hours of storage is not capable of altering the mechanical properties of the acrylic, thus, resistance remains even with the use of different surface preparations.

The adhesive resistance of brackets bonded to temporary materials must be strong enough to resist dental movement without debonding the orthodontic acces-

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sory, and weak enough to be removed without damaging the surface after orthodontic treatment is finished.[4] According to Reynolds[15] and Whitlock et al[18] clinically acceptable adhesive resistance ranges between 5 and 8 MPa, which indicates that any surface treatment used in this research can be clinically used. Moreover, acrylic or composite resin maintains bond strength above the level accepted for clinical use.[15,18]

The present research obtained increase in the shear bond strength when bracket bonding was performed with acrylic resin. This can be explained by the fact that no other material was used, since adhesive resistance increases when materials of similar chemical components are used,[6] because material's cohesive power is substantially higher than adhesion strength obtained by adding another bonding agent. Thus, the results of the present study agree with Zachrisson[21,22] who asserted that acrylic is the recommended bonding material for bonding performed in acrylic surfaces, regardless of the type of bracket. However, this increase in bond strength (18.04 to 22.64 MPa) favors the integrity of the temporary crown surface, since the adhesive remnant remains in the restoration. In this situation, the ARI ranged between 2 and 3.

On the groups bonded with Transbond XT composite resin, the adhesive resistance was statistically lower. This procedure is similar to repairs carried out on acrylic prosthesis. When a relatively new material has been just polymerized and polished, it presents slightly over 50% of non-reactive methacrylate groups. However, as time goes by, there will be less non-reactive methacrylate groups, which will generate few crosslinks with the new material inserted and reduction in the capacity of the monomer in penetrating the matrix. Thus, resistance between the temporary crown material and the resin inserted in the base of the bracket is reduced in about 50%.[10]

Reduction in adhesive resistance makes it difficult to remove the accessory without damaging the temporary restoration because failure occurs in the interface temporary crown/resin, a fact that is confirmed by the Adhesive Remant Index, which ranged between 0 and 1.

The outstanding differences obtained on ARI showed an opposite pattern of debonding, which resulted in regular correlation between this index and the adhesive resistance. Thus, it can be asserted that adhesive resistance increases with acrylic resin being used as bonding material. As a consequence, the amount of material on the temporary crown also increases, facilitating the preservation of the buccal surface. However, the material will need to be mechanically removed by the professional. Despite the differences found in shear bond strength of brackets bonded to temporary crowns made with acrylic resin, additional studies are warranted to further investigate this topic.

CONCLUSION

Both the surface treatment and material influenced bond strength of metallic brackets bonded to temporary crowns made with self-etching acrylic resin. Roughening performed with aluminum oxide blasting increased bond strength when compared to Soflex, in the group bonded with Duralay. Bond strength of Duralay acrylic resin was superior to that of Transbond XT composite resin.

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Mechanical properties of NiTi and CuNiTi shape-memory wires used in orthodontic treatment. Part 1: Stress-strain tests

Marco Abdo Gravina[1], Ione Helena Vieira Portella Brunharo[2], Cristiane Canavarro[3], Carlos Nelson Elias[4], Cátia Cardoso Abdo Quintão[5]

Objective: This research aimed to compare, through traction tests, eight types of superelastic and heat-activated NiTi archwires, by six trade companies (GAC, TP, Ormco, Masel, Morelli and Unitek) to those with addition of copper (CuNiTi 27°C and 35°C, Ormco).

Methods: The tests were performed in an EMIC mechanical testing machine, model DL10000, capacity of 10 tons, at the Military Institute of Engineering (IME).

Results: The results showed that, generally, heat-activated NiTi archwires presented slighter deactivation loadings in relation to superelastic. Among the archwires that presented deactivation loadings biologically more adequate are the heat-activated by GAC and by Unitek. Among the superelastic NiTi, the CuNiTi 27°C by Ormco were the ones that presented slighter deactivation loadings, being statistically (ANOVA) similar, to the ones presented by the heat-activated NiTi archwires by Unitek. When compared the CuNiTi 27°C and 35°C archwires, it was observed that the 27°C presented deactivation forces of, nearly, ⅓ of the presented by the 35°C.

Conclusion: It was concluded that the CuNiTi 35°C archwires presented deactivation loadings biologically less favorable in relation to the other heat-activated NiTi archwires, associated to lower percentage of deformation, on the constant baselines of deactivation, showing less adequate mechanical behavior, under traction, in relation to the other archwires.

Keywords: Orthodontic archwires. Dental movement. Copper. Nickel. Titanium. Physical properties.

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INTRODUCTION

The tooth alignment and leveling constitute the preliminary clinical phase of any orthodontic procedure with fixed appliances.[8] It has been accepted in orthodontics the principle that slight and continuous forces would be desirable for obtainment of physiologic and controlled tooth movement. For this purpose, it has been suggested the superelastic and heat-activated nickel-titanium (NiTi) archwires, which offer a force-bending curve with a defined baseline and a larger activation range.[5,6,11]

Despite the small number of available alloys for manufacture of orthodontic archwires, there is a large number of trade brands of available archwires. The manufacturing companies invest in advertising calling the archwires superior (superelastic and heat-activated NiTi) and emphasize that they provide better performance due to the appropriate mechanical properties. However, these properties not always are described on the product package. Thus, the variety of brands, the large number of manufacturing companies and the lack of information about the material properties make it difficult for the professional to choose the most adequate material and with better cost-benefit for use.[11,22]

Some mechanical properties of orthodontic archwires, such as high resilience, low elasticity module, high flexibility, high elastic recovery, low coefficient of attrition and biocompatibility, are necessary in order to stimulate the adequate tissue response[1,4,15,17,19] and promote slight and continuous forces during the tooth leveling and alignment.[9,30] However, to quantify the ideal force becomes difficult due to individual variations on the tissue response, to root morphology and to type of induced movement.[9] Rock and Wilson[23] asserted that there is a consensus that the ideal orthodontic forces should vary between 15 and 500 gf.

The superelastic NiTi archwires were commercially launched in 1986 (Japanese NiTi and Chinese NiTi). *In vitro* studies showed that such alloys had excellent elastic properties and generated constant forces, when subjected to loadings, even before the increase on deformation. This made the archwires extremely popular for the use in tooth leveling and alignment.[8] The heat-activated NiTi alloys emerged commercially in the 90's. Besides the properties of maintenance of constant loadings during loading and unloading, the heat dynamic NiTi archwires showed shape memory thermally induced, presenting ductility and malleability in lower temperatures returning to the initial configuration, when heated to higher temperatures than their transition temperature.[16,20]

According to Sachdeva,[25] NiTi archwires with addition of copper (CuNiTi) appeared in the 90's and are composed, basically, of nickel, titanium, copper and chromium. For presenting addition of copper (efficient heat conductor) to nickel and titanium, they would present better defined transition temperatures, which would ensure the generation of more homogeneous loadings from arch to arch and from end to end, increasing the effectiveness on tooth movement. They were introduced in the market by Ormco Corporation with three transition temperatures: 27°C, 35°C and 40°C, enabling to clinicians the quantification and application of levels of adequate loadings to the initial purposes of the orthodontic treatment. When compared to the conventional heat-activated and superelastic NiTi archwires, the CuNiTi archwires would present, still, lower elasticity module, i.e., they would experience similar deformations, before lower activation loadings, presenting a high capacity to fit to brackets of misplaced teeth, with less discomfort to the patient and lower potential to generate tooth resorption. Besides, they would present reduced hysteresis, which would ensure the production of more constant forces and for longer periods of time during deactivation, factors biologically favorable to tooth movement.[25]

Because of existing gaps in publications related to comparison of mechanical behavior of NiTi and CuNiTi archwires, it is the objective of the present work to determine and compare some of the mechanical properties, in tests of resistance to traction, presented by the conventional superelastic and heat-activated orthodontic archwires, by different trade brands, to the presented by the NiTi archwires with addition of copper (CuNiTi 27°C and 35°C).

MATERIAL AND METHODS

Sixty orthodontic archwires were used, 0.018-in, precontoured and with the same arch shape. According to the mechanical properties provided by the manufacturers, the archwires were divided into two groups (Table 1).

The mechanical properties of the archwires were determined from the tests of resistance to traction, performed in EMIC mechanical testing machine,

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model DL10000, capacity of 10 tons (EMIC International Corp., Garland, USA) (Fig 1A), at the Military Institute of Engineering (IME), Rio de Janeiro. It was used a 500 N cell (50 kgf) and testing speed of 1 mm of deformation per minute.

The archwires were positioned in the testing machine, as obtained at the store. Initially, it was applied a slight force so the portion of wire positioned between the machine's nails became straight (Fig 1B).

First, three specimens from each subgroup of archwires were stretched until break to determine their yield stress and constant baselines of activation. The obtained results enabled that the following tests, of loading and unloading (three specimens from each subgroups of archwires) were performed with maximum activation loadings immediately inferior to the respective yield stress (Fig 3). With this methodology the mechanical properties of clinical interest from the several subgroups of archwires could be calculated, without permanent deformations, which could invalidate the tests. On the testing, it were obtained the curves that allowed to determine the stress applied on the wire (MPa) versus the deformation (mm).

All tests of resistance to traction were performed at 37 ± 1°C (average oral temperature) to point the possible shape memory effect (SME), according to methodology of Gravina et al.[12] The temperature was controlled with a precision digital heat meter, calibrated by INMETRO (Fig 1C). The testing environment in which the archwires were attached to the machine was isolated with styrofoam plates and the temperature was kept constant (≅ 37°C) using three lamps of 60 watts. The lamps were used to simulate a greenhouse, so the temperature could be controlled through a thermostat (Fig 1C).

Every force-bending curve is constituted of a large number of points, and each one of them is numerically

Table 1 - Orthodontic archwires used in this work.

I – SUPERELASTIC GROUP (36 archwires)		II – HEAT-ACTIVATED GROUP (24 archwires)	
GAC	6 NiTi (REF. 03-018-53T)	GAC Sentalloy	6 NiTi (REF. 02-511-132)
TP Reflex	6 NiTi (REF.381-264)	TP Reflex	6 NiTi (REF. 381-825)
Ormco NiTi	6 NiTi (REF. 219-3204)	Ormco 35OC	6 CuNiTi (REF. 219-4204)
Ormco 27°C	6 CuNiTi (REF. 205-0048)	Unitek Nitinol	6 NiTi (REF. 4286-981)
Masel Elastinol	6 NiTi (REF. 4828-018)		
Morelli	6 NiTi (REF. 50.70.014)		

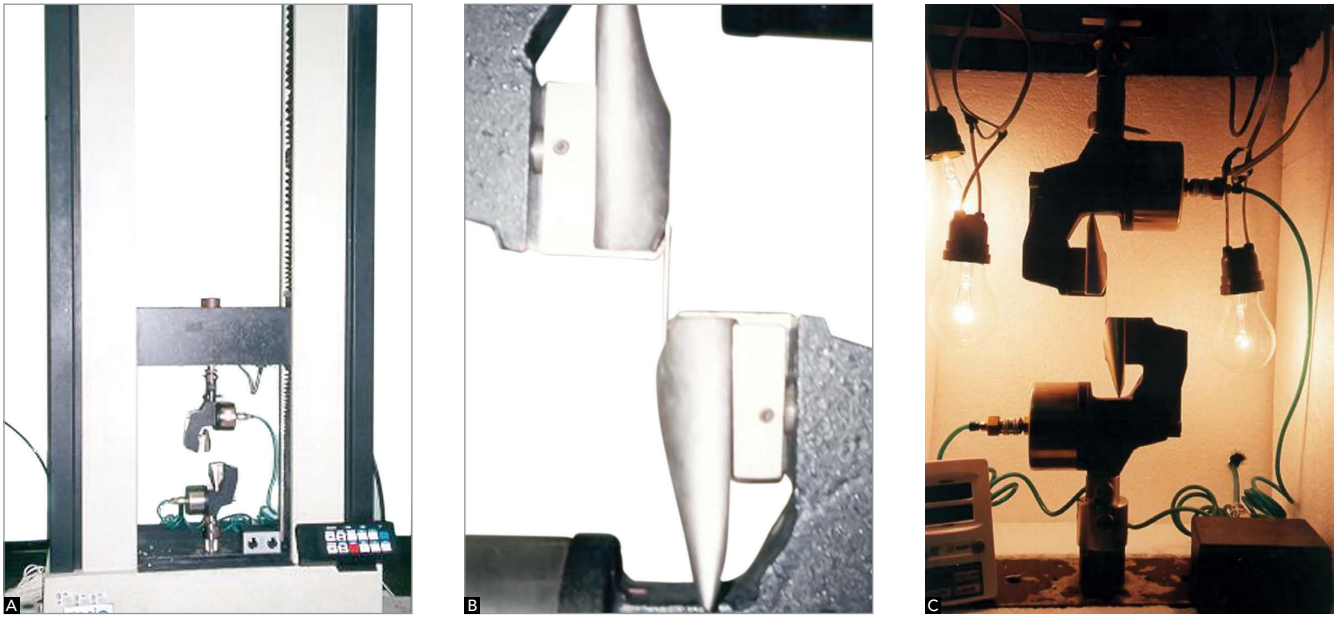


Figure 1 - **A**) Machine used on the performance of traction resistance tests, **B**) Detail of the wire tied by its ends to the machine's nails, **C**) Device used on the performance of tests at oral temperature (37°C).

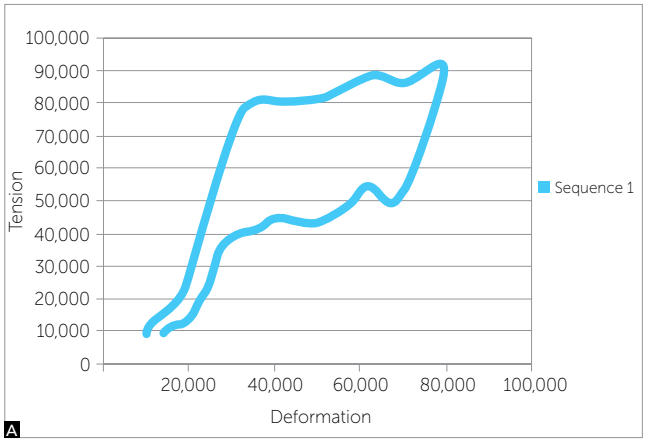
represented by a value where the ordinate (y axis) express the applied force (MPa) and the abscissa (x axis) express the deformation occurred (mm). To calculate the mechanical properties of the several subgroups of archwires, all points component of the curve, obtained during performance of the tests, by the program Tesc 3.04 (São José dos Pinhais, PR, Brasil), were exported to Microsoft Excel (Microsoft Corporation®, Redmond, WA, USA). From this on, the curves were obtained on Excel (Fig 2A) and the mechanical properties were calculated (Fig 2B) and, statistically analyzed to verify the inter-groups differences (significance) as for the maximum break stress, yield stress, percentage of deformation on constant baselines of deactivation, loadings released during deactivations, permanent deformations and resilience. For so, it were used the analysis of variance (ANOVA) and the Tukey test, both parametric tests, through OriginPro 7.0 and Tesc 3.04 (São José dos Pinhais, PR, Brasil), developed for Windows.

RESULTS

Results are shown in Table 1.

DISCUSSION

Several types of laboratorial tests were suggested on the attempt to obtain the mechanical properties of orthodontic archwires, from the test of resistance to traction[27,28,29] to the flexion and bending tests.[3,28] In 1977, the American Dental Association (ADA) released a specification[18] to standardize the laboratorial tests for classification of orthodontic archwires, being chosen the flexion and bending tests. However, the obtained results were controversial in relation to the test of resistance to traction, especially, as for the



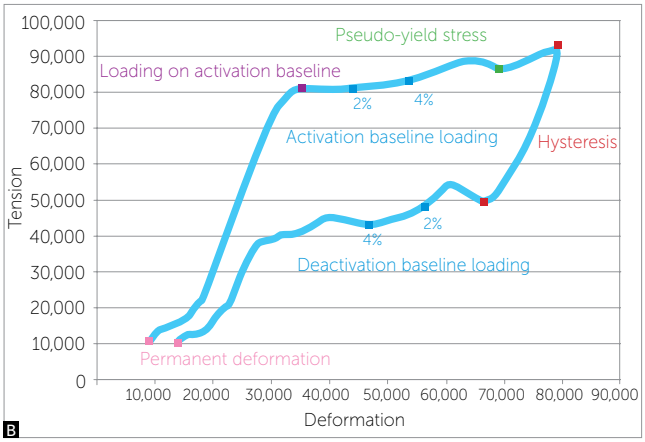


Figure 2 - **A)** Curve initially obtained on Microsoft Excel. **B**) Mechanical properties obtained from the curves.

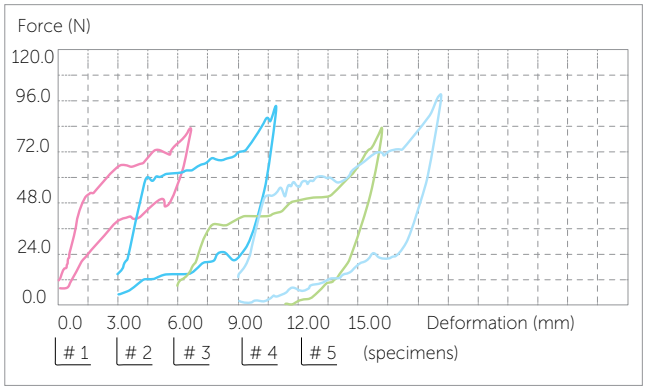


Figure 3 - Stress-strain curve obtained on the tests of heat-activated NiTi and CuNiTi archwires during their loading until their respective limits of flow followed by unloading.

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Table 1 - Values obtained for mechanical properties of the subgroups of tested archwires, where similar symbols indicate similar statistics.

Mechanical properties	Mean									
	GAC NiTi Super	TP NiTi Super	Ormco CuNiTi 27°C	Ormco NiTi Super	Masel NiTi Super	Morelli NiTi Super	GAC NiTi Heat	TP NiTi Heat	Ormco CuNiTi 35°C	Unitek NiTi Heat
Maximum break stress (MPa)	1447.67 ■	1432.49 ■	1458.68 ■	1286.31 +	1267.45 +	1523.25 #	1415.13 ■	1171.78 •	1444.03 ■	1011.44 °
Yield stress (MPa)	604.44 ■#	546.66 ■	450.00 °	555.00 ■	455.60 °	653.55 #	530.00 ■	454.44 °	438.88 °	448.36 °
Deformation deact. bas. (%)	8.23 °	7.64 °	8.84 °	8.64 °	12.83 #	12.32 #+	9.56 +°	7.61 °	8.88 °	12.84 #
Force (N) deactivation baseline	27.62 ■	27.81 ■	11.53 °	35.56 #	16.91 +	41.70 #	3.71 °	0.95 •	29.82 ■	7.59 °
% perm. deformation	6.64 °	4.65 °	10.22 °	12.41 °	4.34 °	6.29 °	17.40 °+	72.67 #	8.80 °	28.52 +

Similar symbols indicate statistical similarities. Heat = heat-activated. Super = superelastic.

values found for the elasticity module. Rantley et al[3] and Asgharnia and Brantley,[2] criticized the precision of the tests suggested by ADA, especially for archwires of gauge lower than 0.020-in, choosing the tests of resistance to traction as the most reliable to obtain the materials mechanical properties, which explains the choice in this present work.

Analyzing the data on Table 2, representative of the mean values for maximum break stress (N) of the subgroups of tested archwires, it was possible to find that the superelastic NiTi archwires by Morelli presented maximum resistance to fracture, for resistance to traction, statistically superior to all others. Among the archwires that presented the lowest resistance to traction are the heat-activated NiTi archwires by Unitek, followed by the heat-activated NiTi archwires by TP. It is also noticed that even for archwires that presented lower fracture loadings, they were extremely high when compared to the clinically used.[4,16] This way, it could be presumed that none of the tested archwires would be clinically used with risk of fracture.

In relation to the yield stress of the NiTi and CuNiTi archwires, it was observed that, initially, the stress and deformation were proportional and abided Hooke's law ($\sigma = E \times \varepsilon$). From this on, the deformation did not increase proportionally to the stress increase. On the contrary, the stress was kept constant while the deformation increased (constant baseline of activation, Fig 2B). Such baseline represents the pseudoplastic deformation behavior, since, when the loading was removed, the metal did not present expressive permanent or residual deformation, being capable to return to its initial configuration. This behavior is clinically favorable, for constant forces would be supposedly accumulated as the wire was activated. In the present work it was considered the loadings corresponding to the end of the constant baselines of activation as equivalent to the yield stress of the tested archwires (Fig 2B).

It was observed that, generally, the superelastic NiTi archwires presented superior yield stress than the heat-activated (Table 2). Among the archwires that presented the highest yield stress, are the superelastic NiTi by Morelli and by GAC, and they suffered the highest stress, for resistance to traction, before permanently deform. It was also observed that the heat activate CuNiTi 35°C archwires by Ormco were the ones that presented the lowest yield stress and consequently the lowest work limits, meeting the report by Sachdeva,[25] who asserted that the CuNiTi archwires would be more resistant to permanent deformation and would show better elastic recovery.

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Regarding the percentage of deformation on constant baselines of deactivation (in relation to original length of 50 mm archwires) it was observed that the superelastic NiTi archwires by Masel and heat-activated archwires by Unitek were the ones that presented, statistically, the highest values (Table 2). Regarding the NiTi archwires with addition of copper (CuNiTi 27°C and 35°C), it was observed percentage of deformation statistically inferior on baselines of deactivation in relation to heat-activated NiTi archwires by Unitek and superelastic archwires by Masel and by Morelli (Table 2). Such results do not confirm the findings by Sachdeva,[25] who asserted that CuNiTi archwires, for presenting reduced hysteresis, would present their plateaus constant of loadings superior in extension, during the unloading, favorable factors to tooth movement. On the other hand, the percentage of deformation found for CuNiTi archwires, on constant baselines of deactivation, were statistically similar to the presented by the superelastic NiTi archwires by GAC, TP and Ormco, which presented the lowest percentage of deformation among all tested archwires (Table 2).

Among all mechanical properties of orthodontic archwires, the strength released during deactivation is the one that expresses the most and it relates to the archwires clinical behavior. It was observed that, generally, the heat-activated NiTi archwires presented slighter loadings of deactivation in relation to superelastic. Among superelastic NiTi archwires, the CuNiTi 27°C by Ormco were the ones that presented the slightest deactivation loadings. Among the heat-activated NiTi archwires, the CuNiTi 35°C were the ones that presented the highest deactivation loadings, being statistically similar to the ones presented by the superelastic NiTi archwires by GAC and by TP (Table 2). Such results meet the report by Sachdeva[25] who asserted that the CuNiTi archwires, for having lower elasticity module, would suffer deformations similar to the conventional superelastic and heat-activated NiTi archwires, before lower activation loadings. Among the archwires that presented the highest deactivation loadings are the superelastic by Morelli and by Ormco, being statistically superior to the presented by the other tested NiTi and CuNiTi archwires. Among the archwires that presented the lowest deactivation loadings are the heat-activated by GAC and by Unitek and the superelastic CuNiTi 27°C by Ormco, with statistically similar deactivation loadings. Although the heat-activated NiTi archwires by TP presented slight deactivation loadings, they presented significant percentage of permanent deformation on most unloading tests at 37°C, which would disable its mechanical properties and explain the obtainment of such loadings.

When compared the CuNiTi 27°C and 35°C archwires, it was observed that the first presented deactivation forces of about ⅓ of the presented by the last ones. This data meets the recommendations from the manufacturer (Ormco Corp.), which supported by the works of Sachdeva,[25] stated that the CuNiTi 27°C archwires should be used in cases where high and biologically acceptable loadings were required and the CuNiTi 35°C archwires should be used to obtain mild loadings. The result of the present work are in agreement to the findings by Dalstra and Melsen,[6] which asserted that some patients reported greater discomfort when using the CuNiTi 40°C archwires, when ingesting warm mouth rinses, in relation to the CuNiTi 27°C archwires, since the loading generated by those, during unloading, would be superior to the produced by these.

In the present work, it was demonstrated that the loading released on constant baselines of deactivation were extremely high when compared to the ones used intraorally, which should vary between 15 and 500 gf.[21,23] From this principle, in the present work, only the heat-activated NiTi archwires by GAC could be clinically used since they released loading corresponding to 3.71 N (371 gf), being the other loadings released by the tested NiTi and CuNiTi archwires, above this baseline (Table 2). Gurgel et al[13] asserted, however, that although the tests of resistance to traction, bending, torsion and deflection do not completely reproduce the clinical situation, they establish adequate values for comparison between archwires of similar or different metallic alloys. Ibe and Segner,[14] however, emphasized that the comparison or extrapolation of values obtained in laboratorial tests, to the clinically obtained, should be done very carefully.[14]

The results of the present work were different from the ones found by Fisher-Brandies et al,[10] which through the deflection test in 3 points, reported that the CuNiTi 35°C archwires (Ormco) and the Neo Sentalloy F80 (GAC), both heat-activated, presented plateaus of unloading under lower loadings related

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to the Rematitan Lite (Dentaurum) and Titanol SE S (Forestadent) archwires, both superelastic. In the present work, the CuNiTi 35°C archwires presented deactivation loadings statistically superior to the other heat-activated NiTi archwires and similar to the superelastic NiTi archwires by GAC and TP (Table 2).

Still contrary to the results obtained in the present work, Gurgel et al,[13] through artificial models of dental arches, showed that the CuNiTi 35°C (Ormco) and Neo Sentalloy F200 (GAC) archwires, presented intermediate deactivation loadings, without statistical difference between them, while the Elastinol 35°C (Masel), heat-activated NiTi (Morelli) and Nitinol heat-activated (3M Unitek) archwires presented the slightest deactivation loadings. It is worth emphasizing however that Gurgel et al[13] used the Neo Sentalloy F200, while the authors of this present work used the Neo Sentalloy F80, both by GAC. In relation to the CuNiTi 27°C archwires (Ormco), Gurgel et al[13] asserted that they presented deactivation loadings statistically higher to the presented by heat-activated archwires by Unitek and CuNiTi 35°C by Ormco,[13] not confirming the results of the present work (Table 2).

On the other hand, the results of the present work were consistent with the found by Sakima et al,[26] which through Force System Identification (FSI), showed that the CuNiTi 40°C (Ormco) and Neo Sentalloy F200 (GAC) archwires were the ones that presented the unloading plateaus under the lowest loadings, followed by CuNiTi 35°C archwires (Ormco); while the superelastic NiTi by Ormco, presented plateaus of unloading under the highest loadings, becoming the most inflexible archwires in this work. Also in the present work the heat-activated NiTi archwires by GAC presented the slightest deactivation loadings among the tested archwires and the CuNiTi 35°C archwires presented deactivation loadings statistically lower to the presented by superelastic NiTi archwires by Ormco, which presented the second highest deactivation loadings among the tested archwires.

Table 2 shows that, generally, the superelastic NiTi archwires presented lower percentage of permanent deformations in relation to the heat activate NiTi archwires. Among the tested superelastic NiTi and CuNiTi archwires it were not observed statistically significant differences between the percentage of permanent deformation. Among the heat-activated NiTi archwires, it was observed that the ones by TP presented the highest percentage of permanent deformation in the work, statistically superior to the ones presented by all other tested NiTi and CuNiTi archwires. However, it was observed, in a pilot trial, that the mean percentage of permanent deformation was reduced from 72.67 to 28.50%, with the increase of testing temperature from 37 to 40°C. As these archwires were not subjected to activation loadings higher than their respective pseudo-yield stress, which could have invalidated the tests and generated permanent deformations, it was concluded that the transition temperature of the heat-activated NiTi archwires by TP was superior to 37°C. For this reason, such archwires presented deactivation loadings extremely reduced.

Confirming the results of the present work, Parvizi and Rock[20] asserted that the complete recovery of the initial configuration after unloading is not always obtained for superelastic and heat-activated NiTi archwires, being kept between baselines of 89 and 94%.[20] The present work showed that, at 37°C, all tested NiTi and CuNiTi archwires presented some degree of permanent deformation, being significantly expressive only for heat-activated NiTi archwires by TP (Table 2). Among the tested superelastic NiTi and CuNiTi archwires, the complete recovery of the initial configuration was kept between 88 and 96%, while for heat activated NiTi archwires, it was kept between 71 and 82% (Table 2).

The results of the present work were against the findings by Damon,[7] who proved the efficiency of the application of slight loadings during the phase of tooth alignment with insertion of the CuNiTi 35°C wire (Ormco). According to the same author, the word "system" (Damon system) would be used to define the combination of self-ligating brackets and high technology orthodontic archwires, carefully selected so the applied loading is kept within the great levels of force or biozone. He recommended for such purpose, the sequential use of CuNiTi 35°C orthodontic arches of diameter 0.014-in, 0.014 x 0.025-in and 0.018 x 0.025-in, being the reduction of the generated attrition the key to a more efficient and fast orthodontic treatment, with reduction of up to 70% on the number of necessary visits to orthodontists.[7] In the present work, the CuNiTi 35°C archwires were the less recommended for clinical use, among the heat activated, because of the loadings released during

deactivation and of the percentage of deformation of the unloading baselines. It is recommended, however, a new work that evaluates the attrition of such archwires in relation to the other superelastic and heat activated NiTi and CuNiTi archwires.

CONCLUSION

1) Among the tested superelastic NiTi and CuNiTi archwires, the CuNiTi 27°C presented mechanical properties superior to the others, releasing lower deactivation loadings. The superelastic NiTi archwires by Morelli were the less recommended for use, for presenting deactivation loadings statistically superior to the presented by the other tested archwires.

2) Among the tested heat activated NiTi and CuNiTi archwires, the ones by GAC and Unitek presented mechanical properties superior to the others, releasing lower deactivation loadings and presenting superior percentage of deformation on the deactivation baselines. In relation to the CuNiTi 35°C archwires, they did not present mechanical properties, under traction resistance, that justified its clinical choice.

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Mandibular growth and dentoalveolar development in the treatment of Class II, division 1, malocclusion using Balters Bionator according to the skeletal maturation

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Objective: The purpose of the study was to evaluate the influence of the skeletal maturation in the mandibular and dentoalveolar growth and development during the Class II, division 1, malocclusion correction with Balters bionator.

Methods: Three groups of children with Class II, division 1, malocclusion were evaluated. Two of them were treated for one year with the bionator of Balters appliance in different skeletal ages (Group 1: 6 children, 7 to 8 years old and Group 2: 10 children, 9 to 10 years old) and the other one was followed without treatment (Control Group: 7 children, 8 to 9 years old). Lateral 45 degree cephalometric radiographs were used for the evaluation of the mandibular growth and dentoalveolar development. Tantalum metallic implants were used as fixed and stable references for radiograph superimposition and data acquisition. Student's t test was used in the statistical analysis of the displacement of the points in the condyle, ramus, mandibular base and dental points. Analysis of variance one-fixed criteria was used to evaluate group differences (95% of level of significance).

Results: The intragroup evaluation showed that all groups present significant skeletal growth for all points analyzed (1.2 to 3.7 mm), but in an intergroup comparison, the increment of the mandibular growth in the condyle, ramus and mandibular base were not statically different. For the dentoalveolar modifications, the less mature children showed greater labial inclination of the lower incisors (1.86 mm) and the most mature children showed greater first permanent molar extrusion (4.8 mm).

Keywords: Angle Class II malocclusion. Orthopedics. Growth and development.

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INTRODUCTION

The treatment of Class II malocclusion with functional appliances, studied for decades in experimental studies in animals and humans, prove that this therapy is able to rearrange the growth and normal development of the face,[26,28] with skeletal and dentoalveolar effects, important for the correction of malocclusion.[12,21,23] Regarding mandible, studies with different methodologies have proven that functional therapy in patients with Class II malocclusion, can alter condylar growth and promote mandibular bone remodeling.[26,28] However, the condylar growth is up to nowadays, a controversial and poorly defined fact.[22]

The importance of this study of Class II treatment with Balters bionator appliance lies in the use of 45° lateral teleradiographs, to allow an evaluation without overlapping anatomical structures,[16] by referential of metallic implants[24] and the distribution of these patients by bone age, which makes the results more reliable.

There are studies already that used similar methodologies[23] however, the clinician still has difficulty in defining the ideal stage to start intervention, because literature is often contradictory, with authors arguing that in young patients the mandibular length increase may occur with the use of these appliances,[5,24] challenged by authors who claim that this form of treatment does not grow the mandible, because puberty is where the child has more growth earnings.[22]

The objective of this study is to evaluate the influence of bone maturation, in mandibular and dentoalveolar growth and development, natural and induced by treatment of Class II malocclusion, division 1, with Balters bionator.

MATERIAL AND METHODS

This study used radiographs of a sample composed by 23 Caucasian patients being 09 males and 14 females, with bone ages between 7-10 years, Angle's Class II malocclusion, division 1, and mandibular deficiency. Oblique lateral radiographs, 45° (oblique teleradiography), of right and left hemimandibles, and hand and wrist radiographs were taken by the same technician on the same day, using X-ray machine (Funk Orbital X15), Lanex screens and TMG film with the factors: 82 kVp, 80 mA and 0.5 seconds exposure. These radiographs were collected prospectively in two stages with an interval of 1 year and archived in the Post-Graduation Course in Orthodontics, School of Dentistry - UNESP, in the city of Araraquara (SP).

Patients in the study were divided into 3 groups according to bone age obtained by the method of Eklöf and Ringertz using the program Radiocef Studio, Radiocef Studio version, based on measurements of 10 dimensions of the bones of the hand and wrist in radiographs images scanned. Control group (C),

Table 1 - Descriptive statistics of samples per treatment group.

		Values			Mean ± S.D.
		n	Minimum	Maximum	
Control group	Chronological age - start	7	6.9	10.2	8.7 ± 1.05
	Chronological age - end	7	7.9	11.2	9.7 ± 1.07
	Treatment time	7	0.9	1	1 ± 0.06
	Skeletal maturity - start	7	8.5	9.4	9 ± 0.34
	Skeletal maturity - end	7	9.3	10.3	9.8 ± 0.41
Group 1	Chronological age - start	6	7.1	9.8	8.4 ± 1.11
	Chronological age - end	6	7.9	10.7	9.4 ± 1.16
	Treatment time	6	0.8	1.1	1 ± 0.09
	Skeletal maturity - start	6	7	8.5	8 ± 0.54
	Skeletal maturity - end	6	8.6	9.7	9.1 ± 0.36
Group 2	Chronological age - start	10	8.7	11.2	9.8 ± 0.78
	Chronological age - end	10	9.8	12.2	10.8 ± 0.78
	Treatment time	10	1	1.2	1.1 ± 0.07
	Skeletal maturity - start	10	9.3	10.7	10 ± 0.42
	Skeletal maturity - end*	9	9.9	11.5	10.6 ± 0.57

* It was not reported the skeletal maturity of a Group 2 patient.

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with patients without treatment with 8.5 to 9.4 years of bone age and, treated Groups 1 and 2, with patients with initial bone age 7 to 8.5 years and 9.3 to 10.7 years, respectively (Table 1).

The appliance used in patients of treated groups was the bionator described by Balters,[4] with acrylic deep extension of the lower arch seeking greater mucosal support in the lingual region and always made by the same professional.[23]

All patients received three tantalum metal implants, measuring 0.5 mm in diameter and 1.5 mm length, positioned on the mandible cortical surface as the method developed by Björk.[8] The first positioned at the center of the symphysis, between the roots of the incisors and the other two positioned in the posterior region, between the roots of the lower first permanent molars, right and left.

Aiming to evaluate mandibular growth and tooth development, natural and induced by orthopedic treatment with Balters bionator, it was established 16 cephalometric points marked in visualized right and left oblique radiographs of the mandible: Condylar points (co, coa, cop, cla, and clp) points in the ramus region (ramp, rams, rma and rmi) and lower border (gop, go, goa, me, bora, borm and borp) (Table 1).

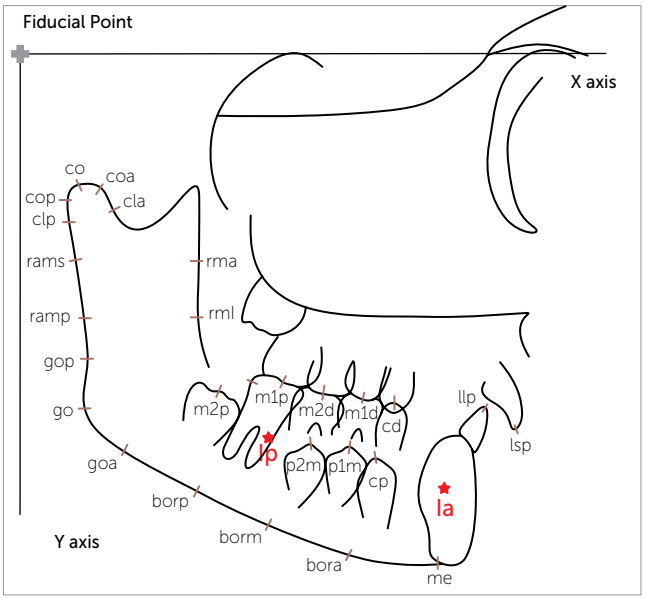

Figure 1 - X axis represented by the horizontal line formed by the orbital plane determined on the initial radiograph (T_1), transferred to the subsequent radiographs through the superposition of metallic implants. Y axis determined by a vertical line passing through the fiducial point located at the posterior end of the orbital plane with points on the mandibular body: Condylar (co, coa, cop, cla, and clp); mandibular ramus points (ramp, rams, rma and rmi); lower border (gop, go, goa, me, bora, borm, and borp); and dental points (isp, iip, cp, m1p, m2p, p1m, p2m, m1d, m2d and cd).

The points marked on the permanent teeth were icp, iip, cp, m1p, m2p, p1m and p2m and on deciduous teeth: cd, m1d and m2d, totaling 10 dental points, and 2 reference points of implant (Fig 1, Table 2).

For analysis of the displacements of cephalometric landmarks it was used a Cartesian coordinate system.

The X axis is represented by the horizontal line formed by the orbital plane determined in the initial radiographic (T_1) and transferred to subsequent radiographs through the superimposition of the images of metallic implants located at the anterior and posterior mandible (Ip and Ia). The Y axis is represented by the vertical line perpendicular to the orbital plane passing through a fiducial point located at the rear end of the orbit plane in a rearmost position to skeletal and dental structures of cephalometric tracing. The anteroposterior position of each cephalometric point was obtained by linear distance from point referred to the Y axis, parallel to the axis X. Similarly, the vertical position of each cephalometric point was obtained by linear distance from the point to the X axis parallel to the Y axis (Fig 1).

The horizontal displacement for each point was calculated as the difference between the linear horizontal distance of the points at two different instants (I_2-I_1) where I_1 represents the beginning of orthopedic treatment (treated group) or beginning of the observation period (control) and I_2, the displacement after 1 year of orthopedic therapy (treated group) or end of the observation period (Control group). The total displacement of each point was obtained using the rule of the right triangle (total displacement equal to the square root of the sum of squared horizontal displacement and vertical displacement squared).

This study was approved on May 4, 2009 by the research ethics committee of the Faculty of Dentistry of Araraquara under protocol 39/06, which is in accordance with resolution 196/96 of the National Health Council/MS.

STATISTICAL ANALYSES

The predetermined points in the radiographs were digitized twice by the same calibrated operator every 15 days, using the IBM compatible personal computer with the program Dentofacial Planner Plus version 2.02, on Numonics Accugrid digitizing tablet. Data were taken to the Excel Program in IBM micro-

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Table 2 - Skeletal and dental cephalometric measurements:

Point	Name	Definition
Condylion	co	Most superior point of the mandibular condyle
Anterior condylion	coa	Most anterior point of the mandibular condyle
Posterior condylion	cop	Most posterior point of the mandibular condyle
Anterior condylar neck	cla	Most anterior point of the mandibular condyle neck
Posterior condylar neck	clp	Most posterior point of the condylar neck
Posterior superior ramus	rams	Most posterior and superior point of the ramus of the mandible
Posterior median ramus	ramp	Most posterior and median point of the ramus of the mandible
Anterior superior ramus	rma	Located at the anterior and superior surface of the ramus of the mandible
Anterior median ramus	rmi	Located at the anterior and median surface of the ramus of the mandible
Superior gonion	gop	Most upper (superior) and posterior point of the gonial angle
Gonion	go	Most lower (inferior) and posterior point of the gonial angle
Antegonial notch	goa	Located at the antegonial notch region
Menton	me	Located at the base of the mandible. In the intersection with mandibular symphysis
The landmarks of the posterior, median and anterior base of the mandible	borp, borm and bora	Landmarks determined, respectively, from goa, by dividing the segment goa me in three equidistant points
Posterior implant	Ip	Mandibular landmark which the implant is Located at the posterior surface of the mandibular body
Anterior implant	Ia	Mandibular landmark which the implant is Located at the anterior of the mandibular body
Upper permanent incisor	isp	Located at the incisal edge of the upper incisor
Lower permanent incisor	iip	Located at the incisal edge of the lower incisor
Lower permanent canine	cp	Located at the incisal edge of the lower canine
Lower deciduous canine	cd	Located at the incisal edge of the lower deciduous canine
Mandibular first premolar	p1m	Located at the incisal edge of the mandibular first premolar
Mandibular second premolar	p2m	Located at the incisal edge of the mandibular second premolar
Deciduous mandibular first molar	m1d	Located at the incisal edge of the deciduous mandibular first molar
Deciduous mandibular second molar	m2d	Located at the incisal edge of the deciduous mandibular second molar
Permanent mandibular first molar	m1p	Located at the middle portion of the occlusal surface of the permanent mandibular first molar
Permanent mandibular second molar	m2p	Located at the middle portion of the occlusal surface of the permanent mandibular second molar

computer and statistically analyzed using SPSS. This procedure was performed to evaluate the error of the method in the scanning process. It was applied Intraclass Correlation Coefficient (ICC) which showed variations from 0.893 to 0.996, with the smallest corresponding to the point m1d(v) and the highest to points oj, cop(v) coa(v) and rmd, demonstrating that the error method was not significant.

For comparison between groups, the data were annualized in order to balance the small difference in time for observation or treatment from 0.8 to 1.2 years (Table 1).

From each patient, at each study point, it was obtained two oblique teleradiographs one on the right side and another on the left side. The study of correlation of the displacements of the predetermined points on both sides employing the Pearson correlation coefficient showed that for 77 % of them the correlation is zero or very weak and 16 % of the correlation is moderate showing that a promoted correction by the device or natural growth is not necessarily symmetric. Based on these results it was chosen to work with the measurements of both sides as independent measures.

For statistical analysis of the displacement of each point, it was employed Student's t test for the mean of a population. To assess whether the means of each measure in the three groups were equal, it was used analysis of variance with a criterion of classification (ANOVA) when the homogeneity test of variances was not significant, otherwise the statistical analysis was performed by the Brown-Forsythe test. It was conducted tests of multiple comparison of means for variables that showed statistically significant results in testing the hypothesis of equality of means. The significance level for all statistical tests was 95 % ($p < 0.05$).

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Table 3 - Mean and standard deviation of mandibular growth, tooth eruption (total, horizontal and vertical) and significance of the Student's t test of the hypothesis that the mean is equal to zero - Control Group.

	Point	n	Total	Horizontal	Vertical
			Mean ± SD	Mean ± SD	Mean ± SD
Mandibular growth	me	14	1.20** ± 0.97	-0.35^{ns} ± 1.12	0.74** ± 0.72
	bora	14	1.37** ± 1.12	-0.69^{ns} ± 1.52	0.20^{ns} ± 0.63
	borm	14	1.73** ± 1.42	-0.55^{ns} ± 1.97	0.11^{ns} ± 1.01
	borp	14	2.14** ± 1.40	-0.87^{ns} ± 2.13	0.02^{ns} ± 1.24
	goa	14	2.07** ± 1.01	-0.71^{ns} ± 1.79	-0.20^{ns} ± 1.37
	go	14	1.90** ± 1.29	-1.03** ± 1.00	-0.86^{ns} ± 1.61
	gop	14	2.07** ± 1.25	-0.89** ± 0.80	-1.21* ± 1.77
	ramp	14	2.28** ± 1.11	-0.69* ± 0.90	-1.40* ± 1.84
	rams	14	2.10** ± 0.95	-0.78** ± 0.85	-1.42** ± 1.44
	clp	14	2.27** ± 1.41	-0.52* ± 0.83	-1.76** ± 1.79
	cop	14	2.18** ± 1.57	-0.68* ± 0.97	-1.51* ± 1.92
	co	14	2.29** ± 1.65	-0.69* ± 0.93	-1.68** ± 1.99
	coa	14	2.35** ± 1.71	-0.40^{ns} ± 1.02	-1.83** ± 2.01
	cla	14	2.40** ± 1.52	-0.45* ± 0.76	-2.02** ± 1.82
	rma	14	1.83** ± 1.10	-0.55* ± 0.82	-1.11* ± 1.58
	rmi	14	2.94** ± 2.23	-0.30^{ns} ± 3.20	-0.80^{ns} ± 1.82
Tooth movement	m2p	14	2.18** ± 1.18	1.48** ± 1.31	-1.16** ± 1.00
	m1p	14	2.19** ± 1.14	0.49^{ns} ± 1.07	-1.85** ± 1.16
	m2d	12	1.54** ± 0.58	0.48^{ns} ± 1.03	-0.59^{ns} ± 1.11
	p2m	14	2.79** ± 2.01	1.31** ± 1.24	-2.36** ± 1.75
	m1d	9	1.13** ± 0.88	0.08^{ns} ± 1.23	-0.46^{ns} ± 0.68
	p1m	14	2.67** ± 2.15	1.38* ± 2.28	-1.84** ± 1.16
	cp	13	4.96** ± 2.12	1.00* ± 1.36	-4.72** ± 2.01
	iip	14	1.52** ± 0.80	0.72** ± 0.84	0.58^{ns} ± 1.22

* - the hypothesis that the mean is zero is rejected at a significance level of 0.05.
** - the hypothesis that the mean is zero is rejected at a significance level of 0.01.
ns - the hypothesis that the mean is zero is not rejected.

Table 4 - Mean and standard deviation of mandibular growth, tooth eruption (total, horizontal and vertical) and significance of the Student's t test of the hypothesis that the mean is equal to zero – Group 1.

	Point	n	Total	Horizontal	Vertical
			Mean ± SD	Mean ± SD	Mean ± SD
Mandibular growth	me	11	1.71** ± 0.73	0.58^{sn} ± 1.31	0.69^{sn} ± 1.07
	bora	11	1.39** ± 1.03	0.55^{sn} ± 1.53	0.39^{sn} ± 0.60
	borm	11	1.64** ± 1.79	0.36^{sn} ± 2.06	0.19^{sn} ± 1.32
	borp	11	1.67** ± 1.33	-0.55^{sn} ± 1.65	-0.48^{sn} ± 1.24
	goa	11	3.30** ± 2.68	-1.69^{sn} ± 3.35	-0.78^{sn} ± 2.03
	go	11	2.31** ± 1.45	-1.30** ± 0.74	-1.32** ± 1.92
	gop	11	2.63** ± 1.40	-1.31** ± 0.66	-1.79** ± 1.93
	ramp	11	2.65** ± 1.86	-0.95** ± 1.03	-2.01** ± 2.16
	rams	11	2.93** ± 1.77	-0.88** ± 1.07	-2.27** ± 2.22
	clp	11	2.64** ± 2.09	-0.73** ± 0.81	-2.22** ± 2.32
	cop	11	2.76** ± 1.67	-0.56^{sn} ± 1.01	-2.39** ± 1.88
	co	11	2.75** ± 1.90	-0.58^{sn} ± 1.13	-2.27** ± 2.16
	coa	11	2.94** ± 1.86	-0.45^{sn} ± 1.18	-2.60** ± 1.98
	cla	11	2.65** ± 2.11	-0.27^{sn} ± 0.60	-2.34** ± 2.39
	rma	11	2.25** ± 1.60	-0.38^{sn} ± 1.48	-1.49** ± 1.84
	rmi	11	2.32** ± 1.26	-0.75^{sn} ± 1.37	-1.59** ± 1.50
Tooth movement	m2p	11	2.55** ± 1.34	2.14** ± 1.32	-0.92** ± 1.12
	m1p	11	3.11** ± 1.93	0.84** ± 0.74	-2.66** ± 2.28
	m2d	8	1.30** ± 0.74	0.61** ± 0.67	-0.56^{ns} ± 1.13
	p2m	11	2.73** ± 1.92	1.45** ± 1.23	-1.95** ± 1.97
	m1d	7	1.57** ± 1.11	0.79^{sn} ± 1.56	-0.45^{ns} ± 0.83
	p1m	11	3.21** ± 2.22	1.23** ± 1.25	-2.66** ± 2.28
	cp	11	4.14** ± 2.00	0.21^{sn} ± 1.19	-3.90** ± 2.15
	iip	11	2.70** ± 1.31	1.86** ± 1.09	1.71** ± 1.26

* - the hypothesis that the mean is zero is rejected at a significance level of 0.05.
** - the hypothesis that the mean is zero is rejected at a significance level of 0.01.
ns - the hypothesis that the mean is zero is not rejected.

RESULTS

According to the analyzed sample and the measurements it is possible to say that, accompanied by one year without treatment, natural growth occurred promoting back horizontal changes at goa and go points and back and down at points gop, ramp, rams, clp, cop, co, coa, cla and rma and, only down at point me, with statistical significance (Table 3).

The results of the displacement of dental points of this Control group were significant for the overall tooth displacement. Horizontally it occurred labial migration of incisors, the m2p points, p2m, p1m and cp points moved to mesial and occlusal and m1p shifted toward occlusal significantly. The remaining evaluated teeth showed no significant changes in this group.

The data from Group 1 (Table 4), of patients with lower bone age or less mature, showed significant total displacement of all studied points, both for measures of skeletal origin as tooth measures.

The total tooth movements were all significant, with mesial movement of all teeth, except the first deciduous molars and canines, and significant extrusion of permanent teeth (m1p, m2p, p1m, p2m, cp).

Significant changes occurred in both horizontal and vertical at goa, go, gop, ramp, rams, clp, cop, co, coa, cla, rmi points, only horizontally at borp point, and vertically at me and rma points.

The dental changes in both horizontal and vertical occurred with significant mesial movement and extrusion of points m2p, p2m, and cp, only extrusion at m1p, p1m points.

Table 5 - Means and standard deviation of the mandibular growth and total dental eruption, horizontal and vertical, and t test significance of the hypothesis that the mean is equal to zero – Group 3.

	Point	n	Total	Horizontal	Vertical
			Mean ± SD	Mean ± SD	Mean ± SD
Mandibular growth	me	20	1.45** ± 0.75	-0.17^{ns} ± 1.19	0.50* ± 1.04
	bora	20	1.95** ± 1.16	-0.73^{ns} ± 1.95	0.29^{ns} ± 0.94
	borm	20	1.77** ± 1.47	-0.89^{ns} ± 1.93	0.01^{ns} ± 0.94
	borp	20	2.18** ± 2.07	-1.31* ± 2.35	-0.48^{ns} ± 1.30
	goa	20	2.68** ± 1.87	-1.61** ± 2.23	-1.13** ± 1.41
	go	20	2.42** ± 1.48	-1.26** ± 1.68	-1.27** ± 1.47
	gop	20	2.58** ± 1.69	-1.24** ± 1.52	-1.48** ± 1.91
	ramp	20	2.77** ± 1.64	-0.94** ± 1.18	-1.53* ± 2.45
	rams	20	3.05** ± 2.26	-0.83** ± 1.07	-2.22** ± 2.80
	clp	20	3.62** ± 3.12	-1.11** ± 1.51	-2.75** ± 3.47
	cop	20	3.53** ± 3.09	-1.04* ± 1.70	-2.70** ± 3.31
	co	20	3.57** ± 3.13	-1.23** ± 1.89	-2.68** ± 3.24
	coa	20	3.70** ± 3.27	-1.28** ± 1.70	-2.77** ± 3.52
	cla	20	3.54** ± 3.02	-1.08** ± 1.54	-2.62** ± 3.39
	rma	20	3.01** ± 1.79	-0.74^{ns} ± 1.61	-1.67** ± 2.58
	rmi	20	3.05** ± 1.64	-1.01* ± 2.15	-1.55** ± 2.07
Tooth movement	m2p	20	3.14** ± 1.17	1.72** ± 0.95	-2.37** ± 1.35
	m1p	20	4.83** ± 2.52	0.40^{ns} ± 0.94	-4.64** ± 2.68
	m2d	18	1.33** ± 0.73	0.14^{ns} ± 1.18	-0.37^{ns} ± 0.93
	p2m	20	2.21** ± 1.81	0.94** ± 1.42	-1.50** ± 1.76
	m1d	5	1.21* ± 0.87	0.95^{ns} ± 1.10	-0.15^{ns} ± 0.48
	p1m	20	5.35** ± 2.40	0.68^{ns} ± 2.34	-4.64** ± 2.68
	cp	19	4.29** ± 2.22	1.08** ± 1.09	-3.97** ± 2.31
	iip	20	1.90** ± 1.12	0.40^{ns} ± 1.55	0.59^{ns} ± 1.46

* - the hypothesis that the mean is zero is rejected at a significance level of 0.05.

** - the hypothesis that the mean is zero is rejected at a significance level of 0.01.

ns - the hypothesis that the mean is zero is not rejected.

To evaluate whether the average of each measure in the three groups were equal it was used analysis of variance with one classification criterion (ANOVA) when the test for homogeneity of variance was not significant, otherwise the comparison of means was performed by Brown-Forsythe test. The results are shown in Tables 6 and 7, and in Table 8 the results of the multiple comparisons of means of variables that showed statistically significant results in test for difference of means.

The data in Table 6 show that, except for the measure iip, there are no statistical differences between the means of the horizontal measures of mandibular growth and tooth migration. The results of the multiple comparisons of means (Table 8) show that the iip mean from Group 1 differs from means of Control group and Group 2. For measures of vertical growth, the results indicate that there is significant difference between the group's means only for some measures of tooth movement, m2p, m1p and p1m. Regarding to p1m it was also observed no significant difference between the variances of the three groups. The results of multiple comparisons of means show that, for the three measures cited above, the vertical growth in Group 2 was higher and significantly different from the other two groups.

DISCUSSION

This work was carried out at 45° oblique teleradiographs of patients who had metal implants inserted in the mandible, used as stable references, what allowed a more reliable evaluation of the results. This feature eliminates variables like the magnification of radiographic images[3] and incorrect positioning of the patients head in cephalostat. The images of implants as suggested by Bjork[8] were marked on the initial teleradiograph and transferred to the subsequent, providing an assessment of the real displacement of the points in evaluated time (for all groups), which otherwise would not be possible.[23]

Identifying whether the orthopedic device only changes the direction of condylar growth or the rate and amount of this growth has been the purpose of many authors. Bjork and Skieller[9] cite the importance, in longitudinal studies, the condylar growth in mandible length increase, being the growth direction of the condyle extremely variable and difficult to predict. The real role of the condyle in the mandibular growth is controversial in craniofacial growth studies. The cartilage of the condyle has a capacity of compensatory growth, generating enough growth to allow adaptation of the mandible to the skull base by articular fossa (mandibular fossa) and to maxillary complex.

In the Control group of our study, the growth of the condyle was significant in all its references, anterior and posterior condylar neck (cla and clp), posterior and superior portion (cop and co), up and back. The anterior condylar region (coa) was an exception and showed no backward growth.

With the use of the appliance in younger children (Group 1) the condyle showed no significant

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Table 6 - Results of tests for homogeneity of variance (Levene's test) and to test the hypothesis that the mean of the 3 groups are equal (ANOVA or Brown Forsythe test) - points with vertical and horizontal movements.

Point	Horizontal movement						Vertical movement					
	Levene's test			ANOVA			Levene's test			ANOVA		
	F	gl1 / gl2	Sig.	F	gl1 / gl2	Sig.	F	gl1 / gl2	Sig.	F	gl1 / gl2	Sig.
me	0.24	2 /42	0.789	2.04	2 /42	0.142	0.47	2 /42	0.629	0.30	2 / 42	0.742
bora	1.29	2 /42	0.287	2.22	2 /42	0.121	1.10	2 /42	0.341	0.19	2 / 42	0.824
borm	0.02	2 /42	0.981	1.43	2 /42	0.252	0.02	2 /42	0.981	0.11	2 / 42	0.899
borp	0.73	2 /42	0.488	0.48	2 /42	0.619	0.10	2 /42	0.902	0.76	2 / 42	0.476
goa	1.90	2 /42	0.162	0.71	2 /42	0.496	0.62	2 /42	0.543	1.45	2 / 42	0.246
go	2.02	2 /42	0.146	0.17	2 /42	0.845	0.22	2 /42	0.807	0.33	2 / 42	0.719
gop	2.55	2 /42	0.090	0.51	2 /42	0.607	0.01	2 /42	0.989	0.29	2 / 42	0.746
ramp	0.40	2 /42	0.674	0.27	2 /42	0.765	0.75	2 /42	0.481	0.25	2 / 42	0.778
rams	0.03	2 /42	0.970	0.03	2 /42	0.971	1.77	2 /42	0.183	0.60	2 / 42	0.555
clp	1.72	2 /42	0.192	1.06	2 /42	0.357	3.02	2 /42	0.060	0.52	2 / 42	0.596
cop	1.55	2 /42	0.225	0.53	2 /42	0.592	2.22	2 /42	0.121	0.85	2 / 42	0.436
co	2.27	2 /42	0.116	0.91	2 /42	0.410	1.48	2 /42	0.239	0.58	2 / 42	0.566
coa	1.05	2 /42	0.359	2.09	2 /42	0.137	2.03	2 /42	0.144	0.50	2 / 42	0.612
cla	2.98	2 /42	0.062	2.20	2 /42	0.123	2.17	2 /42	0.127	0.20	2 / 42	0.823
rma	2.75	2 /42	0.076	0.25	2 /42	0.782	2.53	2 /42	0.091	0.28	2 / 42	0.754
rmi	1.15	2 /42	0.325	0.36	2 /42	0.700	0.93	2 /42	0.402	0.81	2 / 42	0.453
m2p	1.18	2 /42	0.317	1.01	2 /42	0.375	0.61	2 /42	0.550	6.82	2 / 42	**0.003**
m1p	1.08	2 /42	0.350	0.81	2 /42	0.452	5.63	2 /42	**0.007**	7.87[1]	2 / 32	**0.002**
m2d	0.61	2 /35	0.550	0.69	2 /35	0.508	0.58	2 /35	0.563	0.20	2 / 35	0.822
p2m	0.22	2 /42	0.803	0.60	2 /42	0.551	0.01	2 /42	0.988	0.96	2 / 42	0.392
m1d	1.45	2 /18	0.261	0.91	2 /18	0.421	0.46	2 /18	0.639	0.37	2 / 18	0.699
p1m	0.24	2 /42	0.787	0.52	2 /42	0.598	5.57	2 /42	**0.007**	7.93[1]	2 / 32	**0.002**
cp	0.06	2 /40	0.938	2.00	2 /40	0.149	0.48	2 /40	0.620	0.58	2 / 40	0.563
iip	1.50	2 /40	0.235	4.19	2 /40	**0.022**	0.20	2 /40	0.819	2.47	2 / 40	0.097

[1] The analysis of variance (ANOVA) was replaced by Brown and Forsythe statistical due to the heterogeneity of variances.

back growth and vertical growth similar to the Control group. In Group 2, with mature children, the condyle showed significant backwards and upwards growth, showing a modification of condylar growth more to posterior and superior as found by Araújo.[3] This pattern of condylar growth did not differ from that presented by the children in the Control group, but there was greater vertical growth in both treated groups (1 and 2) and horizontal in Group 2 being discordant from results of Bjork[8] who suggests that backward growth from treatment might have been statistically significant compared to the Control group and Huttgren et al,[15] who reported that activators caused a redirection of the condyle in posterior position. These results are consistent with Monini,[25] who found stability in the direction of condylar growth.

Our study showed that there were significant individual changes, but the comparison between groups, changes in relation to the condyle were not significant, allowing us to reaffirm the hypothesis of several authors[3,20] who accepted the redirection of mandibular growth, however, nothing beyond the natural growth potential.

Regarding the mandibular ramus, it was found in the Control group a slip of the ramus to posterior represented by resorption of the anterior ramus (backward and upward) and apposition on the backward posterior. These data were observed both in the upper (rams and rma) and middle ramus (ramp and rmi).

The treated Groups 1 and 2 exhibited a displacement onto the upper anterior ramus and upward and backward in the lower ramus, similar to the Control group. These results are consistent with the process of ramus displacement relative to the mandibular body which occurs naturally during facial skeleton growth and development described by Gu and McNamara.[14]

Table 7 - Results of tests for homogeneity of variance (Levene's test) and to test the hypothesis that the mean of the 3 groups are equal (ANOVA or Brown Forsythe test) – landmarks with total movements.

Point	Total movement					
	Levene's test			ANOVA		
	F	gl1 / gl2	Sig.	F	gl1 / gl2	Sig.
me	0.05	2 /42	0.951	1.21	2 /42	0.309
bora	0.01	2 /42	0.991	1.45	2 /42	0.247
borm	0.08	2 /42	0.921	0.02	2 /42	0.977
borp	1.22	2 /42	0.307	0.34	2 /42	0.714
goa	2.18	2 /42	0.126	1.29	2 /42	0.286
go	0.20	2 /42	0.823	0.59	2 /42	0.562
gop	0.66	2 /42	0.524	0.59	2 /42	0.558
ramp	0.54	2 /42	0.586	0.42	2 /42	0.660
rams	1.83	2 /42	0.173	1.21	2 /42	0.307
clp	3.72	2 /42	**0.033**	1.64(1)	2 /36.6	0.207
cop	3.69	2 /42	**0.033**	1.68(1)	2 /38.7	0.199
co	3.06	2 /42	0.058	1.16	2 /42	0.323
coa	2.49	2 /42	0.095	1.16	2 /42	0.323
cla	1.55	2 /42	0.224	1.04	2 /42	0.364
rma	1.83	2 /42	0.173	2.51	2 /42	0.094
rmi	0.41	2 /42	0.663	0.64	2 /42	0.532
m2p	0.24	2 /42	0.789	2.66	2 /42	0.082
m1p	4.88	2 /42	**0.012**	8.44(1)	2 /34.7	**0.001**
m2d	0.09	2 /35	0.915	0.41	2 /35	0.669
p2m	0.23	2 /42	0.794	0.47	2 /42	0.627
m1d	0.50	2 /18	0.614	0.43	2 /18	0.655
p1m	0.45	2 /42	0.639	6.52	2 /42	**0.003**
cp	0.30	2 /40	0.745	0.54	2 /40	0.588
iip	1.02	2 /40	0.370	3.35	2 /40	**0.045**

(1) The analysis of variance (ANOVA) was replaced by Brown and Forsythe statistical due to the heterogeneity of variances.

Table 8 - Means and standard deviations of tooth eruption and results of multiple comparison tests of mean measures that showed a significant result in the ANOVA.

Point	Control Group	Group 1	Group 2
	Mean ± SD	Mean ± SD	Mean ± SD
Total displacement			
m1p	2.19^{a} ± 1.14	3.11^{a} ± 1.93	4.83^{b} ± 2.52
p1m	2.67^{a} ± 2.15	3.21^{a} ± 2.22	5.35^{b} ± 2.40
iip	1.52^{a} ± 0.80	2.70^{b} ± 1.31	1.90^{ab} ± 1.12
Horizontal displacement			
iip	0.72^{a} ± 0.84	1.86^{b} ± 1.09	0.40^{a} ± 1.55
Vertical displacement			
m2p	-1.16^{a} ± 1.00	-0.92^{a} ± 1.12	-2.37^{b} ± 1.35
m1p	-1.85^{a} ± 1.16	-2.66^{a} ± 2.28	-4.64^{b} ± 2.68
p1m	-1.84^{a} ± 1.16	-2.66^{a} ± 2.28	-4.64^{b} ± 2.68

Note: Different letters correspond to statistically different averages by Student–Newman–Keuls (SNK) test

The comparative results between the 3 groups analyzed show that the mandibular body showed growth in the vertical direction, without statistical significance, suggesting that Balters bionator did not influenced this growth. These results corroborate with Kessner and Faltin[18] because there is a joint remodeling that promotes mandibular adaptation more to anterior without changing mandibular length significantly. Schulhof and Engel,[29] disagree with these findings and emphasize that treatment with the bionator appliance promotes an increase in ascending ramus and mandibular body in relation to normal growth.

In the present study there was no significant increase in mandibular ramus because the condyle grew up to 1.68 mm (c), 2.27 mm (g1) and 2.68 mm (g2) and gonion grew in the same direction, from 0.86 mm (c), 1.32 mm (g1) and 1.27 mm (g2), resulting in a small increase in the co-go distance, respectively of 0.82 mm for the Control group, 0.95 mm for Group 1 and 1.41 mm for Group 2. The results found by Reis et al,[27] were similar to ours, where Balters bionator stimulated the growth of the mandibular body and ramus similarly in both age groups without modifying the tendency of individual growth. Moreover, Malta et al[19] showed that the difference in amount of mandibular growth occurs and is significant (3.3 mm) when comparing cases of Class II patients treated with Balters bionator appliance and untreated, demonstrating that this appliance is efficient.

The data show that the gonion region exhibited significant changes in all studied groups. The points goa, go and gop showed significant upward and backward displacement except for goa in Group 1. The displacement of these points in Group 2 was higher than in other groups, but without statistical significance. These results point to a pattern of remodeling gonion region, especially in mature children, compatible with the natural growth demonstrated by several authors,[8,9,10,14] who observed resorption in the mandible posterior border. So, part of the vertical growth seen in the condylar region is partially offset by reabsorption which occurs in the gonion region, resulting in small changes in mandibular ramus height. Bigliazzi, Kessner and Faltin Jr.,[7] found that in Class II, division 1, patients with mandibular retrognathia, the gonion angle remained unchanged during the treatment period with bionator.

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Clinical observations have shown that the use of orthopedic devices can alter the growth of the mandible, however the exact nature of this change remains a topic of great controversy.[13] Our results showed that in the Control group there was a significantly downward movement of menton and that the mandibular border exhibited backward movement without statistical significance. These data are consistent with other studies,[14,30] which found bone apposition in the anterior portion of the mandibular border.

In Group 1 occurred forward and downward displacement of the mentum and anterior border, while the posterior border had a backward and upward movement, all insignificant. In Group 2, the mentum presented downward movement and the posterior border a significant backward movement and nothing significant of the anterior and middle border. These data indicate a relative stability of the mandibular lower border, mainly in young children.

The results observed for mature children were similar to the Control group, results that are in accordance with other studies.[20,21] On the other hand, Almeida,[1] who treated children aged 10.8 months observed an increase in mandibular protrusion and the effective length of the mandibular body, which according to Almeida-Pedrin,[2] promoted a significant improvement in the maxillomandibular relationship compared to the Control group, which agrees with the study of Basciftci et al,[5] in the same year, that the greatest amount of growth occurs during adolescence.

Opheij et al[26] did not find statistical significant skeletal changes in Class II malocclusion patients with mandibular retrognathia, treated with bionator, noticing the most significant effects on the dentoalveolar structures. For Janson[17] children treated in the pre-pubertal period exhibited dentoalveolar changes, notably a protrusion of the lower incisors and correction of molar relationship in distal-occlusion. It was observed[17] an overjet reduction of approximately 2 mm, similar to what was observed in our study (significant overjet decrease in 1.86 mm in Group 1, compared with 0.72 mm in the Control group and 0.4 mm in Group 2). For Bastos and Mucha,[6] one of the bionator indications is when there is a possibility of backward projection of the lower incisors. For Martins[21] skeletal changes promoted by bionator occur in 32 % through increased lower facial height and 68 % dentoalveolar movement, higher of lower molars and upper incisors.

In the vertical direction occurred greater amount of eruption of posterior teeth, significant for Group 2 that showed nearly twice eruption of molars (2.37 mm of the first molars, 4.64 mm of second molars and 2.66 mm of the first premolars) when compared to the Control group and Group 1. These facts demonstrate that the bionator appliance with occlusal support allows the active eruption of permanent molars. With respect to premolars, these erupt in more mature individuals (Group 2), mainly due to more advanced stage of root formation that they are. For the authors[1,11] there was a significant increase in posterior facial height especially in the treated group with bionator by extrusion of posterior teeth, confirmed by our study when considering the results of the more mature group (Group 2) and the youngest (Group 1), which demonstrated the predominance of dentoalveolar adaptation in the horizontal direction.

CONCLUSION

Due to the methodology adopted in this study and the results, based on statistical analysis, we conclude that:

1 – When it was evaluated the skeletal and dental changes in groups individually, there was growth at all points analyzed.

2 – When the groups were compared with each other, skeletal mandibular changes were similar indicating that the mandibular growth pattern has not changed significantly with the established treatment and.

3 – When it was evaluated dental changes after using bionator, a greater extrusion of the first permanent molars and premolars in more mature group (Group 2) and the labial inclination of the lower incisors was higher in younger patients (Group 1).

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Evaluation of the reliability of measurements in cephalograms generated from cone beam computed tomography

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Objective: The purpose was to compare angular and linear measurements generated in digital cephalometric radiographs and cephalograms synthesized from three-dimensional images.

Methods: Twenty-six individuals (12 men and 14 women) with mean age of 26.3 years were selected. Digital cephalometric radiographs and CBCTs were taken on the same day. The images were imported and analyzed on Dolphin Imaging V.10.5 software, which synthesized cephalograms in perspective projection and magnification of 9.7%. A single observer marked the points and repeated the procedure with an interval of time of ten days to evaluate intraexaminer error. In the statistical analysis paired Student's t test was used to establish the correlation between the measurements.

Results: The angular measurements GoGn.SN and IMPA, which involved the Gonial point (Go) and the linear measurements that involved the lips presented significant difference ($p < 0.05$). The other measurements presented good correlation.

Conclusion: The measurements in the synthesized cephalograms proved to be reliable.

Keywords: Cone beam computed tomography. Digital dental radiography. Interventional radiography.

» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

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INTRODUCTION

The cephalometric radiograph is an essential tool for orthodontic practice and research, providing valuable information to elaborate the diagnosis and treatment plan for growth prediction, evaluation of results and post-treatment stability and surgical evaluation.[1-4] For over fifty years, the cephalograms have been used to analyze the dental and skeletal relations in orthodontics.[5] However, the radiographs represent three-dimensional structures through two-dimensional images and for this reason, present inherent characteristics such as superposition, distortion and magnification of structures of the craniofacial complex, limiting the diagnostic value.[1,6]

Attempting to overcome such limits, the use of medical computed tomography (CT) was introduced in some dental specialties.[6,7] However, high cost, high exposition to radiation and presence of artefacts produced by metallic brackets, damaging the quality of the obtained image, compromised the use for orthodontic purposes.[1,8,9]

A new generation of tomographs was developed specifically to obtain images of head and neck, the cone beam computed tomography(CBCT). Since the introduction of the first equipment, the use of CBCT has increased significantly, specifically in orthodontics.[10,11,12]

The CBCT has been described as the 3D method of choice for obtaining craniofacial images, because of the following characteristics: Dose of radiation around 10 times lower than the medical tomographs, similarity to radiographic exams as panoramic radiograph and full periapical,[13] reduced cost, high spatial resolution for facial bones and teeth, and possibility of obtaining all traditional orthodontic images in a single exposition.[9,14]

However, despite all advantages offered by the CBCT, we must be careful in relation to this new technique in this period of transition, since many points still need to be clarified in relation to the acuity of the measures obtained through radiographs from CBCT.

Thus, it was the objective of this work to determine if the cephalograms generated from radiographs simulated through CBCT reproduce with the same accuracy the measures from the conventional cephalogram.

MATERIAL AND METHODS

The sample had 26 individuals, 12 men and 14 women, with mean age of 26.3 years, from the records of the dental database in Maceió/AL, Brazil. A cephalometric radiograph and a cone beam computed tomograph, obtained on the same day by the same operator should be available in the file. Individuals presenting full permanent dentition, and that signed the Free and Clarified Consent Term allowing the use of the images, were included in this research. The present study was approved by the Board of Ethics of the Federal University of Rio de Janeiro, with number 90/2008. Patients that presented absence of teeth and/or presence of osseointegrated implants or fixed orthodontic retainers were not included.

The x-ray device that was used to obtain the radiographs was the Cranex D (Soredex, Tuusula, Finland) with a digital system that uses CCD sensor (charge-coupled device) as image captivator, eliminating the necessity of radiographic films and/or scanning. The images were generated with resolution of 300 dpi and automatically sent to the work station. The regulation of the Kv was done automatically by the device according to the size of the patient's head, positioned with Frankfurt's horizontal plane parallel to the ground.

All digital radiographs included the image of a millimetric ruler on the right upper quadrant, present on the x-ray device, necessary to perform the adjustment of the image's size.

The CBCTs were obtained through the NewTom 3G tomograph (AFP Imaging, Elmsford, New York, USA). The individuals were positioned in the tomograph lying with their head in natural position, so that the Frankfurt's horizontal plane was perpendicular to the ground.

A 12-in field of view was used, necessary to visualize all structures that compose the cephalometric tracing. The images were exported by the tomograph in DICOM format (Digital Imaging and Communication in Medicine) and the thickness of the slices was of 0.3 mm generating voxels with 0.3 x 0.3 x 0.3 mm of resolution.

All images were imported by the software Dolphin Imaging Version 10.5.02.65 Premium (Dolphin Imaging & Management Solutions) for analysis.

The digital cephalometric images were positioned with Frankfurt's horizontal plane parallel to the lower border of the monitor, for posterior analysis.

The first step to simulate the cephalometric image from the tomogram, was to standardize the orientation of the three-dimensional models. Using the coronal view, the midsagittal plane was vertically oriented passing through nasion and through the anterior nasal spine; the right sagittal view was used as reference to determine the Frankfurt plane, horizontally oriented; the right and left

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sagittal visualizations were used to make the coronal plane touch the anterior walls of the right and left poria (Fig 1).[9]

After the standardization for the volume positioning was performed, adjusting the image segmentation was done for better contrast between structures of the soft tissue and the skull.

Using the 3D module of the Dolphin software, the perspective radiographs were generated using a 9.7% magnification at the sagittal plane, following orientations from the software, and the right and left sides of the image were present, so that the comparison with the digital radiograph could be established.

The center of the X-ray projection on perspective radiographs was determined on the porion of each three-dimensional image, so that it was the closest to the incidence of rays on the conventional or digital device, which pass at the ear rods.

When generating the simulated cephalometric images, a 100 mm ruler was virtually added to the right side of all images, so that during the cephalometric tracing, the images could be resized.

The 2D image analyses were performed using the module Ceph Tracing of the Dolphin Software. In this research 13 common cephalometric measures were compared, 9 being angular and 4 linear (Table 1), based on 14 cephalometric references: Lateral and on the midsagittal plane.

The projection magnification could be corrected by the computer at the beginning of the tracing, marking two points on the ruler present in the 2D image, so that the program could adequate it to its real size.

The craniofacial structures were automatically drawn by the program as the cephalometric points were being marked. After all markings, the cephalogram and the results from the measurements were automatically provided.

The porion point was considered the most superior point of the external auditory canal, since on the tomographic image there is no similar reference to the mechanical porion, present on the digital radiograph.

On a second step, 10 days after making the cephalograms, 6 exams were randomly selected and analyzed again, to perform the reliability study.

During the marking of points, image tools were used for better visualization of the structures, allowing alterations on the level of contrast, saturation and brightness. On the digital image, the possibility of inversion of colors allowed better visualization of bone structures (Fig 2).

On the simulated radiograph, there was the possibility of navigation among several filters pre-defined by the software. Each filter texture facilitates the visualization of bone structures, soft profile or teeth (Fig 3).

RESULTS

The descriptive statistical analysis including mean, median and standard deviation, was calculated for each cephalometric measure of the digital and simulated radiographs (Table 2).

Table 1 - Measurements used in this study.

Angular	Linear
SNA	Upper Lip – Line E
SNB	Lower Lip – Line E
ANB	1-NA
FMA	1-NB
Ocl.SN	
GoGn.SN	
IMPA	
1.SN	
Y axis	

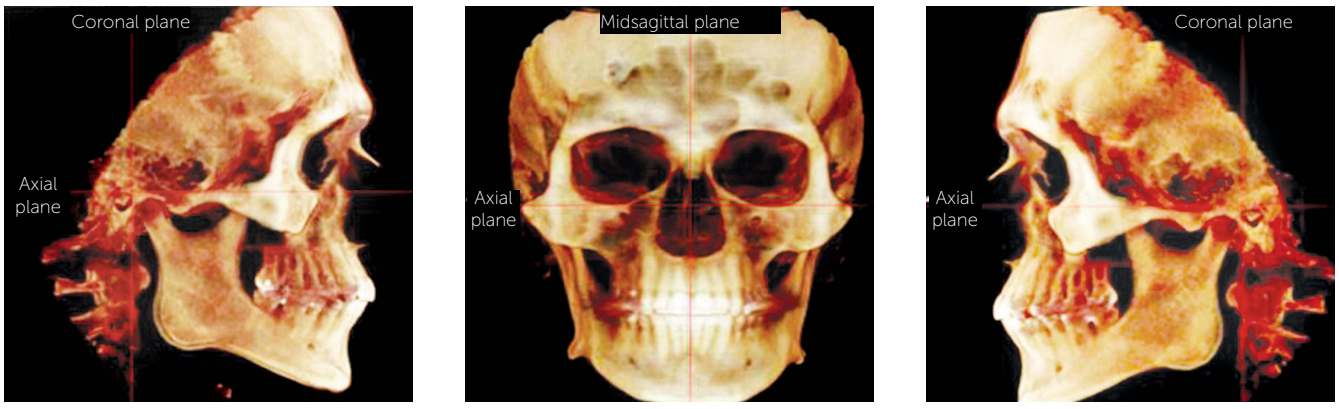

Figure 1 - Image showing the auxiliary reference lines on the positioning of three-dimensional volumes.

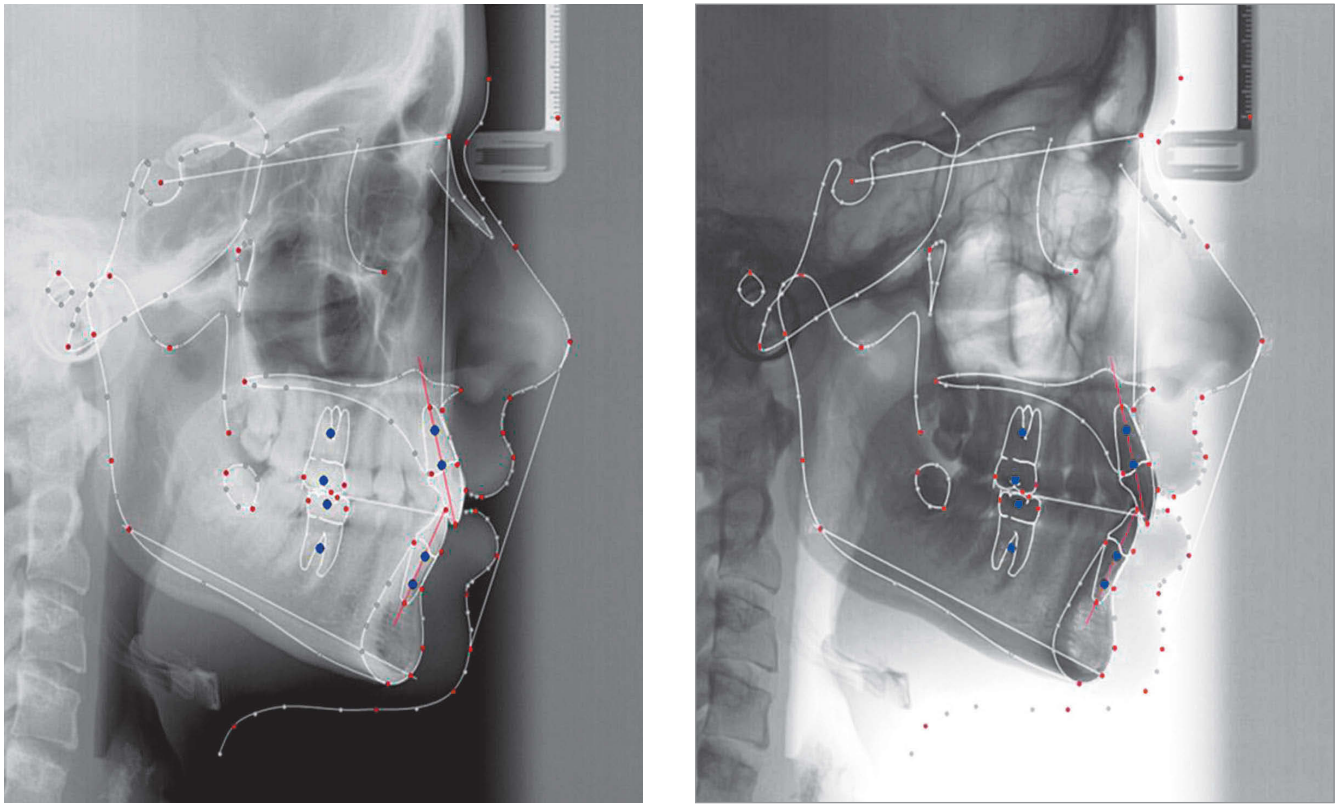

Figure 2 - Difference between original and modified images (inversion of colors).

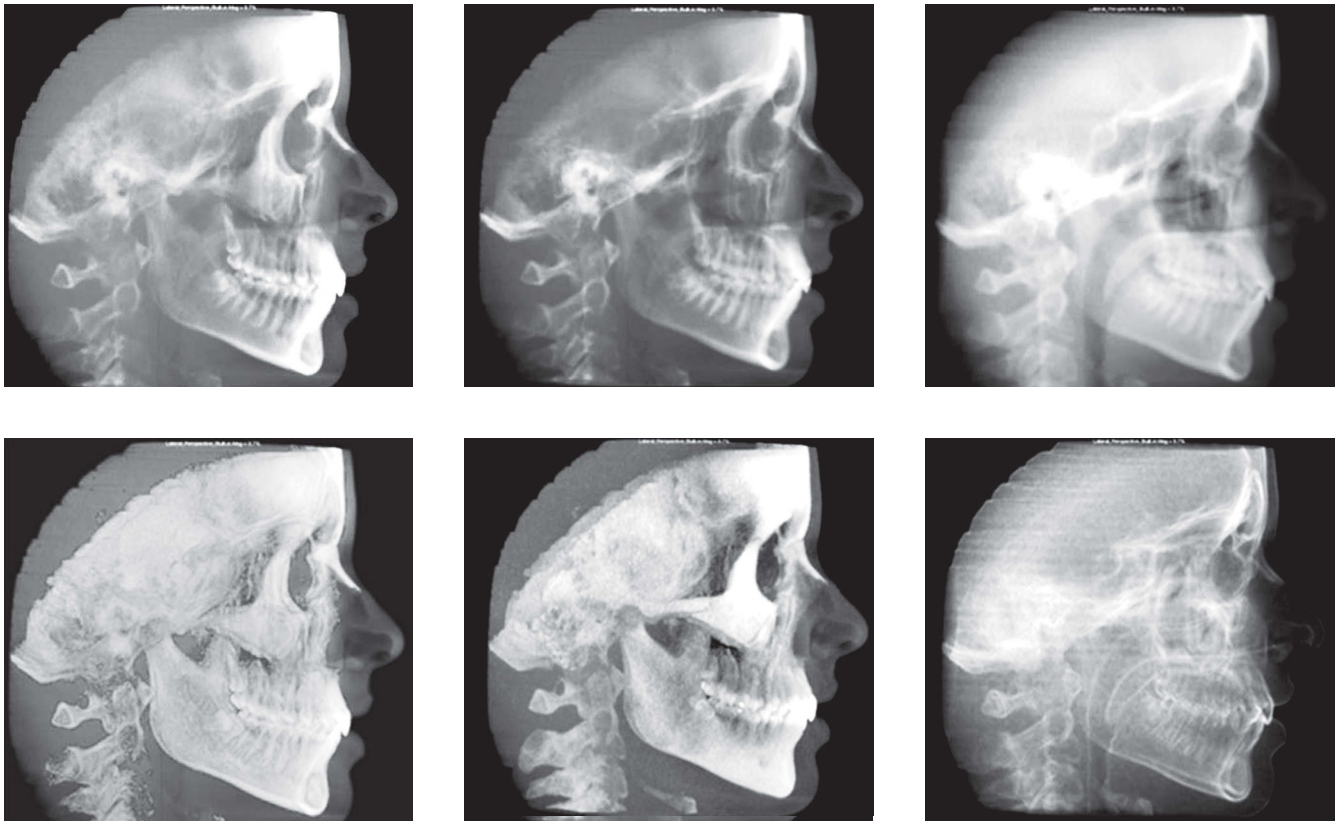

Figure 3 - Several image filters that are provided by Dolphin 3D.

The reliability study on the image capturing was determined by the repetition of six tracings (23%) randomly selected, performed in two different periods by the same examiner. The same point, lines, planes and measures were traced again after a 10 day interval. The values obtained were compared by Intraclass Correlation Coefficient (ICC) and were between 0.969 and 0.999 with statistical significance of $p < 0.05$. Thus, the correlation was shown to be high, indicating reliability on the obtainment of measures.

The paired Student's t test was used on the comparison between the means of values found on the cephalometric tracings of digital and simulated radiographs, with a confidence interval of 95%.

Most angular measures (78%) presented an irrelevant difference between the means (0.07° - 0.56°), and only two measures presented a statistically significant difference ($p < 0.05$), GoGn.SN and IMPA, however the difference was 1.8° and 1.5° respectively.

The linear measurements presented two measures using teeth as reference that showed minimum difference (0.28 mm and 0.30 mm, respectively) and two measures that used the lip as reference presenting differences of up to 1.81 mm ($p < 0.05$) (Table 3).

The Intraclass Correlation Coefficient between the two modalities of images in all the measurements in this work presented an index over 0.927, indicating a strong correlation, as can be seen on Table 4.

The statistical analysis was performed through the software SPSS 16.0 (SPSS Inc.,Chicago, Illinois).

DISCUSSION

The first reports about computed tomography for dentistry occurred in the late 90s.[15] With the appearance of specific softwares, the possibility of simulating radiographs used in the orthodontic diagnosis such as panoramic, lateral and frontal cephalometric became promising especially because of the advantage of taking only one exam.

The validation of extracting two-dimensional images from three-dimensional images becomes extremely important in this transition period or change of paradigm from the 2D to the 3D diagnosis, so that the clinician can continue to use the same cephalometric analysis, until three-dimensional analysis be established in the orthodontic literature and become available for the daily practice.[14] At first sight, the reconstruction of a 3D model and subsequent return to a 2D image seems paradoxical,

Table 2 - Descriptive analysis of linear and angular measurements, including mean, median and standard deviation, of each cephalometric measurement.

Measurement		Mean	Median	S.D.
Angular measurements (degrees)				
SNA	Digital	82.71	82.70	3.65
	3D	82.40	81.75	3.60
SNB	Digital	80.06	79.75	3.56
	3D	79.83	79.30	3.44
ANB	Digital	2.66	2.40	2.27
	3D	2.58	2.70	2.08
FMA	Digital	24.13	24.70	5.97
	3D	24.58	25.10	5.27
Ocl.SN	Digital	14.16	14.85	4.56
	3D	14.09	14.45	5.02
GoGn.SN	Digital	29.72	30.35	7.03
	3D	31.22	32.30	6.17
IMPA	Digital	94.68	93.30	8.47
	3D	92.88	91.70	7.58
1.SN	Digital	104.77	103.75	8.77
	3D	104.21	102.95	8.43
Y axis	Digital	58.33	57.60	3.73
	3D	58.65	58.80	3.65
Linear measurements (mm)				
UL-Line E	Digital	-3.41	-3.55	2.35
	3D	-5.23	-5.20	2.08
LL-Line E	Digital	-0.46	-0.15	2.97
	3D	-1.50	-1.90	2.78
1-NA	Digital	5.40	5.25	3.25
	3D	5.70	4.80	3.01
1-NB	Digital	5.76	5.60	3.17
	3D	6.05	6.05	3.17

Table 3 - Difference between mean and standard deviation of angular and linear cephalometric measurements, carried on digital radiographs simulated from CBCT.

Measurement	Mean	S.D.	p
Angular measurements (degrees)			
SNA	0.31	0.69	0.081
SNB	0.22	0.74	0.142
ANB	0.07	0.66	0.583
FMA	-0.45	2.46	0.361
Ocl.SN	0.07	2.50	0.883
GoGn.SN	-1.50	1.63	0.009*
IMPA	1.80	1.92	0.006*
1.SN	0.56	1.54	0.074
Y axis	-0.31	1.92	0.410
Linear measurements (mm)			
UL-Line E	1.81	0.88	0.002*
LL-Line E	1.03	0.80	0.007*
1-NA	-0.30	1.01	0.146
1-NB	-0.28	0.67	0.040

* $p < 0.05$. Result statistically significant.

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Table 4 - Intraclass correlation coefficient between measurements carried on digital radiographs simulated from CBCT (n = 26).

Measurement	ICC
Angular measurements (degrees)	
SNA	0.991
SNB	0.988
ANB	0.976
FMA	0.950
Ocl.SN	0.927
GoGn.SN	0.985
IMPA	0.986
1.SN	0.992
Y axis	0.928
Linear measurements (mm)	
UL-Line E	0.958
LL-Line E	0.980
1-NA	0.973
1-NB	0.990

but this can make the progressive introduction of CBCT easier to the practice of the orthodontist and research.

Before the employment of cephalometric radiographs simulated from computed tomography, the evaluation of the reliability of the data of the new images is necessary, and this was the objective of the present study.

Some cephalometric points as Gonion and Porion that are used to define the mandibular plane and the Frankfurt horizontal plane, respectively, are located in curved surfaces, which can make the identification more difficult. For this reason, such points have considerable margin of error when marked.[16-20]

The results of comparison between the modalities of images showed statistically significant difference ($p < 0.05$) in two angular measures (IMPA and GoGn.SN) and in two linear measures (UL-Line E and LL-Line E). These 4 measures presented differences of ± 1.8 mm or 1.8°. These differences are probably clinically irrelevant.

The two angular measures that presented statistical difference used the mandibular plane as reference and the difference between mandibular contours on the two modalities of images can be noticed, which probably contributed to the difference between the two measurements (Fig 4).

In a similar work, the angular measure that presented differences was the FMA (-4.36°) that also uses the mandibular plane as one of the cephalometric references. However, when the anatomic porion could not be determined, the most superior part of the image of the auricular positioner (mechanical porion) was used as reference;[9] on the present study all markings were performed on the anatomic porion.

The linear measures that had statistical difference involved lips and E Line (nose tip, soft pogonion). Some hypotheses must be considered in this regard: First, it cannot be assured that the positioning of the lips was exactly the same in both exams; then, the tomography is not the most recommended exam to reproduce soft tissues with high accuracy; and last but not least, the gravity working on soft tissues, when medical or cone beam tomographs are taken with the patient lying dorsally, and the same method used in the present work.

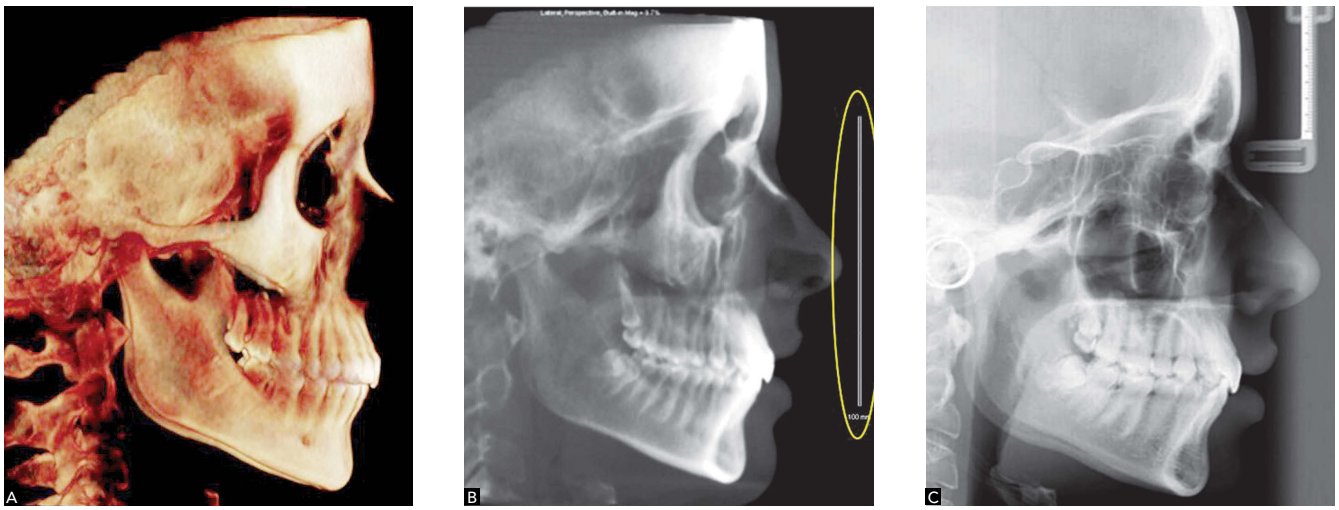

Figure 4 - Illustration of images: **A**) 3D image in a right profile visualization; **B**) perspective simulated cephalometric radiograph, with 100 mm ruler on the right; **C**) digital cephalometric radiograph.

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The stability of the points is affected by several factors. On the lateral radiograph, when the head is deviated from the exact profile position, the sagittal points experience the minimum degree of displacement, while the structures located outside the midsagittal plane change position significantly. In this case, structures in opposite sides of the head move in opposite directions.[21]

The questioning about the validity of the two-dimensional cephalometry in orthodontics is due to four aspects: First, the limitation of the 2D technique in representing a three-dimensional object. When a three-dimensional object is represented in two dimensions, the structures are vertical and horizontally displaced proportionally to the distance to the film or record plane; then, symmetry on the right and left side is very rare, which makes it difficult to evaluate patients with craniofacial anomalies and facial asymmetries; third, the problems inherent to obtaining the image; and fourth, the operational error on the elaboration of the cephalogram and on the process of cephalometric analysis. Despite the amount of variables that compete to make the cephalometric analysis liable, it remains widely used by orthodontist from all around the world and, in many cases, it is essential for the diagnosis and treatment of patients.

Cephalometric analysis is still the only practical quantitative method that allows the investigation and evaluation of the relations between skull, dental and soft-tissue structures.[22-25]

The conventional radiography, as well as the perspective simulated image, show a superimposition of bilateral structures that does not correspond to reality. It is taught that the structures on the left must be traced for being closer to the film and consequently experience lower magnification than those on the right. Probably this error was repeated numerous times until the advent of the tomography. Figure 4 shows one patient from the sample, that clinically did not present any remarkable facial asymmetry and after positioning the exams on the Dolphin software, it was noticed that the left side showed to be larger. However, as the magnification on the right side (closer to the frame) is larger, what is observed is an almost complete overlap of the mandibular planes on both sides, suggesting symmetry. It would be necessary, however, three-dimensional visualization to be sure on which side is larger or smaller in cases of evident asymmetry.

The positioning of the patient is considered a critical factor for cephalometric analysis.[26,27] When the conventional exam is performed, the technician uses reference lines on the tissue, which can complicate the reproducibility. On CBCT, there is the advantage of visualizing only bone structures that can be used to reorient the patient on a better position with greater reproducibility.

Since the research was about a comparison to digital radiographs, that had divergence on X-ray beam and consequently, magnification of the image size, the radiographs from tomographies, were also simulated with divergence on X-rays and magnification. The magnification factor is the amount of magnification of the image on the midsagittal plane and it was defined in 9.7% following orientation from the manufacturer of the Dolphin software. Some researchers used magnification factor of 7.5% justified by the relation between distance object-film and distance x-ray source-object.[1,9] However this calculation cannot be surely used, since some patients who take radiographs in two different x-ray devices have radiographs with different size structures, but the distances from the focus to the object and from the object to the film are similar.

Considering the values related to radiation that the patient absorbs,[28] the substitution of panoramic radiograph for CBCT would not be justified, panoramic radiographs solely could be appropriate for the diagnosis. But, in the case of orthodontic diagnosis, the substitution of panoramic, lateral and frontal cephalometric radiographs for the CBCT can be done, so that the dosage of NewTom 3G with a 12-in FOV, for example, it is approximately two times the dosage of conventional expositions, except for the full periapical exam.

Although some authors propose three-dimensional cephalometric analysis[23,29,30] it is believed that the 3D analysis, in clinical practice, is a lot more qualitative, with spatial visualization and relation between the structures, than quantitative, with preestablished measures; this last one is preferred for the research field.

CONCLUSION

After analysis of results, it can be concluded that the cephalometric measures obtained by cephalograms generated from simulated radiographs through CBCT reproduce with significant accuracy the conventional cephalogram measures.

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Cephalometric changes in Class II division 1 patients treated with two maxillary premolars extraction

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Objective: The purpose of this study was to evaluate the cephalometric alterations in patients with Angle Class II division 1 malocclusion, orthodontically treated with extraction of two maxillary premolars.

Methods: The sample comprised 68 initial and final lateral cephalograms of 34 patients of both gender (mean initial age of 14.03 years and mean final age of 17.25 years), treated with full fixed appliances and extraction of the first maxillary premolars. In order to evaluate the alterations due the treatment between initial and final phases, the dependent t test was applied to the studied cephalometric variables.

Results: The dentoskeletal alterations due to extraction of two maxillary premolars in the Class II division 1 malocclusion were: maxillary retrusion, improvement of the maxillomandibular relation, increase of lower anterior face height, retrusion of the maxillary incisors, buccal inclination, protrusion and extrusion of the mandibular incisors, besides the reduction of overjet and overbite. The tissue alterations showed decrease of the facial convexity and retrusion of the upper lip.

Conclusions: The extraction of two maxillary premolars in Class II division 1 malocclusion promotes dentoskeletal and tissue alterations that contribute to an improvement of the relation between the bone bases and the soft tissue profile.

Keywords: Corrective Orthodontics. Cephalometry. Retrospective studies. Tooth extraction.

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INTRODUCTION

Nowadays, the protocol for Class II treatment with extraction of two maxillary premolars is the second most used protocol of extraction in orthodontic treatments (20.2%), being only inferior to the protocol of extraction of the four first premolars (42.9%). It is especially recommended when there is no cephalometric discrepancy and severe crowding on the lower arch. This treatment protocol favors the patient regarding to collaboration on the use of anchorage reinforcement, once it will be required a shorter period of use of such appliances.[12]

Some authors speculate that dental extractions may cause some problems to the patient such as: Temporomandibular disorder,[2,6] lack of treatment stability,[10,17] and unwanted profile flattening, which would compromise the patient's esthetics by the end of the treatment.[22,23] However, other authors point the numerous favorable results obtained on treatment with extraction of two upper premolars with good occlusal stability in the long term[13,14] and without direct influence on the flattening of the patient's profile.[11,12,15]

The cephalometric alterations promoted by this treatment protocol and often mentioned in literature are: Increase of nasolabial angle, retraction of upper lip, reduction of profile convexity and retraction with verticalization of upper incisors,[24-27] i.e., the orthodontic treatment with extractions of maxillary premolars has little influence in relation to skeletal changes and provides greater dental and profile alterations.

Nevertheless, some doubts and questioning still persist about the real impact of extraction of upper premolars on skeletal, dentoalveolar and tissue components of patients with Class II malocclusion. Before that, this work aims to assess the cephalometric, dentoalveolar and tissue alterations in patients with Angle Class II malocclusion, division 1, orthodontically treated with extraction of two maxillary premolars.

MATERIAL AND METHODS

Material

The sample used in this retrospective study consisted of 68 initial and final teleradiographs of 34 patients (15 females, 19 males, mean age of 14.03 years ± 2.65, with amplitude of 10.83 to 25.83) treated on the course of specialization in Orthodontics at Uningá, Bauru, for a mean period of 3.21 ± 1.43 years, with amplitude of 1.25 to 7.83 and finished the orthodontic treatment with a final mean age of 17.25 ± 2.59 years, with amplitude of 13.49 to 28.24.

The criteria for inclusion of patients in the selected sample was based on presence of the following characteristics: Angle Class II malocclusion division 1 with molar relation of at least ½ Class II (cusp-to-cusp relation), absence of crowding or with mild crowding, presence of all permanent teeth erupted until the first premolars, overjet of at least 5 mm[4,25] and orthodontically treated with extractions of upper first premolars. Patients with Class II malocclusion subdivision were excluded from the sample.

Patients in the sample were treated with Edgewise technique braces, slot 0.022 x 0.028-in. The most used sequence of alignment and leveling was 0.015-in twist-flex or 0.014-in NiTi at the beginning of treatment, followed by arches 0.016, 0.018 and 0.020-in of stainless steel. For the anterior superior retraction phase it was used the arch 0.019 x 0.025-in of stainless steel and some patients used during this phase intermaxillary elastics of Class II and/or headgear for anchorage reinforcement. By the end of active treatment, the patients used a Hawley plate on the upper arch and a retainer 3 x 3 attached on the lower arch.

Methods

Lateral teleradiographs were obtained from all patients at the beginning (T_1) and end (T_2) of the orthodontic treatment. These teleradiographies were obtained in 4 different radiographic units that presented magnification factors ranging from 6 to 9.8%.

The teleradiographies were scanned with flatbed scanner *Microtek ScanMaker i800* (9600 x 4800 dpi, from *Microtek International, Inc., Carson, CA, USA*) and attached to a microcomputer Pentium. The images were transferred to *Dolphin Imaging Premium* 10.5 (*Dolphin Imaging & Management Solutions, Chatsworth, CA, USA)* through which it were unmarked the points by the same examiner and it were performed the measurements of skeletal, dental and tissue measures (Figs 1, 2, and 3).

Skeletal cephalometric measures

» SNA (°): Angle formed by lines SN and NA. It indicates the sagittal relation of the maxilla in relation to the skull base.

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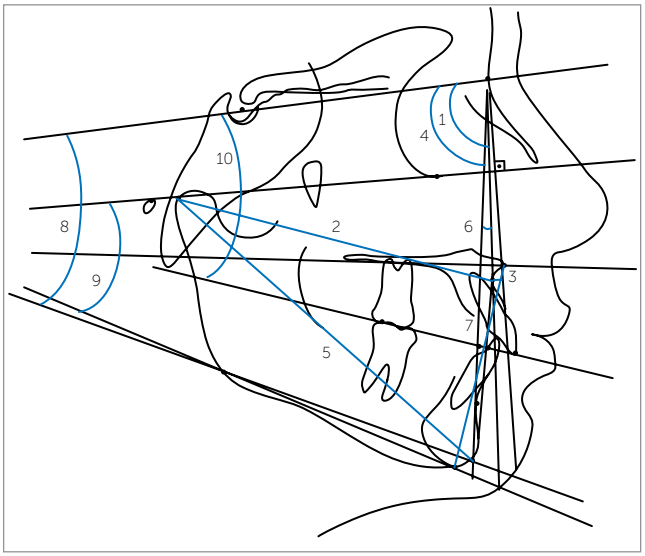

Figure 1 - Skeletal cephalometric measures: 1) SNA (°); 2) Co-A (mm); 3) A-Nperp (mm); 4) SNB (°); 5) Co-Gn (mm); 6) ANB (°); 7) AIFH (mm); 8) SN-GoGn (°); 9) FMA (°); 10) SN.Ocl (°).

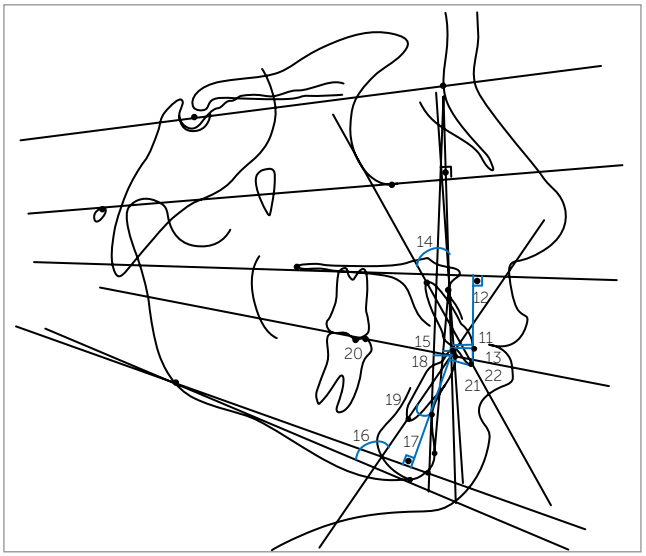

Figure 2 - Dental cephalometric measures: 11) 1-Aperp (mm); 12) 1-PP (mm); 13) 1-NA (mm); 14) 1.NA (°); 15) 1-AP (mm); 16) IMPA (°); 17) 1-GoGn (mm); 18) 1-NB (mm); 19) 1.NB (°); 20) Molar relation (mm); 21) Overbite (mm); 22) Overjet (mm).

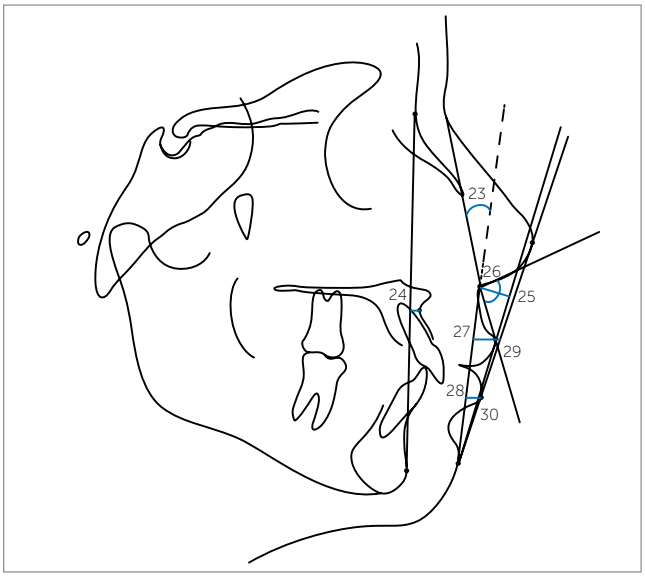

Figure 3 - Tissue cephalometric measures: 23) G'.Sn.Pog' (°); 24) A-NPog (mm); 25) Sn-H (mm); 26) ANL (°); 27) UL-SnPog (mm); 28) LL-SnPog (mm); 29) UL-E (mm); 30) LL-E (mm).

» Co-A (mm): Distance between the points Condyle and A. It represents the effective length of the mean face (maxilla).

» A-Nperp (mm): Distance between the point A and the line N perpendicular to Frankfurt's plane. It defines the sagittal position of the maxilla.

» SNB (°): Angle formed by lines SN and NB. It indicates the sagittal relation of the mandible in relation to the skull base.

» Co-Gn (mm): Distance between the points Condyle and Gnathion. It defines the effective mandibular length.

» ANB (°): Angle between the lines NA and NB. It represents the degree of sagittal discrepancy between maxilla and mandible.

» SN.GoGN (°): Defines the orientation of facial growth pattern.

» FMA (°): Angle formed by Frankfurt's and mandibular planes.

» OP.SN (°): Angle formed between the line SN and the occlusal plane. It relates the occlusal plane inclination to the skull base.

» AIFH (mm): Distance between the points anterior nasal spine and mentalis. It indicates the height of the lower third of the face.

Dental cephalometric measures

» 1-Aperp (mm): Distance from the vestibular portion of the upper central incisor to the line A-perp.

» 1-PP (mm): Distance between the incisal edge of the upper central incisor and the palatal plane perpendicularly measured. It relates the vertical positioning of the upper incisor to the maxilla.

» 1-NA (mm): Distance between the anterior point of the crown of upper central incisor and the line NA. It relates the sagittal position of upper incisor in relation to maxilla and to Nasion.

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» 1.NA (°): Angle between the long axis of upper central incisor and line NA. It defines the degree of inclination of the central incisor in relation to maxilla and Nasion.

» 1-APog (mm): Distance from the incisal edge of lower incisor to line Apog.

» IMPA (°): Angle between the long axis of lower central incisor and the mandibular plane GoMe. It indicates the inclination of this tooth in relation to the mandible.

» 1-GoGn (mm): Distance from incisal edge of lower incisor to mandibular plane GoGn, measured perpendicularly to this plane.

» 1-NB (mm): Distance between the anterior point of the crown of lower central incisor and line NB. It relates the sagittal position of lower incisor in relation to mandible and Nasion.

» 1.NB (°): Angle between the long axis of lower incisor and line NB. It relates the inclination of this tooth to the mandible and Nasion.

» Molar relation (mm): Distance between the mesial cusp of upper and lower first premolars perpendicularly projected on the occlusal plane.

» Overbite (mm): Distance between the incisal edges of upper and lower central incisors measured perpendicularly to the occlusal plane.

» Overjet (mm): Distance between the incisal edges of upper and lower central incisors perpendicularly projected to the occlusal plane.

Tissue profile

» UL-SnPog (mm): Distance from the upper lip to line Subnasal Pogonion.

» LL-SnPog (mm): Distance from the lower lip to line Subnasal Pogonion.

» UL-E (mm): Distance from the upper lip to line Pronasal Pogonion.

» LL-E (mm): Distance from the lower lip to line Pronasal Pogonion.

» ANL - nasolabial angle: Formed by lines columella to Subnasal and from Subnasal to upper lip.

» G'.Sn.Pog' (°): Facial convexity angle. It's formed by lines tissue glabella to Subnasal and from Subnasal to tissue Pogonion.

» A-NPog (mm): Distance from point A to line Nasion to the Pogonion.

» Sn-H (mm): Shortest distance from point Subnasal to line H of Holdaway (Pogonion to upper lip).

For evaluation of intraexaminer error, 20 teleradiographs randomly selected were scanned and measured again after a minimum interval of 4 weeks. For evaluation of systematic error, it was applied the dependent t test and the magnitude of random error was calculated by Dahlberg's formula.

It was performed the evaluation of data normality through Kolmogorov-Smirnov test. The results showed that all variables presented normal distribution. This way, it was applied the dependent t test on the studied cephalometric variables to verify alterations due treatment between initial (T_1) and final (T_2) phases. The statistical analysis was performed with Statistica for Windows (Statistica for Windows - Release 7.0 - Copyright Statsoft, Inc. 2005). It were considered statistically significant the results with p value of $p < 0.05$.

RESULTS

Among the 30 studied cephalometric variables, only 3 presented significant systematic error (FMA, 1-PP and IMPA). The magnitude of random errors ranged from 0.22 (overjet) to 2.12 (IMPA). The results are displayed on Table 1.

Patients with Class II malocclusion, division 1, treated with extraction of two upper premolars presented the following cephalometric alterations: maxillary retrusion in relation to the skull base, increase on the mandibular length and anterior inferior facial height (AIFH), improvement on the maxillomandibular relation, upper incisors retrusion, vestibularization and protrusion of the lower dentoalveolar component, improvement on molar relation, reduction of overbite and overjet, reduction of facial convexity and upper lip retrusion.

DISCUSSION

Evaluating the results found in this work it is possible to establish and assess the alterations caused on dentoskeletal and tissue components due the extraction of upper first premolars, in Class II division 1 patients.

Regarding the maxillary component, the maxilla experienced a significant retrusion noticed by the statistically significant reduction of variables SNA and A-NPerp (Table 1). The reduction of these variables occurred due the necessity of correction of Class II relation of canines and overjet normalization, due the use of intermaxillary elastic and EOA as anchorage reinforcement.

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Table 1 - Results of dependent t test comparing initial phase (T_1) and final phase (T_2) of treatment.

Variables	Initial (T_1)	Final (T_2)	Difference (T_2-T_1)	p
	Mean ± SD	Mean ± SD		
Maxillary component				
SNA (degrees)	75.66 ± 4.73	74.15 ± 3.96	-1.51	**0.017***
Co-A (mm)	84.21 ± 5.12	85.00 ± 5.00	0.78	0.084
A-Nperp (mm)	0.19 ± 3.46	-1.06 ± 3.60	-1.26	**0.024***
Mandibular component				
SNB (degrees)	70.79 ± 3.99	70.55 ± 3.57	-0.24	0.569
Co-Gn (mm)	107.50 ± 6.39	111.55 ± 5.95	4.05	**0.000***
Maxillomandibular relation				
ANB (degrees)	4.87 ± 2.58	3.61 ± 2.20	-1.27	**0.001***
Vertical component				
SN.GoGn (degrees)	30.55 ± 5.59	30.90 ± 5.61	0.35	0.338
FMA (degrees)	24.44 ± 4.21	24.54 ± 4.49	0.10	0.777
OP.SN (degrees)	11.41 ± 4.12	12.49 ± 4.21	1.08	0.016
AIFH (mm)	62.60 ± 4.39	64.93 ± 4.56	2.33	**0.000***
Upper dentoalveolar component				
1-Aperp (mm)	7.68 ± 2.23	5.22 ± 2.18	-2.45	**0.000***
1-PP (mm)	26.65 ± 2.37	26.98 ± 2.60	0.33	0.373
1-NA (mm)	6.49 ± 3.17	4.48 ± 2.67	-2.02	**0.001***
1.NA (degrees)	25.23 ± 6.76	22.76 ± 5.19	-2.47	0.080
Lower dentoalveolar component				
1-APog (mm)	1.91 ± 1.81	3.81 ± 1.76	1.89	**0.000***
IMPA (degrees)	86.21 ± 5.36	89.65 ± 6.38	3.43	**0.001***
1-GoGn (mm)	36.40 ± 2.74	37.36 ± 2.30	0.96	**0.016***
1-NB (mm)	5.93 ± 1.79	7.22 ± 1.57	1.28	**0.000***
1.NB (degrees)	24.60 ± 4.16	28.13 ± 5.04	3.52	**0.000***
Dental relations				
Molar relation	2.89 ± 1.32	4.45 ± 0.83	1.56	**0.000***
Overbite	2.90 ± 2.92	1.78 ± 1.12	-1.13	**0.011***
Overjet	7.63 ± 1.59	2.32 ± 0.84	-5.31	**0.000***
Tissue profile				
UL-SnPog (mm)	5.60 ± 1.55	4.35 ± 1.45	-1.25	**0.000***
LL-SnPog (mm)	3.81 ± 1.80	3.62 ± 1.83	-0.19	0.468
UL-E (mm)	-0.37 ± 2.20	-2.65 ± 2.12	-2.28	**0.000***
LL-E (mm)	0.77 ± 2.09	-0.07 ± 2.24	-0.85	**0.004***
ANL (degrees)	97.57 ± 7.06	99.64 ± 7.51	2.07	0.072
G'.Sn.Pog' (degrees)	18.48 ± 4.73	16.96 ± 4.80	-1.52	**0.000***
A-NPog (mm)	0.19 ± 3.46	-1.06 ± 3.60	-1.26	**0.024***
Sn-H (mm)	7.33 ± 2.01	5.74 ± 1.83	-1.59	**0.000***

*Statistically significant difference for $p < 0.05$.

It is notable that the antero-superior teeth retraction may affect the positioning of point A in relation to the skull base.[4,25]

Scott Conley and Jernigan[25] also observed a statistically significant reduction of the variable A-Nperp in cases treated with extraction of two upper premolars. However, Rains and Nanda[24] did not find significant alterations on point A. But in this study the variable Co-A did not present statistically significant alteration. It is speculated that there was no alteration due the fact that most patients were in growth stage, which disguised the retraction experienced by point A.

On the mandibular component, it was evidenced a significant increase of the mandible effective length (Co-Gn)

(Table 1). This was expected since the evaluated patients in this research were in growth stage, as explained above. In this study, this increase was greater than the expected being corroborated by some authors that reported similar results in literature. [4,7,23]

On the maxillomandibular relation, there was a significant alteration of the anteroposterior skeletal discrepancy, shown by the reduction of angle ANB (Table 1). This alteration was expected because the orthodontic treatment aimed the correction of Class II malocclusion and of the overjet initially increased by upper incisors retraction. Besides, the potential of mandibular growth on this age group helps the reduction of angle ANB. [25,26] Tadic and Woods[26] observed that the greater the overjet at the beginning of treatment, greater the probability of reduction of angle ANB, in cases treated with extraction of two upper premolars. Oliveira et al[20] observed that there was improvement on the anteroposterior maxillomandibular relation, shown by the reduction of ANB. Scott Conley and Jernigan[25] also observed a statistically significant reduction of the angle ANB contributing for an improvement of the existent relation between dental arches, and a significant increase of AIFH as occurred in the present study.

In the work by Chua, Lim and Lubit[5] it was found an increase of AIFH associated to a clockwise rotation of the mandible only in cases treated without dental extractions, while in treatments with extractions it was not observed any significant alteration on AIFH. Differently from the findings of these authors, most works found in literature are in agreement with the present study, in which AIFH presented a statistically significant increase during treatment. It is believed that the responsible for this alteration was the potential growth still present in patients and the orthodontic mechanics that used intermaxillary elastics during closing of spaces after extractions. Some authors observed that the increase of the lower third of the face is related to age and growth potential of the patients, besides the use of intermaxillary elastics.[19] On the work by Oliveira et al[20] the AIFH increased due the compensatory extrusion of molars during anterior retraction phase. Now Merrifield and Cross[19] emphasized that any mechanics that promote dental extrusion causes the increase of AIFH.

On the variables related to growth pattern, both SN.GoGn and FMA did not present statistically significant alterations between initial and final phases of treatment (Table 1). Scott Conley and Jernigan[25] also did not find significant alterations in relation to the change on growth pattern in cases treated with extraction of two premolars. The variable OP.SN presented a statistically significant increase during treatment. This increase does not mean in alteration of growth pattern impressing a vertical characteristic for the patients, because the other variables of this component did not present significant alteration. It is believed that the alterations observed on the variable OP.SN are related to dentoalveolar changes, for instance, the curve of Spee flattening, occurred during the treatment of patients. At the beginning of treatment, it is frequently observed an accented extrusion of lower incisors due to increased overjet.[18,28] During treatment there was flattening of curve of Spee, which led to a clockwise rotation of the occlusal plane. This effect was enough to promote statistically significant change of variable OP.SN being only a reflex of dental alterations and not skeletal since the other variables, SN.GoGn and FMA, that characterize the component, did not present statistically significant changes.

The study by Oliveira et al[20] showed compensatory extrusion of molars during retraction phase in cases with extraction of four premolars, and also did not report statistically significant differences on variables SN.GoGn and SN.GoMe that characterized the growth pattern.

On the upper alveolar component, the upper incisors presented a statistically significant retrusion (1-Aperp, 1-NA). There was no significant alteration of upper incisors on the vertical direction or in relation to inclination (1-PP and 1.NA, respectively) (Table 1). According to several authors, the skeletal effects of the treatment were more evident on the maxilla and on the superior teeth than in the mandible or lower teeth, in cases treated with extraction of two upper premolars.[25,27]

Tadic and Woods[26] verified a significant increase on the inclination of upper incisors related to line N-A also in cases with extraction of two upper premolars and observed that the greater the overjet at the beginning of treatment, greater the probability of reduction of upper incisors inclination, and that the greater the reduction on angle ANB, smaller the necessity of reduction of upper incisors inclination. In this work there was no significant difference between the inclination of

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upper incisors at the beginning and end of treatment, which differs from most works with extraction of two premolars. It can be asserted that there is a tendency of these teeth to obtain a more palatine inclination after the anterior retraction because the numeric value was reduced, but with no statistical significance.

Paiva et al[21] also in cases treated with extraction of 4 premolars reported a statistically significant reduction of linear values (1-NA), however the reduction on angular values (1.NA), was not statistically significant, which is in agreement with the findings in this study.

On the lower dentoalveolar component, all variables related to lower incisors experienced statistically significant alteration (Table 1). It was verified a protrusion, vestibularization and extrusion of lower incisors (1-APog, IMPA, 1-GoGn, 1-NB, 1.NB). This can be explained by the use of intermaxillary elastics of Class II that were necessary in most patients at final stage. Side effects on the inclination of incisors in patients treated with intermaxillary elastics are widely reported in literature, confirming this supposition.[19] On the other hand, Scott Conley and Jernigan[25] did not find statistically significant alterations on IMPA.

By evaluating the dental relations, it was observed a reduction of the value of molar relation, pointing the increase of Class II molar relation, which was expected, for only two upper premolars were extracted, and the cases would be finished with a full Class II molar relation in both sides (Table 1). It was observed a significant improvement on the overbite which was also already expected, for the deep overbite was corrected during treatment with the use of reverse curve wires on the lower arch and accentuated on the upper arch, including during the anterior retraction (Table 1). The overjet reduced significantly with the treatment, which was also expected, because it was taken as criteria for inclusion on the sample that the patients presented an overjet of at least 5 mm and finished the treatment with the malocclusion corrected with canines in Class I relation and normalized overjet (Table 1).

Also on the evaluation of tissue profile results, the data presented an upper lip retrusion, verified on measures UL-SnPog, A-NPog, UL-E, and a lower lip retrusion on measure LL-E, however the variable LL-SnPog did not present statistically significant difference despite presenting a tendency to reduction in its value which shows a tendency to lower lip retrusion, contradicting the expected lower lip protrusion due to vestibularization and protrusion verified on lower incisors (Table 1). These results are in agreement with the works presented in literature.[25,27] Scott Conley and Jernigan[25] also found an unexpected result. They assigned this reduction on the lower lip projection to the presence of an everted lower lip, because with a deep overbite, an accentuated overjet and a Class II dental relation, the lower lip may be artificially kept in a more protruded position trapped in the space between lower and upper incisors and after the upper incisors retraction, returns to its normal position.

Some authors that evaluated cases with extraction of two upper premolars, realized that according to the treatment protocol used, the lip thickness at the beginning of treatment, the vertical control and variety of facial patterns, the lips may be affected by dental moves on the anteroposterior direction, however the magnitude of this alterations is of difficult predictability.[26,27]

Several authors did not find significant differences on the alterations of soft tissue between groups treated with extraction of four premolars and without extractions[7,30] while other authors observed a tissue profile retrusion.[1,3,4]

Considering that a retraction of upper incisors necessarily imply in a retrusion of the upper lip,[30] it is known that the muscle-skeletal-functional complex of the upper lip contributes for the variability observed on alterations of upper lip with the treatment protocol with premolars extractions.[29]

In this work the nasolabial angle did not present statistically significant alteration (Table 1). Despite the upper teeth retraction suggests that occurs an increase of the nasolabial angle, this result was not observed.

Some authors assign this result to nasal growth, occurring a down inclination of the columella and the pronasal, reducing the nasolabial angle. Theses authors assert that the nasolabial angle is formed by soft tissue (pronasal) and cartilage (columella), which continues to grow forth as well as the soft tissue of the upper lip and observed that only a small statistically insignificant change occurred of nasal base retraction (subnasal), therefore, if the projection of the upper lip tends to reduce, while the base nasal projection remains the same, the nasolabial angle must become more obtuse.[1,7,30]

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Kocadereli[16] and Uehara et al[28] observed mean values statistically equal of the nasolabial angle both for patients that did not experience dental extraction and those who were submitted to extractions of four premolars. Tadic and Woods[26] also did not find statistically significant alteration of the nasolabial angle in patients treated with extraction of upper first premolars.

However, Freitas et al[8] observed an increase of the nasolabial angle in cases treated with extraction of four premolars in a proportion of increase of nasolabial angle in 1,49° for each millimeter of retraction on upper teeth which also was confirmed by other authors.[27] Scott Conley and Jernigan[25] also found statistically significant alterations of the nasolabial angle which had an increase of 6.38°.

Erdinç et al[7] observed that the nasolabial angle reduced significantly in groups treated with extraction of four premolars and in groups without extractions these alterations were insignificant.

Despite the generalized idea that extractions cause an increase of the nasolabial angle, the results from this work are in agreement with latest conclusions of works mentioned above.

CLINICAL CONSIDERATIONS

The obtained results showed that profile alterations occur as effect of orthodontic treatment. However, each patient must be individually analyzed so the professional can plan the treatment and instruct the patient about these aspects. Concomitantly, it allows the clinician a greater predictability of possible alterations that the treatment will cause and thus increase the percentage of success in this type of treatment and the patient's satisfaction.

The lower lip retrusion is an essential data when planning the treatment and its positioning must be evaluated in the beginning of treatment and verified if it is affected by the positioning of upper incisors, for this will lead to lower lip retrusion and the patient must be aware. Generally this detail go unnoticed by the clinician, for he only reports the upper lip retrusion due the chosen treatment does not include extraction on the lower arch.

CONCLUSION

Based on the evaluated sample and the used methodology, the alterations caused by extraction of two premolars on Class II division 1 malocclusion were:

» Maxillary retrusion, improvement of the maxillomandibular relation, increase of the anteroinferior facial height, upper incisors retrusion, vestibularization, protrusion and extrusion of lower incisors, besides the reduction of overbite and overjet.

» The profile alterations were: Reduction of the facial convexity and upper lip retrusion.

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Fixed Lingual Mandibular Growth Modificator: A new appliance for Class II correction

Osama Hasan Alali[1]

Introduction: This article demonstrates the description and use of a new appliance for Class II correction.

Material and Methods: A case report of a 10-year 5 month-old girl who presented with a skeletally-based Class II division 1 malocclusion (ANB = 6.5°) on a slightly low-angle pattern, with ML-NSL angle of 30° and ML-NL angle of 22.5°. Overjet was increased (7 mm) and associated with a deep bite.

Results: Overjet and overbite reduction was undertaken with the new appliance, Fixed Lingual Mandibular Growth Modificator (FLMGM).

Conclusion: FLMGM may be effective in stimulating the growth of the mandible and correcting skeletal Class II malocclusions. Clinicians can benefit from the unique clinical advantages that FLMGM provides, such as easy handling and full integration with bracketed appliance at any phase.

Keywords: Orthodontic appliance design. Functional orthodontic appliances. Angle Class II malocclusion.

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» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

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INTRODUCTION

Many different appliances are now available for correcting skeletal Class II malocclusions. Some are removable[1] such as activator and double-plate; and others are fixed[2] such as Herbst appliance and MARA.

Double plate system, that was introduced for the first time by Schwarz in the early 1940s,[3] is a reliable means for treating Angle Class II, Division 1 malocclusions[4]. Sander et al.[5,6,7] have verified the effectiveness of this system in a number of studies, providing detailed information on the biomechanics and thus on the working principles. This effectiveness prompted the author to develop a fixed double-plate system, Fixed Lingual Mandibular Growth Modificator (FLMGM), that would not require patient compliance; especially because several studies[8-11] have proven that fixed functional appliances are much more efficient in stimulating skeletal mandibular growth than removable ones.

From a clinical perspective, the FLMGM offers the following advantages:

1) Permanent effect, independent of patient compliance, as it is fixed.
2) Esthetics, as it is small and lingually located.
3) Eliminates the need for two separate treatment phases, as it is suitable for use in parallel with complete multibracket appliance in both arches.
4) Flexibility in treatment timing, as it can be used anytime during the mixed and permanent dentition.
5) No interference with occlusal development.
6) Wide and comfortable range of mastication movements, as the appliance consists of two separate parts with no permanent and physical intermaxillary connection.
7) Construction bite is unnecessary because of the easy and quick chairside reactivation and progressive advancement of the mandible in small increments.
8) Easy to handle because its insertion, clipping, and removal are very simple.
9) Economic and cost effective, because it does not involve ready-made components, and only one appliance is necessary for entire orthopedic phase.

APPLIANCE DESIGN

The FLMGM consists of two separate and fixed parts. The upper one is palatally positioned but bucally clipped to traditional upper molars bands (Fig 1A), while the lower is lingually welded to traditional lower molars bands (Fig 1B).

Maxillary part

It has the following components (Fig 2):

1) Acrylic button: it is similar to Nance button, and designed to connect wire elements of the maxillary part, preventing them from embedding into the mucosa. This button is seated on the anterior area of the palate as anterior as possible with no contact with front teeth (1-2 mm away from the gingival margin). Its dimensions should be as small as possible to allow mucosal and periodontal hygiene.

2) Two retention wires: one in each side, specifically designed by the author to give excellent retention, facilitate dealing with the appliance, and to enhance oral hygiene condition. They are fabricated with round 1 mm thick stainless steel orthodontic wire. The wires are anteriorly embedded into the acrylic button, run posteriorly without any contact with palatal mucosa, and each one contains an "U" loop with coil (giving some flexibility

Figure 1 - Fixed lingual mandibular growth modificator (FLMGM). No physical attachment between maxillary (**A**) and mandibular (**B**) parts.

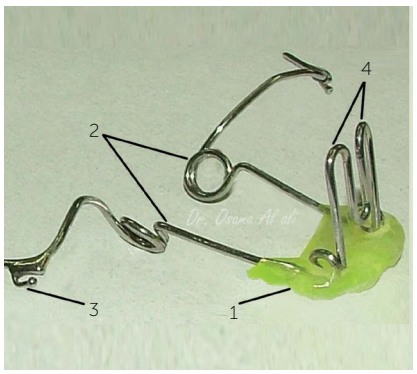

Figure 2 - Components of maxillary part: acrylic button (**1**); retention wires (**2**); retention hooks (**3**) and advancement loops (**4**).

to help in easy insertion and removal) at the level of second upper premolar. After the coils, the wires should run perpendicular to the midline towards the vestibule at the level of the mesial surface of upper first molar through the interdental space. Then, in the vestibule, the wires should run posteriorly to enter into the headgear tube.

3) Two retention hooks: one in each side, have a ball end to avoid irritation, and are directed anteriorly and welded to the retention wire before entering the headgear tube.

4) Advancement loops: wire projection embedded in the acrylic button and extended towards the mandible. They consist of two consecutive long "U" loops, contain small protection coils where the wire exits the acrylic button, and are fabricated with round 1 mm thick hard stainless steel wire. The inclination of this advancing loops to the occlusal plane is about 70 °, measured posteriorly.[12]

Mandibular part

It is made in a similar manner to a standard lingual arch with 1.0 mm stainless steel hard wire welded to the lingual aspect of first molars bands (Fig 3), and has the following features:

1) Its level in the anterior region must be 3-4 mm below the gingival margins of the incisors (Fig 4).

2) It includes an inclined guiding plane, made of acrylic resin, fixed on the anterior part of lingual arch, seated on the lingual alveolar mucosa below the level of incisors necks till the level of mouth floor, and it is smooth to allow sliding against the advancement loops during mandibular closing movement to reach its anterior position.

CLINICAL PROCEDURE

Separators are placed mesial and distal to the lower first molars. Subsequently, bands are selected and placed in position (Fig 5A and C). Optionally, construction bite can be taken in an edge-to-edge mandible position. Upper and lower good alginate impressions are taken over the bands, with a good extension in the lingual sulcus. Bands are removed from the mouth and seated accurately in the impressions (Fig 5B and D). The impressions are sent to the laboratory for appliance fabrication. In the sequence, upper molar bands are cemented in position (Fig 6A). The inclined plane supported by lingual arch must be checked for stability, then the lower molar bands are cemented (Fig 6B). On the next day, maxillary part of corrector is attached to the upper molar bands (Fig 7A) by inserting the posterior ends of the retention wires into the headgear tubes. To ensure good stabilization of the maxillary part, an elastomeric ligature is used to tie the band hook and the retention hook together (Fig 7B).

Reactivation visits

Reactivation is generally required about every 2-3 months, and is carried out at the chairside, intra- or extraorally, by bending the advancement loops using orthodontic pliers.

CASE REPORT

Diagnosis

A 10-year 5-month-old girl presented with the chief complaints of the appearance of proclined upper incisors, retro-positioned chin, and dissatisfaction with her gingival smile. The family was concerned about the

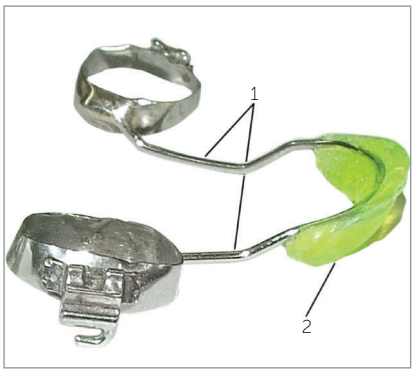

Figure 3 - Components of mandibular part: lingual arch (**1**) and inclined guiding plane (**2**).

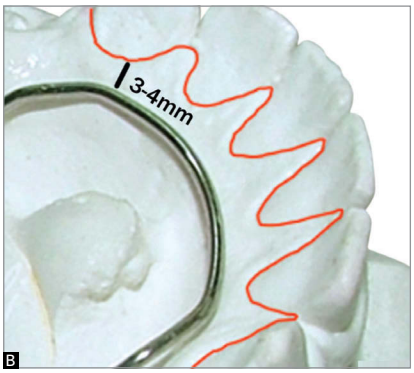

Figure 4 - Level of the lingual arch 3-4 mm below the gingival margin.

lack of facial harmony and anxious for its improvement. The patient reported a history of bad oral habit, lower-lip sucking, many years ago and an early loss of four lower primary molars.

On examination, she presented with a Class II division 1 incisor relationship on a moderate Skeletal II bases. Clinical examination showed a convex-type facial profile with a decreased anterior lower facial height and obviously obtuse nasolabial angle (Fig 8A to C). Pretreatment intraoral examination of her dentition (Fig 8D to I) revealed that the pattern of oral hygiene was good and that she was in the late mixed dentition. The upper and lower labial segments were well aligned and slightly protrusive in appearance. There was some tipping of the lower right canine, first premolar and first permanent molar into the second primary molar extraction site. Apart from this slight constriction in the lower right buccal segment, the lower arch had a good form. In occlusion, the incisor relationship was Class II division I with an increased overjet of 7 mm and a traumatic deep bite of 5 mm (Fig 8E and H). The upper dental midline was coincident with the facial midline, whilst the lower centerline was displaced 1 mm to the right. The molar relationship was an end-on (half unit) Class II on the left side and Class I on the right (Fig 8G and I).

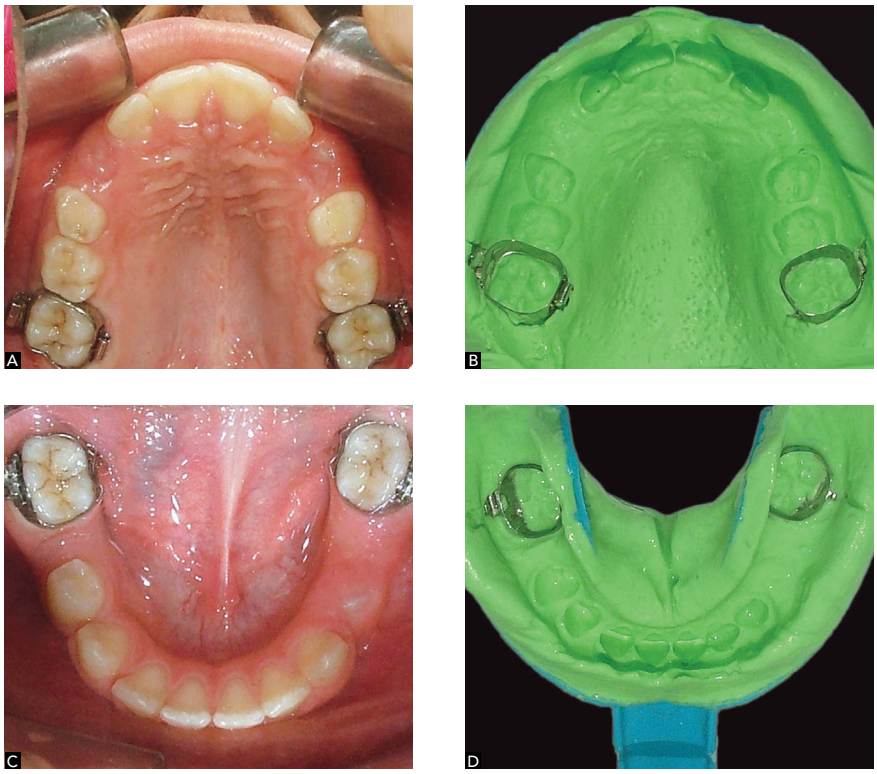

Figure 5 - Molar bands placed in situ (**A** and **C**), and repositioned in alginate impressions (**B** and **D**).

Figure 6 - The upper bands and the mandibular part cemented in place.

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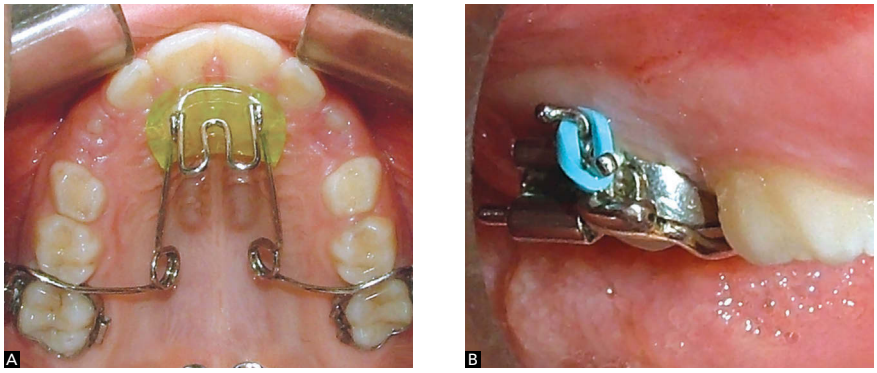

Figure 7 - Maxillary part inserted into headgear tubes (**A**) and an elastomeric ligature placed between the band hook and the retention hook to clip the maxillary part (**B**).

Figure 8 - Pretreatment facial and intraoral photographs (age 10 years and 5 months). Increased overjet and overbite.

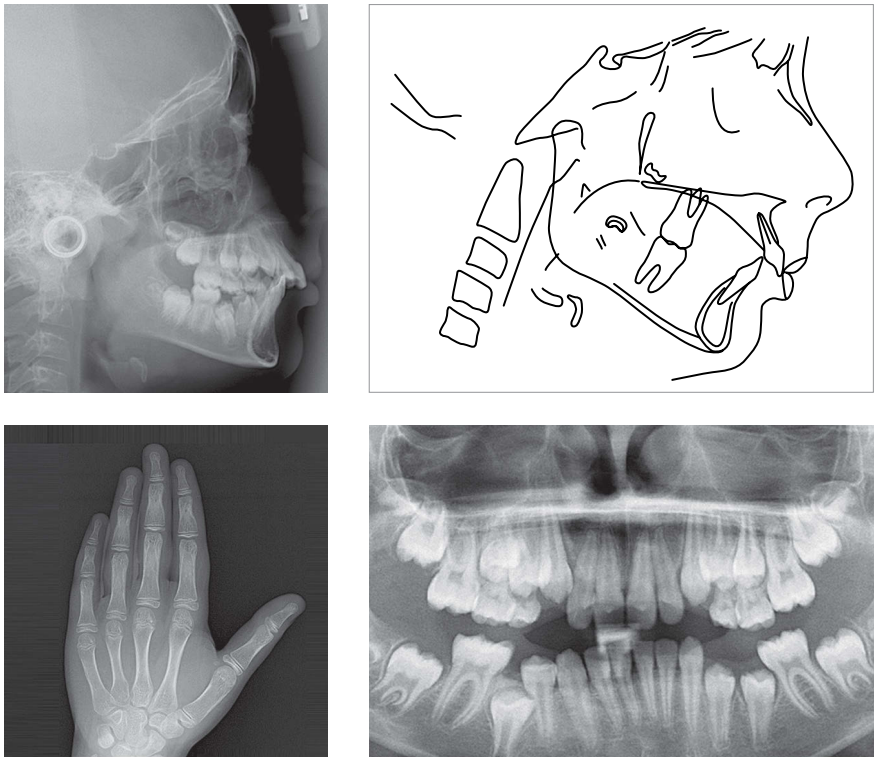

Figure 9 - Pretreatment radiographs and cephalometric tracing.

Cast analysis revealed arch-length discrepancies of +3 mm and -3 mm in the upper and lower arches, respectively. The lower right first molar was mesially drifted. The lateral cephalometric radiograph analysis (Fig 9 and Table 1) confirmed that, skeletally, the patient had a moderate Class II jaw relationship, ANB was 6.5°, and a reduced maxillomandibular plane angle, the ML-NL was 22.5°. Dentally, there was a degree of bimaxillary proclination and the interincisal angle was 120.5°. Soft tissue profile showed that the upper lip was slightly behind 'E' line, and the nasolabial angle was obviously obtuse (124°).

Assessment of hand-wrist radiograph (Fig 9) indicated considerable skeletal growth potential remaining. The patient was in the MP3cap stage.

Panoramic radiograph (Fig 9) revealed no obvious pathology present. The lower right second premolar was impacted. In addition, the third molars were developing.

Table 1 - Cephalometric summary.

variables	T_0	T_1	$\Delta (T_1-T_0)$
SNA (degrees)	84	83	-1
SNB (degrees)	77.5	80	+2.5
ANB (degrees)	6.5	3	-3.5
NSAr (degrees)	128.5	126	-1.5
SNL.NL (degrees)	7.5	7	-0.5
SNL.ML (degrees)	30	31	+1
NL.ML (degrees)	22.5	24	+1.5
U1.SNL (degrees)	108	104.5	-3.5
U1.NL (degrees)	116	111.5	-4.5
L1.ML (degrees)	101.5	98.5	-3
Interincisal angle (degrees)	120.5	126	+5.5
Upper lip (mm)	-1	-2	-1
Lower lip (mm)	1	1	0
Nasolabial angle (degrees)	124	127.5	+3.5

T_0: Pre-treatment records (Fig 9),
T_1: after 8 months and 1 week of orthopedic correction (Fig 13).

Treatment objectives

The objectives of nonextraction treatment for the patient were identified as follows: (1) Reduce the anteroposterior skeletal disharmony; (2) Establish ideal overjet and overbite relationship; and (3) Achieve a functional occlusion with good interdigitation.

Treatment plan

Two-phase nonextraction approach was planned. For the first phase (orthopedic), treatment goal was to stimulate mandibular growth, improving facial appear-

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ance and profile, and reduce the overjet and overbite to an acceptable level (with re-evaluation after 8 months). During the second phase (orthodontic), the goal would be to maintain the improvement achieved in the orthopedic phase, and to obtain a functional occlusion with a Class I molar and canine relationships. Retainers would be placed immediately after appliances were removed for retention purposes.

Treatment progress

At 10 years and 5 months, FLMGM was used to improve skeletal Class II by stimulating mandibular growth. The patient was very motivated with the treatment. An additional motivating factor is the noticeable improvement of facial appearance when FLMGM is fitted. The patient was instructed to bite in an edge-to-edge position and to keep her lips in touch as much as possible (Fig 11). The patient was seen regularly at 6 weeks intervals, and at each visit, the occlusion was checked. The lip seal was maintained throughout treatment. At 11 years and 3 months, to assess the orthopedic changes, only the maxillary part was removed, and a set of facial and intraoral photographs was taken (Fig 12); and radiographs were requested (Fig 13).

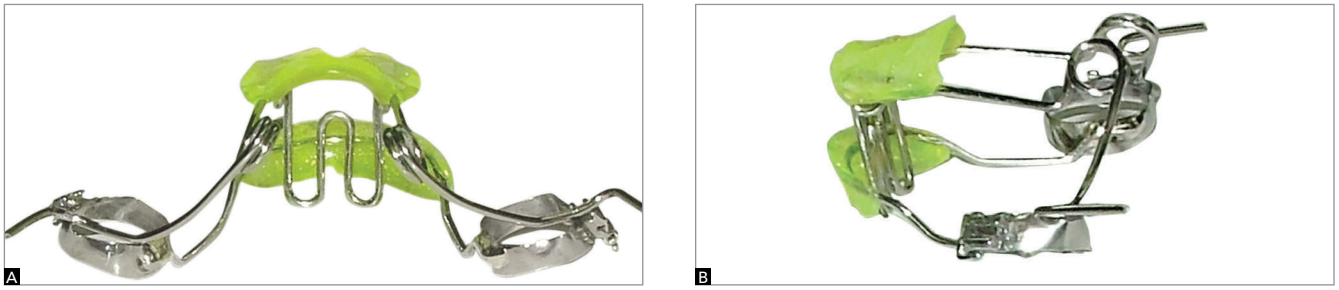

Figure 10 - Design of FLMGM: Posterior (**A**) and lateral (**B**) views.

Figure 11 - Beginning of treatment, the FLMGM in place. Facial and intraoral photographs. The incisors were in an edge-to-edge bite and the lips touching.

Results achieved

Through the course of FLMGM correction, about 8 months, the overjet was reduced from 7 mm to approximately 2 mm, normal incisor and canine relationships were established, vertical eruption of lateral segments was enhanced, the lower midline coincided with the soft tissue midline, and a nice improvement in the facial esthetics and balance were achieved (Fig 12).

Data derived from cephalometric analysis (Fig 13 and Table 1) and superimpositions (Fig 14) reveal that there was continued vertical growth with valuable change in the anteroposterior relationship. Skeletally, ANB angle decreased from 6.5° to 3°, indicating that FLMGM caused skeletal change. Anteroposterior growth of the maxilla was held, although A point still came forward. SNB angle increased by 2.5°, and significant growth of the mandible occurred. ML-NSL angle increased by 1°. Dentally, even with no brackets, the tipped-out upper incisors underwent 4.5° of uprighting, and the lower incisors were extruded and slightly uprighted by 3°, which is considered quite surprising. Eventually, interincisal angle increased to a good value, 130°. In addition to vertical movement, the maxillary first molars also moved distally (Headgear effect) as shown in Figure 14.

Figure 12 - Facial and intraoral photographs immediately after removal of the maxillary part, promoting a normal incisor relationship, with buccal segments partially out of occlusion.

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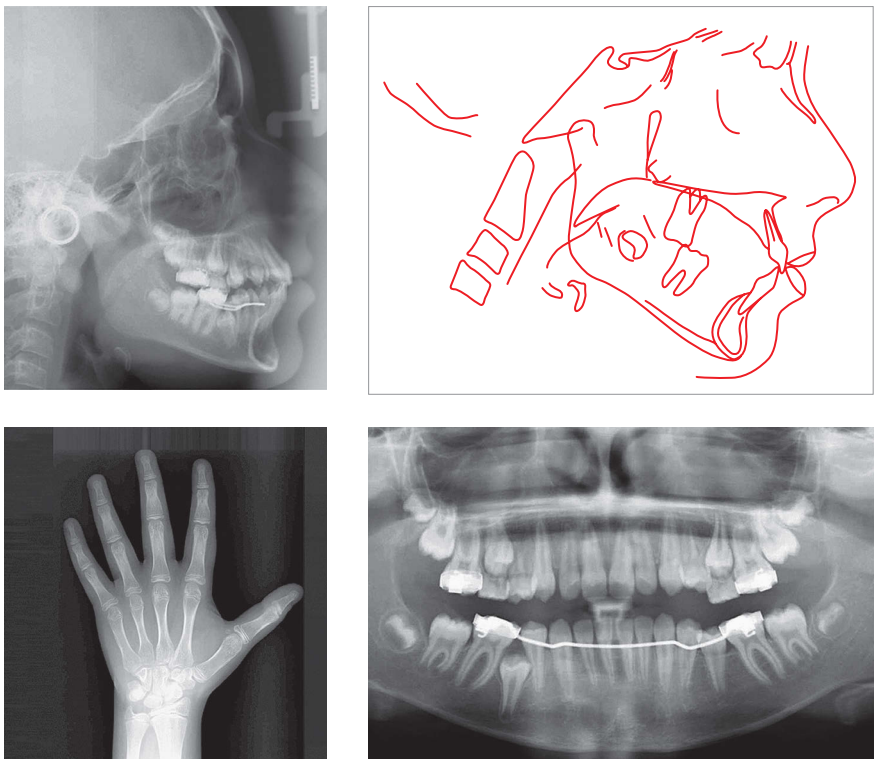
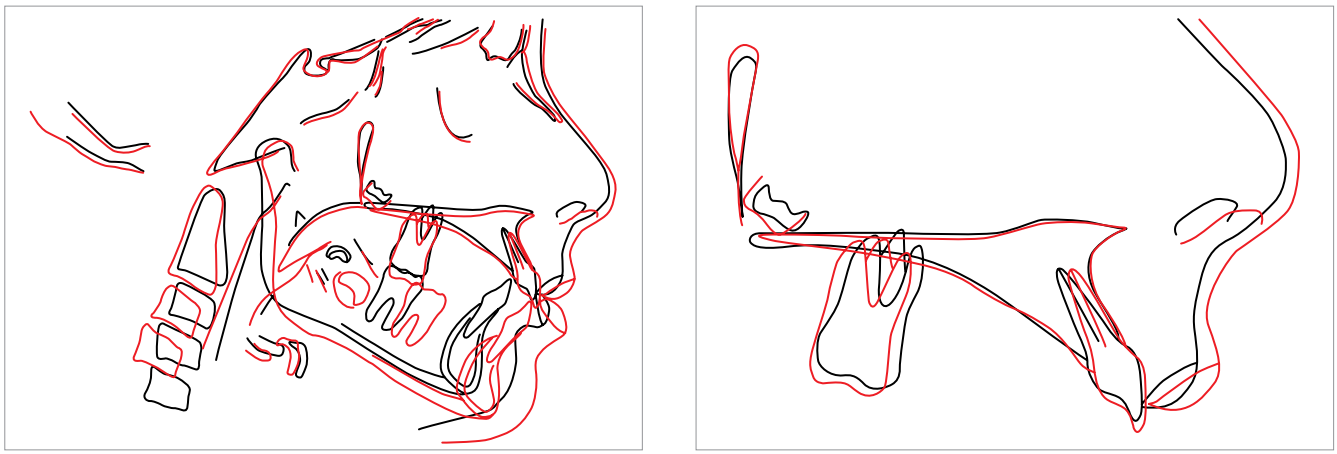


Figure 13 - Radiographs and cephalometric tracing after orthopedic treatment.



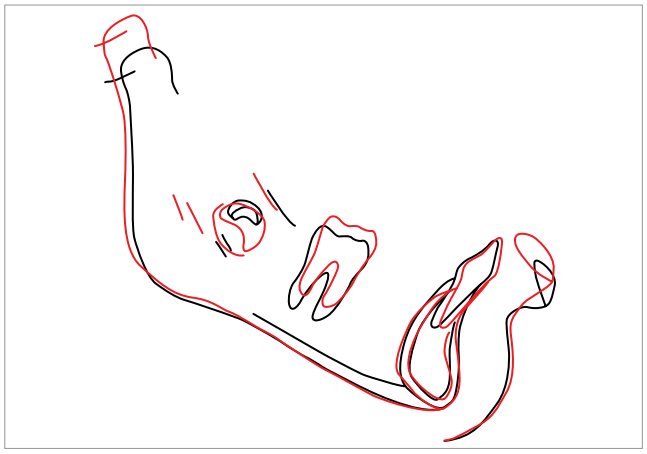


Figure 14 - Superimposition of pretreatment (black) and immediately after orthopedic correction (red) cephalometric tracings on SN line at S. Maxillary superimposition along NL at ANS. Mandibular superimposition on lower border of mandible at Me.

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DISCUSSION

In a growing patient, better aesthetic result would ideally be obtained by using orthopedic appliances to accelerate mandible development.[13-17] The FLMGM has effectively been used by the author in skeletal Class II division 1 patients, and a PhD clinical research is now in progress to identify its effectiveness. In the present case, the author attempted to stimulate mandible growth using FLMGM that was well tolerated without complications. Within 8 months of orthopedic treatment, the overjet was considerably enhanced, and the facial harmony was good. The uprighting of incisors was favorable, and this is believed to be resulting from the mechanism of breaking balance between the tongue and lips. While the vertical loops work as a shield relieving the tongue pressure on the incisors, only lingually-directed functional forces generated by the sealed lips affect the incisors and cause lingual crowns tipping.

Conceptually, FLMGM represents an exercise device for the facial and masticatory muscles, in the same way as other functional appliances. It is proven that muscular training is important factor in the normal development of bone.[18] After the appliance is placed, the patient is asked to keep his mouth closed as long as possible. Once the patient closes his mouth, the inclined plane and the advancement loops will come in contact in the anterior area of the mouth. By continuation of mouth closing, the inclined plane will be forced to slide against the loops, and eventually the mandible will take a predetermined forced anterior position (Fig 15). Functional force, generated by muscles that attempt to return the mandible posteriorly to its original position,[19] causes the upper acrylic button and the lower acrylic inclined plane to apply pressure on the oral mucosa, and this in turn is supposed to cause proprioceptive response that repositions the mandible forward in the same way as the Fränkel II Regulator[20]. In the first period, the patient avoids collision between the loops and the inclined plane by forward-mandibular movement, and with time, the mandible functions without interference in the desired position and the patient will automatically, via neuromuscular reprogramming, close comfortably into the protrusive position. The repetition of the new closure pattern results in orofacial musculature reeducation and induces skeletal adaptation.[19]

Figure 15 - Mode of action.

Figure 16 - Coordination of FLMGM with full-bonded appliance.

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Figure 17 - Mandibular part was modified, and an open coil spring was used to deliver distal force required to distalize the lower right molar. After that, lower right second premolar spontaneously erupted.

Technically, the FLMGM represents a fixed version of the removable double-plate appliance because the two appliances follow an identical mechanism of action, based on incorporating an inclined plane in the mandible and guide bars in the maxilla. The most important two advantages of FLMGM over removable double-plate are: (1) FLMGM is active full-time, regardless of patient cooperation; (2) With FLMGM, the functional appliance phase is not separated from but completely integrated with the bracketed appliance phase (Fig 16). In clinical practices, although not many orthopaedic appliances are suitable for this integration, Dynamax and MARA do approach it.[11,21]

When FLMGM alone in place during orthopaedic or retention phases, fully or partially bracketed appliances can be bonded. Another alternative is to integrate the FLMGM with an existing bracketed appliance. This coordination is a significant feature allowing maximum skeletal Class II correction without extending treatment time and delaying the progress of treatment by eliminating a major drawback of many orthopedic appliances, where there is often a need for an additional interim stabilizing phase, to avoid the relapse which may be seen if the orthopedic phase is abruptly discontinued. Leveling and aligning the dentition and erupting the buccal segment to achieve good interdigitation using fixed appliances, while the FLMGM is maintaining mandibular advancement, is a crucial factor in stability of skeletal correction outcomes.

Extra advantages

• The vertical growth of the alveolus is enhanced during the FLMGM treatment phase, this may be ascribed to two reasons: (1) the upper and lower teeth are free because the FLMGM is supported only by the permanent molars; (2) When the mandible is in a protruded position, there is adequate interocclusal space available for spontaneous eruption.

• The need for permanent extractions may be reduced during mixed dentition FLMGM treatment because the lingual arch maintains the leeway space, and in some cases, it can be modified to help in molar distalization (Fig 17).

• In case of still-active thumb-sucking habit, advancement loops effectively can block the thumb from making contact with the palate.

• In cases associated with lower lip sucking, a lip bumper may be buccally added to the mandibular part of corrector to modify the soft tissue as well.

Disadvantages

• The patient may complain of irritation from the vertically extended advancement loops.

• Swallowing, eating and speaking could be cumbersome, in contrast with buccally positioned appliance, yet the patient accepts it and gets used to it soon.

• Oral hygiene is somewhat difficult in the lower lingual anterior area, but has not been a problem.

CONCLUSIONS

The FLMGM appliance is economic, can be used starting from the mixed dentition and may be effective in stimulating the growth of the mandible and correcting skeletal Class II malocclusions associated with bimaxillary dentoalveolar protrusion. Clinicians can benefit from the unique clinical advantages the FLMGM provides, such as easy handling and full integration with bracketed appliance at any phase.

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Anatomical evaluation of the cervical vertebrae of Wistar rats by means of digital radiographs and its correlation with the maturation stages of human cervical vertebrae

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Introduction: Biological age is an important parameter for growth and development assessment. It can be evaluated through the observation of radiographic changes in skeletal maturation of cervical vertebrae.

Objective: This study aims to: a) verify if there is correlation between growth curve and the stages of bone age of animals used in laboratories, by evaluating radiographs of the cervical vertebrae; b) correlate these stages with their correspondents in humans.

Methods: 35 Wistar rats were evaluated for a period of 160 days, starting at day 22nd (weaning), with cross sections for periodic weighing, length measurement and digital radiography. Radiographs of the cervical vertebrae (C2 and C3) were measured by means of a computer program (Radio IMP). Data were submitted to statistical analysis (ANOVA) and Pearson correlation.

Results: Growth spurt was characterized by fast increasing in weight and length. Through ANOVA, differences were observed in the cervical measurements between days 22, 97, 127, 157, 187 and 217 ($p < 0.001$). A high correlation was found between increasing in body length and weight, as well as in cervical vertebrae height ($r = 0.86$). Increments in concavities of vertebrae were also observed, similar to humans.

Conclusions: There is correlation between body growth and maturation of cervical vertebrae in rats. Despite the continuous development of concavities, it was not possible to clearly identify the 5/6 stages as in studies of cervical vertebrae maturation in humans.

Keywords: Growth and development. Cervical vertebrae. Radiography.

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INTRODUCTION

The understanding of facial growth is indispensable to the orthodontic and orthopedic treatment planning. Treatment of skeletal, dental and muscular discrepancies should focus on mixed dentition, preferably before completion of second dentition[1]. Since the development of structures of stomatognathic system occurs simultaneously with the body growth,[2] the comprehension of the process of growth as a whole, by studying its moments of peaks and stability, is essential.

Obtaining information concerning growth includes the use of laboratory animals. It would not be the ideal though, to compare the effects of proposed therapies for patients with mixed dentition using adult rats. Ideally, they should be studied in the corresponding phases of human growth, so that treatment effects can be evaluated and compared.

This concern about correlating humans and animals according to age is present in recent studies.[3] In order to understand the influence of age on the efficacy of therapies with stem cells, the authors compared stem cell markers in younger (4 months) and older (15 months) rats, suggesting correlation between their findings and therapies in elderly patients.

Besides the use of chronological age, evaluating biological age of humans and animals undergoing growth is also important to establish reliable correlations between them.

The growth process can be assessed by changes in the morphology of different bones during its maturation.[4,5]

The comparison between chronological age and bone age (by means of lateral cephalometric and carpal radiographs) shows that chronological age of a person does not always precisely correlate with the bone age. The latter may present himself advanced or delayed in relation to the first.[6,7,8]

Besides the assessment of cervical vertebrae maturation[9,10,11] and skeletal maturation of the hand and wrist,[12,13] several other methods for measurement of age are studied and compared, such as dental age,[14] variations in height and weight,[4] mandibular growth[15,16] and expression of secondary sexual characteristics,[17,18] each of them used according to the interests of diagnosis.

The cervical vertebrae maturation (CVM) in humans can be classified in five stages (CVM I to V)[19] or six stages (initiation, acceleration, transition, deceleration, and final maturation).[20] This evaluation method is statistically valid and reliable,[19,20,21] presenting the same clinical value to the evaluation of hand and wrist. The inherent advantage of this method would be eliminating the need for radiographs other than those that comprise regular orthodontic exams.

Often the stages of growth and development are studied in laboratory animals based on chronological age.[22] There are, however, no studies evaluating radiographic stages of bone development and its correlation with the development of cervical vertebrae during the pubertal growth in humans.

Thus, this study aimed: 1) to observe, by means of digital radiographs, the anatomical stages of maturation of cervical vertebrae 2 and 3 (C2 and C3) of animals (Wistar rats) during growth, correlating bone age with chronological age, weight and length; and 2) compare cervical vertebrae maturation stages in rats and in humans.

MATERIAL AND METHODS

Ethical aspects

Approval was obtained from the Ethics Committee of Research Involving Animals, School of Dentistry, UNESP-São José dos Campos, protocol 046/2007-PA/CEP.

Characteristics of the animals

Thirty five Wistar rats (*Rattus norvegicus albinus*), 20 males and 15 females, were supplied by the vivarium of the School of Dentistry, Universidade Estadual Paulista Julio de Mesquita Filho, Campus de São José dos Campos - SP.

The study started after weaning of the animals and with the introduction of solid food diet at 22 days after birth. At this phase, their weight was approximately 80-100 grams. The animals were kept in cages, each with five rats in light-dark cycle of 12 hours with controlled temperature and humidity and fed with a balanced diet (Labina®, Guabi - Guabinutrilabor for rats and mice) and water *ad libitum*.

The animals were treated with single doses of polyvalent anthelmintic (Zentel®, São Paulo, Brasil) and multivitamin (Vita Gold Potenciado®, Tortuga Companhia Zootécnica Agrária, São Paulo, Brasil), 40 drops per liter of solution for 5 days.

Completed the periods of observation, the animals were sacrificed by overdose of anesthetic.

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Periods of observation

Considering that within 1.5 months, rats reach their puberty, and after 6 months, they reach maturity,[23] a wide age range was included taking in consideration the need of observation from the initial to the final phase of growing.

All animals were examined 22 days after birth and thereafter, every 14 days until the observation of growth peak. After that, exams were done every 29 days, until the completion of maturity phase and adulthood (160 days), totaling nine acquisitions of radiographic images per animal.

Since rats were observed for more than 7 months, the observation period of this studied included: weaning, puberty and maturity.

In adulthood, each rat month is approximately equivalent to 2.5 human years.[24] It was considered that main changes are expected to happen during the growth peak, explaining the higher frequency of examination during this period.

Preparation of the animals for X-ray analysis

After weighing, the animals were anesthetized with a combination of ketamine chloride (Vetaset®, Fort Dodge Animal Health Fort Dodge, Iowa, USA) dose of 5 mg/kg, associated with xylazine (Rompum®, Bayer S.A. - Saúde Animal, São Paulo, Brazil), sedative, analgesic and muscle relaxant at a dose of 10 mg/kg, administered intramuscularly.

RADIOGRAPHIC ANALYSIS

Protocol of image acquisition of the cervical vertebrae

A wooden table, especially made for this purpose, was adapted for the positioning of the animal in a niche excavated to accommodate the sensor (Fig 1). After immobilization and positioning of the rat through this positioner, a digital radiography was obtained using the system Visualix Gx-S-HDI (Gendex Dental System, Dentsply International, Chicago, IL, USA). This system captures digital radiographic image by means of a CCD sensor (Charge–Coupled Device), with active area of 20.0 mm (width) x 30.0 mm (length). The X-ray machine used was Gendex 765 DC (Gendex Dental X-Ray Division, Dentsply International Inc., IL, USA), set to 65KVp and 7mA. The rats were placed on the sensor positioned parallel to the ground with the central beam of X-rays directed perpendicular to the table. The focus-object distance was 40 cm, 90 degree angle of incidence and duration of exposure to X-rays of 0.01 seconds. The digital radiographic images were stored in JPEG file format.

Anatomical analysis of cervical vertebrae in rats

The animals were followed-up until the final phase of growth (160 days). Each animal had a chart and spreadsheet for analysis of the maturation of cervical vertebrae (C2 and C3) and other growth indices such as body length, weight, chronological age, for comparison of stages of development and growth.

In order to evaluate the growth and anatomical changes of the vertebrae, the diameter, height, width and area were measured and calculated (Fig 2).

The analysis of maturation of cervical vertebrae (C2 and C3) of animals was performed based on the method of Hassel and Farman[20] summarized in Table 1 and schematically shown in Figure 3. The following changes were made to this method: it was used digital radiography and the cervical vertebrae was measured with the Radio IMP software (Radiocef).

Analysis of body length and weight of rats

The body length was measured by a metal rule (Tramontina, RS, Brazil) in millimeters, from the

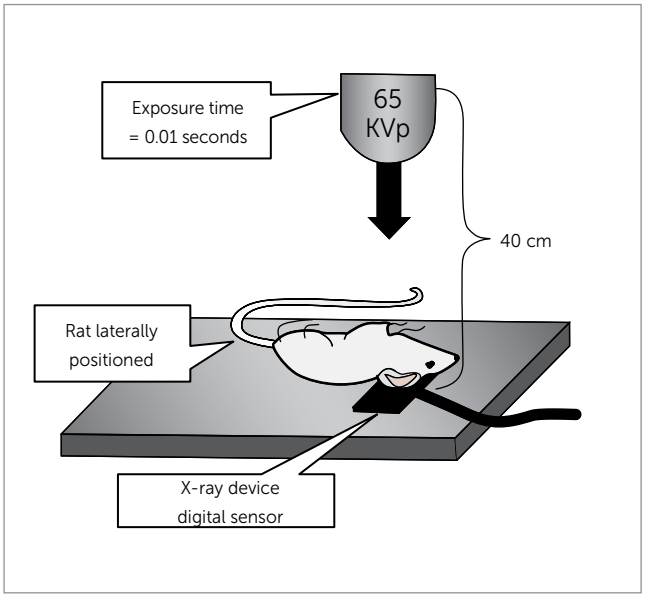

Figure 1 - Schematic representation of radiographs taken using the Visualix Gx-S-HDI system.

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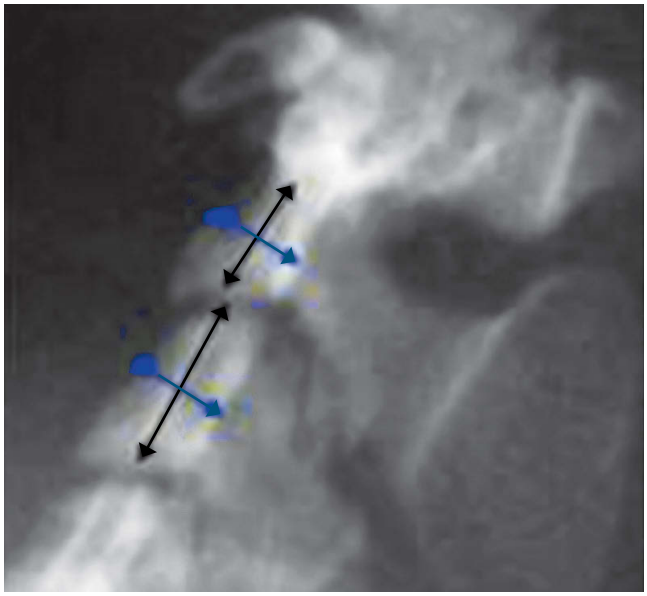

Figure 2 - Digital radiography in lateral view of cervical vertebrae (C2 and C3) of adult rat, for linear measurement.

Table 1 - Maturation stage of cervical vertebrae.

Stage	Growing activity	Inferior margin	Vertebrae morphology
Initiation	High	Flat (C2, C3, C4)	Triangular
Acceleration	High	Concavity (C2 and C3) Flat (C4)	Rectangular (C3) (width> height)
Transition	Moderate	Apparent concavity (C2 and C3) Initial concavity (C4)	Rectangular (width> height) (C3, C4)
Deceleration	Low	Apparent concavity (C2, C3 and C4)	Squared (C3, C4)
Maturation	Insignificant	Accentuated concavity (C2, C3 and C4)	Squared (C3, C4)
Final	Completed	Deep concavity (C2, C3 and C4)	Rectangular (height > width)

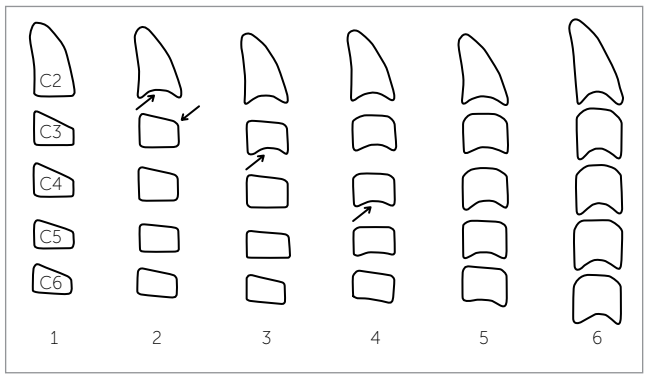

Figure 3 - Six stages of maturation of cervical vertebrae according to Hassel and Farman[20].

outer portion of the nose to the beginning of the tail. The animals were weighed on a digital scale (Filizola BP15, Campo Grande, MS) in grams.

Statistical analysis

Normality test (Anderson-Darling, through Minitab 16 Software) was done and it was verified that the variables were normally distributed. Data were then tested for analysis of variance (ANOVA) and Pearson correlation.

RESULTS

Sequences of measurements and analysis of gradual length and weight

An increase in weight and length was observed for all animals (Tables 2 and 3).

Statistically significant differences were found between males and females in relation to weight. As expected, greater weight was found in males, when compared to females.

Three distinct phases could be observed:

1) Growth spurt from the weaning day to their 10-13th week, when females and males respectively reached 250% and 350% of their initial weight.

2) Slow growth period: from 10-13th to 27th week.

3) Final growth phase: when males continued to gain weight, while females stabilized (Fig 4).

In relation to length, the first and second phases were very similar to the weight curve. In the growth spurt phase, the animals increased approximately 70% of their initial length. After that, increasing in length became slow and constant.

The final phase of growth was observed when losses or gains in weight were observed and length (Fig 5) was constant. The breeding phase began before the end of the growth in length and weight, corresponding to a month old.

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Table 2 - Mean body length and weight of females.

	Days of life								
	22	37	52	67	97	127	157	187	217
Weight (g)	87	125.03	190	231.33	357	405.66	454.33	500.66	511.66
Length (cm)	13.85	16.13	18.82	20.73	23.16	24.23	24.86	25.36	26

Table 3 - Mean body length and weight of males.

	Days of life								
	22	37	52	67	97	127	157	187	217
Weight (g)	87.5	154.4	206.5	235	273.2	279.8	285.5	317.5	317
Length (cm)	13.55	16.88	19.1	19.9	21.25	21.3	21.75	22	22.05

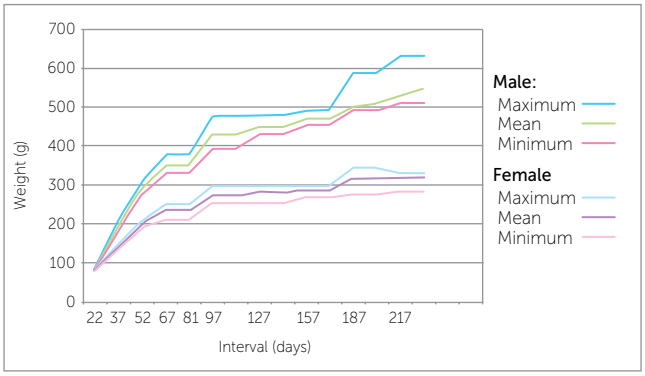

Figure 4 - Graphical representation of mean, minimum and maximum weight for females and males.

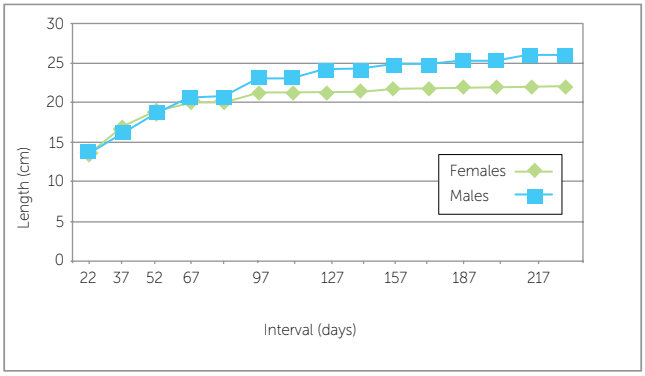

Figure 5 - Graphical representation of the mean length of females and males.

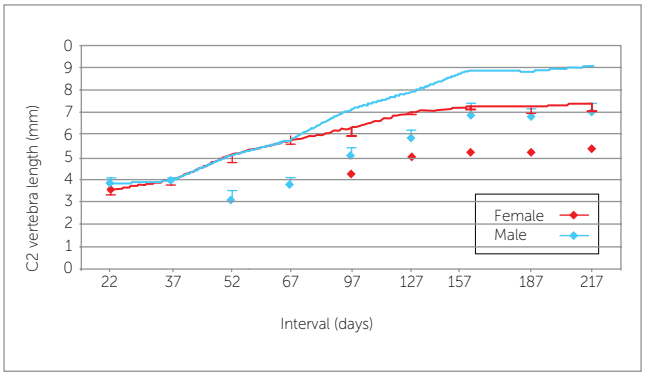

Figure 6 - Graphical representation of the growth of vertebra (C2).

Results of changes in cervical vertebrae of rats according to the Radio IMP software

Repeated Measures Analysis of Variance showed that males and females presented significant differences in height of the cervical vertebrae along the assessments ($p < 0.001$).

Cervical vertebrae showed statistically different values between days 22, 97, 127, 157, 187 and 217 ($p < 0.001$) but presented similar values on days 37 ($p = 0.5489$), 52 ($p = 0.9852$) and 67 ($p = 0.7560$) (Fig 6).

Increasing of the cervical vertebrae was relatively constant from weaning day to 22nd week. After that, a stable phase was observed.

In relation to morphological changes, increasing in concavities on the bottom edge of the vertebrae of the animals was observed. From the radiographic exams, these changes allowed the differentiation of stages: Initial, growth spurt and final.

According to Pearson correlation, a high correlation ($r = 0.86$) was found between changes of cervical vertebrae and growth (increase in body length). The height and width of C2 and C3 vertebrae of rats increased along with growth.

DISCUSSION

In the present study, increasing in concavities on the bottom edge of the vertebrae of the animals was observed according to chronological age, consistent with studies about bone maturation in humans.[4]

While in humans, increasing of height of the vertebrae is observed during the entire period of growth regardless of sex,[4] the present study presented higher values for males than females.

In rats, it was not possible to clearly identify the five or six stages as in studies of human cervical vertebrae.[18,19]

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Even in humans, however, there are still some difficulties regarding the identification of the maturation stage. The comparison of three mostly used methods for cervical vertebrae in orthodontic patients shows that the determination of skeletal maturation stage via cervical vertebrae has satisfactory clinical applicability.[25] However, it is also suggested modifications in order to facilitate the classification of the maturation stage.

Width measurements showed considerable oscillations, probably depending on the difficulty to position the rats during radiograph exam.

Even with the standardization of the position of the rats, a minimum of rotating or tilting the animal's head in relation to the body may have caused differences in measuring the widths of the cervical vertebrae, causing differences in the results.

It is suggested that among the cervical vertebrae, one should also be studied is the axis (first cervical vertebra) due to its relationship with the articular function and positioning of the head of the animal / patient.

Height measurements for vertebrae C2 and C3 increased according to body growth (increase in length and weight) in animals.

The existence of good correlation between the changes in the concavity of the lower border, height, and shape of cervical vertebrae in humans,[26] in accordance to this study, suggests that these parameters are useful to evaluate maturation of cervical vertebrae.

Unlike what is expected in humans, however, there were no differences between rats with regard to body length and height of the vertebrae, which should be explained due to the environmental standardization and parity in the growth of animals.

The same strain, same food and space are factors that may have influenced the growth pattern of the animals, causing them to reach the same stability in the final period of growth.

In this context, we suggest a new study with different food and environment for observation of differences in growth and development between the animals.

The weight, especially in males, showed significant differences. Part of this difference in weight is due to fat accumulation. The length and weight of females was significantly smaller than males, even with the same food.

Comparisons between chronological and bone age show that in humans, there is a significant correlation between them. Besides that, the correlation is higher between radiographs of cervical vertebra and hand and wrist, than chronological age.[27]

Also regarding the relation between growth and the maturation of the vertebrae, as well as development of mandibular length and height, significant increments during growth are present for all parameters, demonstrating that the analysis of cervical vertebrae maturation is an appropriate method for assessing the mandibular bone maturity by the analysis of lateral cephalometric radiography.[28]

CONCLUSIONS

A high correlation was found between increasing in body length and weight, as well as in cervical vertebrae height.

Cervical vertebrae of rats showed growth in length, a slight increase in width and continuous development of concavities. However, it was not possible to clearly identify the five or six stages described in studies of cervical vertebrae maturation in humans.

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Effect of moisture on dental enamel in the interaction of two orthodontic bonding systems

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Objective: The purpose of this study was to assess by means of scanning electron microscopy (SEM) the remaining adhesive interface after debonding orthodontic attachments bonded to bovine teeth with the use of hydrophilic and hydrophobic primers under different dental substrate moisture conditions.

Material and Methods: Twenty mandibular incisors were divided into four groups (n=5). In Group I, bracket bonding was performed with Transbond MIP hydrophilic primer and Transbond XT adhesive paste applied to moist substrate, and in Group II a bonding system comprising Transbond XT hydrophobic primer and adhesive paste was applied to moist substrate. Brackets were bonded to the specimens in Groups III and IV using the same adhesive systems, but on dry dental enamel. The images were qualitatively assessed by SEM.

Results: The absence of moisture in etched enamel enabled better interaction between bonding materials and the adamantine structure. The hydrophobic primer achieved the worst micromechanical interlocking results when applied to a moist dental structure, whereas the hydrophilic system proved versatile, yielding acceptable results in moist conditions and excellent interaction in the absence of contamination.

Conclusion: The authors assert that the best condition for the application of primers to dental enamel occurs in the absence of moisture.

Keywords: Dental primer. Scanning electron microscopy. Orthodontic brackets.

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INTRODUCTION

Bonding procedures are based on histomorphological changes occurring in the enamel due to the action of surface treatments initially proposed by *Buonocore* in 1955,[5] who noted that the action of acid substances on the adamantine structure enables a micromechanical interaction between resinous materials and etched/conditioned dental enamel.

Subsequently, findings disclosed by Buonocore were used in Orthodontics (1970), producing undeniable clinical benefits.[2,5] This bonding mechanism remains in use to this day despite numerous changes undergone by orthodontic attachments as well as adhesive systems.

Such benefits led to some unfavorable clinical situations, namely: increased likelihood of injuries to dental enamel structures occurring after bracket removal, since this procedure may damage the enamel surface due to great bond strength.[1-5] Furthermore, resin remnants remain bonded to the enamel and may not only induce plaque accumulation, but also undermine esthetics.[2,5]

Therefore, when choosing a bonding system one should consider the type, concentration and etching/conditioning time, selecting the less deleterious systems,[4,5] thereby preserving clinical performance.

New bonding systems which blend into one single product both etching and primer materials, have been proposed. With the development of one-step self-etching systems,[1-5] an estimated reduction of 65% in the time required for bonding orthodontic brackets was achieved,[1,2] thus, decreasing the risk of surgical field contamination by oral fluids. Nevertheless, the effects of these bonding agents on tooth enamel have been questioned by lab and clinical studies.[8-11]

New hydrophilic bonding systems have been launched into the dental market. These products address substrate contamination without interfering in the orthodontic bonding process.[6,18,23,25,28]

The foregoing considerations emphasize the importance of shedding light on the true nature of the interaction between hydrophilic primers and dental enamel, and comparing it with the performance of a conventional bonding system under various substrate conditions.

Objective

This research aims at assessing — by means of scanning electron microscopy (SEM) — the remaining adhesive interface after debonding orthodontic attachments bonded to bovine teeth with the use of hydrophilic and hydrophobic primers under different dental substrate moisture conditions: a) Moisture interference in the systems used in this study; b) Advantages of the micromechanical interlocking system under different conditions; c) Systems that provide the best results.

MATERIAL AND METHODS

The sample for this *in vitro* study consisted of 20 permanent bovine incisors[18] freshly extracted from three-year old heifers or steers confined in slaughterhouses. After cleaning the teeth, they were stored in aqueous 0.1% thymol until use.[5-12,17,26]

Cracks were detected in the enamel by transilluminating the buccal surface of the teeth[12] with the aid of a stereomicroscope with 1.2 x magnification. Only those teeth which were free from cracks and carious lesions on all surfaces, were selected.

In order to render the buccal surfaces more regular, flat and smooth, they were polished for 10 seconds with a rotary polisher (Buehler Ecomet 3) using silicon carbide discs (Buehler) at 150 rpm in decreasing grain size order (320, 600, 800, 1200).

Afterwards, the crowns were polished with felt discs (Buehler) Texmet 1000 soaked in 1 μm diamond suspension, followed by 0.3 μm suspension (Fig 1).

Subsequently, teeth were randomly divided into four groups according to bonding system and substrate condition (Table I). Pre-adjusted stainless steel maxillary central incisor brackets (Abzil.Lancer) with mesh bases (two-point welding) were bonded to all specimens.

Group I: Specimens had Transbond MIP adhesive system applied according to the manufacturer's recommendations, followed by prophylaxis of the enamel buccal surface carried out by means of pumice, water and a Robinson brush at low speed. In the following step, the enamel surface was etched with phosphoric acid at 37% for 15 seconds. The entire substrate was then washed with distilled water and excess was removed with absorbent paper, always preserving tissue moisture. Primer was then applied using the brush that comes with the product, followed by gentle jets of compressed air for about 5 seconds.

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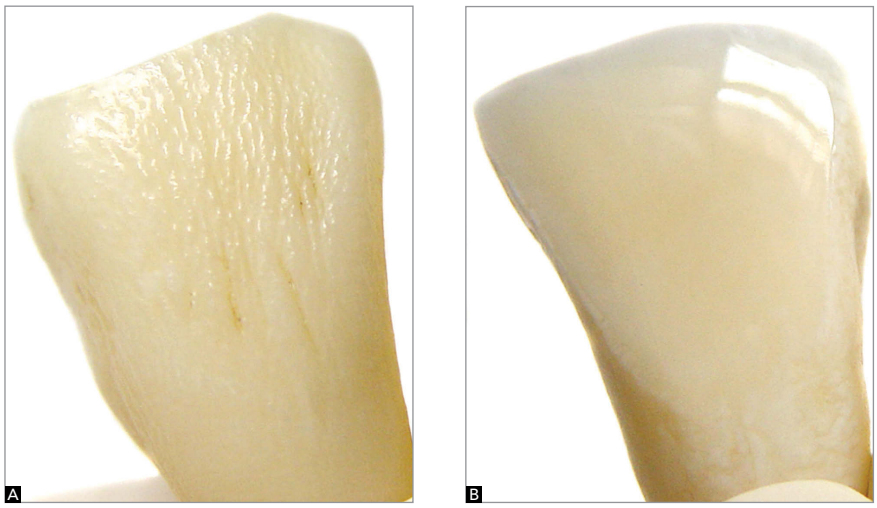


Figure 1 - Bovine teeth before (**A**) and after (**B**) polishing the buccal crown surfaces.

Table 1 - Experimental groups, orthodontic bonding material and substrate condition.

Group	n	Bonding material	Manufacturer	Batch	Substrate
I	5	Transbond MIP (*Moisture Insensitive Primer*)	3M/Unitek Dental Products	6KN 2008-10	Moist
II	5	Transbond XT	3M/Unitek Dental Products	6CW/6WB 2007-09	Moist
III	5	Transbond MIP (*Moisture Insensitive Primer*)	3M/Unitek Dental Products	6KN 2008-10	Dry
IV	5	Transbond XT	3M/Unitek Dental Products	6CW/6WB 2007-09	Dry

Transbond XT light cure adhesive was subsequently applied to the bracket bases under a pressure of 300g, measured with a tension gauge (Dontrix, ETM Corporation, Monrovia, CA),[18] to determine the minimum compression weight and ensure similar paste flow on all teeth. Excess was removed with the aid of an explorer #5 (Duflex SSWhite) accurately circumscribing the Orthodontic Bonding Area (OBA).

Soon afterwards, the materials were light cured for 10 seconds on the mesial and 10 seconds on the distal surface by means of an Ultralux (Dabi Atlante, Ribeirão Preto, Brazil) curing light of 500mW/cm^2 intensity. The specimens were then immediately debracketed with debonding pliers/AEZ (Ormco Corp. Glendora, CA, USA). The pliers tips were positioned at the bracket/adhesive interface and brackets were pulled off (Fig 2).

Group II: A conventional bonding system was applied to the specimens in this group (Table 1), which underwent the following steps: prophylaxis, etching, substrate moistening, excess removal and light curing, performed in the same manner as described for Group I, except that for the latter group bonding was performed with Transbond XT adhesive system associated with acrylic resin cement. The specimens were then immediately debracketed using the technique previously described.

Group III: Brackets were bonded to these specimens by means of the Transbond MIP bonding system. The same steps described for Group I were performed, but after etching, washing and drying the tooth surface, the enamel remained completely dry.

Group IV: Brackets were bonded using the conventional bonding system (Transbond XT - 3M Unitek Dental Products) following the same procedures performed for Group II, but under the same substrate conditions adopted for Group III.

All brackets were bonded by a single operator to minimize random errors.

Preparing the specimens for electron micrograph

In order to assess the adhesive interface, two teeth from each group were cut with a diamond disc

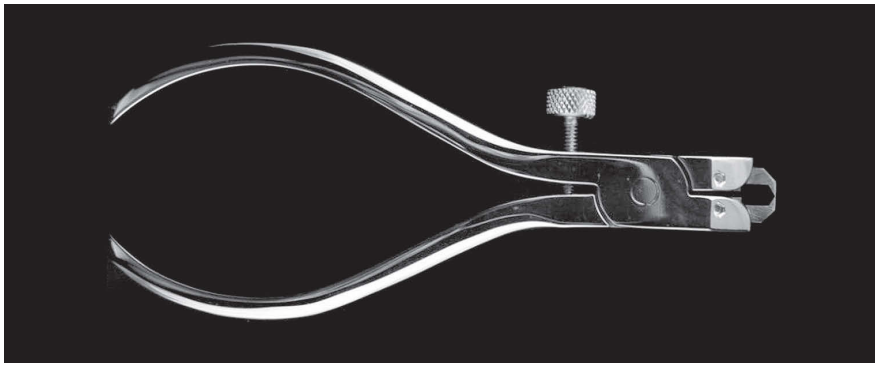
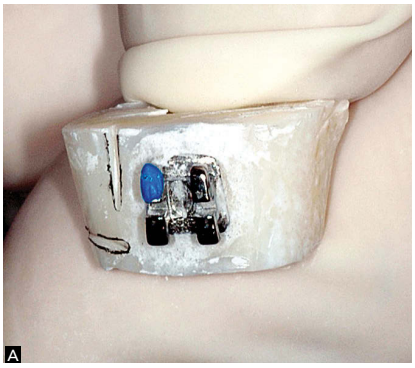


Figure 2 - Debonding plier.



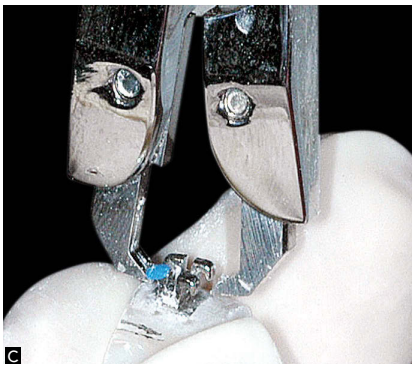


Figure 3 - **A**) Specimen cut in the orthodontic bonding area. **B**) Sectioning nearly as far as the buccal enamel. **C**) Debracketing using debonding pliers/AEZ, **D**) Specimen after debonding.

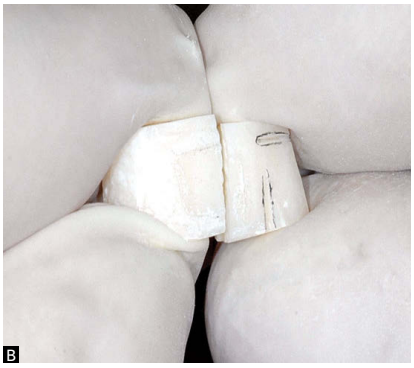


Figure 4 - **A**) Chisel in position to perform fracture. **B**) Specimen transversely fractured for SEM assessment.

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(Buehler, Lake Bluff, IL, USA), yielding small dental fragments where the brackets had been previously bonded (Fig 3).

The area was subsequently fractured with a gouge chisel tip (Duflex SSWhite) to enable microscopic analysis of the adhesive interface (Fig 4). To highlight such an interface, etching was carried out with phosphoric acid for 5 seconds and rinsed with water for 20 seconds.

The fragments obtained from each specimen were placed on stubs, identified and metallized with gold alloy to render the surface electrically conductive (Fig 5).

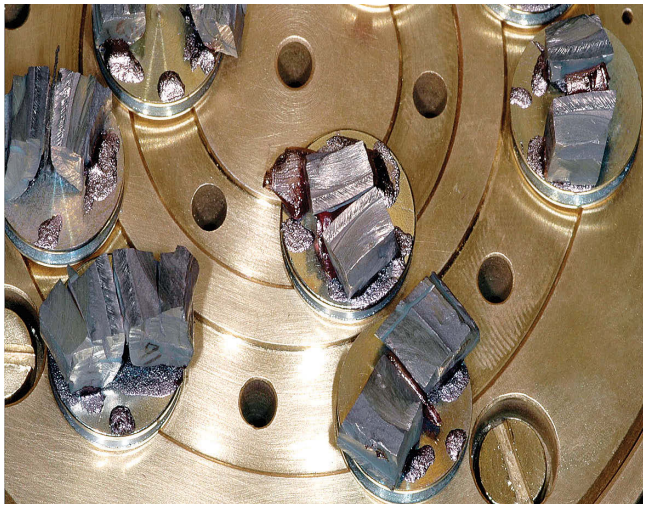

Figure 5 - Metallized specimens placed on stubs.

Microscopic analysis of the adhesive interface

The SEM device (JEOL JSM5600 LV, Japan) was set at 13KV voltage acceleration at a working distance of 30 mm. Images were obtained at 1300, 3000, 6000-times magnification. The adhesive interface underwent qualitative analysis and the photographed regions were representative of each specimen.

RESULTS

The most representative regions of each specimen were evaluated, taking into account the adhesive interface (assessment at 1400 X) and the quality of the micromechanical interlocking (assessment at 1300 X, 3000 X and 6000 X magnification).

In Group I, the adhesive interface showed good micromechanical interlocking, developing tags (T) and few gaps (L), indicative of decalcified regions not fully filled with adhesive material, possibly due to the presence of water. In general, these characteristics indicate that Transbond MIP hydrophilic adhesive system had a satisfactory interaction with the enamel, even in the presence of moisture (Fig 6A).

This interaction was better assessed after removing the mineral content, assessing the micromechanical interlocking and the surface topography of adhesive remnants at 1300X, 3000X and 6000X magnification (Figs 6B, 6C and 6D).

Figure 6B reveals that there was homogeneous penetration of the adhesive system across the study area (Ad), showing that the presence of moisture did not prevent the adhesive from penetrating the etched area. Here, the presence of Gaps (L) in etched areas are more evident, which enables increased penetration of the adhesive material.

At higher magnifications (Figs 6C and 6D), it appears that there was in-depth micromechanical interaction in the enamel structure, preserving much of the mineralized prismatic area (Ep), although in some places there was partial dissolution of the rods generating nano interlocking areas with inter-crystallite adhesive penetration (Pic).

Group II showed (Fig 7A) the presence of clear, extensive and wide gaps (L) all over the bonding interface. These observations confirm that the presence of moisture, to some extent, insulated the substrate and did not allow satisfactory micromechanical interlocking to take place, since irregular and scarce tags (T) became visible in restricted and isolated areas.

With the removal of the mineral content (Figs 7B, 7C and 7D), the bonding system (Sc) showed irregular topography and the presence of gaps (L). This means that water filled most of the area that had been demineralized by the phosphoric acid, which not only prevented the inter prismatic spaces from being filled up, but also hindered inter crystallite penetration by the adhesive system.

As for Groups III and IV, (teeth treated with Transbond MIP hydrophilic primer and hydrophobic Transbond XT Primer (Sc), respectively) the enamel/adhesive interface (Figs 8A and 9A) showed good micromechanical interaction with the enamel (E), absence of cracks and the development of numerous and continuous tags (T). These characteristics demonstrate that the application of phosphoric acid followed by rinsing and drying of the surgical field, produces excellent adhesive interfaces regardless of the primer used for bonding.

At larger amplitudes and after removal of the mineral content (Figs 8B and 9B), it became apparent that

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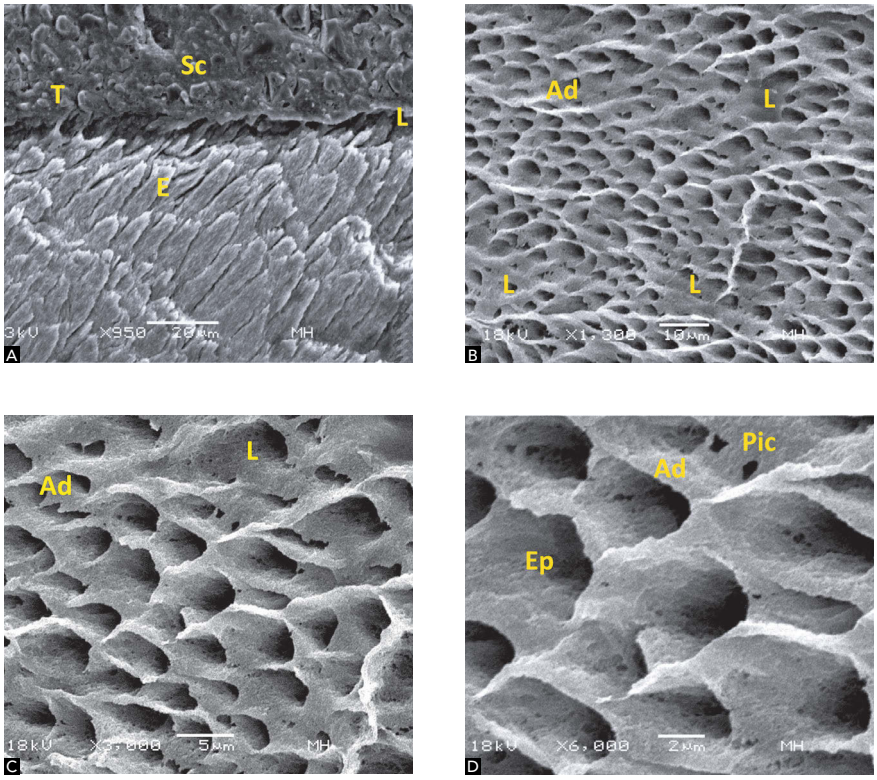

Figure 6 - Electron micrographs: Moist MIP and enamel bonding interface. **A**) Relationship between the material and the enamel surface (950X) showing irregularities in the interaction between primer/enamel, areas with gaps (L) and presence of tags (T). **B**, **C** and **D**) Irregular primer surface after enamel dissolution. Images at 1300X, 3000X and 6000X.

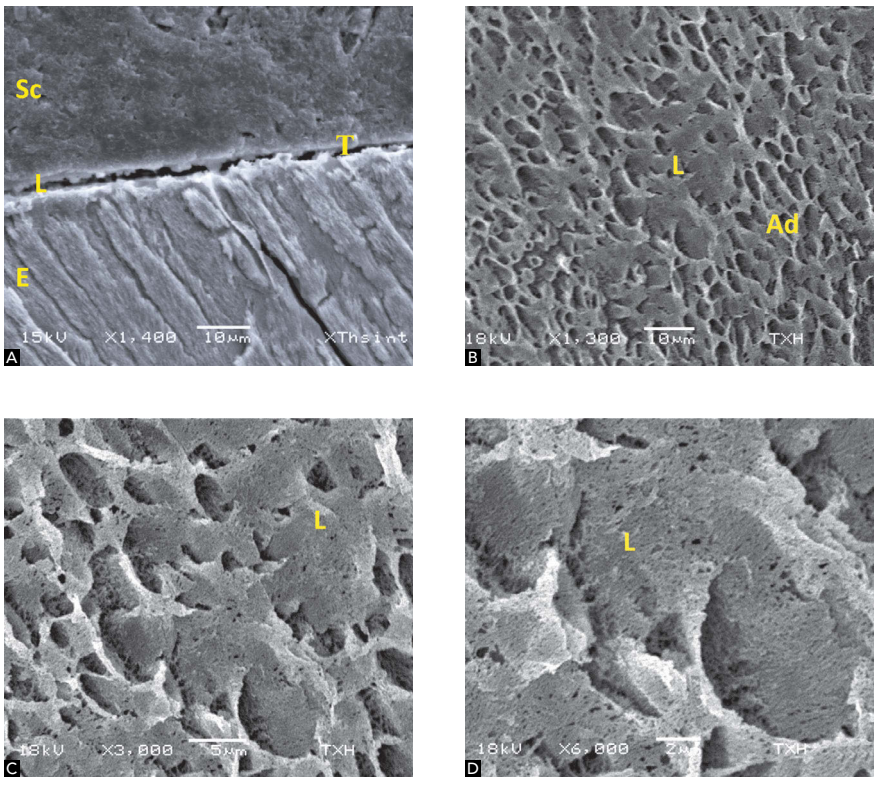

Figure 7 - Electron micrographs: Adhesive interface and interlocking achieved by the Transbond XT bonding material in moist conditions. T-Tags, Sc-Bonding system, L-Gaps, E-Enamel, Ad- Primer. Images at 1400X, 1300X, 3000X and 6000X magnification.

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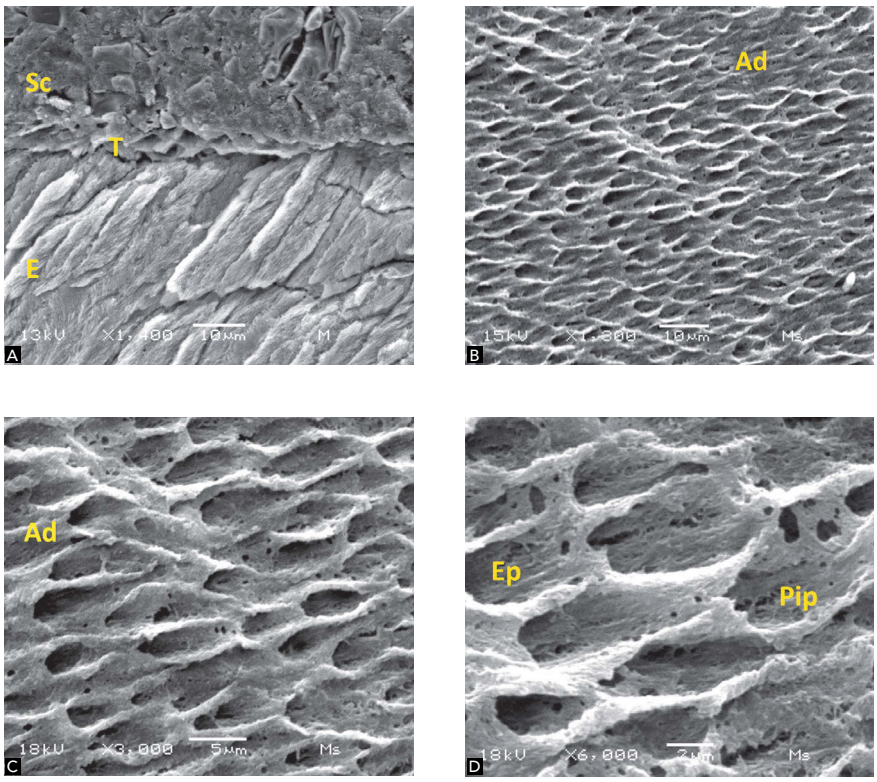

Figure 8 - Electron micrographs: Bonding interface and interlocking achieved with Transbond MIP in the absence of moisture. T-Tags, Sc-Bonding system, E-Enamel, Ad-Primer, Ep-Space occupied by the rods, Pip-Inter-crystallite penetration. Images at 1400X, 1300X, 3000X and 6000X magnification.

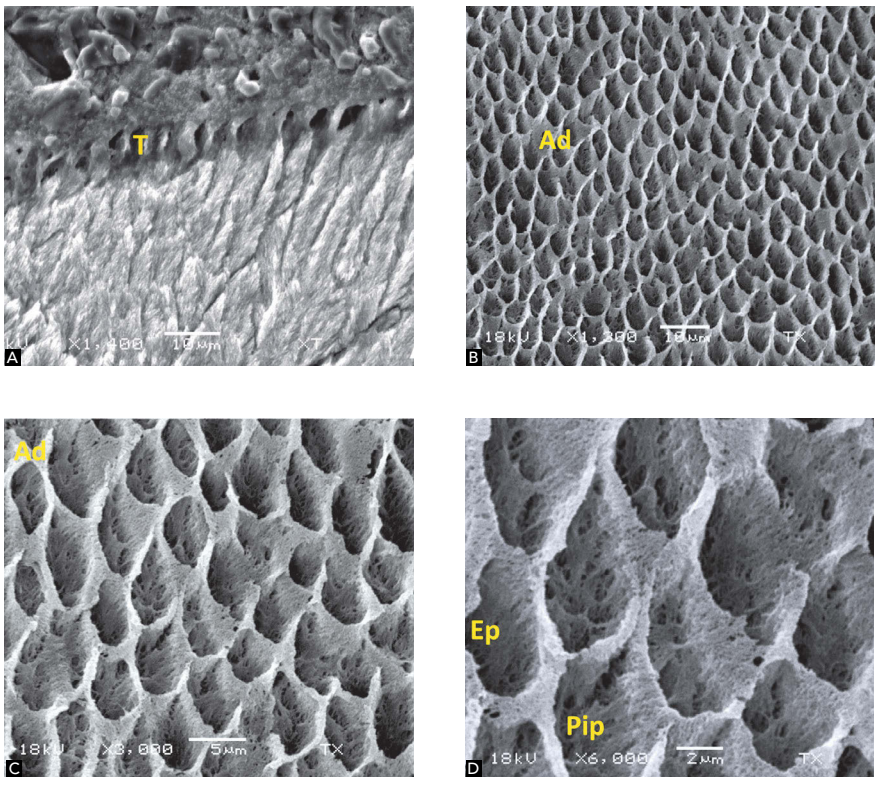

Figure 9 - Electron micrographs: Bonding interface and interlocking achieved with Transbond XT bonding material in the absence of moisture. T-Tags, Sc-Bonding system, E-Enamel, Ad-Primer, Ep-Space occupied by the rods, Pip-Inter-crystallite penetration. Images at 1400X, 1300X, 3000X and 6000X magnification.

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interlocking was consistent in the interprismatic spaces without the presence of gaps, which had been previously occupied by water. This fact indicates that the primer (Ad) penetrated into all previously etched areas.

Figures 8C, 8D, 9C and 9D show excellent penetration of both primers. Likewise, the spaces occupied by the rods (Ep) are clear, with the primer also penetrating the inter-crystallite spaces (Pip), thus, highlighting excellent bond strength.

DISCUSSION

Hydrophilic adhesive systems are used in restorative dentistry to ensure interaction with the dentin tissue, which is inherently moist. In this structure, etching — in association with these systems — forms a hybrid adhesive layer and dentin tags, i.e., structures that play an essential role in successful direct and indirect restorations.

During bracket bonding processes, enamel surface contamination, by blood, saliva or oral cavity moisture, is a major concern. Therefore, moisture insensitive primers are also suitable for bonding orthodontic attachments.

This research analyzed the adhesive interface of hydrophilic and hydrophobic bonding materials under different substrate conditions using scanning electron microscopy (SEM). This method provides good image resolution, allowing detailed observation of the substrate and the interfaces produced by adhesive systems.[2,4,5,8,16,18,19,23,25,28]

The results demonstrate that the specimens in Group I developed adequate micromechanical interlocking between adhesive system and enamel, forming resin tags in the interprismatic spaces, although cracks and/or gaps were also observed in some regions. This performance, even in the presence of moisture, is possibly related to the composition of the primer.

The outcome of this study may explain the findings of Cacciafesta et al,[18] who achieved the highest bond strength in contaminated enamel using hydrophilic systems. This study emphasizes the limitations of using hydrophobic systems in contamination cases in which the substrate had been previously etched.

No adhesion relation was observed in specimens of Group ll, which showed low interaction between enamel and primer, allowing the formation of gaps in the adhesive/enamel interface and a lack of tags which, even when present, were restricted to small areas. These observations are also justified by the composition of the primer, which contains no carrier or hydrophilic resin monomers. Thus, once the etched area is moist, a reliable bonding interface is unlikely to develop if moisture control is not absolute. Webster et al[30] compared the effectiveness of these materials in moist conditions, and concluded that when hydrophobic primers are used in moist conditions they provide low bond strength.

The results yielded in Groups III and IV showed that, in the absence of moisture, all bonding systems used in this investigation displayed micromechanical interaction with the enamel structure and the development of numerous, continuous, gap-free tags. Undoubtedly, successful bonding could only be achieved through the demineralizing action of phosphoric acid, which removed the aprismatic layer and exposed the spaces between the enamel rods. When these spaces were present on a surface with high surface energy and no contamination, they were easily filled by the primers, which also exhibited low viscosity. The findings of this study corroborate those of Cal-Neto et al,[19] who used SEM to assess the behavior of conventional hydrophobic primers in dry conditions, noting that there was adequate bonding between adhesive and enamel with the development of long, uniform tags and adequate micromechanical interlocking.

Data from this study associated with those obtained from the literature allow the authors to assert that the best condition for the application of primers to dental enamel occurs in the absence of moisture, regardless of bonding system features. However, the use of moisture insensitive (hydrophilic) systems is recommended, given the clinical impossibility of ensuring that the application areas are 100% dry.

CONCLUSIONS

This study led the authors to conclude that: (a) the absence of moisture in etched enamel enabled better interaction between bonding materials and the adamantine structure; (b) the hydrophobic primer achieved the worst micromechanical interlocking results when applied to a moist dental structure; and (c) the hydrophilic system proved versatile, accomplishing acceptable results in moist conditions and excellent interaction in the absence of contamination.

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Comparison of shear bond strength of orthodontics brackets on composite resin restorations with different surface treatments

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Introduction: Orthodontic patients frequently present composite resin restorations, however there are few studies that evaluate the best way for orthodontic bonding in this situation.

Objective: The objective of this work was to evaluate the bond strength of orthodontic brackets in resin restorations with surface treatment.

Methods: Fifty one bovine lower incisors were randomly divided into three groups. On the control group (CG) the brackets were bonded to dental enamel; on experimental groups, brackets were bonded to resin restoration with diamond drill treatment (EGT) and with no treatment (EGN). The teeth were placed in PVC tubes with autopolymerized acrylic resin. The shear test was performed in EMIC universal testing machine. The groups were submitted to ANOVA analysis of variance with Tukey post test to verify the statistical difference between groups ($\alpha = 0.05$).

Results: CG (6.62 MPa) and EGT (6.82 MPa) groups presented similar results, while EGN (5.07 MPa) obtained statistically lower results ($p < 0.05$).

Conclusion: Therefore, it is concluded that the best technique for bonding of orthodontic brackets on composite resin restorations is the performance of surface detritions.

Keywords: Shear bond strength. Dental restoration. Dental bonding

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INTRODUCTION

The direct bonding of brackets became a conventional protocol after innumerable studies that proved its effectiveness, especially regarding the debonding (shear).[1-6] According to literature, appliances bonded to the enamel must have shear bond strength between 6 and 8 MPa[2,5,7] in order to achieve the clinical needs that support orthodontic and occlusion forces.[8] On the other hand, they must not present exceeding bond strength that may cause enamel cracks or fractures during debonding of appliances. Other authors mentioned variations of 20 MPa as highest acceptable bond strength.[9,10]

Today, it is observed considerable increase of adults seeking orthodontic treatment, due to greater number of professional orthodontists, great valorization of esthetics, access to affordable dental materials and awareness of the necessity of orthodontic therapy. It is quite common to find in this group of patients, or even in younger patients, restorations of amalgam, composite resins or ceramics. Authors assert that recent progress on materials and techniques indicate that it is possible an effective direct bonding of orthodontic appliances on the surface of these materials.[11,12]

In relation to the amalgam surface, studies show that the bond strength is inferior to the obtained on enamel,[12,13] however the creation of mechanical retention with aluminium oxide blasting on the surface[13,14], roughening with diamond tip or confection of wholes with spheric drill ¼ increases the bond strength of the orthodontic material to the restorative material.[14] Other works[15] show that for porcelain restorations the best results were observed when it was applied phosphoric acid at 37% for 60 seconds for cleaning, followed by application of silane, adhesive system and adhesive resin. On the other hand, others affirm the necessity of hydrofluoric acid application, posteriorly using silane specific for porcelain.[3,11,15]

Authors[3,12,14] assert that the bonding of brackets on surfaces restored with composite resin is similar to technique recommended for amalgam and porcelain, however, it were not found enough studies for such affirmation. Therefore, the objective of this work was to evaluate the bond strength on teeth with composite resin restorations under different surface treatments, as well as to correlate these results with the adhesive remnant index (ARI).

MATERIAL AND METHODS

Sample

Fifty one bovine lower incisors were stored in Timol 0.1% and refrigerated at 5°C, for assemblage of specimens. The specimens were randomly divided into three groups: Control group (CG) (brackets bonded to dental enamel) and experimental groups with and without surface treatment, EGT and EGN, respectively. Brackets were bonded to resin restoration previously performed).

Assemblage of specimens

Initially, it was performed the polishing of the dental enamel with water sandpaper of silicon carbide (granulation 1200) making the surface free of roughness. The teeth were embedded in PVC tubes with autopolymerized acrylic resin JET (Clássico Artigos Odontológicos - Campo Limpo Paulista, Brazil). The vestibular face of each tooth was positioned perpendicular to the base of the PVC tube with assistance of an acrylic set-square. After placing teeth into the tubes, samples were stored for 24 hours for the complete resin polymerization (Fig 1).

To limit the area to be restored on experimental groups, it were performed cavities of 0.5-1 mm deep with diamond spheric drill 3018HL (Microdont - São Paulo, Brazil) on the middle third of the dental crown. The size of the groove for restoration corresponds to a larger area than the base of the bracket to be bonded (16 mm^2). Then, the cavities were restored following orientations from the manufacturer of 4 Seasons composite resin (thin particles for restorations highly esthetical, Ivoclar Vivadent - Schaan, Liechtenstein) and using adhesive Adper Single Bond 2 (3M ESPE - St. Paul, USA). The specimens were immersed in recipient with artificial saliva for one week. Posteriorly, finishing with drill for composite resin 3195F (KG Sorensen - São Paulo, Brazil) and polishing with Enhance tips, Poligloss paste and sanding discs (TDV - Pomerode, Brazil) were performed.

For the group with treatment (EGT) superficial detrition of composite resin restoration through application in one way of the diamond milling cutter 2200 (Microdont - São Paulo, Brazil) was performed, without any type of groove, for increase of mechanical retention. The specimens were immersed again in recipient with artificial saliva at 37°C.

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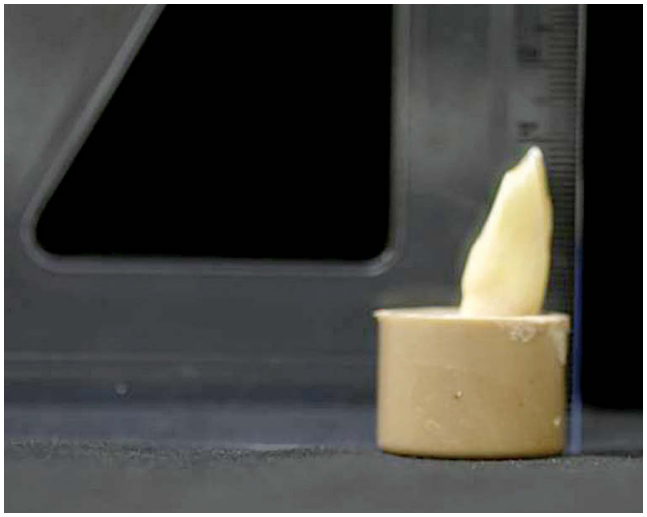

Figure 1 - Photograph of specimen showing vestibular face perpendicular to the ground.

Bonding of brackets

The specimens from the three groups were cleansed through prophylaxis with pumice and water for 10 seconds using low rotation micromotor and rubber cup. Then the specimens were rinsed and dried with air for 10 seconds. The bonding of brackets was done by standardized 200 gf pressure with assistance of a tensiometer.

The groups received direct bonding of brackets Edgewise Standard Slim, for upper central incisors of dimensions 0.022 x 0.030-in (Dental Morelli, Sorocaba, Brazil). The specimens received acid conditioning (orthophosphoric) at 37%, adhesive Transbond XT Light Cure Adhesive Primer (3M Unitek - Monrovia, USA) and resin Transbond XT (3M Unitek - Monrovia, USA), according to manufacturer's instructions.

The exceeding orthodontic resin was removed with explorer previously to the polymerization performed for 30 seconds with the device Ultraled (Dabi Atlante - Ribeirão Preto, Brazil). After the bonding of brackets, the specimens were stored in distilled water at 37°C, during 7 days for posterior shear test.

Shear test

The shear test was performed in EMIC DL 10.000 (São José dos Pinhais, Brazil) machine with speed of 1 mm/minute and load cells of 10 kN. The results of maximum force were recorded by the software Mtesc, version 1.01 (EMIC). The data were obtained in Megapascal (MPa).

Adhesive remnant index

After performing the shear test, the interface enamel-resin was examined in stereoscopic microscope Carl Zeiss (Göttingen, Germany), binocular model KL 1500 LCD with attached photographic camera Pixelink, on magnification of 16X to determine the amount of remnant resin (Fig 2). This was classified according to Adhesive remnant index which score ranges from 0 to 3 being:

- 0 - indicative of absence of remnant composite;
- 1 - less than a half of composite remained;
- 2 - more than a half of composite remained, and
- 3 - all the composite remained adhered to the dental enamel.

Statistical analysis

The statistical analysis was performed on SPSS program version 16.0 (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL, USA). Initially, it was done descriptive analysis of the groups, as well as verification of normality by Shapiro-Wilk test and intraexaminer agreement by weighted Kappa test for Adhesive remnant index.

The groups were submitted to analysis of variance (one-way ANOVA) with Tukey post test for verification of statistical difference.

Finally, it was done the Spearman correlation, given the regular distribution of groups, between ARI and the bond strength. The confidence interval was of 95% ($p < 0.05$).

RESULTS

The descriptive analysis showed variability quite low, mean and standard deviation 6.44 ± 1.28; 7.01 ± 1.61; and 5.06 ± 1.35 MPa for groups CG, EGT and EGN, respectively (Table 1). After verification of normality of groups, it was applied the analysis of variance for one criteria (Table 2), results showed statistically significant difference, and Tukey post test was applied for elucidation of which groups were different (Table 3).

Table 4 describes the groups according to adhesive remnant index and Spearman correlation coefficient for each group in study. For intraexaminer calibration, 17 specimens were used, the weighted Kappa measure of agreement presented value of $r = 0.843$ with statistical significance ($p < 0.001$).

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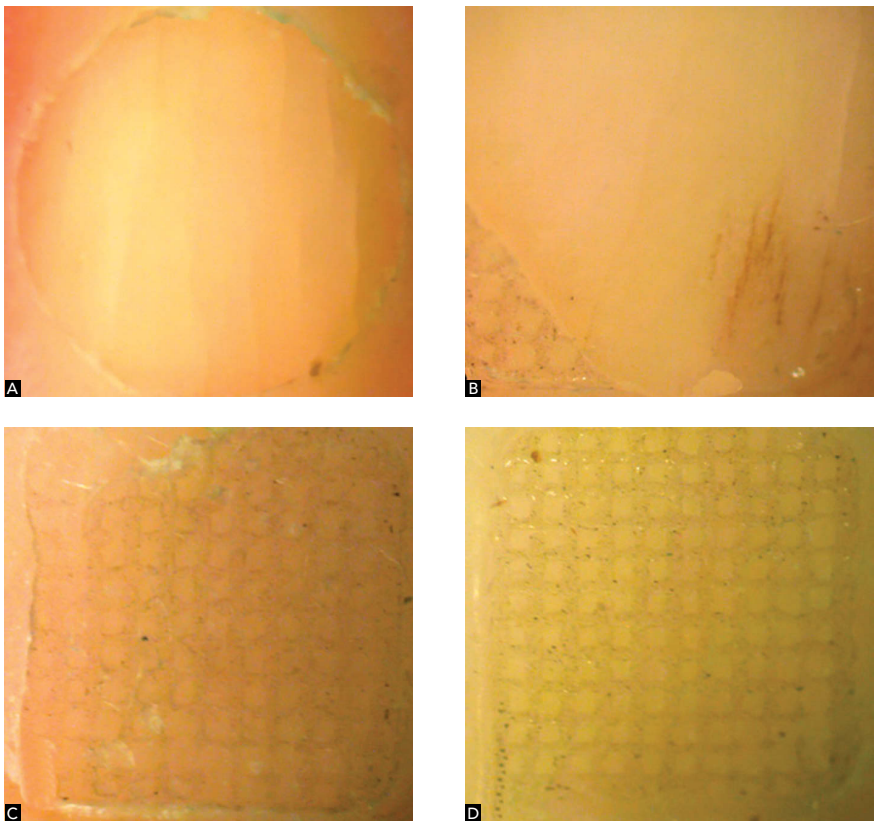

Figure 2 - ARI scores: 0 (**A**); 1 (**B**); 2 (**C**); 3 (**D**) evaluated under stereoscopic magnifying glass with magnification of 16X.

Table 1 - Descriptive analysis of three groups according to shear strength (MPa).

Group	n	Minimum	Maximum	Mean ± SD		Coefficient of variation	Standard error
CG	17	3.74	9.18	6.62	1.28	19.37	0.31
EGT	17	4.56	9.88	6.82	1.61	23.69	0.39
EGN	17	3.10	7.68	5.07	1.35	26.66	0.32

Table 2 - Analysis of variance (ANOVA one-way) comparing the shear strength between the three groups.

Number of groups	F	R^2	p
3	7.658	0.2419	0.0013

Table 3 - Tukey post test evidencing differences between groups (2x2).

Group	Mean difference	Q	Significance	Difference of CI 95%
CG *vs* EGT	-2.034	0.5762	N.S.	-14.12 to 10.05
CG *vs* EGN	15.81	4.479	**	3.720 to 27.89
EGT *vs* EGN	17.84	5.055	**	5.754 to 29.93

** = p < 0.01.

Table 4 - Values for each value of Adhesive Remnant Index (ARI) and Spearman correlation with shear bond strength of studied groups.

Group	ARI values								r	p
	0		1		2		3			
	n	%	n	%	n	%	n	%		
EGN	7	41.17	5	29.41	4	23.52	1	5.88	0.713	0.001
EGT	0	0.0	4	23.52	6	35.29	7	41.17	0.936	0.000
CG	0	0.0	2	11.76	10	58.82	5	29.41	0.816	0.000

DISCUSSION

This work found similar results for groups CG (6.62 MPa) and EGT (6.82 MPa) and statistically superior to EGN (5.07) (Tables 1 to 3). These values of CG and EGT are considered acceptable for clinical use. However, the values for EGN may be questionable, given that the results from this group are found out of the range of recommended bond strength (6-8 MPa).[2,5,7]

The orthodontic resin used in this study was Primer Transbond XT (3M Unitek, Monrovia, USA), basically composed of Triethylene glycol dimethacrylate (Bis-GMA), silica, silane, N-dimethyl benzocaine, hexafluoride phosphate. This composition is very similar to the composites used for orthodontic bonding of other manufacturers, except the composites chemically activated that presents Benzoyl peroxide as catalyst.

These components are the same present in composite resins for anterior and posterior teeth. The difference between orthodontic bonding resins and restoratives resins is the percentage of each component and the size of inorganic particles (about 8 μm for orthodontic resins). The orthodontic resins present greater fluidity than restorative composites, and larger amount

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of organic matrix, while restorative resins need more esthetic and excellent mechanical properties, larger amount of inorganic load and less fluidity.[16]

The inappropriate bond strength for EGN can be explained by the absence of chemical interaction. In this situation, it is found a superficial layer of composite resin non reactive due the inexistence of free resinous monomer for chemical bonding.[17] This situation with free and reactive monomers would occur when bonding of orthodontic brackets is done right after finishing the composite resin restoration on the tooth to be restored without contact with oral fluids. However, this situation is quite rare in orthodontic practice. Besides, it is concluded that the conditioning of resinous surface with phosphoric acid at 37% for 30 seconds was not capable to produce any roughness on these surfaces that would allow mechanic imbrication.

Some professionals apply hydrofluoric acid, used on the bonding of brackets in ceramic surfaces, for the bonding on composite resin restorations. However, this procedure is not justified from the point of view of provision of roughness on the resin surface, because the hydrofluoric acid is specific for ceramic surfaces (vitreous), different from resinous.[2,12] Actually, it would be necessary the study of another acid that is able to condition the plastic surface of resins.

Because orthodontic and restorative resins have similar compositions, the method for bonding of orthodontic appliances on teeth with previous composite resin restorations is the same as the procedure of repair of restorative resins. The repair occurs when a composite resin restoration is done over another, as in cases of partial fracture of restoration or removal of superficial layer due to unsatisfactory coloration and substitution for a more esthetic one.[16]

In this regard, studies about resin restoration repair[17,18] prove that surface treatments with aluminium jet and superficial detrition with diamond drills present bond strength superior to surfaces with no treatment, as confirmed on the present study. These works also show through scanning electron microscopy the mechanic imbrication of these composites.[18] Besides, such justification is added to the result of Spearman correlation (Table 4) for the adhesive remnant index, that showed larger amount of orthodontic resin on the resinous restorations of groups EGT and CG while for EGN, most of the orthodontic resin remained on the base of the bracket.

Clinically some patients can refuse the resin restoration detrition with diamond drill claiming the necessity of restore it at the end of the treatment. However it is valid to say that at the end of the orthodontic treatment, after the debonding of brackets, it will be necessary the removal of remnant orthodontic resin adhered to the restoration, possibly leading to unwanted detrition of this surface.

CONCLUSIONS

It is concluded that the surface treatment with diamond drills on resin restoration for bonding of orthodontic brackets provides bond strength similar to the bonding direct on the enamel. The ARI showed the lack of interaction between the resin restoration without surface treatment and the orthodontic resin.

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Long-term evaluation of apical root resorption after orthodontic treatment using periapical radiography and cone beam computed tomography

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Objective: To evaluate the frequency of Apical Root Resorption (ARR) after orthodontic treatment at 52-288 months using periapical radiography (PR) and cone beam computed tomography (CBCT).

Methods: Radiographic images obtained from 58 patients, before (T_1) and after orthodontic treatment (T_2), and following 52-288 months of treatment were analyzed by three members of the Brazilian Board of Orthodontics. Apical structures were evaluated by PR images (T_2 and T_3), using Levander and Malmgren scores. The presence of ARR on CBCT images were detected only at T_3. The Kolmogorov-Smirnov test was used for statistical analyses, and the level of significance was set at 5%. Kappa statistics determined interobserver agreement.

Results: The more frequent ARR were with scores 1 in T_2 (51.6%) and T_3 (53.1%), when evaluated by PR ($p > 0.05$). When compared the frequencies of ARR in T_3 among PR and CBCT images, the differences were significant for maxillary and mandibular pre-molar groups, and for mandibular molar group ($p > 0.05$). The teeth with highest frequency of ARR presence using CBCT images were maxillary lateral incisors (94.5%) and mandibular central incisors (87.7%), while the premolars showed the lowest frequency. The CBCT images showed that the teeth involved in orthodontic treatment with extraction present higher ARR frequency ($p < 0.05$).

Conclusion: PR showed more frequency of ARR in posterior teeth groups when compared with CBCT images. ARR did not change in long-term post treatment.

Keywords: Tooth resorption. Cone beam computed tomography. Corrective orthodontics.

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INTRODUCTION

Apical root resorption may occur after orthodontic tooth movement. Its etiology is multifactorial and may be associated with individual biological variability, genetic predisposition, effect of mechanical factors, root morphology, and tooth injuries sustained before orthodontic treatment.[1-6]

Root resorption associated with orthodontic tooth movement is classified as inflammatory because it results from inflammation of the apical periodontium and the consequent destruction of tooth structures caused by clastic activity.[7] Clinical relevance is not often mentioned when the rate of ARR is low. However, in severe ARR, structural tooth changes may result from an unfavorable combination of factors, such as anatomic, physiological and genetic variations.[8,9,10] The understanding of the pathological mechanisms of radicular resorptions due to orthodontic treatment may help to establish accurate treatment plans.

Clinically, periapical radiographs are often used for diagnosis, treatment planning and follow-up. The revolution of information technology in health investigations started with computed tomography (CT), which has been used for planning, diagnosis, treatment and prognosis of several diseases.[11,12] Cone beam computed tomography (CBCT) is a recently developed technology[13,14] with important applications in research, clinical dentistry in general, and orthodontics in particular.[15-18]

A longitudinal prospective study[19] of the progression of ARR associated with orthodontic treatment using PR showed that central incisors do not continue to lose root length during the retention phase. Furthermore, no association with gender, age, overbite, overjet, headgear use, or intrusion mechanics was found. ARR was greater in patients that had undergone extractions.

Reukers et al[20] used digitally reconstructed images of maxillary incisors and found that ARR prevalence was 63% in the group of incisors. Relevant root shortening was found in only a few cases.[10,20] In another study, orthodontically induced ARR was evaluated using panoramic radiography and CBCT, and results showed that ARR was found in 69% of the teeth when CBCT scans were used and in 44% when panoramic radiography was the imaging method.[21]

As the application of CBCT in orthodontics seems promising, it may become a useful tool for the long-term follow up of patients that may develop ARR in association with orthodontic tooth movement in different tooth groups. However, few studies have focused on that use of CBCT. This study evaluated ARR at 52 to 288 months after treatment using periapical radiography and cone beam computed tomography. The null hypothesis was that there was no difference in apical root resorption frequencies detected by periapical radiography and cone beam computed tomography.

MATERIAL AND METHODS

Patients

Fifty-eight patients, 28 male and 30 female (1,392 teeth) were selected in a database search of a private orthodontic clinic in Goiânia, GO, Brazil. Inclusion criteria were: Complete orthodontic records, radiographs, pictures, plaster models, and orthodontic treatment completed at least 52 months before. Only patients whose radiographs showed high quality were included, and no patient had any history of retreatment. Time since treatment completion was up to 52 months, and patient mean age was 12 years and 4 months (SD = 2.31).

All the patients had been treated using edgewise mechanics by the same orthodontist and were invited to return for a follow-up examination, which included a full mouth set of periapical radiographs and CBCT scanning. The study was approved by the local Ethics in Research Committee (UFG, Prot. #169/2008).

Imaging methods

Periapical radiographs were acquired using a Spectro 70X Dental X-ray unit (Dabi Atlante, Ribeirão Preto, SP, Brazil) at 70 kV, 8 mA, 0.8 mm x 0.8 mm focal spot, using Kodak Insight film (Eastman Kodak Co, Rochester, NY, USA), using bisector technique with position indicating device and exposure time in accordance with the region imaged. All films were processed automatically and developed using standard methods (Peri-Pro II, Air techniques, NY,USA).

CBCT images were acquired with a first generation i-CAT Cone Beam 3D imaging system (Imaging Sciences International, Hatfield, PA, USA). The vol-

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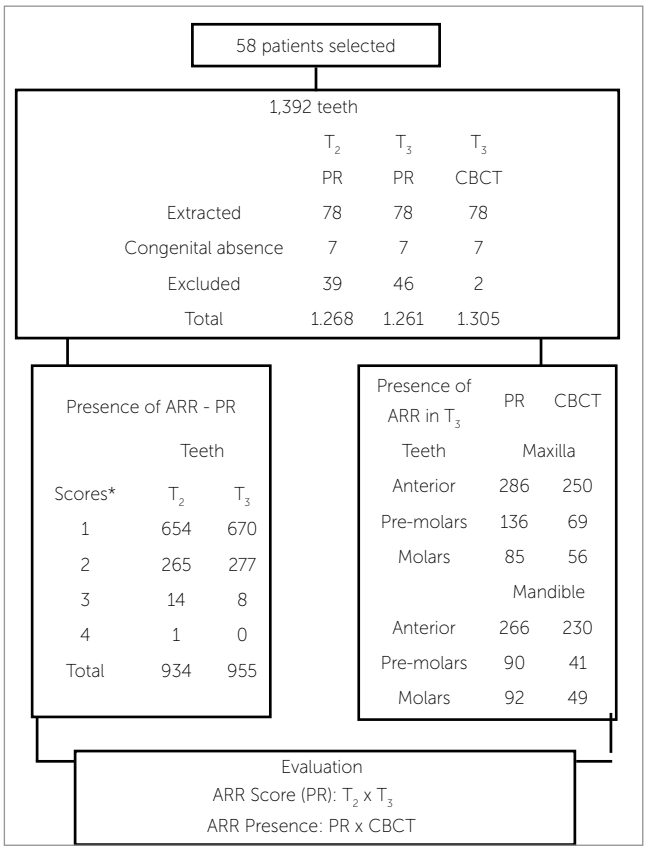

Figure 1 - Distribution of teeth according to presence or absence of ARR. (Source: modified from Levander and Malmgren[2]).

umes were reconstructed at 0.2 x 0.2 x 0.2 mm voxel size. The tube voltage was 120 kVp, and the current, 3.8 mA. Exposure time was 40 seconds. Images were examined using the scanner proprietary software (Xoran 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) in a PC workstation running Microsoft Windows XP professional SP-2 (Microsoft Corp., Redmond, WA, USA), Intel® Core™ 2 Duo-6300 1.86 GHz (Intel Corporation, Santa Clara, CA, USA), NVIDIA GeForce 6200 turbo cache videocard (NVIDIA Corporation, Santa Clara, CA, USA) and an EIZO - Flexscan S2000 monitor at a resolution of 1600 x 1200 pixels (Eizo Nanao Corporation Hakusan, Ishikawa, Japan). The program tools permitted the evaluation of each tooth in three dimensions.

Evaluation methods

Periapical radiographs were analyzed at three time points: T_1 – before fixed orthodontic treatment; T_2 – after fixed orthodontic treatment; T_3 – at 52 to 288 months after treatment. Three members of the Brazilian Board of Orthodontics individually evaluated all images of PR in all teeth (except second and third molars) to detect ARR. The teeth with periapical lesions, traumatism history, and impossibility of diagnosis due to image overlapping and incomplete rhizogenes were excluded. The high number of teeth with incomplete apexes hindered the evaluation of apical structures in T_1. To evaluate interexaminer reliability, 10% of the sample was examined.

Levander and Malmgren[2] modified scoring system was used to evaluate ARR. Root apexes were classified into 5 levels of root resorption: 0= no root resorption; 1= irregular root outline; 2= apical root resorption, less than 2 mm; 3= apical root resorption, from 2 mm to one third of the original root length; 4= apical root resorption exceeding one third of original root length. The radiographs were mounted on slit sheets of cardboard and examined in a darkened room using a light box (Medalight LP-300, Universal Electronics Ind., NY, USA) at 3X magnification.

The CBCT images obtained in T_3 were evaluated by a radiology specialist with 5 years of training. CBCT was used only at T_3 because this imaging diagnostic tool was not available at the other time points.

The analysis of apical region was performed in a dynamic way into different plans (axial and cross-sectional). The thickness slices varied between 1 and 1.5 mm.

ARR presence or absence in PR and CBCT images were evaluated in all dental groups. In teeth with more than one root, the most resorbed root was selected to determine the score for that tooth.

The expected initial number of teeth was 1,392; extracted and congenitally absent teeth and teeth whose images had superposed structures (Fig 1) were excluded. The number of teeth involved or not with ARR was recorded.

The Kolmogov-Smirnov test was used to evaluate the data. The level of significance was set at 5%. Kappa statistics was used to determine interobserver agreement according to the study methods.

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RESULTS

From all 58 patients, 40 had been classified, at the beginning of orthodontic treatment as Class I; 14 patients classified as Class II, division 1; 2 patients classified as Class II, division 2; 2 patients classified as Class III. Forty-nine patients used some type of intermaxillary elastics. The mean duration of treatment was 22.9 months (SD = 6.72).

The distribution of teeth in sample, showing the presence or absence of ARR, is presented in Figure 1. The radiographic images of 1,268 teeth were analyzed in T_2, 1,261 in T_3, and 1,305 CBCT images in T_3.

The frequency of ARR by PR after orthodontic treatment (T_2) and 52-288 months (T_3) is shown in Table 1. ARR more frequent score was 1, presenting 51.6% in T_2, and 53.1% in T_3. There was no significant statistical difference between T_2 and T_3, when evaluated by PR, in none of the scores.

Kappa value used to determine interobserver agreement according to modified Levander and Malmgren[2] study methods varied from 0.86 to 0.96 for PR images.

Table 2 summarizes the results of frequency (%) of teeth group most affected with ARR using PR and CBCT scans. The difference was statistically significant to pre-molar maxillary and mandibular group and to molar mandibular group, when compared the frequencies of ARR in T_3, between PR and CBCT images. The highest presence of ARR by PR was detected in these groups. So, the null hypothesis was rejected. Table 3 shows frequency (%) of teeth group most affected with ARR using CBCT scans. The maxillary lateral incisors were the teeth most affected by ARR. The second group of teeth most affected by ARR was the mandibular central incisors. The teeth group presenting less ARR was the premolars. Table 4 shows frequency (%) of ARR according to CBCT scans (T_3) and effect of extractions. The frequency of teeth with ARR was higher in the group with teeth involved in orthodontic treatments with extractions (66.7%) than in the group without extractions (45.2%). The difference was statistically significant.

Figure 2 shows periapical radiographs of the maxillary lateral incisor suggesting that apical root resorption do not change after finishing the orthodontic tooth movement in long term. Figure 3 shows presence or absence of ARR in central incisor, by PR and CBCT, while Figure 4 shows the same in upper premolar.

Table 1 - Frequency (%) of ARR after orthodontic treatment (T_2) and past 52 to 288 months follow-up according to PR.

Score	T_2 - PR	T_3 - PR	p
0	334 (26.3%)	306 (24.2%)	p > 0.05
1	654 (51.6%)	670 (53.1%)	p > 0.05
2	265 (20.9%)	277 (21.9%)	p > 0.05
3	14 (1.1%)	8 (0.6%)	p > 0.05
4	1 (0.1%)	0	p > 0.05
Total	1,268 (100%)	1,261 (100%)	p > 0.05

Table 2 - Frequency (%) of teeth group most affected with ARR using PR and CBCT scans.

Teeth	PR n (%)	CBCT n (%)	p
Maxilla			
Anterior	286 (22.7%)	250 (19.2%)	p > 0.05
Premolars	136 (10.8%)	69 (5.3%)	p < 0.05
Molars	85 (6.7%)	56 (4.3%)	p > 0.05
Mandible			
Anterior	266 (21.1%)	230 (17.6%)	p > 0.05
Premolars	90 (7.1%)	41 (3.1%)	p < 0.05
Molars	92 (7.3%)	49 (3.8%)	p < 0.05

Table 3 - Distribution of teeth most affected with ARR using CBCT scans

Teeth	Absence of ARR	Presence of ARR	Classification
Maxilla			
11/21	23 (19.8%)	93 (80.1%)	3rd
12/22	6 (5.4%)	104 (94.5%)	1st
13/23	63 (54.3)	53 (45.6%)	
14/24	45 (59.2%)	31 (40.7%)	
15/25	77 (66.9%)	38 (33.0%)	
16/26	60 (51.7%)	56 (48.2%)	5th
Mandible			
31/41	14 (12.2%)	100 (87.7%)	2nd
32/42	26 (22.4%)	90 (77.5%)	4th
33/43	76 (65.5%)	40 (34.4%)	
34/44	66 (82.5%)	14 (17.5%)	
35/45	87 (76.3%)	27 (23.6%)	
36/46	67 (57.7%)	49 (42.2%)	

Table 4 - Frequency (%) of ARR considering tooth involved in orthodontic treatment with or without extraction, analyzed by CBCT (T_3).

Enrolled teeth	Absence of ARR	Presence of ARR
Orthodontic treatment without extractions (n = 815)	446 (54.7%)	370 (45.2%)
Orthodontic treatment with extractions (n = 490)	163 (33.2%)	327 (66.7%)
p	p < 0.05	p < 0.05

p = significance of percentage differences.

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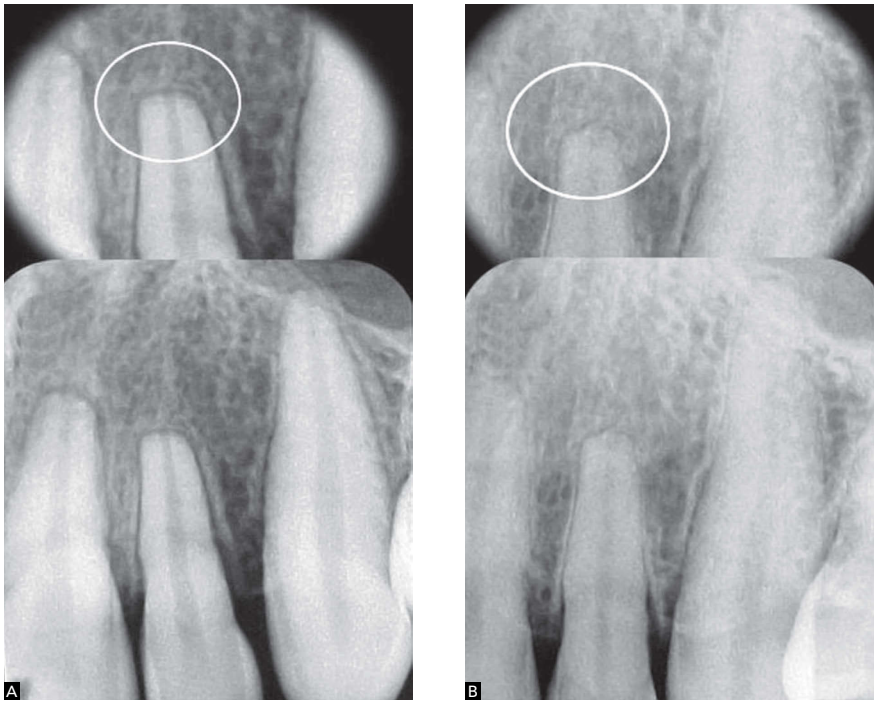

Figure 2 - Periapical radiographs of an upper left lateral incisor presenting the same ARR score after orthodontic treatment (**A**) and 288 months after treatment (**B**).

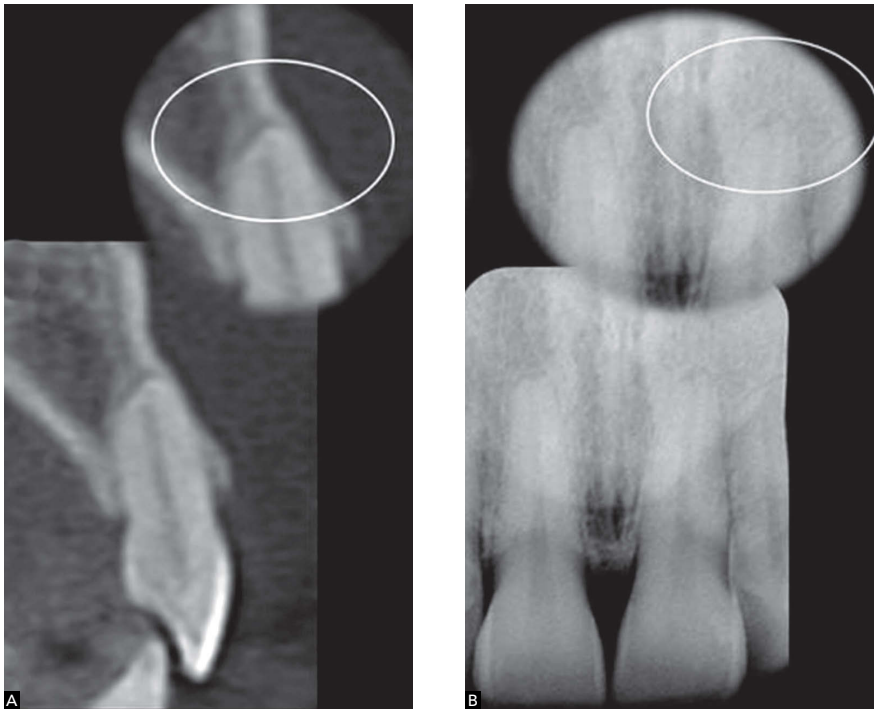

Figure 3 - CBCT scan of a maxillary left central incisor (**A**) (transverse view) shows more details of apical root resorption than periapical radiography (**B**).

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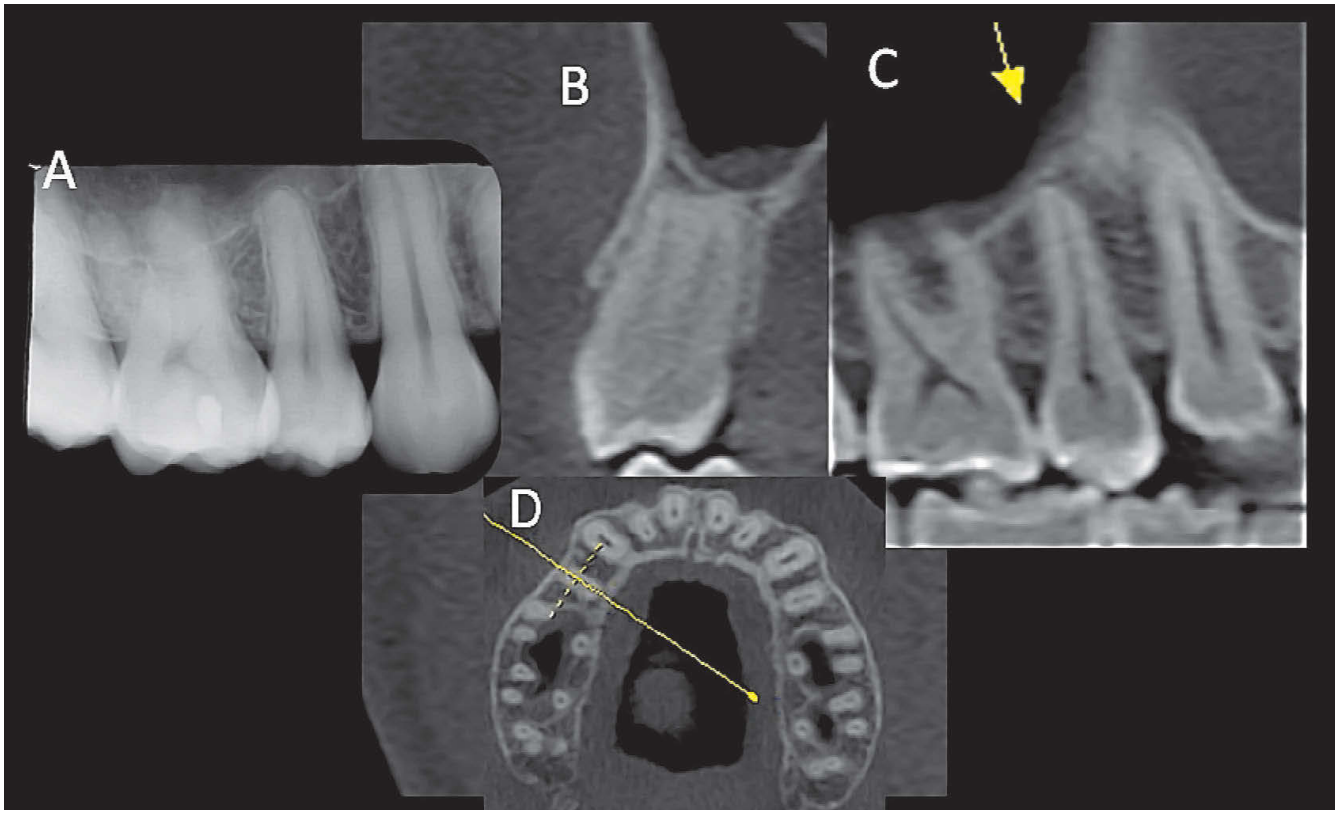

Figure 4 - Periapical radiograph of a maxillary right second premolar shows score 2 according to Levander and Malmgren system (**A**). The same tooth on CBCT scan presenting absence of ARR (**B-D**).

DISCUSSION

The advent of computed tomography brought a true revolution in medical sciences.[15-18] Particularly in dental specialties, the possibility of acquiring information from three-dimensional images of the maxillofacial region minimized the chances of underestimating lesions, such as ARR,[21,24] in dental structures.[15-18,21-25]

ARR characterize the loss of tooth structure and occurs due to several factors such as individual biological variability, genetic predisposition, mechanical factors, root morphology, and apical lesions prior to orthodontic treatment.[1-6] The extent of this resorption after orthodontic treatment influences the prognosis. Harmful consequences for the tooth may occur when severe resorption is present, even if observed in a small percentage and forward to well-planned and conducted orthodontic treatment.

Current knowledge does not allow the orthodontists to identify which patients are vulnerable to serious ARR. In a recent systematic review about ARR associated with orthodontic treatment, Weltman et al[1] found only 11 suitable studies and the protocols were too variable to undertake a quantitative analysis. This revision reflects the timing of the published research about ARR. No study allowed consistent evidence about the longevity of teeth with severe resorption.[28]

The frequency of ARR, after completion of orthodontic treatment (T_2) and after 52 to 288 months (T_3), was determined by PR images (Table 1). The most frequent ARR score were 1, which did not show significant difference between T_2 (51.6%) and T_3 (53.1%). This study is in agreement with previous findings.[9,10] Copland and Green[9] (using lateral cephalometric radiograms) examined 45 individuals to investigate whether ARR in maxillary central incisors associated with orthodontic treatment continues after the end of the active treatment. Mean time between treatment end and final cephalometric radiogram was 2 years 4 months (28 months). When active treatment stopped, further ARR practically stopped, too.

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Remington et al[10] conducted a retrospective study (using periapical radiography) to evaluate ARR in 100 patients at a mean 14.1 years (169 months) after orthodontic treatment. They found no apparent changes after appliance removal, except remodeling of rough and sharp edges (Fig 2).

Despite method differences between several studies[9,10] and our investigation, some important aspects should be analyzed: The mean duration of treatment was 22.9 months; the variation of follow-up time was 52 to 288 months, mean time between treatment end and the final cephalometric radiogram was 1.1 months, range was 0 to 7 months, the evaluation was made according to teeth groups; the scoring system of ARR detected by PR was the one described by Levander and Malmgren,[2] while the presence or absence of ARR was detected by CBCT images.

The results of CBCT and PR images at T_3, (52-288 months after treatment) revealed differences between the two imaging methods (Table 2). When comparing the frequencies of ARR in T_3, the difference was significant for the group of upper and lower premolars, and for the group of mandibular molars. In these dental groups a greater presence of ARR by PR images was detected. The results suggest that PR, due to limitations, tends to overestimate the ARR into posterior teeth groups (Figs 3 and 4). These findings might be assigned to the fact that analyses were made according to teeth groups. In different teeth group, the apical morphological variations, surrounding bone density (thick or thin bone cortex), x-ray angulations, radiographic contrast and overlapping of anatomic structures may affect radiographic interpretations.[26]

Advanced technologies that may potentially aid in establishing diagnoses, such as CBCT, bring up challenges that might only be overcomed when its properties and limitations are fully understood. Developing new software may greatly improve the acquisition and reconstruction of CBCT scans. In this study, a map-reading approach was used to examine all planes of the root apex, as suggested in a recent study[27] which showed that it promotes the perfect management of CBCT images and might reveal abnormalities not detected in conventional PR. For both imaging methods, extra care was taken to ensure an optimal interpretation environment.

Dudic et al[21] compared ARR in 275 teeth of 22 orthodontic patients using panoramic radiography and CBCT and the scoring system develop by Levander and Malmgren.[2] They found significant differences between the two methods and for all degrees of ARR. Panoramic radiography underestimated ARR after orthodontic treatment. CBCT imaging should be used to help to monitor patients at risk for developing severe root resorption during orthodontic movement. Our results were similar, but we evaluated ARR after a long-term follow-up of orthodontic treatment using PR and CBCT images.

Maxillary lateral incisors (94.5%) and mandibular central incisors (87.7%) were the most affected teeth (Table 3). ARR analysis, using CBCT, forward to the most affected teeth has not been compared with other literature data by a lack of studies. Newman[5] investigated possible etiological factors of external root resorption and found that maxillary incisors, maxillary premolars, and mandibular second premolars had the greatest incidence of apical resorption. This sequence differed from that found in other studies about root resorption.[29,30] In the present study, premolar were the least affected teeth by ARR when evaluated through CBCT image. Hemley[29] through PR showed that the teeth more susceptible to ARR were central incisors (9.1%). The lower central incisors were more likely to be affected than upper ones. Sharpe et al[30] found a higher frequency of ARR using PR in the central upper central incisors (52.7%) followed by lower ones (45.7%).

In this study, it was found that the most affected teeth are the anterior teeth, as demonstrated in other studies.[5,9,10,28] It might be suggested that a radiographic control of this dental group during and after orthodontic treatment is benefic for detecting of ARR.[9]

Tooth extraction was shown to be a risk factor for ARR during orthodontic tooth movement (Table 4). The frequency of teeth with ARR was higher in the tooth involved in orthodontic treatment with extractions (66.7%) than the group without extractions (45.2%) analyzed by CBCT ($p < 0.05$). One explanation for these results may be the fact that, in orthodontic treatment with extractions, extensive movements are needed. Our results are in agreement with those reported by Marques et al,[28] who found that the main factors directly involved in severe resorption

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were extraction of premolars, triangle-shaped roots and root resorption before treatment. Those authors also found a high prevalence of severe root resorptions in Brazilian patients treated with the edgewise method; differently from our findings.

CBCT is not commonly available in most dental offices. The analysis of the cost-effectiveness of 3D imaging in clinical routine should include the caution with radiation dose, variability of radiation between scanners and the lack of a standard recommended dose in some countries.

Silva et al[22] compared the radiation doses of conventional panoramic and cephalometric imaging with the doses of 2 different CBCT units and a multi-slice computed tomography (CT) unit in orthodontic practice. They concluded that conventional imaging still emits the lowest dose of radiation, and when three-dimensional imaging is required in orthodontic practice, CBCT scans should be preferred over CT imaging.

It is presumed that a new technology with potential to assist in diagnosis, such as CBCT, set new challenges until there is a complete understanding of their properties and limitations. New machines with low radiation doses and new software to reduce metal artifacts in CBCT image reconstruction should be developed. Further longitudinal studies should determine the behavior of severe ARR due to orthodontic movement.

CONCLUSION

PR showed more frequency of ARR in posterior teeth groups when compared with CBCT images. ARR did not change in long-term post treatment.

Acknowledgments

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Morphometric evaluation of condylar cartilage of growing rats in response to mandibular retractive forces

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Introduction: The mandibular condylar surface is made up of four layers, i.e., an external layer composed of dense connective tissue, followed by a layer of undifferentiated cells, hyaline cartilage and bone. Few studies have demonstrated the behavior of the condylar cartilage when the mandible is positioned posteriorly, as in treatments for correcting functional Class III malocclusion.

Objective: The aim of this study was to assess the morphologic and histological aspects of rat condyles in response to posterior positioning of the mandible.

Methods: Thirty five-week-old male Wistar rats were selected and randomly divided into two groups: A control group (C) and an experimental group (E) which received devices for inducing mandibular retrusion. The animals were euthanized at time intervals of 7, 21 and 30 days after the experiment had began. For histological analysis, total condylar thickness was measured, including the proliferative, hyaline and hypertrophic layers, as well as each layer separately, totaling 30 measurements for each parameter of each animal.

Results: The greatest difference in cartilage thickness was observed in 21 days, although different levels were observed in the other periods. Group E showed an increase of 39.46% in the total layer, reflected by increases in the thickness of the hypertrophic (42.24%), hyaline (46.92%) and proliferative (17.70%) layers.

Conclusions: Posteriorly repositioning the mandible produced a series of histological and morphological responses in the condyle, suggesting condylar and mandibular adaptation in rats.

Keywords: Articular cartilage. Angle Class III malocclusion. Mandibular condyle.

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INTRODUCTION

The surface of the mandibular condyle consists of four layers: an external layer, composed of dense connective tissue, followed by a layer of undifferentiated cells, hyaline cartilage and bone. The condyle features two key functions: joint function and endochondral growth.[16,19] Similarly to other articular cartilages in the body, the mandibular condylar cartilage can withstand biologically-induced stress.

However, it differs in several biological aspects, such as ontogenetic development, postnatal growth and histological structures.[19] One peculiarity of the condylar cartilage is its adaptive capacity due to endochondral ossification.[14,18] This feature may enable orthopedic appliances to modify not only the direction, but also the amount of mandibular growth.[16]

Nevertheless, few studies have shown the behavior of the condylar cartilage when the mandible is positioned posteriorly as in the treatment of functional Class III malocclusion.

The number of studies evaluating the adaptive capacity of rat condylar cartilage under stress significantly increased in the past years. Some authors found an increase in cellular response and growth when the mandible is held in a protrusive position.[8,14,15,21] Other researchers[9,18] have shown modifications in the two condyles when the mandible is deviated laterally. The result obtained in lateral postural deviation indicates that the lateral displacement of the mandible can (a) increase the thickness of the condylar cartilage and proliferation of precondroblasts on the contralateral side, and (b) decrease them on the ipsilateral side.[4,18]

Controversial reports on occlusion and temporomandibular disorder (TMD) can be found in the literature. Some authors believe that there is no scientific evidence that malocclusion is a risk factor for TMD,[7,12] whereas others found a high correlation between TMD and posterior condylar displacement due to malocclusion,[6,11,22] especially deep overbite in patients with Angle Class I or Class II malocclusion. Nevertheless, many changes arising from the posterior positioning of the condyle are still unknown.

In this context, the objective of this study was to assess the characteristics of the condylar cartilage of young rats during mandibular retrusion.

MATERIAL AND METHODS

Thirty 5-week-old male Wistar rats (Fig 1A) were randomly divided into two groups: control (C) and experimental (E). Both groups were fed with a soft diet and water *ad libitum*. Animals were maintained under standard conditions with a 12h light/dark cycle and controlled temperature (23°C).

This study was approved by Maringá State University (UEM) Institutional Review Board, under No. 080/2008.

The 12 animals of group E were fitted with an intraoral device capable of promoting mandibular setback and modifying functional occlusion (Fig 1B). To this end, impressions of the mouths of two animals were taken to enable the devices to be fabricated and adjusted on dental casts. Subsequently, acetate trays were fabricated to allow a standardized technique.

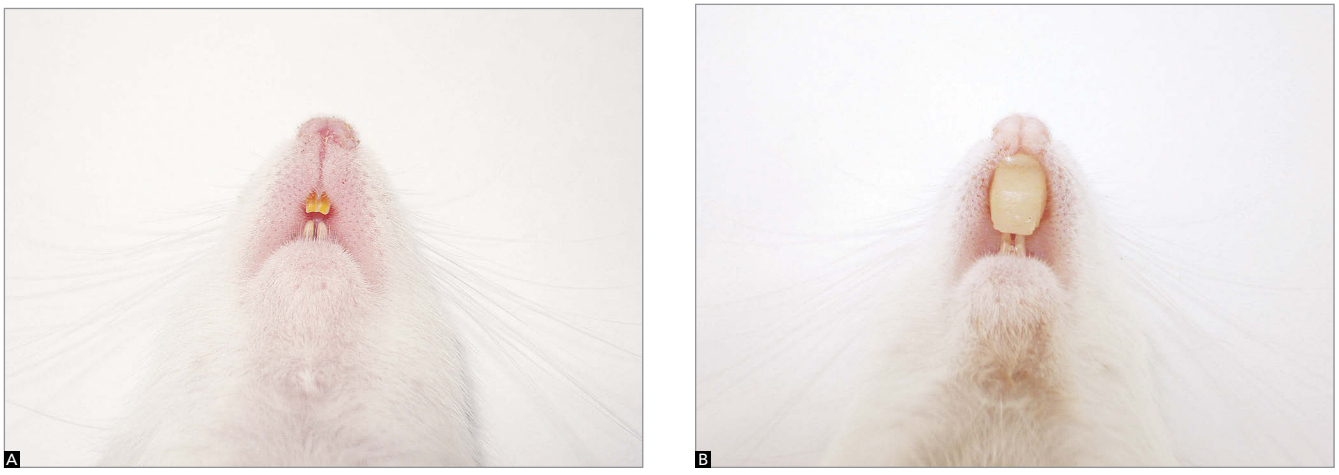

Figure 1 - Occlusal view of Wistar rat. **A**) Control group. **B**) Experimental group.

The devices were fabricated with Z250 composite resin (3M Dental Products, St. Paul, MN / USA) on the upper incisors of group E. The animals were anesthetized with an intramuscular injection of 1:1 combination of Ketamine (10%) and Xylazine (2%) at a dosage of 0.5 mg/100g. Once the animals were under anesthesia, the teeth were etched, self-etching primer was applied, and a thin layer of adhesive was applied and light-activated. The acetate matrix was filled with adhesive and fitted on the teeth of the rats for final light-activation.

Group C received no device and, therefore, corresponded to the characteristics of a normal occlusion (Fig 2). In group E, on the other hand, the presence of the devices and their inclination prevented the mouth from closing in habitual occlusion, which caused mandibular retrusion (Fig 3).

Tissue preparation

The animals were sacrificed with an overdose of anesthetic after a treatment period of 7, 21 and 30 days.

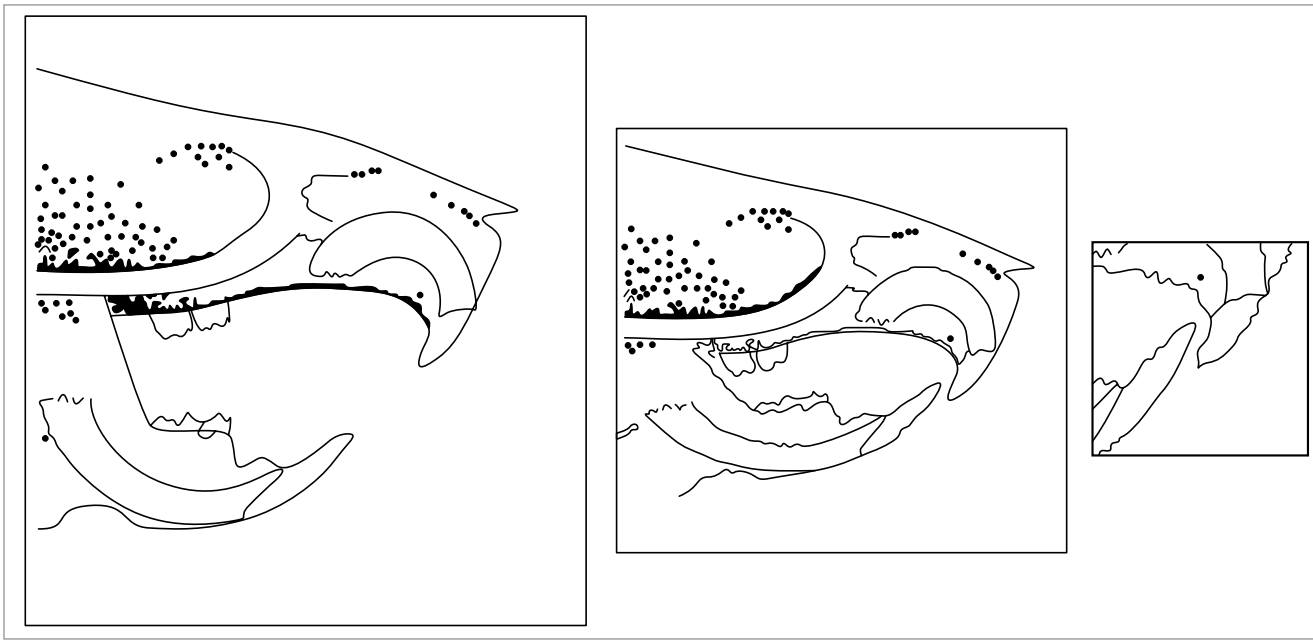

Figure 2 - Schematic sequence of habitual occlusion in a rat (Control Group).

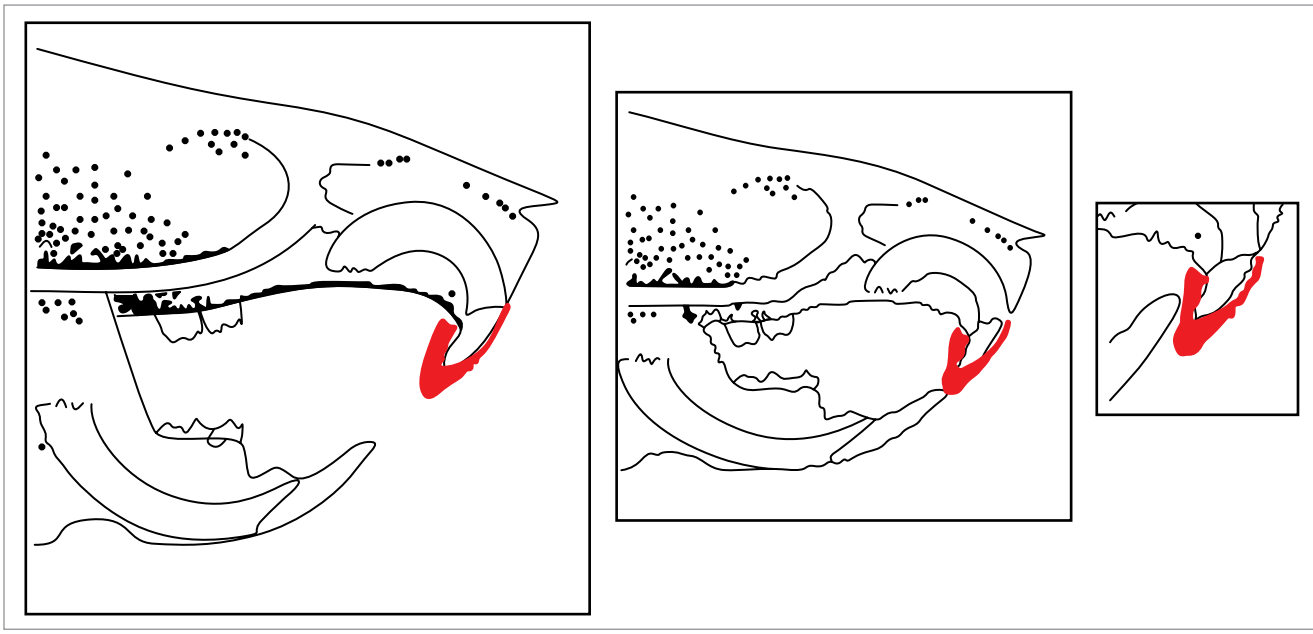

Figure 3 - Schematic sequence showing how the device was fitted onto the upper incisors of the rat, causing mandibular retrusion.

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Immediately after death, the animals' heads were dissected and immersed in a fixing solution (Bouin) for 4 days. After consecutive changes of alcohols, the TMJ regions were dissected and decalcified in a solution containing 20% of sodium citrate, formaldehyde and distilled water for 5 days. The pieces were washed in running water for 4 hours in order to have the decalcifier removed. Histological routine was performed and the pieces subsequently embedded in paraffin, using the same plane of orientation with the ramus parallel to the surface of the block. Semi-serial sections were cut into sagittal sections of 7 µm in the region of the condyle using a Leica RM 2145® microtome. Sections were stained with hematoxylin and eosin and mounted under a coverslip using Permount.

Morphometric analysis

The images were captured in high definition by an Optical Microscope (Motic BA400) and exported to a computer. Using ImageProPlus 4 (Media Cybernetics, USA) image analysis software, the various thicknesses of the proliferative, hyaline and hypertrophic layers were measured, totaling 6 sections from each animal.

In each section, 5 measurements were made for each layer, totaling 30 measurements of each animal (Fig 4).

Statistical analysis

Data were obtained through a double-blind study and subsequently processed with Statistica® 7 software for statistical analysis. Data distribution did not show normal characteristics, which prompted the use of non-parametric tests. The groups were broadly assessed with the Kruskal-Wallis test.

RESULTS

Significant differences were found in total cartilage thickness, but only after 21 days (Table 1). In group E, after 7 days, a slight change was observed in the way the hyaline and hypertrophic layers were arranged (Figs 5A and 5B). Total thickness showed no statistically significant difference compared to group C (Table 1), which could be confirmed by superimposing the data distribution curve (Fig 6A). Although the hypertrophic layer of group E seemed to be very similar to that of group C (Figs 5A and 5B), there was a slight decrease (9.60%) in the hyaline layer and a subtle increase of 10.09% (Table 1) in the proliferative layer (Figs 6C and 6D).

After 21 days, histological changes were observed in group E (Figs 5C and 5D), across the entire condylar cartilage. There was an increase of 39.46% in the total layer (Table 1), reflected in an increase in the thickness of the hypertrophic (42.24%), hyaline (46.92%) and proliferative (17.70%) layer, according to the data shown in Table 1 and Figures 6B, 6C and 6D.

Over 30 days of experiment, the condylar cartilage in group E seemed to be histologically similar to that of group C (Figs 5E and 5F). However, total thickness greater than 17.15% was observed due to an increased thickness in the hyaline and proliferative layers of 26.56% and 23.31% respectively, as shown in Table 1.

Both the experimental and the control group showed a significant decrease in the total layer of the condyle at the end of the experiment compared to C7 and E7 times, respectively.

Although the hypertrophic layer of group C showed an increase between C21 and C30 times (see table), such increase was not statistically significant and can be explained by the fact that during natural growth, a decrease in the total thickness of the condylar cartilage occurs (Figs 5A, 5C and 5E). In group E, however, this pattern of development was altered, in particular with regard to thickness of the hyaline and hypertrophic (Figs 5B, 5D and 5F) layers.

DISCUSSION

During growth phase, the chances of achieving a successful treatment which is performed by means of functional orthodontic appliances that promote changes in mandibular posture, is higher, since cellular activity is more dynamic. The ages of the animals used in this study ranged from 5 to 9 weeks, spanning the prepubertal phase

Table 1 - Layer thickness: Total (µm), hypertrophic (µm), hyaline (µm), proliferative (µm) layers of the following groups: control group in 7 (C7), 21 (C21) and 30 (C30) days, and experimental group in 7 (E7), 21 (E21) and 30 (E30) days. N = 5 animals per group.

	Total	Hypertrophic	Hyaline	Proliferative
C7	240.51 ± 39.43	131.06 ± 33.84*	65.92 ± 22.88*	43.54 ± 10.72
E7	245.90 ± 39.46	137.32 ± 33.23	60.15 ± 18.22	48.42 ± 12.70
C21	170.42 ± 23.77**	72.92 ± 17.28**	54.99 ± 13.35**	42.50 ± 10.23**
E21	281.50 ± 52.93	126.26 ± 31.33	103.60 ± 38.99	51.64 ± 28.93
C30	157.29 ± 24.89	73.95 ± 16.69	51.94 ± 13.86#	31.39 ± 12.30#
E30	189.84 ± 28.34	78.18 ± 15.06	70.72 ± 18.27	40.93 ± 13.42

*p < 0.05 when compared to E7, ** p < 0.05 when compared to E21, # p < 0.05 when compared to group E30.

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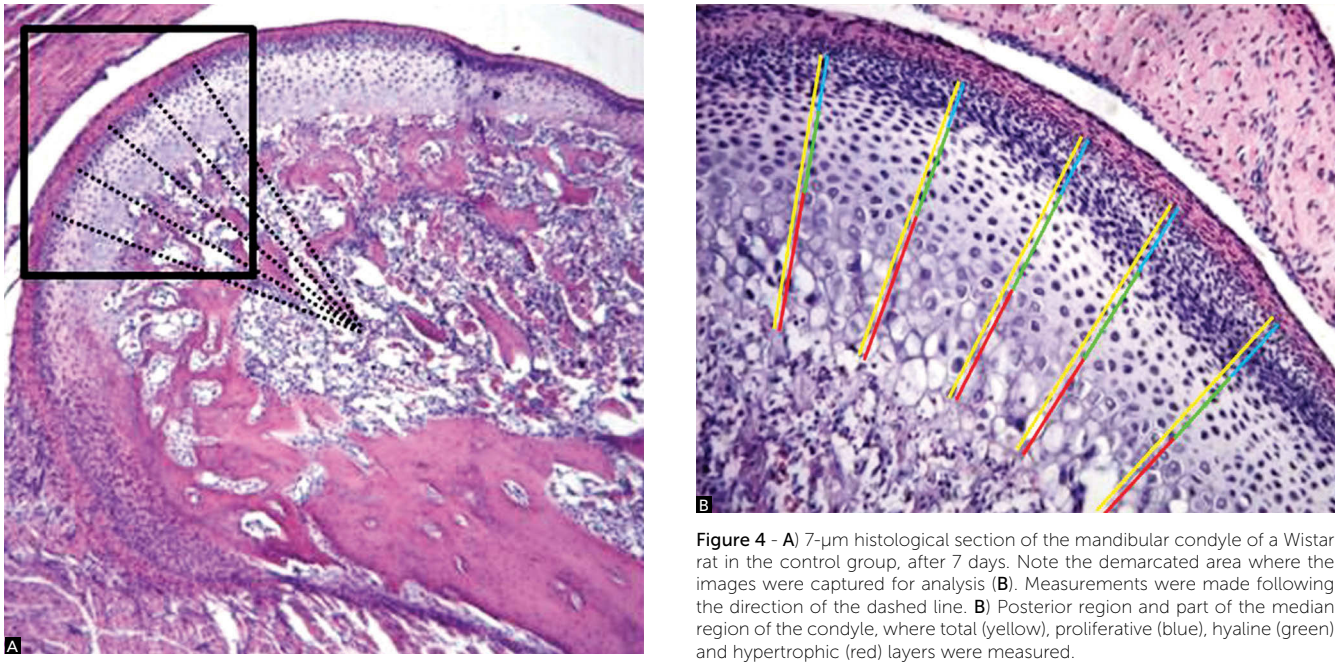

Figure 4 - **A**) 7-µm histological section of the mandibular condyle of a Wistar rat in the control group, after 7 days. Note the demarcated area where the images were captured for analysis (**B**). Measurements were made following the direction of the dashed line. **B**) Posterior region and part of the median region of the condyle, where total (yellow), proliferative (blue), hyaline (green) and hypertrophic (red) layers were measured.

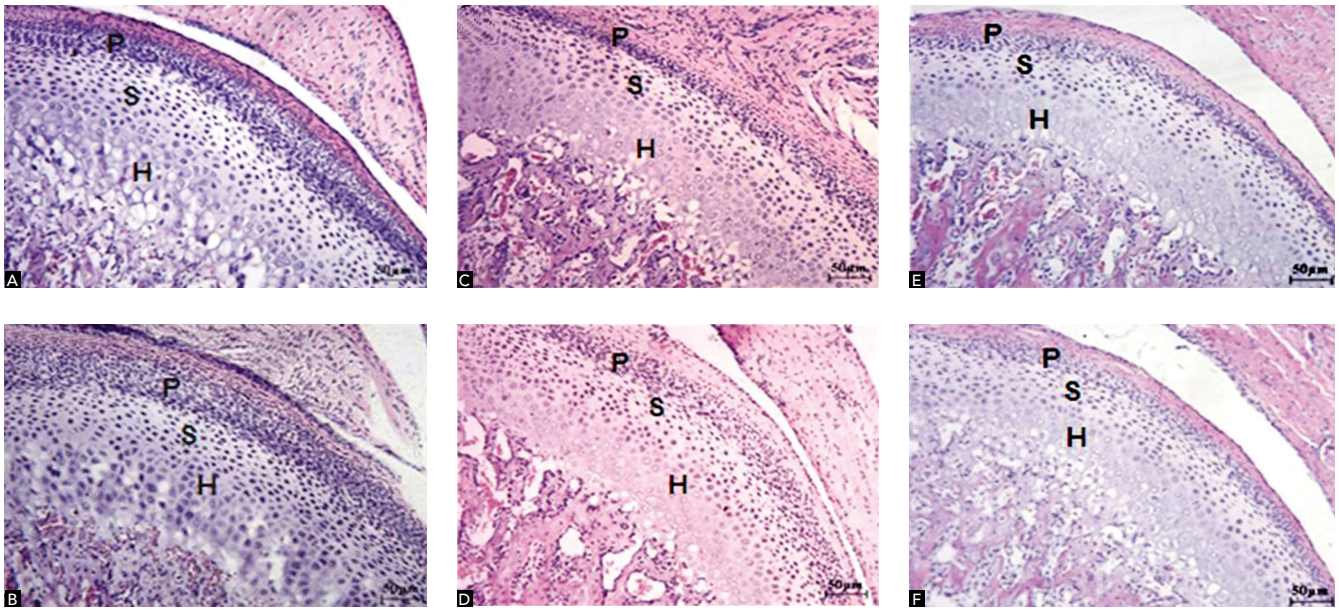

Figure 5 - Photomicrograph of the condylar region of rats showing the proliferative (P), hyaline (S) and hypertrophic (**H**) regions which belong to the following groups: (**A**) control group after 7 days (**B**) Experimental group after 7 days. (**C**) control group after 21 days (**D**) experimental group after 21 days. (**E**) control group after 30 days (**F**) experimental group after 30 days. Staining: Hematoxylin and eosin. Calibration bar (50 µm).

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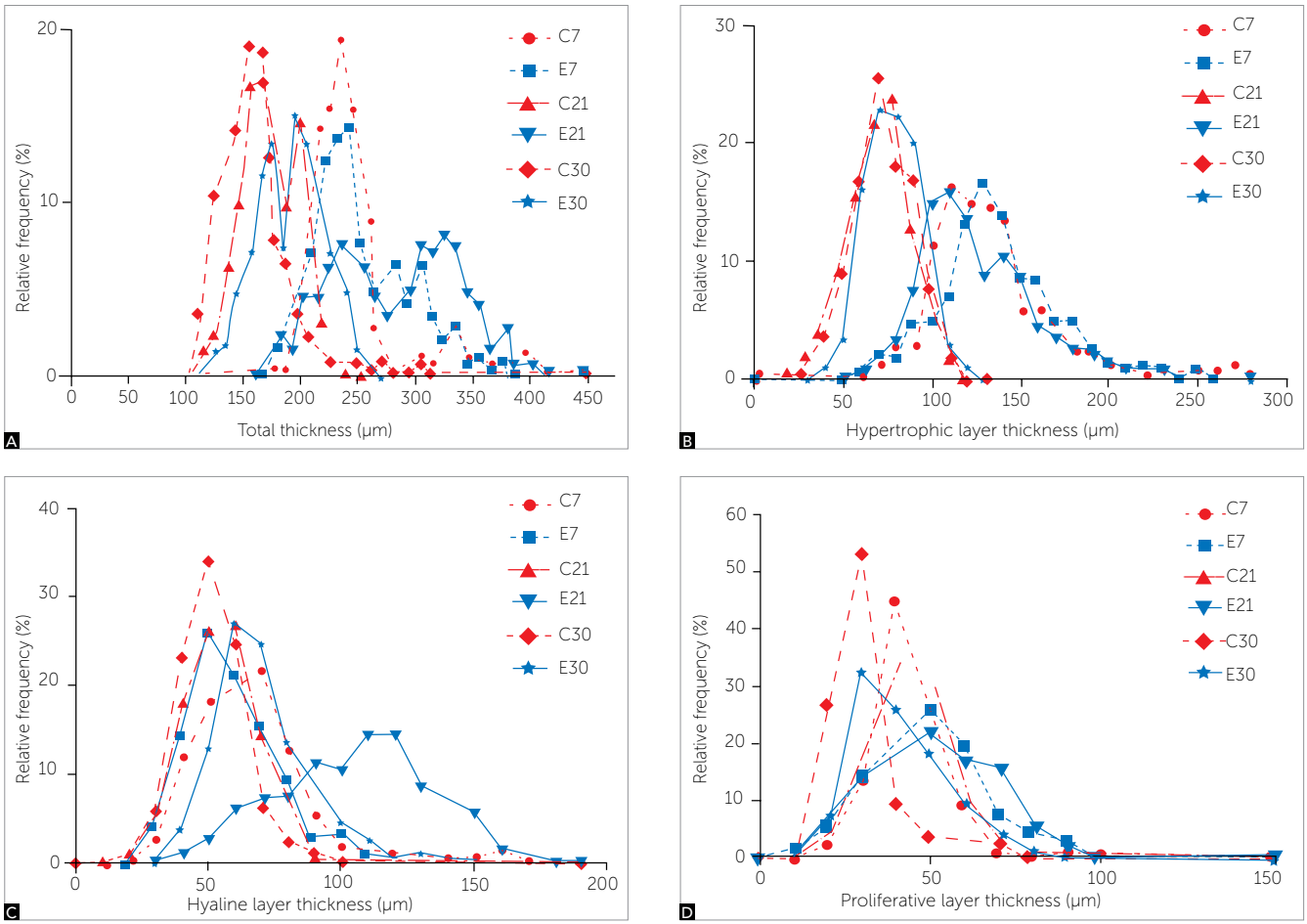

Figure 6 - Distribution of relative frequencies of the different layer thicknesses: (**A**) Total, (**B**) Hypertrophic, (**C**) Hyaline; (**D**) Proliferative, control groups after 7 (C7), 21 (C21) and 30 (C30) days and experimental after 7 (E7), 21 (21) and 30 (E30) days (n = 5).

to the pubertal growth spurt stage.[19] The experimental model that makes use of rat TMJs is widely accepted and studied due to its similarity to the human TMJ.[17]

Few reports in the literature involve changes in posture by mandibular setback.[1,2] Some studies[4,9,18] report cellular changes when the mandible is deviated to one side. The obtained results showed that after 14 days, there was an increase in growth in the condyle in the protruding or contralateral side, and a reduction in the non-protruding or ipsilateral side. Based on these data, the cartilage was expected to yield a total value below that of the control. However, the question is not so simple. The response mechanism of the condylar cartilage was markedly different on the 21st day. There was an increase in total cartilage thickness in group E, with the predominance of the hyaline and hypertrophic layers. It was not possible to determine that this increased cartilage thickness consisted of growth. A greater adaptive capacity of the condylar cartilage can be explored in appositional growth.[19]

It is known that the condylar cartilage has features that are similar to secondary cartilage, and that growth begins with the mesenchymal tissue (undifferentiated cells) covering the prenatal or postnatal condyle.

It should be recalled that during natural growth mesenchymal cells are further divided into smaller cells. Afterwards, these cells will reach their full size, resulting in migration of some of them out of the covering membrane and into the condyle.[5] Differentiation occurs when the mesenchymal cells migrate to the cartilage, becoming immature cartilage cells. The new lineage of cartilage cells will then be added, not by means of mitosis of cartilage progenitor cells (interstitial growth), but by mitosis of undifferentiated mesenchymal cells. This growth mode, in which new external cells are added, consists of appositional increase.[3,10] This study, therefore, did not disclose any increase in the proliferative layer, leading the authors to question any actual growth gains.

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According to Liu, Kaneko and Soma,[9] in addition to the amount of growth, direction may also be altered. For example, on the side where the condyle is positioned a decrease occurs in the horizontal direction and an increase in the vertical direction. In this study, thickness of the posterior and middle portion of the cartilage was measured, which revealed an increase within 21 days.

Further studies are warranted to provide greater awareness and understanding of the characteristics of condylar cartilage when the mandible is retropositioned. New data could be observed if bone layer measurement were to be included and if the device were removed after 30 days, thereby promoting mandibular repositioning.

CONCLUSIONS

Application of a device to retrude the mandible modified the characteristics of the condylar cartilage in the experimental period. The most significant difference in cartilage thickness was observed after a period of 21 days, when stimulation promoted the prevalence of growth in the hyaline and hypertrophic layers. Mandibular retrusion produced a number of morphological and histological responses in the condyle and suggests the occurrence of a condylar and mandibular adaptation in rats. Clinically, this indicates that the use of orthopedic/orthodontic treatments can contribute to mandibular adjustments, facilitating mandibular positioning and basal bone interrelation.

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Occlusal assessment in surgically assisted unilateral cleft lip and palate patients

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Objective: The aim of this study was to assess the magnitude of occlusal changes in individuals with unilateral cleft lip and palate (CLP). The study was conducted on study casts of 25 subjects, 14 men and 11 women aged from 7 to 20 years, without previous orthodontic treatment and with surgical repair carried out at São Marcos Hospital, Teresina, Piauí State, Brazil.

Methods: The casts were assessed by three orthodontists based on the occlusal scores established by Atack et al., whose scores range from 1 to 5, according to the magnitude of transverse and sagittal changes.

Results: Intra and inter-observer reproducibility of occlusal scores was satisfactory and statistically significant according to the Spearman Correlation test with significance level set at 5%. With regard to the distribution of occlusal scores, 30.67% of the subjects achieved scores 1 and 2, 22% score 3 and 47.53% achieved scores 4 and 5.

Conclusions: Four was the score most frequently assigned by the observers, disclosing a high degree of transverse and sagittal disorders in the occlusion of patients.

Keywords: Growth. Malocclusion. Cleft lip.

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INTRODUCTION

Individuals with cleft lip and palate exhibit functional and morphological changes and may, in some cases, manifest psychosocial changes given that the affected region is highly visible, causing a negative esthetic impact. As for their morphological diversity, lip and palate clefts yield different levels of severity and consequences, requiring not only changes in treatment protocol, but also an interdisciplinary team composed of an orthodontist, pediatrician, plastic surgeon, speech pathologist, psychologist, geneticist and social worker, to promote adequate esthetic and functional rehabilitation as well as seamless social and psychological integration to patients.[6]

In Brazil, clefts are currently classified on the basis of a system proposed by Spina,[18] which uses the incisive foramen, the only single structure connecting the primary and secondary palates during intrauterine life, as anatomical reference. These palates ultimately formed the midface. Thus, this classification defines clefts based on length, in line with their embryonic origin.[17] According to this classification, clefts are divided into four different groups: Group I = Pre-foramen clefts; Group II = Trans-foramen incisor clefts; Group III = Post-foramen incisor clefts; and Group IV = Rare facial clefts.[14]

Some treatments should be provided as soon as patients with this anomaly are born in order to improve the quality of life of these individuals. Soon after the third month of life, the lip should be reconstructed (cheiloplasty) and in the twelfth month, the palate should be reconstructed (palatoplasty). These surgeries are called primary surgeries as they are aimed at restoring the anatomic integrity left unfinished in intrauterine life. If necessary, secondary surgeries are performed to close the fistulas, as well as pharyngoplasty while finishing touches are applied to the primary surgeries.

The craniofacial growth of individuals with unilateral cleft lip and palate (CLP) should be constantly monitored due to the adverse effects of primary surgeries on the anteroposterior and transverse growth of the maxilla. Some changes in the occlusion are frequently found, especially anterior crossbite and posterior crossbite.[12]

The impact of primary plastic surgery on the midface growth makes it important to study the magnitude of occlusal changes undergone by patients with unilateral cleft lip and palate (CLP) subjected to surgery at São Marcos Hospital in Teresina, Piauí State (PI), Brazil, an institution recognized by the Ministry of Health as a reference center in the Northeastern region of Brazil.

MATERIAL AND METHODS

Sample characterization

The NOVAFAPI Institutional Review Board (CEP/NOVAFAPI) reviewed this research project and found that it met the provisions of resolution No. 196/96, issued by the National Council of Health (CNS/MS). Therefore, the project was authorized and filed under number 0430-08.

The sample comprised 25 individuals aged from 7 to 20 years old, with unilateral CLP, subjected to primary plastic surgery at the São Marcos Hospital in the city of Teresina, Piauí State, Brazil. Out of 25 patients who participated in this study, 14 (56%) were men while 11 (44%) women. Patients' age range was 14 years and 3 months (Table 1). According to the number of primary plastic surgeries and the time when they were performed, the first lip repair was carried out by means of the Millard's technique, on average, when the patient was 7 months old; whereas

Table 1 - Mean, median and standard deviation of ages (in years) of patients with unilateral CLP who underwent surgery at São Marcos Hospital. Data displayed according to sex.

Sex	Mean ± standard deviation	Median
Feminine	14.24 ± 5.97	14.00
Masculine	14.23 ± 3.55	15.00
TOTAL	14.25 ± 5.30	15.00

Table 2 - Distribution of the 25 patients with unilateral CLP who underwent surgery at São Marcos Hospital. Data displayed according to the number of surgeries and the time when the first plastic surgeries were performed (in months).

Surgery	Mean ± standard deviation	Median
Number of procedures		
cheiloplasty	1.29 ± 0.62	1.00
palatoplasty	1.29 ± 0.62	1.00
Age (months)		
1st cheiloplasty	7.63 ± 8.24	3.00
1st palatoplasty	30.17 ± 31.29	20.00

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palatoplasty was performed at 30 months of age, using a modified version of Von Langenback's technique (Table 2).

The following inclusion criteria were applied: Plastic surgeries performed at São Marcos Hospital; cheiloplasty (lip surgery) before 2 years of age; palatoplasty (surgery of the palate) before 3 years of age; no prior orthopedic treatment performed to achieve expansion and/or reverse traction of the maxilla; no syndrome in the craniofacial region; no alveolar bone graft in the cleft area.

Assessment of occlusal characteristics in the study casts

The occlusal characteristics of the 25 patients with unilateral CLP were evaluated on study casts (Fig 1) by 3 examiners (orthodontists and professors at the NOVA-FARI Specialization Course in Orthodontics) using the occlusal index proposed by Atack et al.[2] (Table 3).

The casts were carefully arranged in ascending order on a bench concealing the patients' personal identification data. This evaluation was performed individually with no communication between examiners, who were previously calibrated for application of the occlusal index, while changing the numbering on the casts in both assessments to prevent memorization.

In order to verify method reliability, all casts were reassessed 15 days after the first evaluation.[8]

Statistical analysis

Method reliability

Evaluation results were exported to a database created with SPSS software, version 13.0. Inter-examiner correlation was determined in both assessments

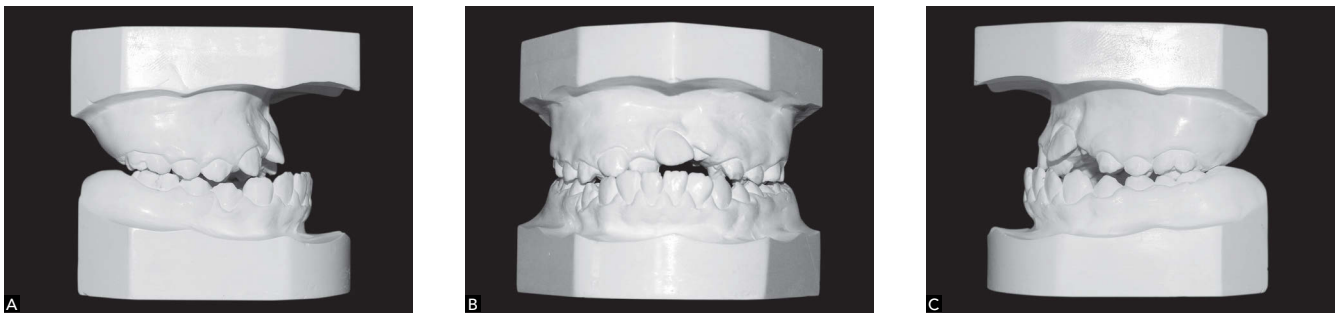

Figure 1 - Study casts of an individual from the sample used in this study, showing unilateral CLP. **A**) Right lateral view. **B**) Frontal view. **C**) Left lateral view.

Table 3 - Evaluation index of the occlusal characteristics using casts (inter-arch relationship) in individuals with unilateral CLP.[3]

Group	Occlusal characteristics	Long-term outcome prognosis
1	– Positive overjet with normal inclination or lingual inclination of the incisors; – Absence of crossbite and open bite; – Satisfactory morphology of the upper dental arch	Excellent
2	– Positive overjet with normal inclination or labial inclination of the incisors; – Unilateral crossbite / tending towards crossbite; – Tendency towards open bite adjacent to the cleft	Good
3	– End-on relationship with normal inclination or labial inclination of the incisors, or negative overjet with incisors inclined lingually; – Tendency towards open bite adjacent to the cleft	Regular
4	– Negative overjet with normal inclination or labial inclination of the incisors; – Tendency towards unilateral/bilateral crossbite; – Tendency towards open bite adjacent to the cleft	Bad
5	– Negative overjet with labial incisor inclination – Bilateral crossbite; – Substantially changed upper jaw morphology	Very bad

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(initial and after 15 days), as well as intraexaminer correlation with the purpose of verifying method reliability using Spearman's correlation test with a significance level set at 5% ($p < 0.05$).

To define the degree of agreement, the scale proposed by Altman[2] was applied to the values shown in Table 4. Only "good" and "very good" scores were considered satisfactory.

Table 4 - Relevance of the level of agreement as described by Altman.[2]

Value	Level of agreement (LA)
≤ 0.2	Poor
0.21 to 0.40	Regular
0.41 to 0.60	Mild
0.61 to 0.80	Good
0.81 to 1.00	Very good

RESULTS

Intra and inter-observer agreement in determining the occlusal index

Table 5 depicts a correlation between the first and second scores assigned to each observer (p), and shows whether the degree of agreement is acceptable. A statistically significant correlation (R) was found for all examiners.

As regards inter-observer correlation, the degree of agreement ranged between "good" and "very good" (Table 6). The good repeatability accomplished in the test was expected because all examiners were orthodontists and the index designed by Atack et al.[3] proved to be easy to apply.

Magnitude of occlusal changes exhibited by the patients with CLP

The results showed that 30.67% of patients were included in indices 1 and 2, 22% in index 3, and 47.33% were included in indices 4 and 5 (Fig 2).

Table 5 - Intraobserver agreement in determining the occlusal index in the 25 patients with unilateral CLP who underwent surgery at São Marcos Hospital. Teresina, Piauí State, Brazil.

Examiner	Correlation		
	P	R	LA
Orthodontist 1	0.000*	0.896	VG
Orthodontist 2	0.000*	0.627	G
Orthodontist 3	0.000*	0.917	VG

Spearman correlation. N = 25, *significant at $p < 0.05$.
Captions for Level of Agreement: P - Poor, M - Mild, R - Regular, G - Good, VG - Very good.

P column= correlation between the first and second score assigned to each observer. R column = correlation for all examiners.

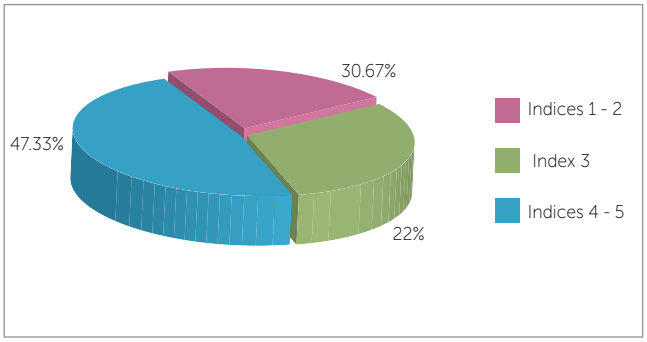

Figure 2 - Distribution of occlusal indices in the 25 patients with unilateral CLP who underwent surgery at São Marcos Hospital.

Table 6 - Inter-observer agreement in the first and second evaluations in determining the occlusal index in the 25 patients with unilateral CLP who underwent surgery at São Marcos Hospital.

Examiner 1st Evaluation	Orthodontist 1			Orthodontist 2			Orthodontist 3		
	p	R	LA	p	R	LA	p	R	LA
Orthodontist 1	-	-	-	0.000*	0.667	G	0.000*	0.785	G
Orthodontist 2	0.000*	0.667	G	-	-	-	0.000*	0.809	VG
Ortodontist 3	0.000*	0.785	G	0.000*	0.809	VG	-	-	-
Examiner 2nd Evaluation	**Orthodontist 1**			**Orthodontist 2**			**Orthodontist 3**		
	p	R	LA	p	R	LA	p	R	LA
Orthodontist 1	-	-	-	0.000*	0.700	G	0.000*	0.892	VG
Orthodontist 2	0.000*	0.700	G	-	-	-	0.000*	0.651	G
Orthodontist 3	0.000*	0.892	VG	0.000*	0.651	G	-	-	-

Spearman correlation. N = 25, *significant at $p < 0.05$. LA (Level of Agreement): P - Poor, M - Mild, R - Regular, BG- Good, VG - Very good.
P column= correlation between the first and second score assigned to each observer. R column = correlation for all examiners.

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DISCUSSION

Lip and palate clefts are a congenital defect with diverse clinical manifestations. Its involvement can range from a small notch in the lip vermilion or mucosa of the uvula to a complete breakdown of the maxilla. In summary, from an embryonic point of view, clefts can affect the primary and secondary palate with different levels of severity. Given their higher prevalence, this study aimed at assessing the behavior of post-surgical complete unilateral clefts involving the primary and secondary palate, also known as unilateral cleft lip and palate (CLPs). Corroborating the literature,[3] this study also showed a higher prevalence of unilateral CLP in males.

According to surveys conducted at the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC-USP), these clefts account for approximately 33% of occurrences.[16] Among unilateral CLPs, there are numerous variables that influence their anatomical configuration and differentiate one patient from another, such as cleft width, the presence of Simonart's band and degree of nose asymmetry. Simonart's band is formed by a bridge of soft tissue that joins the mesial and distal edges of a complete lip and palate cleft, which can positively affect the morphology of postoperative upper dental arches when the band is bulky.[11]

Primary plastic surgery reconstructs lesions in the lip and palate and in so doing influences the behavior of the nasomaxillary complex, of which expression of genetic growth potential is restricted. The more numerous the morphological variables inherent in clefts are, the greater will be the number of therapeutic variables that may influence the patient's face and occlusion in the long-term. Among these variables, one could mention the amount of time required to complete surgery, surgical techniques, number of repetitive surgeries as well as the extra-surgical care provided pre- and postoperatively. Undoubtedly, the surgeon's skill in manipulating young tissue plays a key role in ultimately shaping the face.[11,13,14]

The current surgical protocol adopted at São Marcos Hospital recommends the performance of lip repair at 6 months of postnatal life and palatoplasty at 18 months. However, the protocol used at the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC-USP) recommends that such procedures be carried out at 3 and 12 months of postnatal life, respectively.[11]

Choosing a straightforward occlusal index is of paramount importance since it interferes in method reliability and in determining the number of examiners. The results of this study agree with those of Okada,[11] who also found the occlusal index of Atack et al.[3] to be straightforward and easy to apply, since there was no statistically significant intraobserver differences, even when different groups of examiners were used, such as oral maxillofacial surgeons, plastic surgeons and orthodontists. Therefore, the ease with which the occlusal assessment method was applied precluded the need for a greater number of examiners.

The quality of a given rehabilitation protocol used by a reference center in treating patients with cleft lip and palate can be measured by the magnitude of occlusal changes that occur, especially in patients with CLP, since sequelae inherent to the morphology of the clefts as a result of the surgical repair procedure, involve significant changes in the transverse and anteroposterior growth of the maxilla. Results showed that cases considered "very bad" (indices 4 and 5) accounted for almost half of the sample, confirming the negative effect of primary plastic surgery in the growth of midface structures, for which there seems to be consensus in the literature.[1,5,7,9-12]

On assessing the magnitude of occlusal alterations observed in patients rehabilitated at São Marcos Hospital (Teresina, Piauí State), this magnitude was found to be close to results achieved by reference centers both in Brazil and abroad - such as the Hospital for Rehabilitation of Craniofacial Anomalies, Bauru, São Paulo State, and the Rehabilitation Center of Oslo, Norway. The indices found in this study were compared to those obtained by Okada,[11] which were assessed by the Bauru and Oslo centers. For indices 1 and 2, the data showed a percentage of 30.67% in Teresina, 34% in Bauru and 60% in Oslo. As for index 3, the percentage was 22% in Teresina, 27.72% in Bauru and 22% in Oslo. For indices 4 and 5 (which represent the major occlusal sequelae and comprise the cases requiring orthognathic surgery) the percentages were 47.33% in Teresina, 38.20% in Bauru and 18% in Oslo. Thus, it can be asserted that the Oslo Center results were higher than those of the Brazilian centers, especially when comparing the percentage of cases with greater occlusal sequelae.

With regard to the average occlusal index based on all scores assigned by examiners in both assessments,

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there was an index of 3.28 in Teresina, 3.07 in Bauru and 2.52 in the Oslo Center. In examining the median scores assigned by examiners in the present study, index 4 proved to be the most frequent, indicating a high degree of transverse and anteroposterior changes in the occlusion of the patients.

How can one explain Oslo's higher results in terms of occlusion conditions? Many variables certainly play a role in the diversity of the outcomes, but according to Shaw et al.[13] one major factor is the standardization of the protocol and the surgical techniques adopted, along with a small number of surgeons, with surgeries being performed by virtually one single surgeon.

When the results obtained in Teresina were compared to those of Bauru, a higher percentage of cases with greater occlusal sequelae were found in Teresina. However, age is yet another key factor to be taken into account when interpreting these results. The vast majority of patients in this study were at the permanent dentition stage, whereas those assessed by Okada[11] in Bauru were at the early mixed dentition stage. Given that plastic surgery cumulatively affects the growth of the midface, patients at the stage of occlusal maturity tend to produce more sequelae in transverse and anteroposterior maxillary growth compared to younger patients. It is worth noting that variables such as the anatomical extent of the cleft, the presence of Simonart's band, surgical procedure variables such as the surgical technique, surgeon skills and pre and postoperative care were not assessed.

The findings of this study confirmed the assumption that the maxillomandibular relationship of a patient with cleft lip and palate undergoes — starting from the stage of embryo formation — the strains imposed by the cleft and the resulting functional deviations. Furthermore, maxillomandibular relationship is potentially undermined by reconstructive surgeries (lip repair and palatoplasty), which hinder maxillary growth to varying degrees, resulting in changes in craniofacial growth and deficiencies in the intra and inter-arch relationships.

CONCLUSIONS

» With regard to the magnitude of occlusal changes, it was found that 30.67% of the subjects exhibited indices 1 and 2, 22% index 3 and 47.53% exhibited indices 4 and 5.

» On examining the scores assigned by examiners, occlusal index 4 proved to be the most frequent, indicating a high degree of transverse and anteroposterior changes in the occlusion of the patients.

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Angle Class II malocclusion treated with extraction of permanent teeth

Gustavo Mattos Barreto[1]

Angle Class II malocclusion associated with anterior open bite in adult patients demands a carefully elaborated orthodontic planning, aiming at restoring not only harmonious dental and facial esthetics, but also a balanced masticatory function. Orthognathic surgery or permanent teeth extraction are often the choice of treatment, therefore, treatment decision is related to all dental, skeletal and functional aspects. The present report discusses orthodontic compensation carried out by means of upper premolar extraction performed to correct the Class II canine relationship and, consequently, the anterior open bite, accepting that the upper incisors be retroclined. This clinical case was presented to the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO) as part of the requirements for obtaining the BBO Certification.

Keywords: Class II malocclusion. Anterior open bite. Orthodontic compensation.

INTRODUCTION

A 17.11-year-old female patient came to the clinic reporting difficulty in gripping food with her front teeth and dissatisfaction regarding dental esthetics, particularly concerning her smile. In the anamnesis, the patient presented history of mouth breathing, with adenoids treated during childhood, allergic rhinitis, good oral health with few restorations, lingual interposition and absence of the third molars which had already been extracted.

DIAGNOSIS

On assessing the patient's face, a dolichofacial pattern was observed in addition to absence of passive lip seal, increased lower facial third, significative exposure of the lower lip vermilion, wide buccal corridor when smiling, straight profile, normal upper and lower lips and increased nasolabial angle (Fig 1).

Clinically, the dental arches presented Angle Class II, division 1 malocclusion with greater magnitude on the right side (full), being cusp-to-cusp on the left side.

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* Clinical case, category 2, accepted by the Brazilian Board of Orthodontics and Dentofacial Orthopedics, BBO.

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

» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

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Figure 1 - Initial facial photographs.

Therefore, severe anterior open bite, restricted from canine to canine, was also observed in addition to a 2 mm deviation of the lower midline to the right, overjet of 8 mm and lingual inclination of the posterior teeth. With regard to interdental distances, the upper intercanine distance was of 30.5 mm while the lower one was of 27 mm. Functional guides were absent and there was difficulty in gripping food by the anterior region (Figs 2 and 3).

The maxillomandibular relationship was within the range of normality (ANB = 3°), however, with both the maxilla and the mandible retruded in relation to the cranial base. SNA= 75° and SNB= 72°, with a vertical growth pattern (SN.GoGn = 45°, FMA = 36° and Y axis = 66°). Moreover, the patient presented buccal inclination and protrusion of the upper incisors (1.NA = 35.5° and 1-NA = 9 mm). Additionally, she presented retroclination of lower incisors (1.NB = 16° and IMPA = 76°) (Fig 4 and Table 1). On assessing the panoramic radiograph, absence of the third molars which had already been removed, and slight root shortening of teeth #11, #12, #21, #22 and apical rounding of teeth #33, #32, #31, #41, #42 and #43 (Fig 5) were observed.

TREATMENT PLAN

Two treatment plans were elaborated. The first one involved orthognathic surgery and was immediately discarded by the patient as well as by her parents. The second one involved extraction of the upper first premolars. With regard to the latter, parents were aware that it would take longer, with the possibility of slight upper lip retraction. Moreover, in this planning, the upper first premolars would remain in Class II relationship, but with the canines in key of occlusion.[1,2] For the correction of the anterior open bite, the space left after the extractions would allow retroclination to be planned and consequent extrusion of the upper incisors, favoring bite closure.[3,4] As for arch atresia, expansion performed with a Haas appliance was recommended. Treatment prognosis would be favorable, but careful, in order to slightly maintain or change the upper lip position due to retraction. Additionally, speech monitoring would be necessary due to lingual interposition. With regard to stability, it is important to consider the removal of the etiologic factor of the anterior open bite (lingual interposition after mouth breathing during childhood).[5] Occlusal adjustments were also planned after treatment finishing.

PERFORMED TREATMENT

Initially, the Haas expander appliance was installed for upper expansion. It was activated at ¼ of a turn every 12 hours, during 12 days, with a retention period lasting for five months. Afterwards, a 0.022 x 0.028-in Edgewise standard system conventional fixed appliance was installed, however, not including teeth #14 and #24, which would be removed. The extraction of teeth #14 and #24 was requested and a 0.9 mm palatal

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Figure 2 - Initial intraoral photographs.

Figure 3 - Initial casts.

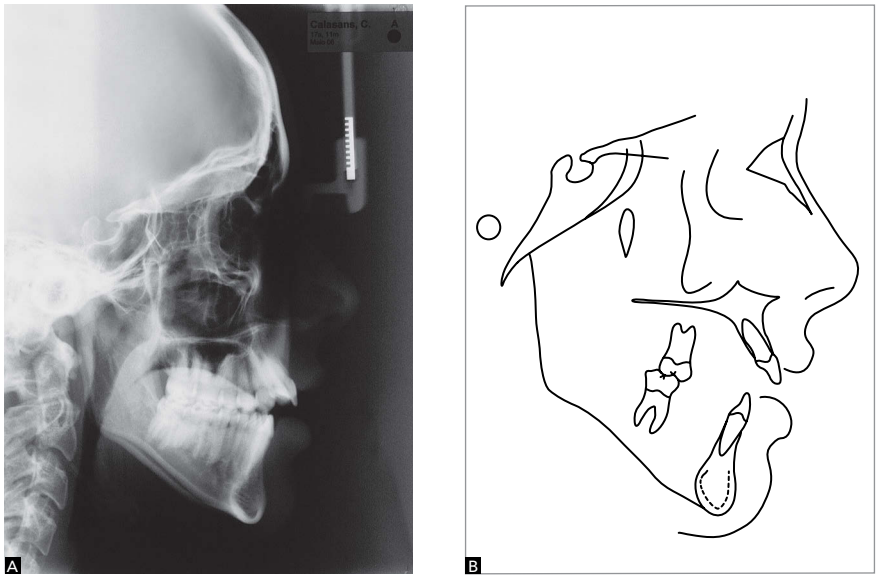

Figure 4 - Initial profile cephalometric radiograph (**A**) and initial cephalometric tracing (**B**).

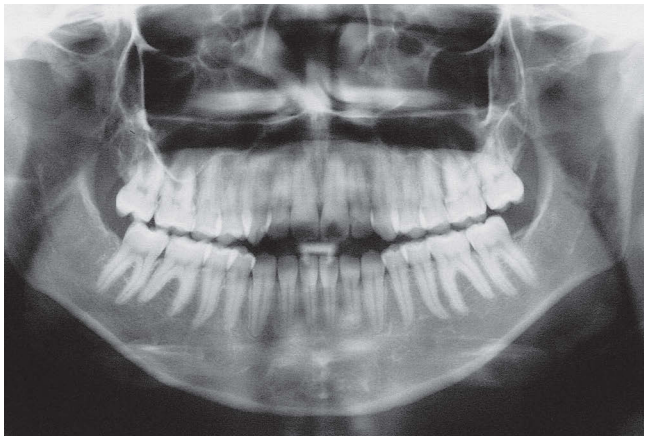

Figure 5 - Initial panoramic radiograph.

bar was installed for anchorage control. On the upper arch, alignment and leveling were performed on three segments: On teeth #13 to #17, #12 to #22 and #23 to #27. All segments began with 0.014-in NiTi wire, followed by 0.016, 0.018 and 0.020-in stainless steel wires, and, at last, 0.018 x 0.025-in stainless steel wire. At this phase, an extrusion arch was placed for the upper incisors, with a 0.017 x 0.025-in TMA wire — coming out from the auxiliary tubes of the upper first molars, bypassing, being superimposed on the region of the upper incisors and being activated for extrusion. After leveling, the upper occlusal plan was realigned with a continuous arch prior to mass space closure conventional mechanics, using stainless steel 0.018 x 0.025-in and 0.019 x 0.025-in archwires, with Bull loops between teeth #13 and #14, and #23 and #24.

At treatment finishing, stainless steel 0.019 x 0.025-in rectangular archwires were used with first, second and third order bends individualized as necessary. In the lower arch, alignment and leveling were initiated with NiTi archwire 0.014-in, followed by 0.014 to 0.020-in SS archwires with first and second order bends. Stainless steel 0.019 x 0.025-in rectangular finishing archwires, coordinated, with first, second and third order bends individualized as necessary, were used next.

As retention protocol, a fixed bar was installed between teeth #11 and # 21 (Bond a Braid) and a full removable upper plate was installed with stainless steel 0.032-in archwire. In the lower arch, an intercanine fixed bar was installed with 0.032-in Twist Flex archwire. The patient needed speech monitoring for six months, starting one month before the removal of the fixed appliances. Occlusal adjustments were performed in three moments: at the finishing phase, six months and one year after removal of the appliance. Furthermore, anatomic recontouring of the upper incisors was performed in addition to gingival plasty carried out on the posterior teeth for better dental exposure and, consequently, better esthetics.

OBTAINED RESULTS

After orthodontic finishing, exams were performed in two moments: At final phase (Figs 6 and 7) and after two years of control (Figs 8 and 9). Improvement in lip seal, smile harmony with good visualization of the posterior teeth and good exposition of the incisors (gingival plasty was extremely relevant for the beauty of the smile) and mild alteration in the upper lip (UL-Line S = -1 mm after treatment and -1.5 mm after two years of control) were observed.

The molars finished in Class II relationship, as expected, but with canines in key of occlusion. The anterior open bite was corrected and the results were maintained after the control period. Improvement in midline deviation (with slight deviation), correction of the overjet (1 mm final and after two years) and in the upper arch shape (Figs 6 to 9) were observed.

Vertically, the patient presented the same characteristics, as expected, since an exclusively orthodontic treatment was chosen. On the anteroposterior direction, there was slight improvement in the ANB angle (3° initial, 2° final and after two years of stability). Cephalometrically, the upper incisors were retroclined and retracted (1.NA = 13° and 1-NA = 3.5 mm, maintained after two years of control) (Figs 10 and 11, Table 1).

On assessing the final panoramic radiograph, good root parallelism after space closure was observed. Such parallelism was preserved after two years of control and root lengths underwent minor alterations, only (Figs 12 and 13).

Interpretation of the cephalometric superimpositions demonstrated improvement in facial profile and lip position, which promoted not only a better seal, but also mild alteration of the upper lip and correction of the overjet and overbite. Partial assessment of the maxilla demonstrated significant retroclination, retraction and extrusion of the upper incisors, in addition to mesialization of the upper molars due to anchorage loss. Partial assessment of the mandible did not demonstrate any significant alteration (Fig 14).

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Figure 6 - Final facial and intraoral photographs.

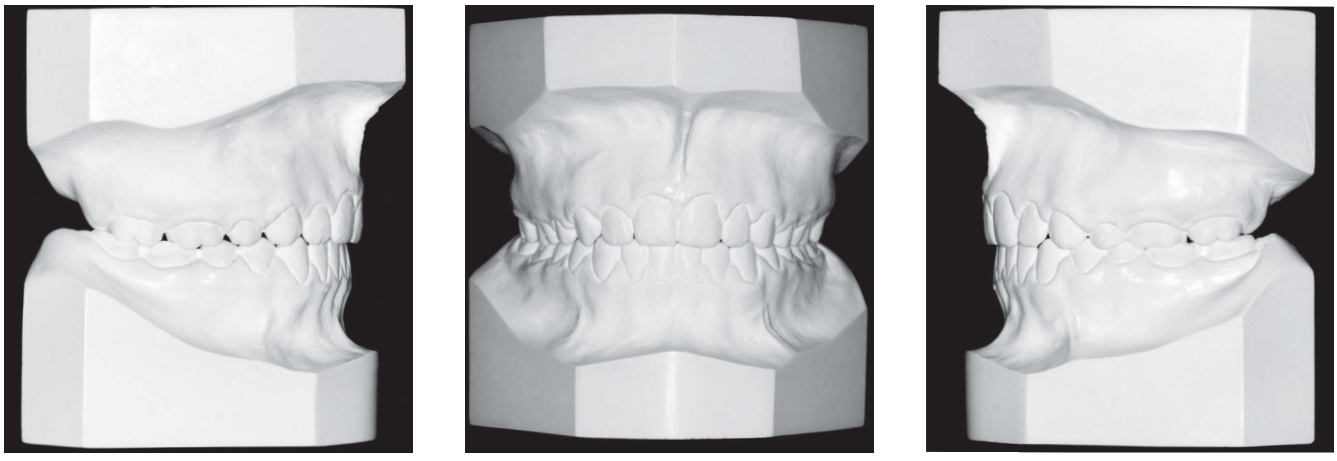

Figure 7 - Final casts.

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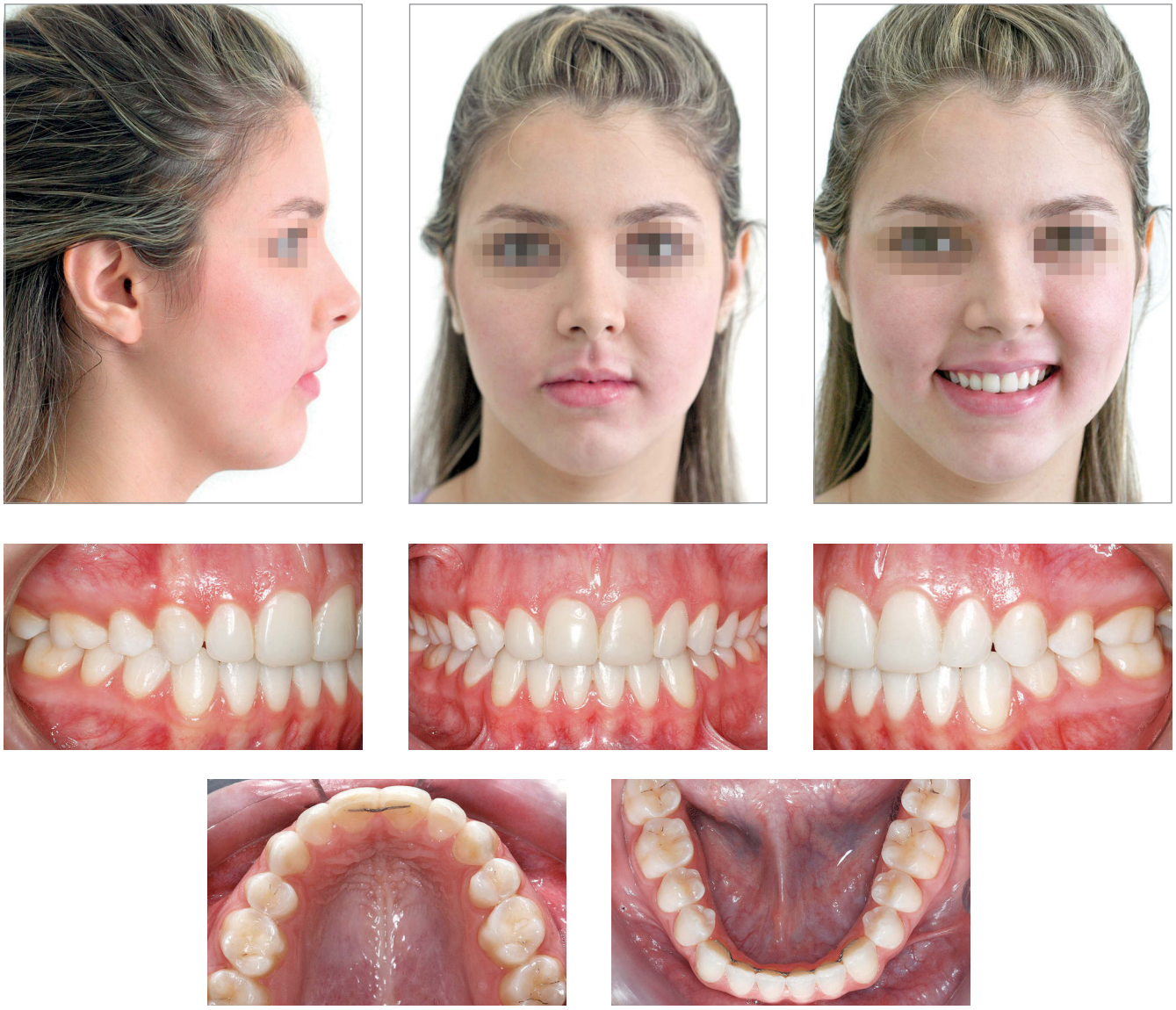

Figure 8 - Facial and intraoral photographs of control after two years.

Figure 9 - Control casts after two years.

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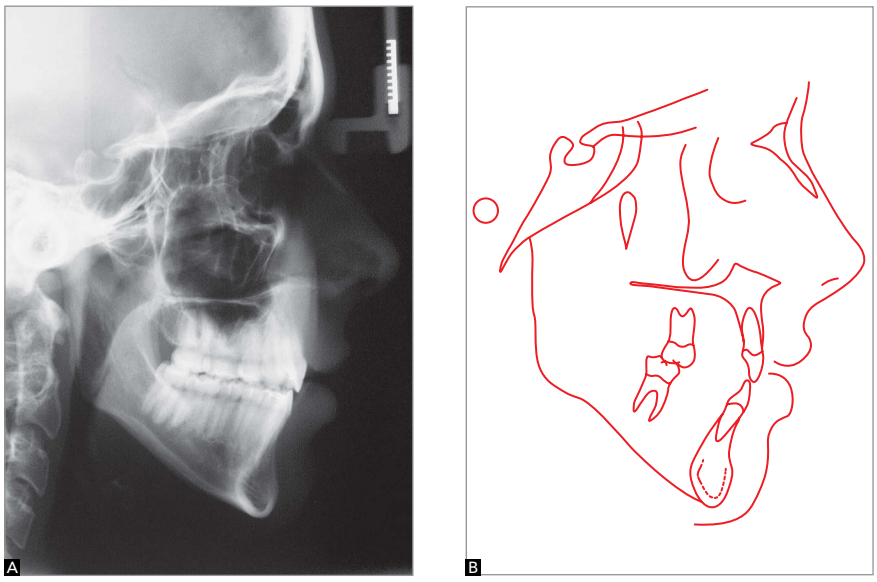

Figure 10 - Final profile cephalometric radiograph (**A**) and cephalometric tracing (**B**).

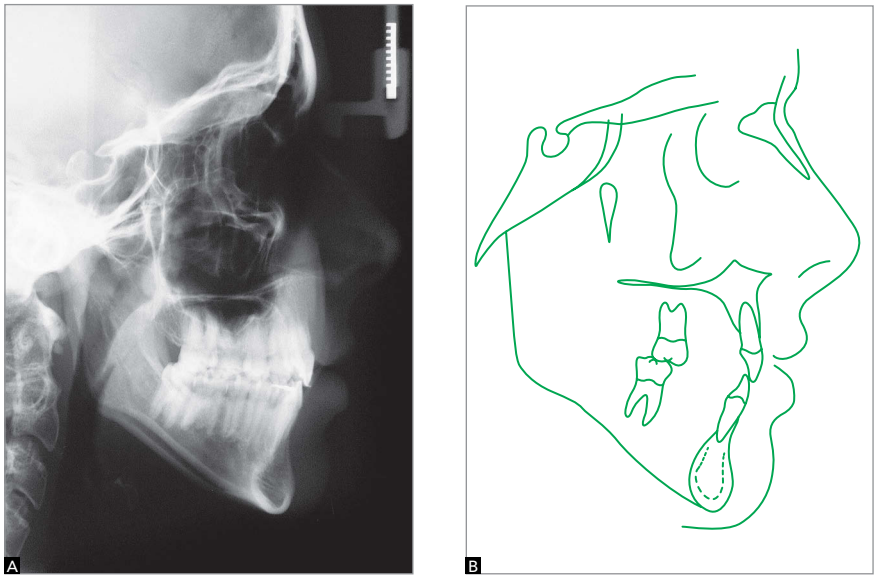

Figure 11 - Cephalometric radiograph (**A**) and profile cephalometric tracing (**B**) of control after two years.

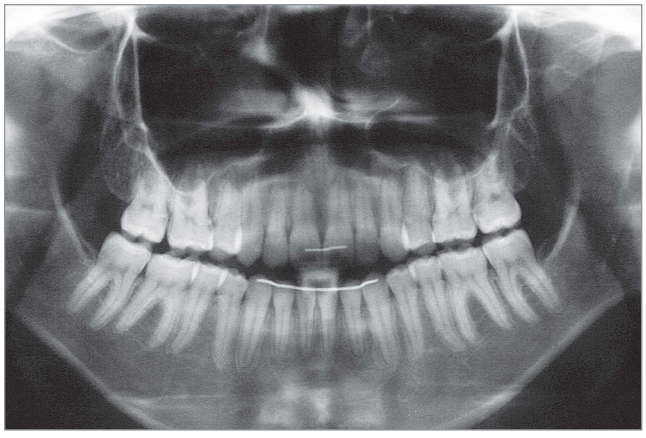

Figure 12 - Final panoramic radiograph.

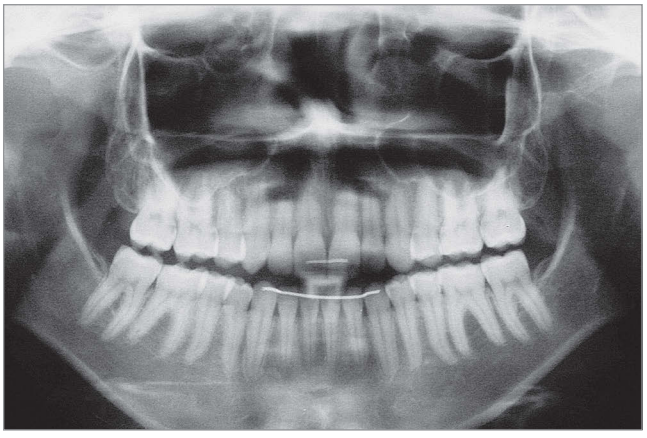

Figure 13 - Panoramic radiograph of control after two years.

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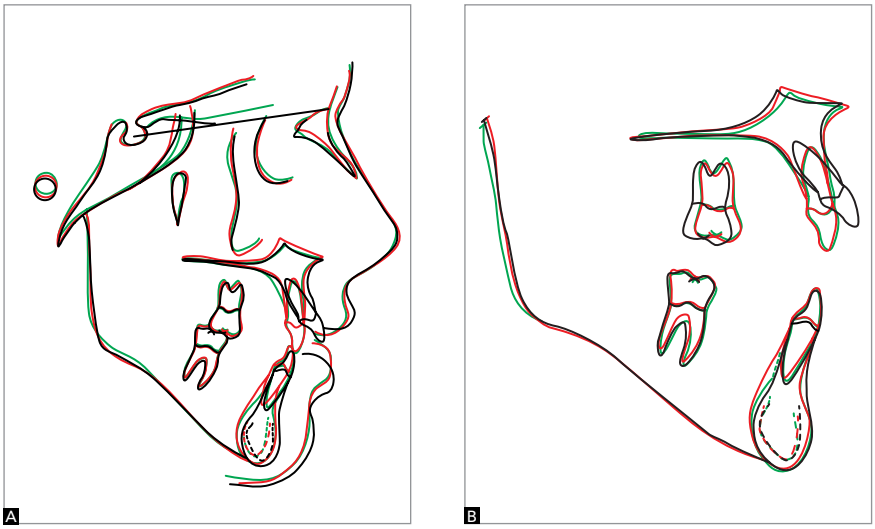

Figure 14 - Total (**A**) and partial (**B**) superimpositions of initial tracing (black), final tracing (red), and tracing of control after two years (green).

Table 1 - Cephalometric measurement summary.

	Measures		Normal	A	B	A/B diff.	Control
Skeletal pattern	SNA	(Steiner)	82°	75°	73.5°	1.5°	73°
	SNB	(Steiner)	80°	72°	71.5°	0.5°	71°
	ANB	(Steiner)	2°	3°	2°	1°	2°
	Facial angle	(Downs)	0°	2°	2°	0°	2°
	Y axis	(Downs)	59°	66°	67°	1°	67°
	Facial angle	(Downs)	87°	83°	82.5°	0.5°	82°
	SN-GoGn	(Steiner)	32°	45°	45°	0°	45°
	FMA	(Tweed)	25°	36°	36.5°	0.5°	37°
Dental pattern	IMPA	(Tweed)	90°	76°	78°	2°	77.5°
	1.NA (degrees)	(Steiner)	22°	35.5°	13°	22.5°	13°
	1-NA (mm)	(Steiner)	4 mm	9 mm	3.5 mm	5.5 mm	4 mm
	1.NB (degrees)	(Steiner)	25°	16°	16°	0°	16°
	1-NB (mm)	(Steiner)	4 mm	3 mm	3.5 mm	0.5 mm	4
	$\frac{1}{1}$ - Interincisal angle	(Downs)	130°	127°	150°	23°	150°
	1-APo (mm)	(Ricketts)	1 mm	-1 mm	0 mm	1 mm	0 mm
Profile	Upper lip – S line	(Steiner)	0 mm	-0.5 mm	-1 mm	0.5 mm	-1.5 mm
	Lower lip – S line	(Steiner)	0 mm	0 mm	0.5 mm	0.5 mm	0 mm

FINAL CONSIDERATIONS

The results were satisfactory and the objectives were achieved. It should be highlighted that in this treatment, orthognathic surgery was considered, but discarded by the patient as well as by her parents. Additionally, the final smile was pleasant and expressive, with good dental exposure, correction of anterior open bite and overjet, with good stability after a two-year follow-up. The patient was very glad, since treatment exceeded her expectations as well as her family's. It is worth emphasizing the importance of a multidisciplinary approach involving Cosmetic Dentistry and Periodontics, for the success of the treatment.

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Treatment of midfacial hypoplasia in syndromic and cleft lip and palate patients by means of a rigid external distractor (RED)

Eduardo Franzotti Sant'Anna[1], Adriana de Alcantara Cury-Saramago[2], Geórgia Wain Thi Lau[3], John W. Polley[4], Álvaro A. Figueroa[4]

Introduction: Distraction Osteogenesis (DO) became an alternative for the treatment of severe craniofacial skeletal dysplasias. The rigid external distraction device (RED) is successfully used to advance the maxilla and all the maxillary-orbital-frontal complex (monobloc) in children, adolescents and adults. This approach provides predictable and stable results, and it can be applied alone or with craniofacial orthognathic surgical procedures.

Objective: In the present article, the technical aspects relevant to an adequate application of the RED will be described, including the planning, surgical and orthodontic procedures.

Keywords: Distraction. Maxilla. Midface.

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

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

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INTRODUCTION

Distraction osteogenesis (DO) has been used in the last decades to treat midface hypoplasia, for promoting its significant advancement (by means of a process of gradual stretch of the facial bones), when compared to the advancement at once, through the conventional orthognathic surgery or the monobloc surgery.

DO can be the treatment of choice for patients with Crouzon syndrome or Apert syndrome;[8,17,23,30] hemifacial macrosomia;[19] and mandibulofacial dysostosis, also known as Treacher Collins syndrome. Its successful application benefits patients with secondary severe maxillary hypoplasia and orofacial clefts;[11,12,14,21,22] newborns presenting obstructive respiratory problems, as the occurred in patients with Pierre Robin sequence;[3,4] and patients presenting large bone defect resulting from the resection of tumors or from trauma.

Molina et al[18] were the pioneers on the use of DO for maxillary advancement, after incomplete horizontal osteotomy of the maxilla, with the aid of application of reverse traction by means of face mask and rubber bands.

The results of these first treatments motivated the development of alternative treatments and the formulation of new distractors with different designs — including the rigid external distraction device (RED).

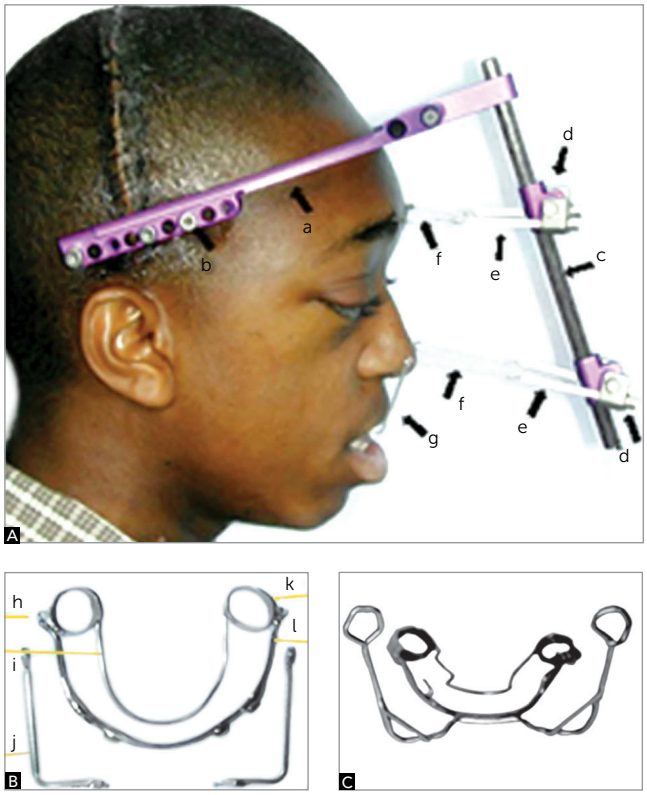

Figure 1 - **A**) Rigid external distraction device components: (a) cranial external halo; (b) fixation titanium screws, with active part of 45 mm; (c) carbon fiber anterior vertical rod; (d) distractor screws; (e) horizontal bars; (f) surgical steel wires (0.018-in); (g) external hooks connected to the intraoral splint. **B**) Intraoral splint composed of a buccal arch (0.051-in) + weld (h); a palatine arch, similar to a lingual arch (0.036-in) (i); external hook 0.051-in (j); orthodontic band (k) and buccal arch 0.051-in (l). **C**) Splint made from prefabricated extraoral arch of 0.051-in.

TECHNIQUE PRESENTATION

DO for maxillary advancement

Device

The device used to perform the distraction osteogenesis is composed of a rigid external structure, described on Figure 1A, and of an intraoral splint (Fig 1B), which will be connected with surgical wires (0.018-in) to the distractor screws, assembled between the vertical rod and the horizontal bars.[12]

Two medial rectangular tubes, welded to the anterior portion of the buccal arch of the splint (0.051-in), are used to anchor the connector hooks of the splint, which will be installed, in the doctor's office, after surgery – along with the carbon fiber anterior vertical rod, the distractor screws and the horizontal bars (Fig 1C). Besides, during surgery, the anterior part of the splint is fixed to the skeletal anchorage screws, bilaterally, between the canines and the upper lateral incisors (Fig 2A). This avoids the downward movement of the device during the distraction process and makes it quite rigid, adding stability to the splint.[9]

Surgery

The protocol for maxillary DO treatment with this external distraction device may or may not include presurgical orthodontic dental alignment, depending on the evolutionary stage of the dentition of the patient with maxillary hypoplasia and severe facial cleft. The making of the intraoral splint is mandatory, being fixed to the teeth in a clinical appointment which will leave the patient ready for surgery — because the splint provides a point of anchorage for the maxillary advancement, and the other structures allow the connection between the dentition and the external halo.

The beginning of surgery is characterized by the installation of mini-implants between the root apexes of the lateral incisor and upper canines on both sides, followed by the connection to the splint, with surgical steel wire, which adds security to intraoral stability (Fig 2A). Then, a complete Le Fort I osteotomy is performed, with pterygomaxillary disjunction.

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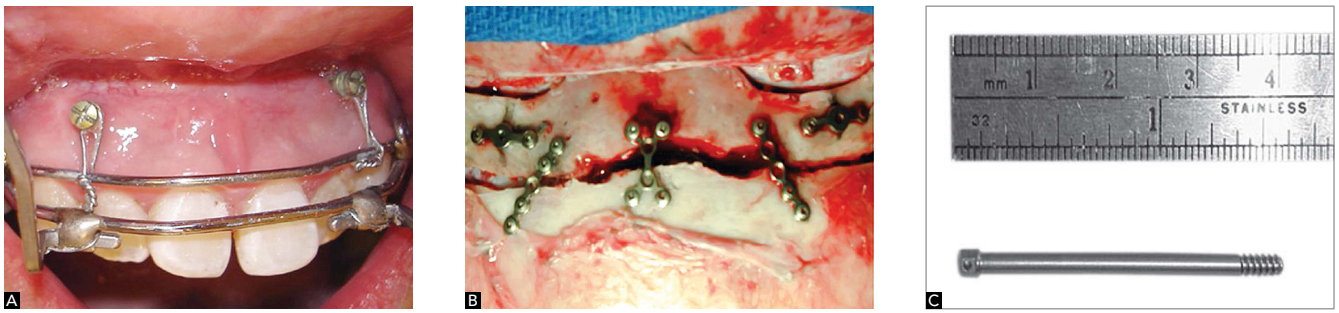

Figure 2 - **A**) Intraoral splint fixed with mini implants bilaterally installed between lateral incisors and canines. **B**) Rigid fixation, with titanium plates, of the frontal bone to the supraorbital protuberances. **C**) Upper traction pin, which is set to the lateral titanium plate, on the frontal bone. (**B, C** - Source: Figueroa, Polley,[9] 2007).

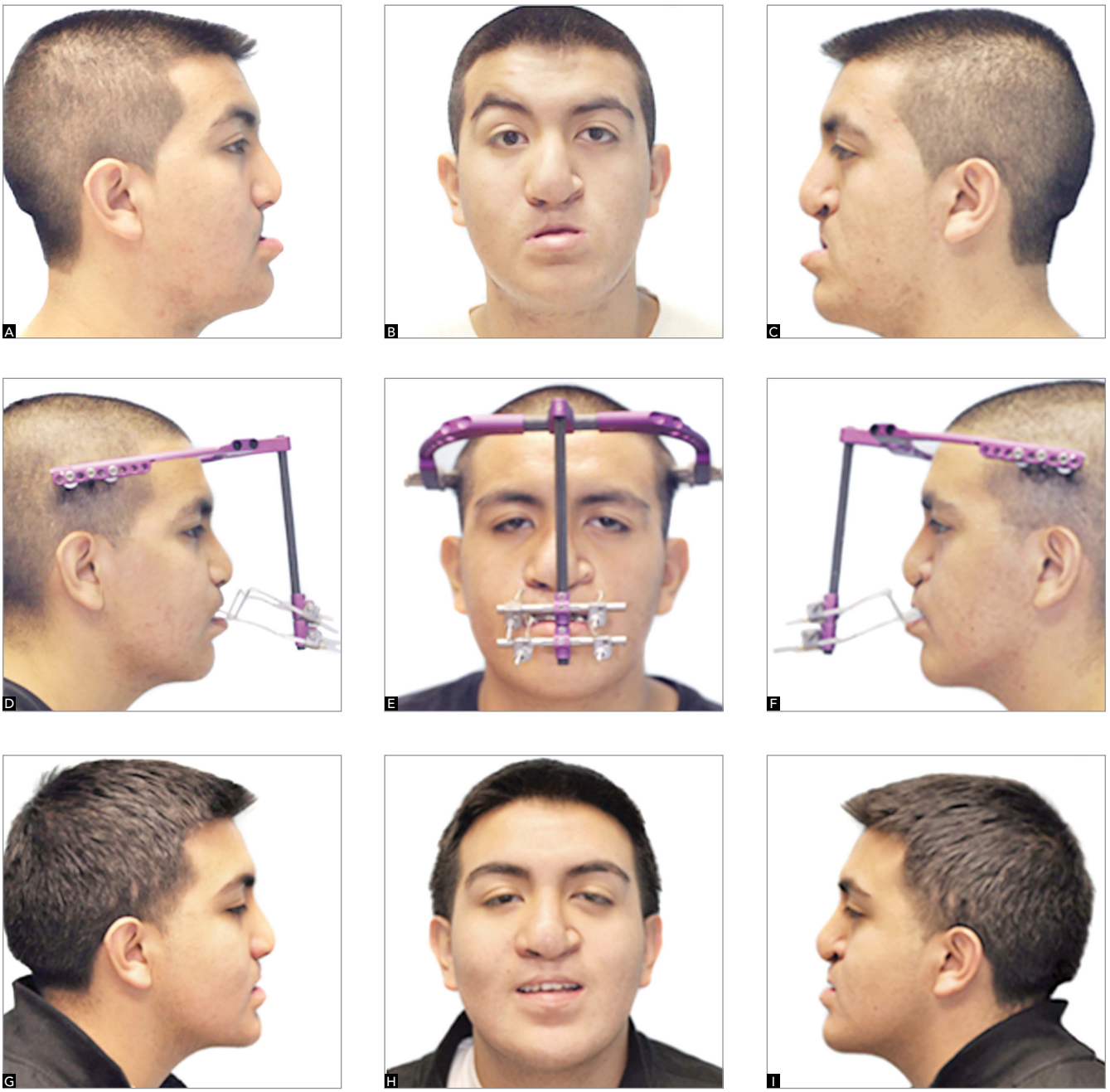

Figure 3 - **A**, **B**,**C**) Initial facial photographs of an adolescent with maxillary hypoplasia associated to cleft lip and palate. **D, E, F**) Patient with rigid external distractor device installed, after Le Fort I osteotomy. **G, H, I**) Final photographs: Maxillary advancement providing better maxillomandibular relation.

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The maxilla is not fractured and displaced downward, as frequently seen in the conventional orthognathic surgery. However, the surgeon must make sure of the complete mobility of the maxillary bone. There is the option of including the base of the malar bones and, also, the lateral aspect of the nasal bones during the osteotomy, which allows a significant advancement of the nasal and infraorbital regions (Fig 2B). The external halo is securely fixed to the skull, using specific titanium cranial pins. The correct positioning of the pins is imperative (Figs 1A and 1B) on the thicker part between the temporal and parietal bones — generally from 3 to 6 cm above the ear lobe —, in parallel or a little tilted upward in relation to Frankfurt's Horizontal Plane.

Figure 4 - Intraoral photographs of the patient presented on Figure 3: Initial images (**A, B, C**); pre-surgical orthodontic preparation (**D, E, F**) and finished treatment, after maxillary advancement with RED and Le Fort I orthognathic surgery (**G, H, I**).

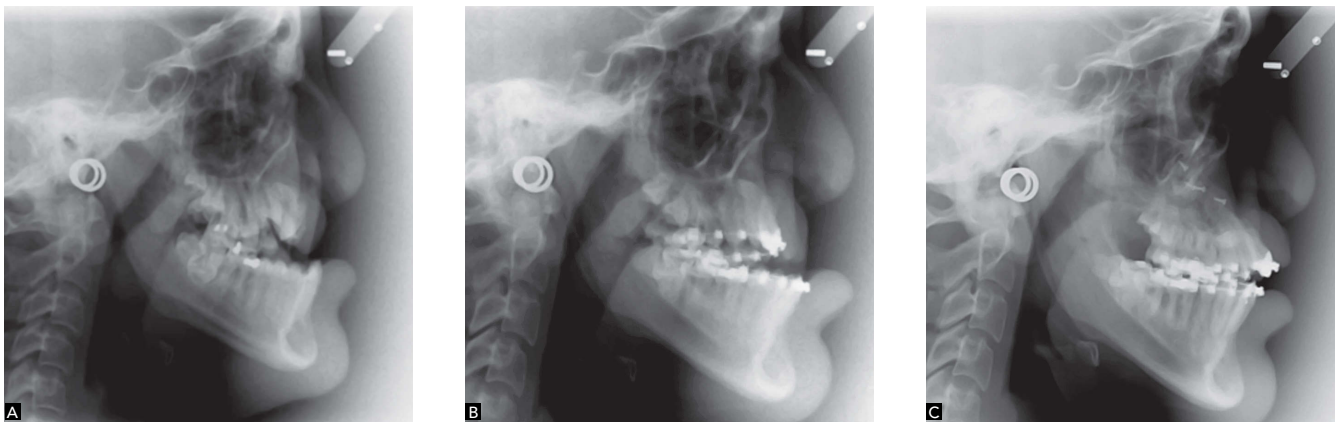

Figure 5 - Lateral cephalograms for monitoring the maxillary advancement of the patient of Figures 3 and 4: **A**) initial radiograph; **B**) radiograph illustrating the pre-surgical orthodontic preparation; **C**) radiograph after maxillary advancement with RED.

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The anterior vertical rod, the distractor screws and the horizontal bars will only be installed between 3 and 7 days after the surgery (latency period), without discomfort for the patient and in clinical environment. When installed, the vertical rod is anteriorly moved away from the face, from 3 to 5 cm, positioned on the midline and in parallel, or divergent in relation to the inferior region of the facial plane (Figs 3D, E and F).

The diet for the first post-surgical 24 hours is liquids and, then, soft foods are incorporated.

Protocol

The distraction protocol follows a rhythm of activation between 1 and 2 mm/day, depending on the severity of the condition and age of the patient (in young patients, there might not be a latency period

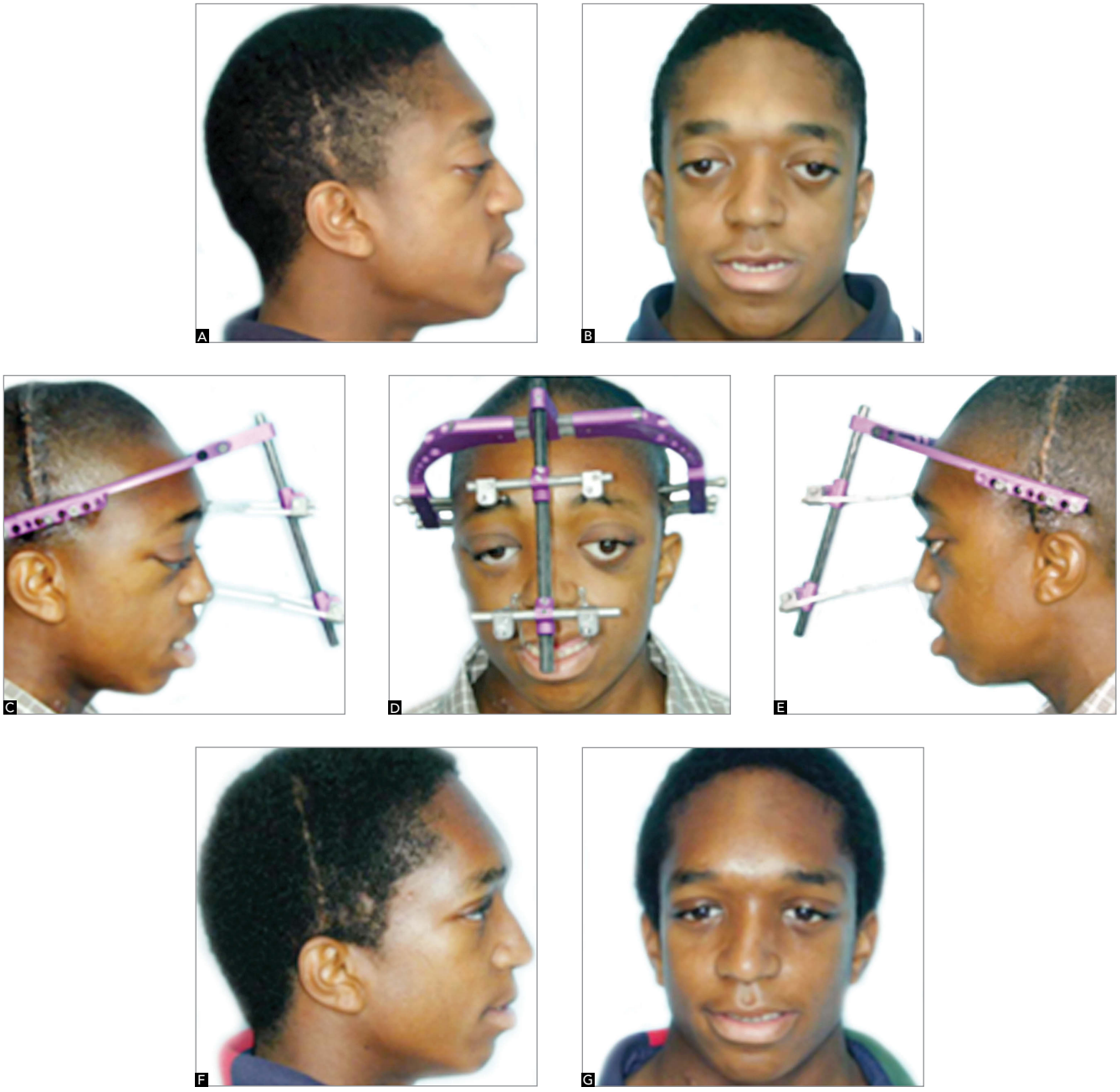

Figure 6 - **A**, **B**) Adolescent with Crouzon syndrome, maxillary and midface hypoplasia. **C, D, E**) Facial photographs after restorative surgery during childhood. Rigid external distraction device installed, after osteotomy for advancement in monobloc. (**F, G**) Final photographs, with remarkable improvement on the facial harmony, due to advancement of the maxilla and of the midface.

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and the rhythm may be faster). A period of about one or two weeks of distraction is enough for the correction in most patients, when the bone consolidation phase is initiated, which is between 4 and 8 weeks (Figs 3, 4 and 5). There are occasions in which a resistance to the maxillary advancement appears, at the end of the active phase of distraction. In these situations, the assemblage of a second distractor system on the vertical rod is chosen. In this way, a traction system is provided with two distractor systems, each one presenting two screws for activation (left and right side), significantly stronger and capable of overcoming any resistance offered by the soft tissues.

On patients in which an extreme maxillary advancement is planned, the clinician might notice the mobility of the maxillary bone in up to 12 weeks after removal of the external halo. Should the maxillary mobility cause discomfort, the surgeon might decide for the rigid fixation plates, to increase the stability of the maxillary bone. It is worth emphasizing that on patients in which there is insufficient consolidation of the maxilla, there is bone mobility on the vertical and transverse planes, and practically no tendency of anterior or posterior movement.

Retention

After maxillary consolidation, the external halo, the horizontal bars, the distractor screws and the surgical wires are removed in a clinical environment. Often, it is unnecessary to anesthetize adolescent and adult patients, unlike what occurs in children, in which removal is recommended under anesthesia in the surgical room and under mild sedation. Then, the external hooks of the intraoral splint are removed and the patient is oriented to use the Petit face mask during the night, promoting an active retention. The mask is used with rubber bands, through which a 400 to 500 gf load is exerted for 6 to 8 weeks, until the stability of the maxilla in its new position is clinically verified, being possible to remove the intraoral splint and start or restart the orthodontic treatment.

DO for midface advancement in monobloc

In cases of patients with severe craniofacial syndromes, involving important frontal, orbital and maxillary deficiencies, the use of the rigid external distraction device also promotes improvement of this condition (Figs 6 and 7). The midface advancement in monobloc technique follows steps similar to those

Figure 7 - Intraoral photographs of the patient presented on Figure 6: **A, B, C**) initial; **D, E, F**) after the distraction osteogenesis; **G, H, I**) final, after the orthodontic treatment and orthognathic surgery (Le Fort I and genioplasty).

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performed in patients that need exclusively maxillary advancement. It is begun with the optional orthodontic preparation followed by the making of the intraoral splint. During surgery, the splint is fixed to the maxillary bone by means of titanium screws. The incision is performed and a classic osteotomy, for the separation in monobloc,[20] culminating in the complete mobilization of the skeletal segment. The rigid fixation between the frontal bone and the supraorbital protuberances is done by the installation of three titanium plates (Fig 2B). Two lateral plates are for the anchorage of the screws that, in the future, will receive the upper traction pin, which perforate the skin at the eyebrows' level (Fig 2C). After the anchorage of the traction pins, the coronal incision is sutured and the surgeon positions the external cranial halo.

In cases with craniofacial syndromes already surgically treated, it is important to carefully fix the cranial pins, because many patients have cranial defects inherent to the condition or from previous surgery. The halo must be very carefully anchored in solid bone. The anterior part of the halo is positioned 2 to 3 cm from the forehead — being located in parallel or a little tilted upward in relation to the Frankfurt Horizontal Plane — and from 3 to 6 cm above the ear lobe. The patient will return 5 to 7 days after surgery and, the distraction device will be installed in a clinical environment with two distraction systems: One upper, at the supraorbital level, by means of traction pins; and one lower, at the dental level, through the external hooks connected with surgical wires to the intraoral splint (Figs 6C, D and E).

The distraction protocol is similar to that applied in patients with only maxillary advancement, in an activation rhythm of 1 to 2 mm a day, until achieving the correction of the skeletal deformity. The rhythm of distraction may need to be decelerated if the patient presents signs of cerebrospinal fluid leak. The rhythm might also be increased in cases of severe deficiencies, especially in young patients, who have greater healing potential. In cases subjected to monobloc advancement, it is impossible to use the face mask as retention; therefore, it is recommended that the period of consolidation be longer than in patients with cleft, or limited to the moment when the clinician assures the stability of the skeletal segment, by means of clinical, radiographic and tomographic exams.

DISCUSSION

The standard treatment of patients with dentofacial deformities is orthognathic surgery associated to orthodontic treatment. The surgical procedures of choice for correction of these conditions includes Le Fort I osteotomy, Le Fort III osteotomy, surgically assisted rapid maxillary expansion and sagittal osteotomy of the mandibular ramus; all using rigid fixation techniques.

These approaches often provide successful and predictable correction, however, similar satisfying result is not expected when the technique is performed in patients with a more serious or complex conditions, related to severe maxillary hypoplasia, orofacial clefts and syndromes.[31]

The maxillary advancement in patients without clefts is more stable in the long-term than in patients with clefts.[1,7] Instead of the radical advancement performed in conventional orthognathic surgeries, the segment will be gradually advanced and the main disadvantages of the rapid advancement will be avoided, that is: The leak of cerebrospinal fluid; the creation of an intracranial space vulnerable to infection; the necessity of massive bone graft and of bone fixation.[5]

In addition, there is limitation on the amount of advancement, dictated by the restrictions of soft tissues;[33] the radical treatment requires blood transfusion[17] and at last, the stability in the long-term is questioned.[26] On the other hand, the advantages of the gradual advancement of the segment in monobloc include: A stable and predictable advancement of the midface; reduction of the complications, reducing the infections; reduction of the intraoperative and postoperative morbidity; simplification of the procedure; no requirement of bone graft nor rigid fixation; the surgical period is shorter and it also reduces the risk of necessity for blood transfusion.

Both patients with clefts and presenting syndromes, experience stability resulting from treatments with, respectively, advancement of the maxilla and midface (Fig 8). The large amount of bone formation on the pterygomaxillary area is the crucial event that favors this prognosis. Besides the volume, the dense type of lamellar bone — verified in histological and radiographic examination[11,16] — strengthens the prognosis. This local bone formation also allows additional space for dental eruption (Fig 9).[28]

There is still the possibility of combining the treatment with RED to conventional orthognathic surgery,

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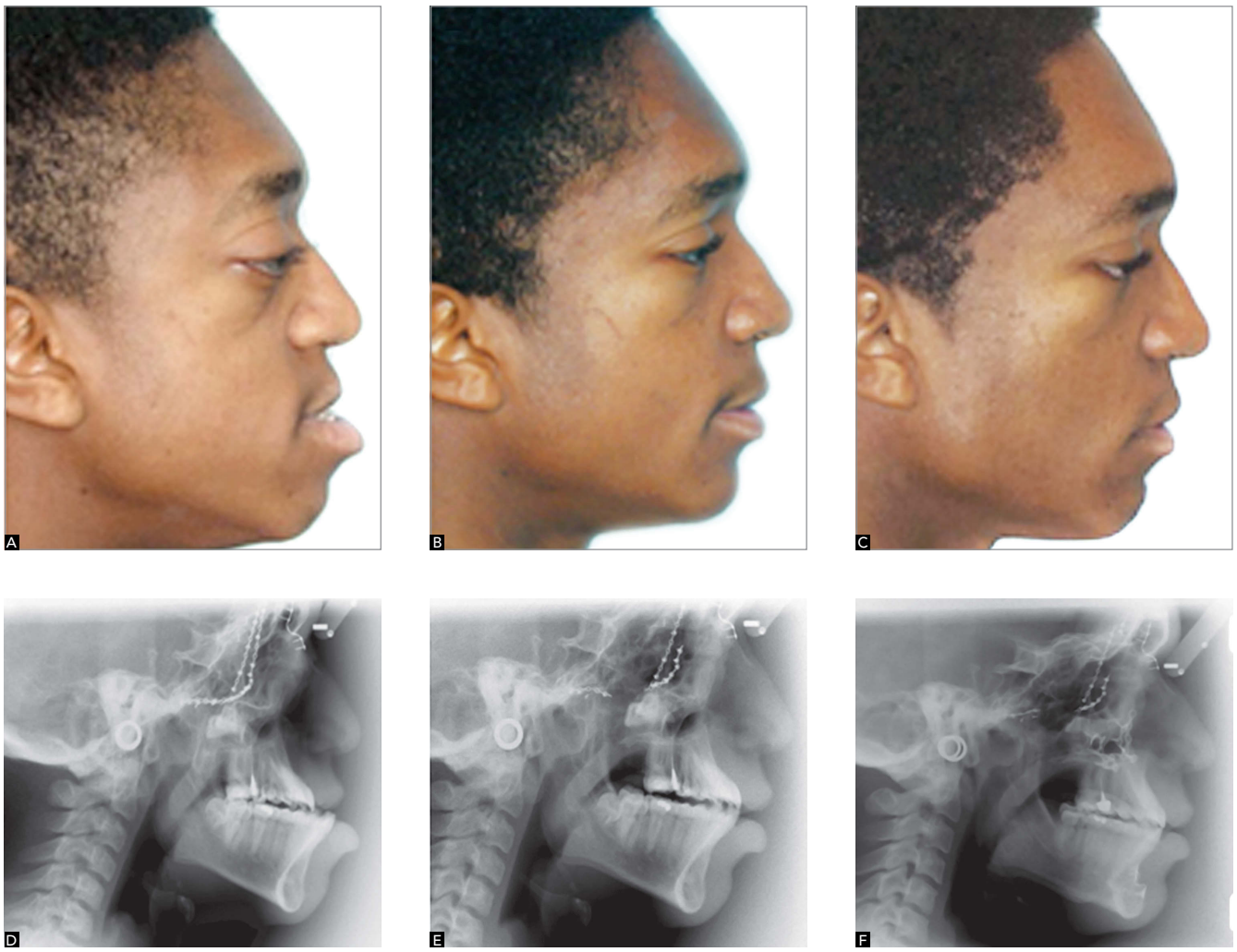

Figure 8 - Photographic and radiographic monitoring of patient with Crouzon syndrome: **A, D**) initial phase; **B, E**) final phase, after the distraction osteogenesis; **C, F**) five years of monitoring, after orthodontic treatment and orthognathic surgery (Le Fort I and mentoplasty).

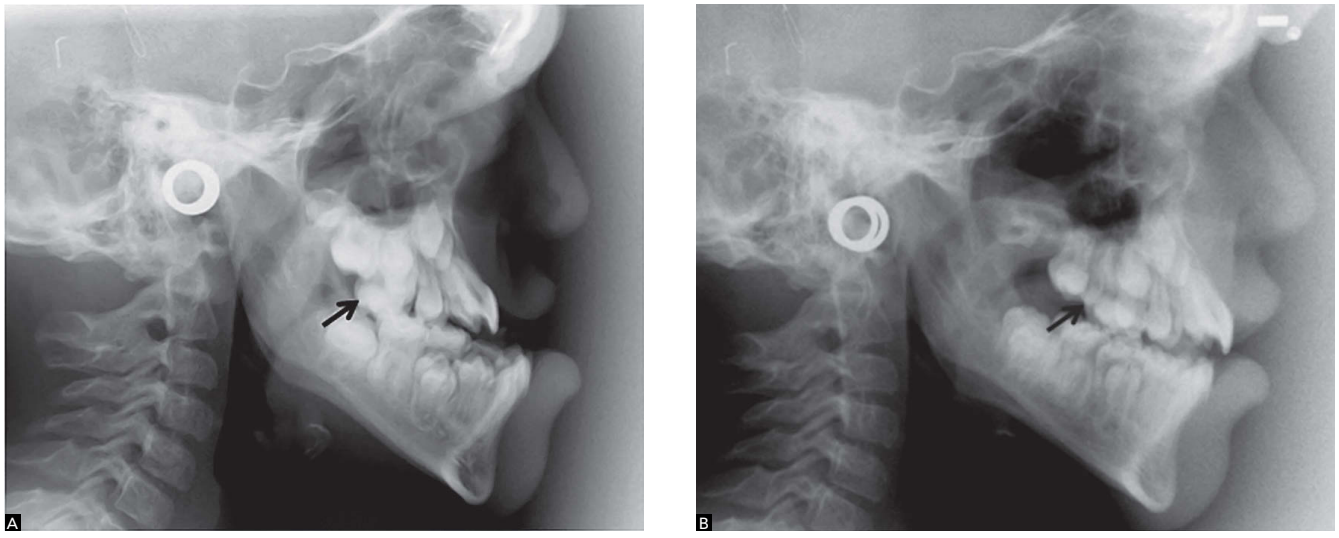

Figure 9 - **A**) Initial radiograph, before the distraction. **B**) Radiograph after maxillary advancement, illustrating the gain of space for eruption of the first molar (arrows).

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applied in cases in which only the distraction technique would be insufficient, like some cases in which occurs the limitation of directional movement of the distraction. The benefit of combining these two techniques includes a skeletal correction resulting, mainly, from the distraction technique, followed by a refinement of the positioning of bones and of the occlusion, consequent from the orthognathic surgery; or from the use of osteotomies with simultaneous distraction.[32]

The treatment of patients with maxillary and midface hypoplasia, depending on the distraction osteogenesis technique, involves technical aspects that need more studies to clarify questions related to the individual response to the treatment. Regarding the technique, there are guides for the recommendation of isolated distraction or combined to conventional orthognathic surgery. Other questions are specific to the distraction technique, such as the choice between the use of external or internal distractors for different situations. The internal systems are more interesting, because they are confined; however, there are limitations related to localization, adaptation and degree of advancement.[10,24]

Other considerations, still challenging, include the duration of the consolidation period. It is known that there is direct relation with age, since, on younger patients, this period is shorter. The amount of advancement can also be directly related to the duration of the ideal period of consolidation, which could make the consolidation phase very long and even impracticable. This way, it is vital to obtain a relation of cooperation between clinicians and researchers, to allow the reduction of the consolidation period on the distraction technique. The recent use of morphogenetic proteins, growth factors and low-intensity ultrasound compose the scientific effort for this purpose.[2,6,9,25,27,29] Studies seek to elucidate the response of soft tissues to the gradual movement of the bone in which they are inserted. Some of these changes seem more favorable when using the distraction technique than when using the conventional orthognathic surgery, like the improvement of lips and nose, as consequence of the maxillary advancement.[33] Besides, a more positive response from the velopharyngeal tissues is noticed when the gradual and radical advancement are compared.[13,15]

FINAL CONSIDERATIONS

The rigid external distraction technique for advancement of the maxilla and midface, in patients who present clefts, as well as with severe craniofacial syndromes, is secure, predictable and stable. The clinical knowledge available for evaluation allows to recommend the distraction osteogenesis as a treatment technique for conditions which, once, were challenging with the application of traditional surgical techniques. However, the use of the distraction techniques do not exclude the possibility of combining them to traditional surgical techniques. Despite the well-known benefits of the distraction, there are still challenges for its clinical adaptation in patients with clefts and syndromes. This includes the development of new devices, the reduction of the consolidation period and the comprehension of the response of soft tissues to the gradual distraction.

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Articles with more than six authors

De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res. 2005 Feb;84(2):118-32.

Book chapter

Higuchi K. Osseointegration and orthodontics. In: Branemark PI, editor. The osseointegration book: from calvarium to calcaneus. 1. Osseointegration. Berlin: Quintessence Books; 2005. p. 251-69.

Book chapter with editor

Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wieczorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

Dissertation, thesis and final term paper

Kuhn RJ. Force values and rate of distal movement of the mandibular first permanent molar. [Thesis]. Indianapolis: Indiana University; 1959.

Digital format

Oliveira DD, Oliveira BF, Soares RV. Alveolar corticotomies in orthodontics: Indications and effects on tooth movement. Dental Press J Orthod. 2010 Jul-Aug;15(4):144-57. [Access 2008 Jun 12]. Available from: www.scielo.br/pdf/dpjo/v15n4/en_19.pdf.

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1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (http://www.who.int/ictrp/network/en/index.html), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
- Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;
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DENTAL PRESS JOURNAL OF ORTHODONTICS endorses the policies for clinical trial registration enforced by the World Health Organization - WHO (http://www.who.int/ictrp/en/) and the International Committee of Medical Journal Editors - ICMJE (# http://www.wame.org/wamestmt.htm#trialreg and http://www.icmje.org/clin_trialup.htm), recognizing the importance of these initiatives for the registration and international dissemination of information on international clinical trials on an open access basis. Thus, following the guidelines laid down by BIREME / PAHO / WHO for indexing journals in LILACS and SciELO, DENTAL PRESS JOURNAL OF ORTHODONTICS will only accept for publication articles on clinical research that have received an identification number from one of the Clinical Trial Registers, validated according to the criteria established by WHO and ICMJE, whose addresses are available at the ICMJE website http://www.icmje.org/faq.pdf. The identification number must be informed at the end of the abstract.

Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

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