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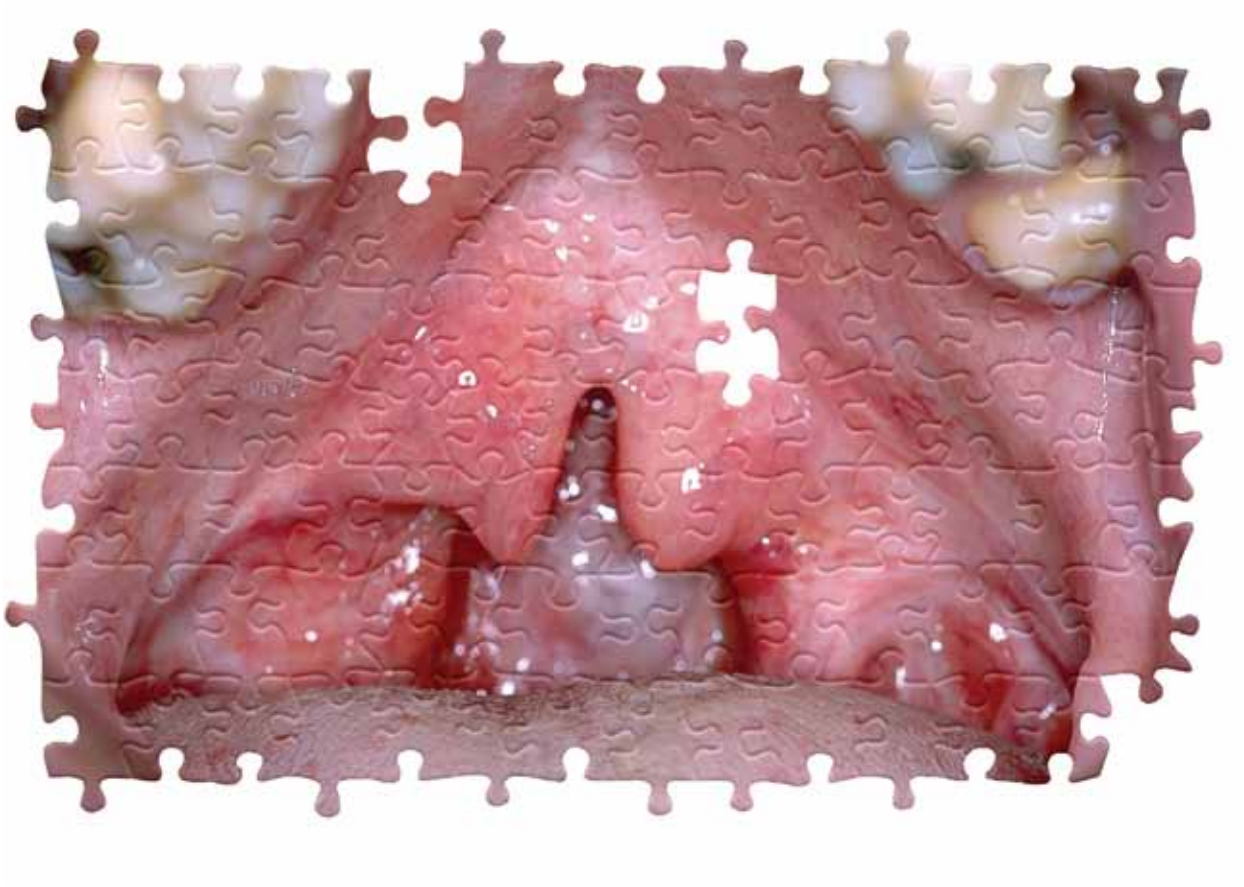

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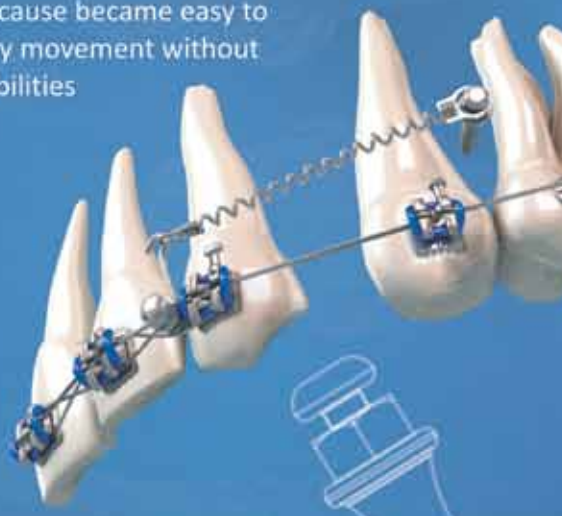

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Optimizing time and space

To sail is necessary; to live is not necessary.
(Pompey, Roman general, 106–48 BC)

In my first editorial,[1] I made a brief analysis of the construction of the Dental Press Journal of Orthodontics (DPJO). In contrast to the poetic and emotional vein of that first text,[1] fruit of the profound gratitude to those that appointed me captain of this ship, I will use this opportunity to describe, to our readers and other collaborators (publishers, authors and reviewers), some of the adjustments to be made in this journal. These changes begin in this issue and will be completed in the next (17.3), or maybe will never cease, depending on sea winds and our disquiet. The role of the editor is to chart the course of the journal and to steer the helm so that the prow is kept in the direction of the route defined by our predecessors.

The main scope of such effort was to reduce the navigating time between manuscript submission and effective publication, as stated at the end of that previous editorial.[1] The high incoming of manuscripts is the main reason why DPJO takes a mean of three years to complete the whole process. Our objective is to reach, by the end of 2012, a maximum time of eighteen months and reduce it further until we manage to navigate this route in six to twelve months. Unfortunately, to achieve these goals, some "not so sympathetic" measures should be taken.

The acceptance rate for manuscripts submitted in 2009 was 60%; it went down to 50% in 2010, and corresponded to only 1/3 (34%) of all submissions in 2011 (Fig 1). Although no rigid goal has been defined, the level of rejection of manuscripts submitted in 2012 is expected to be close to 75%.

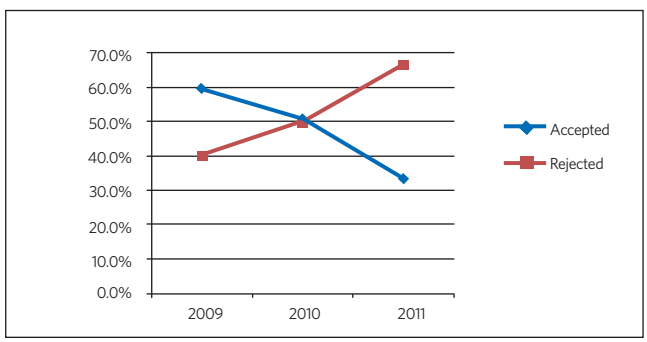

Figure 1 - Relative frequency (%) of manuscripts accepted and rejected by the Dental Press Journal of Orthodontics in 2009, 2010 and 2011.

The second measure is to increase the number of manuscripts published in each issue of the journal. For that, the number of studies published online will increase, a measure that has started to be delineated in 2010. The perspective for this year is to publish six online articles for each issue. The new layout of the journal, starting with the current number, will also favor the inclusion of four more manuscripts in each journal issue. These measures, in association with the reduction of articles size, now limited to 3500 words, will lead to more objective manuscripts in which the main information receives intense focus. Therefore, our readers will have more information in each issue and authors will enjoy the pleasure of seeing their production sailing away into the world sooner.

Submissions will also be adjusted. We are conducting a minor restructuring of the board of reviewers to increase the number of foreign collaborators and to meet the requirements of international indexing databases. Moreover, the Dental Press Journal of Orthodontics will soon accept only submissions in English. The purpose of this decision is to make it easier to prepare the journal layout. However, the print version in Portuguese will continue being delivered to all subscribers; for now, only the English version will remain available online via SciELO.

For a mature journal, the changes suggested actually amount to almost nothing in light of such a well conceived and consolidated enterprise. Only a few changes at the helm to prioritize the movement to where the prow is directed. Modest adjustments to make our cartography more precise and to optimize time and space so that we achieve the aim of consolidating the "necessity" so acclaimed by Pompey and that have been part of our lives since before Christ.

Enjoy your reading!

David Normando – Editor-in-chief
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9 to 7 p.m

Anchorage miniplates for protraction of the midface in patients with Class III and distalization of molars in patients with Class II

Dr. **Hugo de Clerck //** Belgium

The biggest advantage of skeletal anchorage with modified miniplates is their fixation at a distance from the dental arch. This makes them very appropriate for the complete distal movement of the upper arch in the treatment of Class II with no premolars extraction. This movement can be performed with sliding mechanics along light archwires or by en masse retraction of all upper teeth using heavy archwires. For maximum efficiency, it is necessary a correct control of the vertical dimension. The skeletal anchorage can also be used to intrude the extruded molars or to upright second molars, and for mesial movement of inferior molars in cases of agenesis of second premolars. Furthermore, miniplates are more resistant to heavy and intermittent forces than mini-implants. Therefore, they can be used for intermaxillary orthopedic traction. Class III elastics can be inserted between the Bollard miniplates in the skeletal maxillary and mandibular bases of growing patients. Can the growth of the maxilla and/or mandible be stimulated, restricted or redirected? Which biomechanical approach should be used? The results of continuous orthopedic traction will be discussed based on Cone-Beam CT images superimposed on the skull base. These results will be compared between the control group and the undergone face mask protraction. All the biomechanical applications will be explained step by step and will be illustrated with several clinical cases.

NATIONAL COURSE // 07.14.2012

9 to 13 p.m

Esthetic and functional excellence: a transdisciplinary approach

Dr. **Roberto Carlos Brandão**
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Dr. **Carlos Eduardo Ferreira**
Periodontics

Integrated procedures of Orthodontics, Periodontics, Implantology, Occlusion and Prosthetic Dentistry will be discussed together and simultaneously, with the three lecturers exploring the same clinical cases — within the spectrum of each specialty — using the highest level of available scientific evidence to support the procedures. The transdisciplinary approach should be faced from a common philosophy among professionals, the different specialties should have their dogmas rethought so that procedures are concatenated in search of clear objectives. The following themes will be discussed: The best position for the implants, restorative procedures that meet the limitations of orthodontics, the use of corticotomy to accelerate tooth movement, use of gingival and bone graft, and the application of autotransplantation. It will also be addressed the determinants of facial esthetics, considering: vertical dimension, smile line, smile curve, gingival contour, buccal corridor, black spaces, gingival smile, dental and facial proportions and forms.

CONGRESS // NATIONAL CONFERENCES // 07.12.2012

9 a.m

Invisalign - Necessity or luxury?

Dr. **Maurício Casa**

Stability and instability in orthodontics

Dr. **Carlos Jorge Vogel**

10 a.m

Orthodontics in face of dental trauma cases

Dr. **Renato Lenzi**

You, orthodontist, are prepared for the current job market?

Dr. **Fernando Habib**

11h30 a.m

Limits of projecting incisors. How far can we go?

Dr. **Flavio C. de Carvalho**

Tooth autotransplantation: Esthetic and functional solution

Dra. **Deise Lima Masiolli**

2h30 p.m

Self-ligating brackets: Fad or future?

Dr. **Weber Ursi**

4D orthodontics: Time as a fourth dimension

Dr. **Jonas Capelli Junior**

3h30 p.m

Obstructive sleep apnea: Where should we begin?

Dr. **Rowdley Rossi**

Osseointegrated implants: Planning and treatment

Dr. **Carlos E. Sabrosa**

5 p.m

How to make smiles more attractive with lingual orthodontics?

Dr. **Júlio Pedra e Cal Neto**

Orthognathic surgery in patients with normal occlusion

Dr. **Henrique M. da Silveira**

6 p.m

Evaluation of long-term stability of the open bite treatment in adults

Dr. **José Nelson Mucha**

Orthodontic mechanics with mini-implants

Dr. **Antônio Carlos Ruellas**

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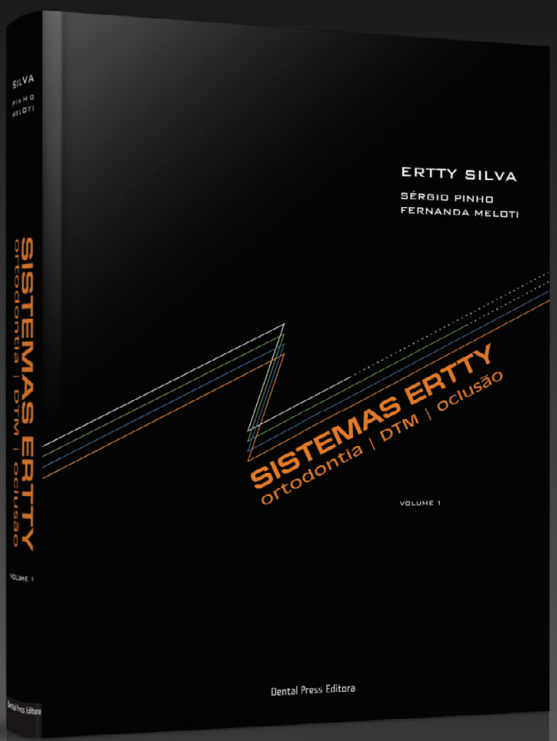

"When we think we have got all answers, life comes and changes all questions".

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Nickel: Humoral and periodontal changes in orthodontic patients

Leandro Silva Marques[1], Camila Alessandra Pazzini[2], Mariele Cristina Garcia Pantuzo[3]

Introduction: Although several studies have discussed nickel influence on the development of immunological reactions in orthodontic patients, it is noticed that the evidence towards the appliances, as well as towards the possible consequences of this material on the oral and general health of the individual are still inconsistent.

Objective: The aim of this article is to present the current stage of knowledge on this issue, highlighting the most recent findings considering the periodontal and humoral aspects of allergic subjects.

Keywords: Nickel. Allergy. Orthodontics.

INTRODUCTION

Uncover the mechanisms associated with nickel allergy in orthodontic patients means a huge challenge for orthodontists and health researches. Clinical changes like gingival hyperplasia, chapped lips, burning mouth sensation, a metallic taste, angular cheilitis and periodontitis have been associated with the release of nickel from orthodontic appliances.[1-8] However, critical literature reveals that the most part of evidences provided by researches are little consistent. Part of this issue occurs due to methodological limitations (design, sample size and nature, type of evaluation), leading to conflicting results, affecting the clinical decisions. In addition, there are still unanswered questions, such as:

- What are the implications for clinical and biological nickel allergy?

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- Are the effects associated with the accumulation of nickel along the orthodontic treatment or with local nickel release?
- Are the reactions mediated by a systemic immune response and/or change of local inflammatory response in the periodontium?
- What is the best way for a clinical orthodontist to deal with a nickel allergic patient?

WHAT IS NEW?

Recently, prospective studies as well as systematic reviews and meta-analysis, provided important informations for better comprehension of periodontal aspects and humoral characteristics of nickel allergic orthodontic patients.[9-13]

Periodontal conditions were worst in nickel allergic individuals when compared to the non-allergic throughout treatment.[9] The authors made a longitudinal comparison on the clinical condition of these individuals by means of Löe index for 12 months (one evaluation at every 3 months). A blind evaluation was performed by one single examiner, followed by prophylaxis and hygiene instructions. Significant differences were found between groups in moments T_3 and T_4 for gingival index, in which allergic individuals presented higher means than the non-allergic ones (hyperplasia, color change and bleeding). Such results suggest nickel cumulative effects along orthodontics treatment, associated with clinically significant periodontal changes.

The authors from the previously mentioned paper also verified the humoral aspects of nickel allergic orthodontic patients and verified a correlation between blood components and possible periodontal changes. Nickel allergy was diagnosed using the patch test, periodontal condition by Löe index and humoral characteristics by means of a complete hemogram, including the measurement of blood nickel and IgE rate. Stool tests were carried out to control parasitic infections. Significant changes were observed between groups considering the granulocytes rate and absence of correlation between blood nickel correlation and IgE rate. Nevertheless, there was positive correlation between gingival index and amount of granulocytes. It can be concluded that there are significant differences considering humoral and periodontal aspects of nickel allergic and non-allergic patients.[12]

Nickel-free brackets have acquired popularity as an adequate alternative for orthodontic allergic patients. This fact has been corroborated by two recent studies: The first, a systematic review developed by Pazzini et al,[10,11] points out evidences pro-use of nickel free brackets (maximum 2% Ni), although it also highlights the limitation of studies included in the review and the necessity of more consistent evidences. The second study compared longitudinally the periodontal condition of individual treated with traditional and nickel-free brackets. The periodontal condition (gingival hyperplasia, color change and bleeding) was evaluated before beginning treatment (T_0) and regularly for 12 months (one evaluation at every 3 months – T_1, T_2, T_3 and T_4) using Löe index. Blind evaluations were performed for a single calibrated examiner, followed by prophylaxis and hygiene instruction. The periodontal condition for the groups did not differ during the initial 9 months of orthodontic treatment, however, significant changes were found in T_3 and T_4. Nickel allergic individuals treated with nickel-free brackets showed better periodontal health than individuals treated with conventional brackets.[10] Figures 1, 2 and 3 illustrate a clinical case whose patient presented nickel allergy and had a significant improvement of periodontal condition after replacing a conventional appliance for a nickel-free one.

Another systematic review on nickel hypersensitivity prevalence in orthodontic patients concluded that orthodontic treatment is not associated with the increase of nickel hypersensitivity prevalence, unless the patient had wore skin piercing.[13]

CLINICAL IMPLICATIONS

Nickel can promote periodontal changes in allergic patients. This issue becomes critical mainly when we consider the actual increase of demand for orthodontic treatment for adult patients. Such patients, usually, already have had some degree of periodontal commitment. This way, nickel may show itself an aggravating factor. The clinical signs and observed symptoms include oral edema, gingival hyperplasia, perioral stomatitis and gingivitis. No studies were found pointing out how long after bracket removal the reestablishment of normal patterns of the periodontium occurs.

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Figure 1 - Clinical condition of allergic patient after six months of treatment.

Figure 2 - Clinical condition of patient 1 month after stopping treatment.

Figure 3 - Clinical condition of the patient three months after reassembly with nickel free bracket.

The potential of orthodontic metals causing allergic reactions is related to the pattern and manner of corrosion, with subsequent release of metal ions, which depends of metal composition, temperature, pH of the environment, welding presence, wire tension, among others factors.[1-4]

CLINICAL PRACTICE

It is important to ask during anamnesis about previous nickel sensibility. In allergic patients, the professional must opt for biocompatible materials, thus avoiding welded materials. The use of ceramic, titanium and nickel-free brackets is indicated besides coating the surface of orthodontic accessories with titanium nitride because this nitride is capable to reduce the nickel proportion. Furthermore, it is important to demand special attention of the patient to oral hygiene to minimize metal corrosion.

Further studies should include chromium and cobalt rates, which are substances also present in orthodontic materials and may be overestimating (bias) the effects of nickel. In addition, studies with molecular approach may offer even more solid answers about the actual mechanisms associated to nickel allergy in orthodontic patients.

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An interview with

Ki Beom Kim

- Associate Professor and Clinical Director of the Department of Orthodontics, New Southeastern University, Fort Lauderdale (Florida), United States.
- Adjunct Professor, Department of Orthodontics, Saint Louis University, United States, from 2005 to 2011.
- Graduated in the American Board of Orthodontics, 2011.
- Residency in Orthodontics at Vanderbilt University (Nashville), United States, 2005.
- Doctor of Orofacial Pain by Dankook University, South Korea, 2002.
- Graduated in the American Board of Orofacial Pain, 2000.
- Master in Dentistry by Dankook University, South Korea, 1995.
- Residency in Oral Medicine and Temporomandibular Disorders by Dankook University, South Korea, 1995.

It is a great honor and I am glad to bring to the readers a little bit of the scientific experience and knowledge from one of the most important current researchers and clinician in the United States: Prof. Dr. Ki Beom Kim. We have confirmed that Prof. Kim dedicated a profound attention when answering the questions from the interviewers, proving respect for us, the readers of the Dental Press Journal of Orthodontics. During this interview, he discussed with a lot of property important current matters and of great relevance, such as the use of 3D image technologies, self-ligating brackets, mini-implants and orthodontic treatment on patients with temporomandibular disorder. A deep lover and fond of sports and photography, Prof. Kim, despite working with state of the art means available in Orthodontics, he believes in diagnostic and in strict and individual planning as the main way to reach success in orthodontic treatments. Married and father of 2 sons, Prof. Kim was born in South Korea and there he graduated in Dentistry and post-graduated in Orofacial pain. After this, he moved to the United States and never left. Nowadays, he is an Associated Professor and Clinical Director on the Department of Orthodontics at the New Southeastern University (Fort Lauderdale, Florida/United States), where he is the Clinical Director of the Post-Graduation Program. I hope you all enjoy this opportunity of knowing some of his point of view and the way this great researcher and clinician works.

Marcelo Castellucci

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What has been your experience with the self-ligating brackets? What are their real benefits and disadvantages? Is there a particular profile of the patient or professional to whom this type of bracket fits best or is it worthwhile for everyone? (Marcelo Castellucci)

I have been using self-ligating brackets for about 10 years. In spite of many claims from the bracket companies, I don't see a big difference. Currently there is no scientific evidence supporting the benefit of the self-ligating brackets.

There have been many studies presenting lower friction with the self-ligating brackets but all of them were done in the lab setting. If we consider the force decay of the elastomeric ties, perturbation from the mastication, 1st, 2nd, and 3rd order misalignments of the teeth, the lower friction of self-ligated brackets is meaningless. We oversimplified and overestimated the results from the lab studies.

Some people claim that self-ligation brackets are more hygienic than the conventional brackets.[1] However, the other study reported that the self-ligating brackets do not have an advantage over conventional brackets with respect to the periodontal status of the mandibular anterior teeth.[2] There is not enough evidence to support the claim that conventional brackets are less hygienic than self-ligating brackets.

Few studies indicated that the self-ligating bracket systems have quicker wire removal and placement.[3,4] In a recent systemic review, only 2 outcomes, chair time and final mandibular incisor inclination, showed significant differences.[5]

The only benefits in my opinion are shorter chair time and possible longer appointment interval.

The self-ligated bracket system industry tries to disseminate the idea of reduced treatment time. Based on the principle that teeth biological response is the same, whatever is used to move them, how could treatment time be reduced? (Orlando Tanaka)

A lot of studies tried to compare the efficiency of the self-ligation brackets, but I haven't come across any articles that showed that they could reduce the treatment time other than the company's claims. Like you mention in here, the biological responses are exactly the same. The self-ligating brackets don't have an artificial intelligence, they are just handles to move teeth. We are just brain washed from all those commercials from the companies. It is simply not true.

According to AJO-DO reader's forum, in 2010 August, only two advantages of self-ligated bracket systems are scientifically proven, which are chair time reduction and lower incisor torque control. Do you agree with that? What about the expansion stability, also defended by these brackets sellers? Why are these bracket systems being so much used, despite of their higher price? (Orlando Tanaka)

You can decrease the chair time once you get used to the bracket system. You can decrease 3 seconds per bracket for every appointment.[6] If we use the self-ligating brackets from bicuspids to bicuspids, that means 20 brackets. We can save 60 seconds per each appointment. We have to calculate the economy of shortening the chair time versus higher cost of the self-ligating brackets.

Figure 1 - Patient shows severe crowding in both arches.

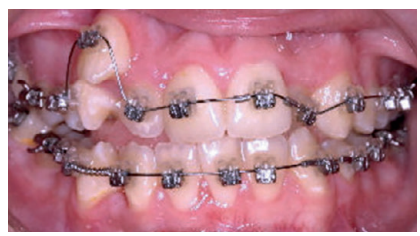
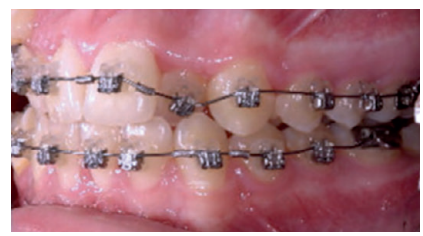
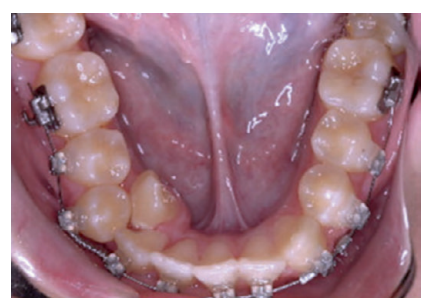



Figure 2 - Passive self-ligated brackets were bonded. If lower friction in self-ligated brackets is true, the NiTi wire should slide through the brackets with low pressure and upper right canine should extrude without intrusion of adjacent teeth.



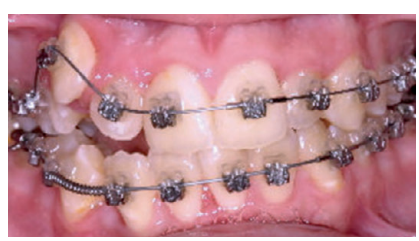
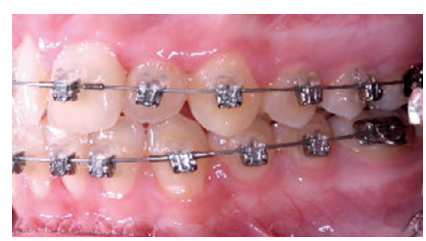
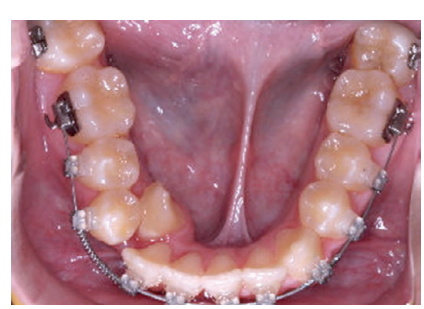



Figure 3 - One month after. Like the conventional bracket systems, as upper right canine extruded, adjacent teeth intruded, and the patient developed a lateral open bite.



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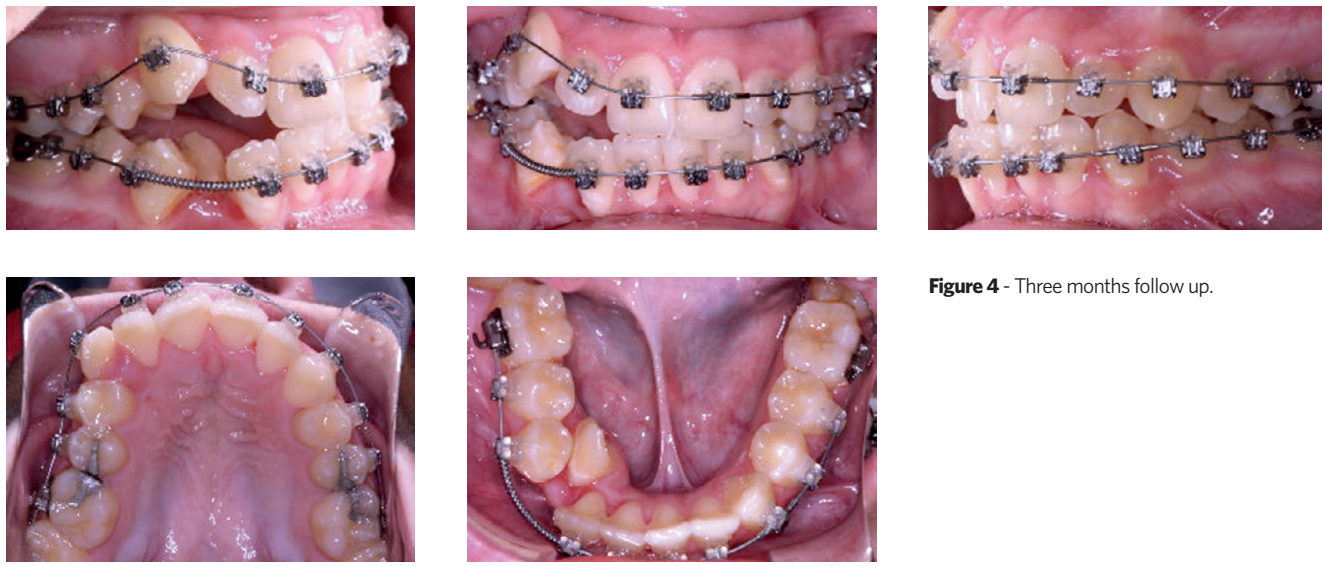

Figure 4 - Three months follow up.

Figure 5 - CBCT image. Because of the expansion with archwires, all the posterior teeth show buccolabial tipping.

The expansion is related to the arch form. One company is using a very broad arch form, so the arch expansion is a result from the arch wire, not from the self-ligated brackets. You can do arch expansion with any bracket system. It doesn't matter what kind of brackets you use. One company stated that their system doesn't need RME but we do know if we just expand through the arch wire, it is going to be unstable and also create potential periodontal consequences.

I think the company's marketing strategy was very successful. Orthodontists want them to be shown as a cutting edge or they would like them to be seen as better then other orthodontists. We like to believe that if a product costs more, the product should be better. Current orthodontics is driven by industries not by orthodontists ourselves.

In recent years, some clinicians have tended toward overuse of mini-implants in clinical orthodontic treatment. Yet, literature still lacks some information about the long-term response of surrounding tissues (i.e. roots) and the stability of some clinical results. Do you think, based on the current literature, we should treat with caution or dive in headfirst? (Luiz Gandini Jr.)

Some of the very difficult cases with traditional biomechanics can now be successfully treated with mini-implants. We as orthodontists are so excited about the possibility of the mini-implant, and we have tried many different applications. As a faculty of post graduate orthodontic program, I often noticed that our residents believe mini-implants will magically solve all the biomechanical problems for them. Rather than trying to figure out the conventional treatment mechanics, they simply mention "I will use mini-implants."

However, we must remember the same biomechanical rule also applies to the patients with mini-implants. We have to consider the risk of root damage, infection, and soft tissue inflammation. Extra chair time, and the cost of the mini-implants also need to be considered. We have to carefully examine the benefit and risk of using the mini-implants in every single case.

Mini-implants are one of the main topics in current orthodontics journals and meetings. How predictable, effective and stable do you believe are the vertical (posterior intrusion) and transverse dimensions (maxillary expansion) when managing an orthognathic adult patient with mini-implants? (Luiz Gandini Jr.)

It has been only a couple of years using mini-implants for molar intrusion and expansion. It may take a while to have a long-term studies for stability and relapse.

But based on the studies that are currently available and case reports, it seems very effective. Just the possibility to correct the difficult problems without going through a major orthognathic surgery itself is very exciting.

According to the study from South Korea, a relapse rate of 23% at the 3-year follow-up in long-term stability of anterior open bite cases by intrusion of maxillary posterior teeth.[7] But we can't make a conclusion based on just one study. Until we have more data, we cannot jump to conclusions.

With the TAD (Temporary Anchorage Device), 3D cone beam images and the technology present in new brackets and wires, is the technique becoming more important than orthodontic diagnosis? With the TAD, procedures such as "surgery first" will be the rule or the conventional treatment will still be necessary in surgery cases treatment? Did the extraction frequency reduce? Has the stability results improved? (Orlando Tanaka)

It is obvious that this new technological advancement gives us additional diagnostic information. We can see many unseen anatomical structures with cone beam computed tomography and evaluate the three-dimensional topographic structures with the soft tissue scanning technique.

Now we are applying these new image techniques to re-evaluate the treatment effectiveness and efficiencies. This will help us understand many different aspects of the diagnosis, treatment and stability.

However, the new technology can not make a diagnostic decision for us. We have to consider all the other diagnostic information including 3D images, make a diagnosis and develop a treatment plan by ourselves. None of the technology can replace this very subjective diagnostic procedure.

I agree that there are potential benefits for some patients in surgery-first approach. But we can't assume all the patients will show the same treatment response even with new imaging techniques, computer simulation and very sophisticated articulators. If we are dealing with the mechanical objects, then I would also try surgery-first approach because I can expect the outcome very precisely, but we are treating a human being, not a mechanical object.

Orthognathic surgery is not a reversible procedure, it is an invasive and irreversible procedure. If I can minimize the uncertainty out of the equation, I would chose the traditional approach rather than risky surgery-first approach.

With the advent of 3D cone beam technology, 2D cephalometric analysis in conventional orthodontics may be facing a paradigm shift. What is the current state of 3D technology in orthodontics and where do you see us going in the near future? (Luiz Gandini Jr.)

As I mentioned before, we can obtain very large amounts of information through various 3D imaging techniques. We can precisely locate the relationship between the anatomical structures and teeth. In two-dimensional cephalometrics, we can only look at the changes of the midline structures or overlapped bilateral structures, but now we can evaluate all the structures separately without overlapping other structures. This is a quite revolutionized development.

Although we are in a very exciting moment, we are not fully ready to use this newly available information. Not all cephalometric norms based on the two-dimensional radiographs can be directly applied to the three-dimensional images. We need to establish a new method for understanding the craniofacial structures. In two-dimensional radiographs, it is not very difficult to locate the landmarks on the lines of the images. But locating reliable points on the three-dimensional surfaces is not easy. Another difficulty is that it's very hard to describe the three-dimensional changes.

It is easy to explain the difference in two dimension, basically the distance or angulation changes, but the changes in space are not easy to describe. Furthermore, if we want to describe surface changes, instead

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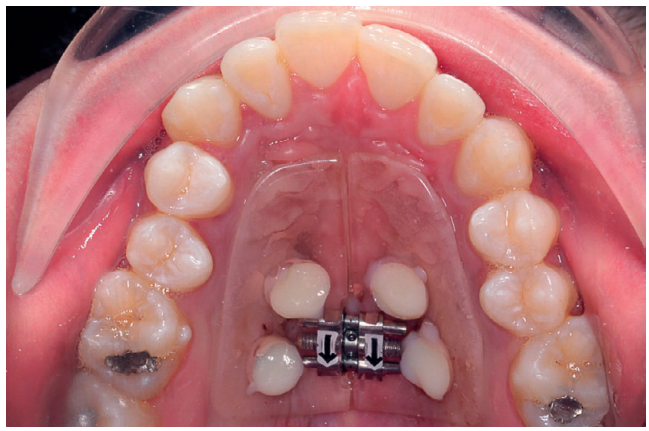

Figure 6 - Implant-supported RME: Pre-expansion.

Figure 7 - Implant-supported RME: Post-expansion.

Figure 8 - Pre-expansion: Frontal view.

Figure 9 - Post-expansion: Frontal view.

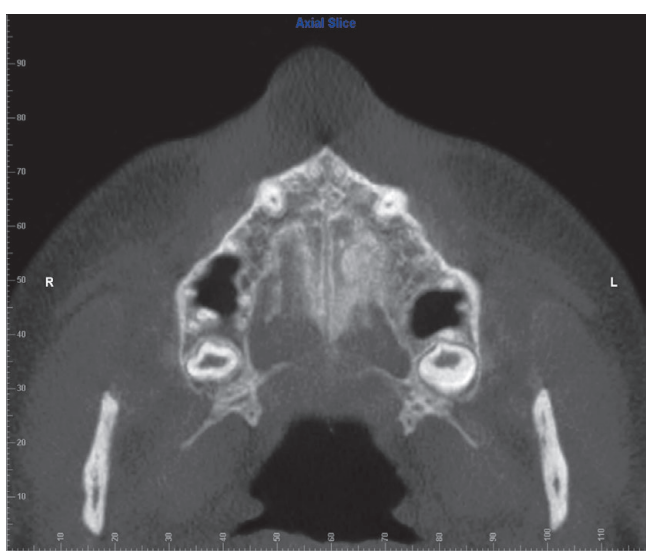

Figure 10 - Pre-expansion transverse section at the palatal plane.

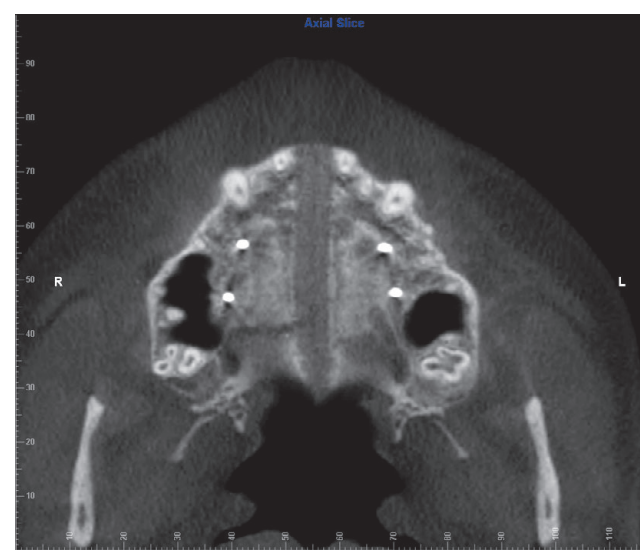

Figure 11 - Post-expansion transverse section at the palatal plane.

of point changes, it is a very tricky situation. We have to go back to the two-dimensional radiographs and describe the distance or angulation changes.

One more thing we need to consider is that CBCT is still using ionized radiation. The newer machines reduced a lot the amount of radiation but there are lots of debate about the radiation safety and risk and benefit concerns.

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MRI can be the answer for the future imaging technique. Currently it is a lot more expensive than the CBCT machine and needs a larger space to install and takes minutes to obtain the images. But MRI doesn't use the ionized radiation to attain the images. If we have a smaller, cheaper and faster MRI machine, it will replace the CBCT technology soon.

Do you think that a 3D cephalometric analysis may arise and become so used and recognized such as the 2D analysis already established? (Marcelo Castellucci)

Currently, we don't have an agreed method for a three-dimensional cephalometrics. Before we develop an analysis, we need to reconsider all the landmarks that we have been using for a two-dimensional cephalometrics. Some of the landmarks are constructed landmarks which are imaginary points. Therefore we have to re-establish the landmarks for the three-dimensional cephalometric first. As I mentioned before locating a landmark in a three-dimensional image is not easy and it is a time consuming process. Every single landmark should be evaluated in three different planes. Automatic landmark positioning would be very helpful for orthodontists because we can save time and it will give us more reliable, reproducible and precise measurements.

There have been a couple of articles that suggested methods for the three-dimensional superimposition. It needs to be evaluated for the accuracy and effectiveness.

We have to change our view from the two-dimensional way of thinking which we look at the length and angulation to a three-dimensional way of thinking which is space or volumetric analysis.

Do you use any protocol for the treatment of TMD patients seeking orthodontic treatment? Orthodontic treatment can be started immediately or the patient must go through any other therapy before it? (Marcelo Castellucci)

Some of the patients with minor masticatory problems can start the orthodontic treatment right away, but general rule is that don't start orthodontic treatment before the problems are identified and diagnosed correctly.

If a patient is having pain, any type of orthodontic treatment shouldn't be started. When TMD symptoms are present, the orthodontist should attempt to determine what problems are contributing to the TMD. Usually an occlusal appliance is delivered to reduce the TMD symptoms along with pain medications, physical therapy and behavioral modification. Patient is advised to use an appliance for 24 hours per day initially, then decrease to part-time use, most commonly at night. Once the patient's symptoms are gone, the orthodontist should ask the patient to reduce the use of the appliance. If the symptoms don't return, then the orthodontic treatment can be started.

Patients should be pain free before the orthodontic treatment, but that doesn't mean that all the joint noises need to disappear.

If we consider removing the joint noises as one of the treatment goals, then treatment success rate is going to be only 20–30%. Many studies have been suggested that we should focus on the pain not the joint noises.

Especially in osteoarthritic patients, the orthodontic treatment should be postponed until all the symptoms are gone and also patients' condyles are stable which means degenerative change is stopped and the condyle shape is stable and unchanged.

It is not clear when orthodontic treatment can be started from that point. If we wait longer then it would be safer but there is no consensus among the orthodontists how long we need to wait. I would wait at least 3 months after all the symptoms are gone and indirectly evaluate the condyle through the occlusal contacts on the occlusal appliance.

And for chronic muscle orofacial pain patients, what medicine protocol do you suggest? (Paulo Rocha)

Chronic muscle pain conditions are very difficult to manage. Because of the chronic nature, many patients suffer depression. Tricyclic antidepressants (TCA) are usually prescribed along with some muscle relaxants but the efficiency of muscle relaxants are now being questioned. Many side effects may be related to the antimuscarinic properties of the TCAs. Such side effects are relatively common and may include dry mouth, dry nose, blurry vision, constipation and urinary retention.

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Figure 12 - Patient presented anterior open bite with osteoarthritic joints on both TMJs.

Figure 13 - Mandibular stabilization splint was delivered.

Figure 14 - Progress photograph: Anterior open bite got worse.

Figure 15 - All the TMD symptoms disappeared. Anterior open bite continued to get worse (Compare to the initial photograph).

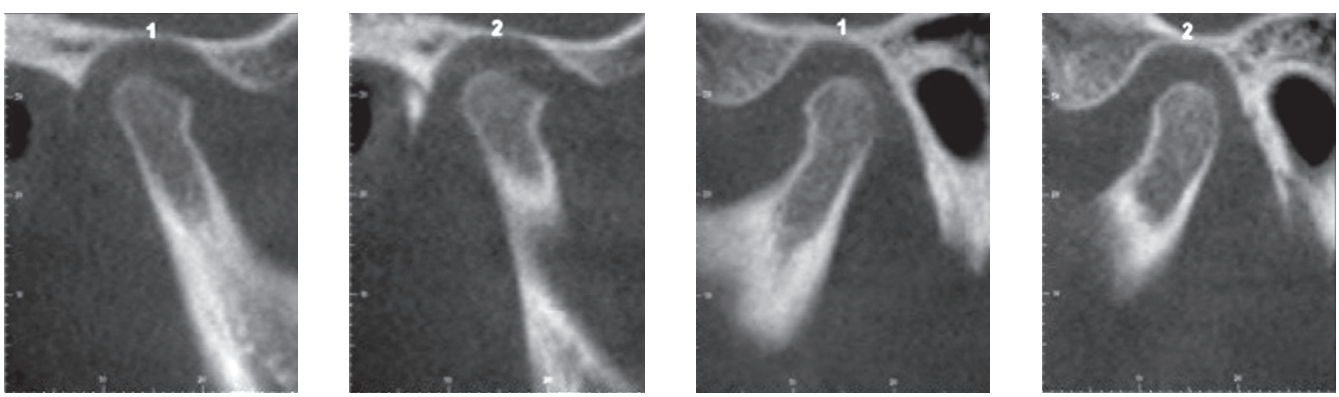

Figure 16 - Pre-treatment CBCT image.

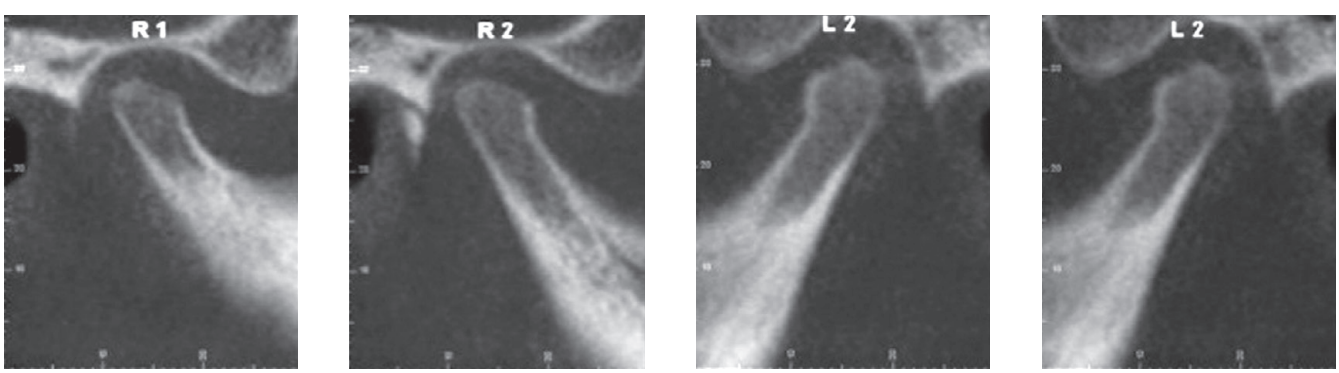

Figure 17 - Post-treatment CBCT image.

What do you think about the use of botulinum toxin in the control of patients with muscle hyperactivity? (Paulo Rocha)

Injecting hyperactive muscles with minimum quantities of botulinum toxin would result in decrease muscle activity by blocking the release of acetylcholine from the neuron. This will effectively weaken the muscle for a period of three to six months.

If a patient has a normal facial height and normal incisor position but shows an excessive gingival display because of the muscle hyperactivity, then botulinum toxin injection can be very helpful. However, the treatment effect is only temporary. Patients need repetitive injections every 3 to 6 months. Currently there is no guideline for the amount of toxin and location of the injection. There is no long-term studies of the effectiveness of this type of treatment. Further studies need to establish the guidelines for the injection locations, injection amount of botulinum toxin and long-term treatment effects.

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Induced tooth movement: Standardization of terms to describe the effects of forces on the periodontal ligament

Compression/Traction instead of Pressure/Tension

Alberto Consolaro[1]

There is no reason for Dentistry to use different terms for phenomena defined in Physics, the specific field in which concepts associated with forces are established and adapted. In place of pressure/tension, the compression/traction pair should be used. This study defines each one of these terms and justifies their use. Our contemporary world demands standardized criteria, methods, measures, concepts and terms to ensure that study protocols, results and applications are used in the same way in any country or area of human action.

Keywords: Tooth movement. Orthodontic movement. Pressure. Tension. Traction. Compression.

INDUCED TOOTH MOVEMENT AND ORTHODONTIC MOVEMENT

The first microscopic examination of bone after induced tooth movement was conducted in dogs by Carl Sandstedt[7,9] in 1901. His study reported on phenomena still currently observed[4,6] and even described remote bone resorption. His studies, first published in Swedish, were translated into English as "*some contribution for the orthodontic movement theory*". Later he reported his results in three studies,[8,9] summarized and translated into German in 1904 and 1905. In human tissues, the first microscopic observation was reported by Herzberg in 1932.[3]

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The mechanical forces applied to teeth do not result in mechanical movement only: They also produce biological stimuli capable of promoting desirable tissue reactions to achieve a stable and long-lasting change in tooth position. Similar suggestions have been made for decades, particularly by Noyes,[5] in 1942, and Baumrind and Buck,[1] in 1970. This process received the name of mechanotransduction: A physical stimulus is translated into a biological event represented by the set of changes induced in cells and tissues. Mechanotransduction may be expressed as the set of biological effects in response to the break of tensegrity, or physical balance, of the architecture of cells and tissues.

Orthodontic movement is produced using wires, and it is classified as orthodontic if the purpose of tooth movement is to correct esthetic and functional problems of teeth and face. Therefore, *orthodontic movement* is perceived as a specific tooth movement because it has very specific objectives. Induced tooth movement, by definition, is not physiological, differently from movement due to tooth eruption or tooth displacement due to the action of vectors generated during growth. *Induced tooth movement* is a movement triggered by other stimuli, external to teeth and bones, usually mechanical, and originated from forces generally released by appliances applied to teeth.

The comparison of the terms *orthodontic* movement and *induced* tooth movement suggests that orthodontic movement results from orthodontic treatment and corresponds to an *induced tooth movement*. Induced tooth movement does not necessarily correspond to orthodontic movement, because its purpose may be different and not defined as orthodontic, that is, to correct dental and maxillofacial changes. In experimental trials with animals, the purpose of tooth movement is to investigate the changes in support tissues of the teeth involved. The most accurate definition for this type of displacement is *induced tooth movement* even when performed with an appliance commonly used in Orthodontics. The appliance, however, may not be defined as an orthodontic appliance if the precise meaning of the words is respected.

PRESSURE/TENSION: AN IMPORTANT CHANGE INTO COMPRESSION/TRACTION

For many decades, orthodontic movement and the effects produced by forces on the periodontal ligament and the alveolar process were referred to as areas of pressure and areas of tension in practically all studies,[4,6] except in rare situations. In the pressure side, the ligament was compressed by the tooth against the alveolar bone and, in the tension side, at the same time, the periodontal ligament was stretched or pulled.

Some authors drew attention to several nuances of concepts and terms common to Physics when attempting to define the characteristics of these areas in the study and understanding of the biology of induced tooth movement. Our contemporary world demands standardized criteria, methods, measures, concepts and terms to ensure that procedures, trials and applications may be used in any country and area of human action.

In the biopathology of orthodontic movement, based on the third edition of the book *Dental resorptions in clinical specialties*,[2] we suggested a reorganization of these terms, which describe several biological events, and did so in light of the definitions presented below.

The concept of tension

Tension identifies a force or system of forces that acts upon a solid body per unit of area and that is capable of producing compression, shearing or traction. In orthodontic movement, the set of forces applied may be called tension all together because they compress the periodontal ligament on one side and pull or stretch it on the other side; that is, it is a system of forces.

The concept of pressure

In everyday language, pressure may also be synonymous with compression and tension. It may mean the act or effect of pressing, compressing and tightening. It may also be translated as a force applied to a body by other body in contact with it. The use of this term in orthodontic movement may generate confusion for those familiar with the physical concept. Tension is a system that may compress or pull.

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The concept of traction

Traction is one of the effects that forces may exert on a body when applied within a system called tension. Traction means the act or effect of pulling, dragging and moving. In mechanics, it expresses the situation of a body when under the action of a force that tends to elongate it. In induced tooth movement, this term is more precise to describe what was generally called the tension side.

The concept of compression

When forces are applied within a tension system, compression is the most appropriate term to describe the act or effect of applying compression. This term indicates an increase of pressure in a physical system due to the action of forces or external agents, such as in orthodontic movement. The term is perfectly consistent with what was previously called the pressure side.

FINAL CONSIDERATIONS

In our contemporary world, the economic system and the intense and fast exchange of information constantly demands greater uniformity of criteria, methods, measures, concepts and terms. Such uniformity enables the use of protocols, trials and industrial, commercial and clinical applications of research and studies in any country and area of human action. There is no reason for Dentistry to use different concepts for the same phenomena in Physics, the specific field to define and adapt concepts associated with forces. In place of pressure/tension, we suggest the use of the compression/traction pair, a change that will contribute to the required uniformity.

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Influence of saliva contamination on the shear bond strength of adhesives on enamel

Tatiana Feres Assad-Loss[1], Mônica Tostes[2], José Nelson Mucha[3]

Objective: To evaluate shear bond strength of 3 adhesive systems (Single Bond, Transbond™ MIP and Transbond™ XT) applied on bovine enamel under saliva contamination condition.

Methods: One hundred and twenty enamel surfaces of bovine incisors were divided into 6 groups (n = 20) according to the adhesive system used (Transbond™ XT, Transbond™ MIP and Single Bond) with or without saliva contamination. For each adhesive system, there were two groups defined as no contamination group (NC): 37% H_3PO_4 conditioning for 30 seconds and two layers of adhesive systems; saliva contamination group (SC): After the first adhesive layer application, the examined areas were contaminated with saliva. Samples were mounted appropriately for testing and stored in deionized water at 37 °C for 7 days. Samples were then submitted to shear bond strength trials at a speed of 0.5 mm/min. The Adhesive Remnant Index (ARI) was evaluated under stereomicroscopy. Two-way analysis of variance and the Tukey test were used to compare mean values ($\alpha = 0.05$).

Results: Groups XT (NC) = 26.29 ± 7.23; MIP (NC) = 24.47 ± 7.52 and SB (NC) = 32.36 ± 4.14 XT (SC) = 19.59 ± 6.76; MIP (SC) = 18.08 ± 6.39 and SB (SC) = 18.18 ± 7.03 MPa. ARI 0 and 1 were the most prevalent scores in all study groups examined.

Conclusion: Saliva contamination significantly decreased bond strength of the three adhesive systems examined ($p < 0.05$). However, the comparison of groups with and without saliva contamination did not reveal any significant differences, and, therefore, the three systems may be considered equivalent.

Keywords: Enamel bonding. Saliva contamination. Shear bond strength.

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Editor's abstract

Adhesive failures may occur during orthodontic bracket bonding due to saliva contamination. To minimize this problem, manufacturers developed hydrophilic primers that, maintain acceptable bond strength even when used in a moist environment. The authors evaluated bond strength to bovine enamel of an orthodontic composite sample bonded using an hydrophilic (Transbond™ MIP), a conventional (Transbond™ XT) and a dental (Single Bond) adhesive system. For that purpose, 120 bovine incisors were embedded in PVC cylinders filled with polystyrene resin. The enamel surfaces were polished for standardization. After that, enamel underwent prophylaxis with pumice and water, and the specimens were randomly divided into six groups (n=20). The specimens in the groups with no saliva contamination, XT(NC), MIP(NC) and SB(NC), underwent etching with 37% phosphoric acid for 30 seconds followed by the application of the Transbond™ XT, Transbond™ MIP and Single Bond adhesive systems. In the other 3 groups, XT (SC), MIP (SC) and SB (SC), the same procedures were made, but the enamel was contaminated with saliva, the excess was removed with gauze and air spraying, and another layer of the adhesive material was applied. Cylinders of the Transbond™ XT orthodontic composite resin were thus bonded to the center of the enamel surface for all samples. After 7 days, the specimens underwent shear bond strength trials followed by the evaluation of the adhesive remnant index (ARI). The results revealed a statistically significant reduction in bond strength for all adhesive systems tested when the enamel surface was contaminated with saliva. The SB(NC) group had the best results (32.36 ± 4.14), whereas the MIP (SC) group had the most deficient ones (18.08 ± 6.39). The authors concluded that saliva contamination reduced bond strength significantly in the three systems under tested. Moreover, results were equivalent for the three systems.

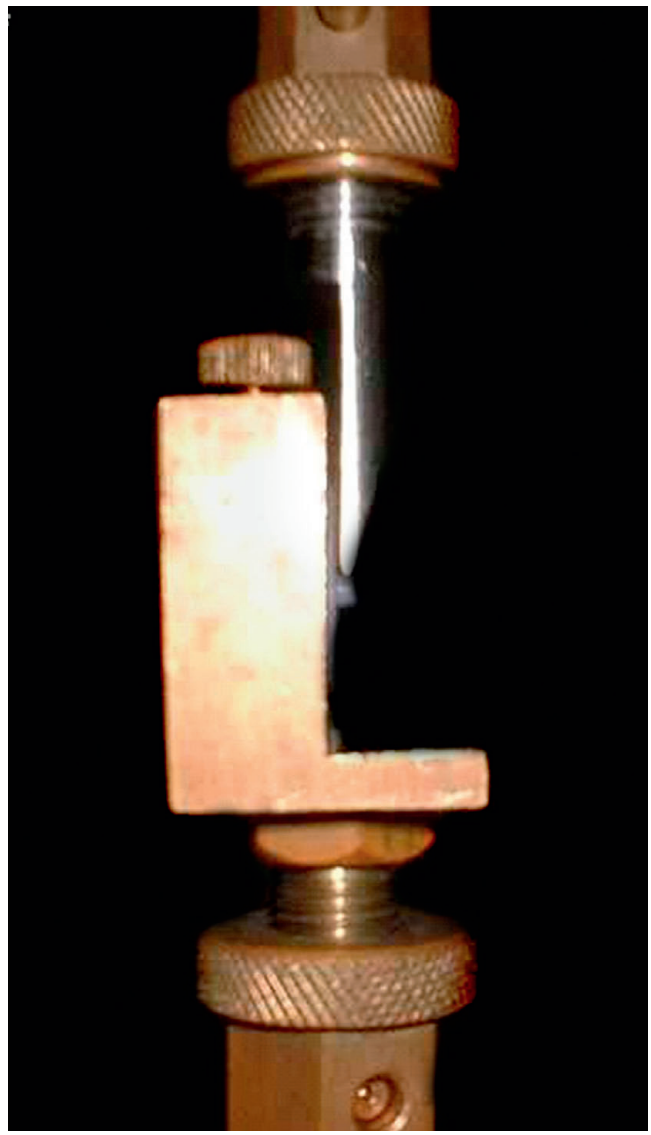

Figure 1 - Representation of specimen being submitted to shear bond strength trial (DL 10.000, EMIC, Curitiba, Brazil) at crosshead speed of 5 mm/min and 50 N load.

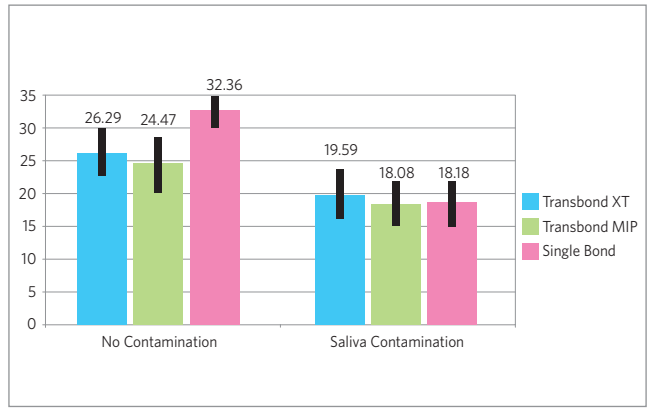

Figure 2 - Means and standard deviations of the 3 systems examined, with or without saliva contamination.

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Questions to the authors

1) How can you explain the fact that the Single Bond dental adhesive system had results that were similar to those found for the Transbond MIP system, a product developed exclusively for use in moist environments?

The composition and hydrophilic characteristics of the materials affect the passage of fluids through them. Of the commercial adhesive systems available, the most hydrophilic ones have sorption and solubility performance, as well as a water diffusion coefficients, greater than those found for the less hydrophilic products. Although MIP has more than one hydrophilic monomer (2-hydroxy-1-3-dimethacryloxy propane), which has a polar hydroxyl group, its bonding strength in moist environments was not better than that of other materials.

2) Which of the materials under test had the best cost-benefit ratio for clinical use?

According to the method used, the Transbond MIP system caused the greatest debond -damage to enamel when bonded in a dry environment and should be, therefore, contraindicated for use under that condition. The use of the SB systems seems to have the best cost-benefit ratio, correlating adequate bond strength and lower enamel fracture risk in a dry or moist environment.

3) Do you plan to conduct further studies in the same line of investigation?

This study was conducted in vitro, and we plan to conduct other in vivo and in vitro studies to evaluate the behavior of these adhesive systems.

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Effectiveness of CO_2 laser in removal of papillary gingival hyperplasia

Sabrina Kívia Correia Gama[1], Fernando Antônio Lima Habib[2], Antônio Luiz Barbosa Pinheiro[3], Telma Martins de Araújo[4]

Introduction: Laser applications have increased in a variety of dental procedures, especially in surgeries of soft tissues. Radiation is not invasive and is very well tolarated by tissues. CO_2 laser acts in small vessels promoting blood coagulation, making it possible to work in a controlled way. Patients undergoing fixed orthodontic therapy often present injuries of gingival hyperplasia, originating esthetical and functional problems.

Objective: This study aimed at evaluating the CO_2 laser effectiveness in removal of hyperplasia lesions in gingival papilla regions of patients with fixed orthodontic appliances. For this, ten patients were chosen and in these 75 teeth with gingival hyperplasia were identified. Measures from the papilla to incisal edge were performed with the use of a digital caliper. Besides that, the individuals were submitted to previous examinations to the surgical procedure with laser: Full blood count, blood coagulation profile and fasting blood glucose. After this, patients were submitted to the surgery for lesion removal, carried out at the Laser Center of FOUFBA, utilizing a CO_2 laser machine (Sharplan 20C, Tel Aviv, Israel).

Results: It was showed that laser provided a significant increase ($p<0,001$) in the distance from the papilla to the incisal edge of the teeth, with no tissue contraction, aspects which were maintained for over two months.

Conclusion: It can be concluded that CO_2 laser has proved to be effective in removal of papillary gingival hyperplasia lesions.

Keywords: Laser. Gingival hyperplasia. Orthodontics.

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

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Editor's abstract

Gingival hyperplasia is a very frequent condition in patients undergoing fixed orthodontic treatment. Its development is usually attributed to chronic inflammation. Initially, gingival hyperplasia may be treated with improvement of the oral hygiene. However, when there is persistence of tissue hyperplasia, the classical treatment would include gingivectomy, which consists in surgically removing hyperplastic tissue, followed by mechanic dental plaque control and effective control of oral hygiene.

The modalities of gingivectomy include the conventional method performed with a scalpel, electrosurgery with electrocautery or through the use of lasers. Among surgical lasers, the most commonly used in the oral cavity are the Nd:YAG, Argon and CO_2 lasers. In CO_2 laser, the long wavelength has the advantage of being highly absorbed by tissues that contain large amounts of water, presenting evaporation and providing easier removal of the lesions without causing a deep burn. This study aimed to assess the effectiveness of the use of the CO_2 laser on the removal of hyperplasia of the gingival papilla in orthodontic patients.

Ten patients were selected and a total of 75 teeth with hyperplasia were diagnosed. Following routine preparation for surgery, measurements of the distance of papilla to the incisal edge of teeth were perfomed with a digital caliper (Fig 1).

The laser used was a CO_2 laser (Sharplan 20C, Tel Aviv, Israel; λ 10.600 nm, 5 W, 0.2 mm focus, RSP/CW). The surgeries were performed by a single

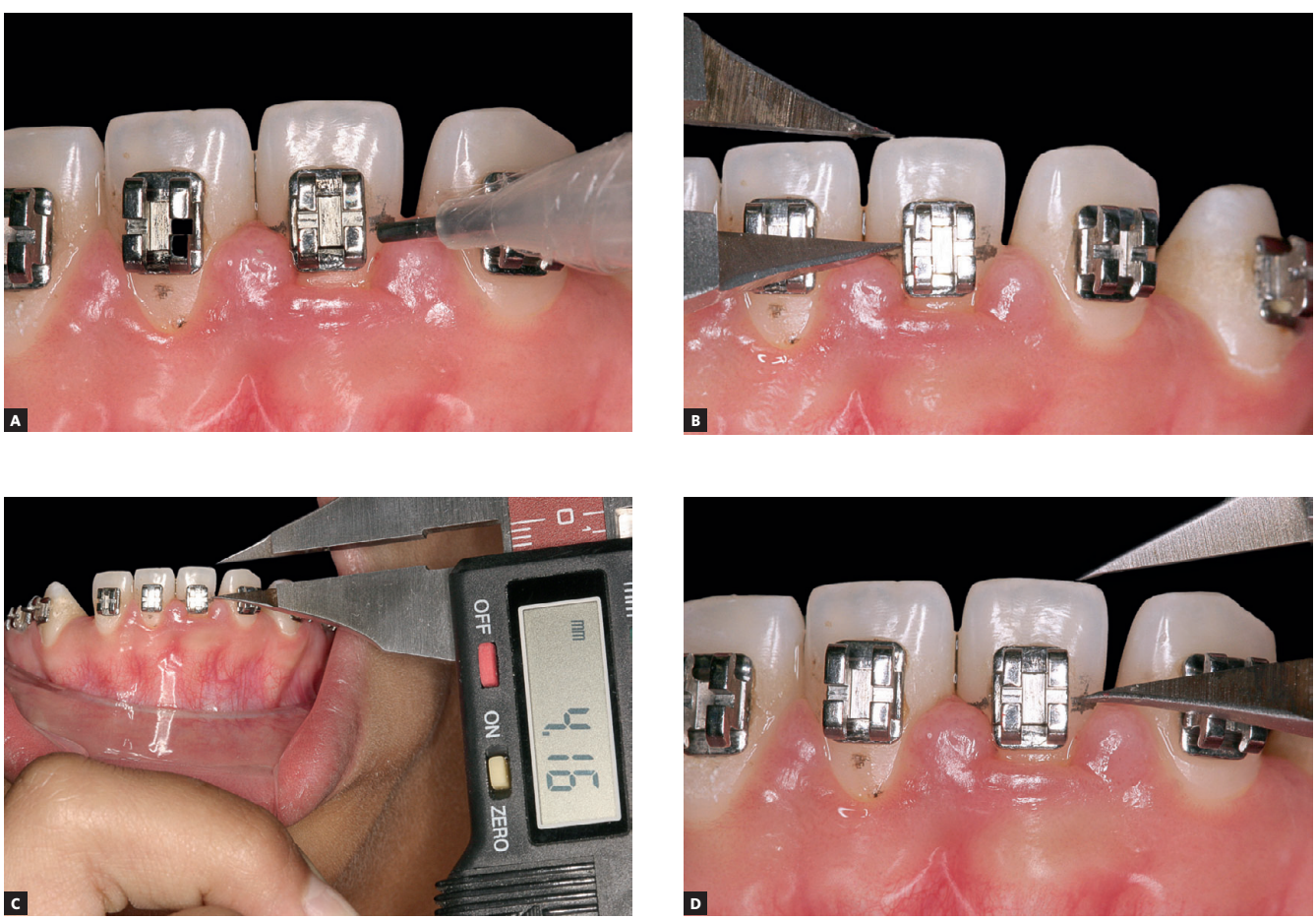

Figure 1 - **A**) Marking the height of the papilla before surgery. **B**, **C** and **D**) Measuring the distance from the papilla to the incisal edge.

professional. The distance from the papilla to the incisal edge was measured four times: Before surgery - Time 0, immediately after surgery – Time 1, one month - Time 2 (Fig 2) and two months after the surgical procedure - Time 3.

The results showed that the laser treatment resulted in a statistically significant ($p<0.001$) increase in the distance of papilla to the incisal edge of the teeth and this was kept throughout the experimental period of two months. It can be concluded that the use of the CO_2 laser was effective on the removal of gingival hyperplasia in orthodontic patients.

Figure 2 - One month after the surgical procedure.

Questions to the authors

1) What would be the two main advantages and disadvantages of using CO_2 laser to correct gingival hyperplasia?

The two main advantages are: The absence of bleeding, allowing the bonding of brackets during the same clinical session, and an easier post-operative recovery, which is usually fast and with minimal discomfort. The disadvantages are the high cost of the equipment and the need for specialized training for the procedure.

2) It would be interesting to include two other groups with conventional gingivectomy and electrosurgery? What would be the next step in this research?

The idea of including the group of conventional gingivectomy was thought at the beginning of the work, but since this was an early work between the Laser and Orthodontics Departments at our University, we decided to do it later. We did not think of electrosurgery because of the contraindications that this technique presents.

3) The high cost of a CO_2 laser device compensates its use in a private practice?

The cost is really high, but depending on the size of the private practice, the number of partners and the public, would compensate because this laser device can be used for other purposes, such as caries removal, endodontic treatment, apical surgery, surgical treatment of soft tissues lesions, surgical treatment of premalignant and malignant lesions of oral cavity.

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Orthodontic retainers: Analysis of prescriptions sent to laboratories

Washington Komatsu Assumpção[1], George Kenji Bezerra Ota[1], Rívea Inês Ferreira[2], Flávio Augusto Cotrim-Ferreira[2]

Objective: To investigate the most commonly fabricated orthodontic retainers.

Methods: Information on the type and amount of maxillary and mandibular retainers produced in a three-month period was collected from six laboratories (in the cities of São Paulo, Mauá and Guarulhos). The retainers were grouped according to the total production. For the maxillary arch, the groups were: 1S – Begg retainer, 2S – Hawley retainer, 3S – transpalatal arch retainer, 4S – buccal resin-arch retainer, and 5S – vacuum-formed retainer, Planas appliance, bonded lingual retainer and V-loop bonded lingual retainer. The groups relative to the mandibular arch were: 1I – 3-3 bonded lingual retainer (canine-to-canine), 2I – Hawley retainer and V-loop bonded lingual retainer, 3I – Begg retainer, 4I – buccal resin-arch retainer, vacuum-formed retainer and Planas appliance. The data were presented in box plots. Groups were compared using the Student's t-test with Bonferroni correction.

Results: The average of maxillary appliances fabricated ranged from 189.5 (1S) to 3.95 (5S). There were significant differences between groups 1S versus 5S and 2S versus 5S ($p < 0.0001$). Mean values for the mandibular retainers ranged from 55.3 (1I) to 4.2 (4I). Significant difference was observed between groups 2I and 4I ($p < 0.0001$).

Conclusions: For the maxillary arch, the most requested retainers were Begg and Hawley retainers. Regarding the mandibular arch, bonded lingual retainers and Hawley retainer were the most frequent ones.

Keywords: Orthodontics. Corrective. Orthodontic appliances. Relapse.

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Editor's abstract

Relapse of orthodontic treatment may be associated with several factors, such as periodontal and occlusal status, pressure applied by soft oral tissues, and growth. Consequently, the important function of retainers is to provide stability to the results of orthodontic treatment. Several orthodontic retainers have been described in the literature, and the frequency at which certain appliances are prescribed has raised a controversy because there are variations according to geographic areas and patient characteristics. This study investigated which retainers are most frequently manufactured in laboratories in the city of São Paulo and two other neighboring towns in Brazil. The authors collected information about the types and numbers of retainers for the maxillary and mandibular arches produced during three months in six laboratories that manufacture orthodontic appliances in the city of São Paulo (n = 4), Mauá (n = 1) and Guarulhos (n = 1). Cluster analysis was used to group appliances according to total number of retainers made during the study time. For the maxillary arch, in descending order of demand, the groups were: 1S – Begg retainer (Fig 1), 2S – Hawley retainer, 3S – retainer with transpalatal arch, 4S – retainer with buccal resin bar and 5S – vacuum-formed acetate or polyethylene appliance, Planas retainers, fixed lingual arch, modified fixed lingual arch or V-loop bonded lingual retainers (Fig 2). Groups according to mandibular retainer were: 1 – 3-3 fixed lingual arch; 2 – Hawley retainer, modified fixed lingual arch and V-loop bonded lingual retainer; 3 – Begg retainer; 4 – retainer with buccal resin bar, vacuum-formed acetate or polyethylene appliance and Planas retainer (Fig 3). Results for the groups of maxillary and mandibular appliances were compared using the Student t test and the Bonferroni correction. The level of

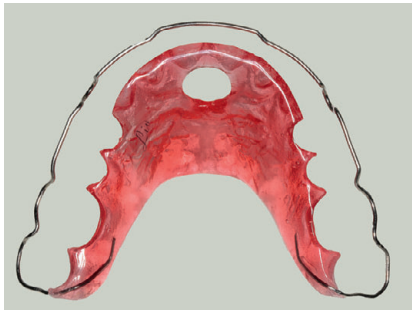

Figure 1 - Maxillary Begg retainer after manufacture.

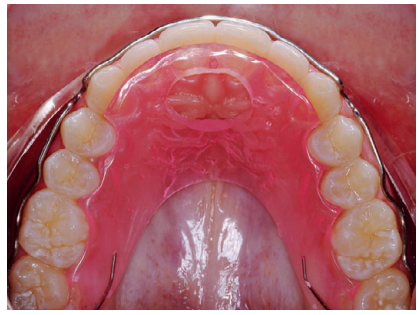

Figure 2 - Begg retainer placed in maxillary arch. This retainer has an area to stop the tongue at the level of the incisive papilla.

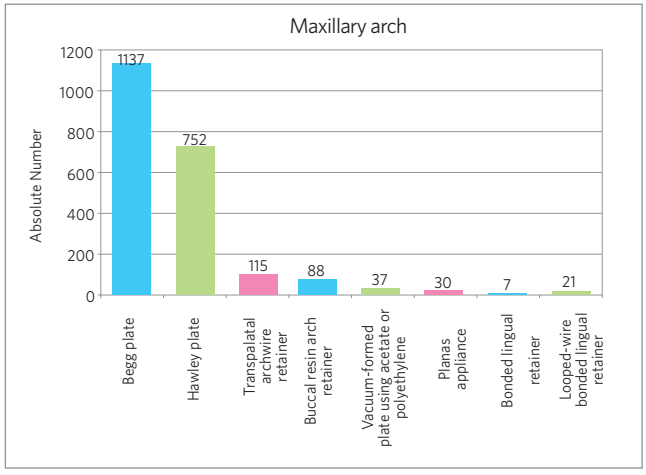

Figure 3 - Absolute numbers corresponding to the total production of maxillary orthodontic retainers, in six laboratories.

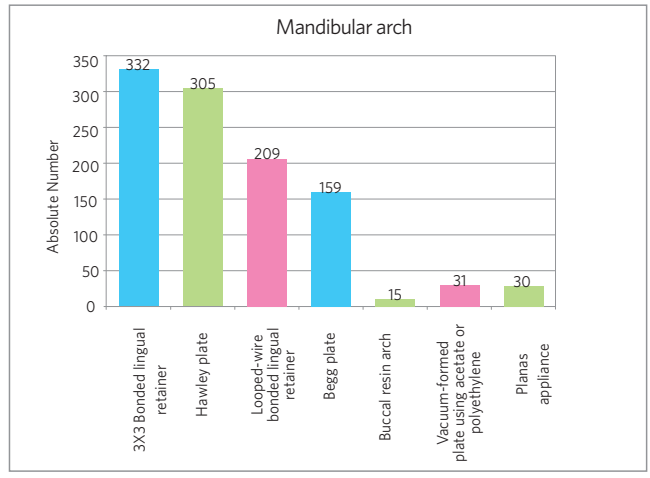

Figure 4 - Absolute numbers corresponding to the total production of mandibular orthodontic retainers, in six laboratories.

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significance was set at 5%. Results showed that the mean number of maxillary appliances ranged from 189.5 (1S) to 3.95 (5S). There were significant differences between groups 1S and 5S, and between 2S and 5S ($p<0.0001$). Mean number of mandibular retainers ranged from 55.3 (group 1) to 4.2 (group 4), and results of group 2 were significantly different from those of group 4 ($p<0.0001$). The authors concluded that the retainers most often prescribed for the maxillary arch were the Begg and Hawley retainers, and, for the mandibular arch, the fixed lingual arch and the Hawley retainer.

Questions to the authors

1) What criteria should be adopted by orthodontists to choose orthodontic retainers?

Orthodontists should analyze four factors that determine the prescription of retainers:

1. The characteristics of the dental arch to be retained. Adaptation of maxillary fixed retainers is difficult because of the occlusal contacts on the lingual surface of incisors. In contrast, fixed retention is a better choice for the mandibular arch, because it is more prone to the relapse of incisor crowding.
2. However, the compliance of patient should also be taken into consideration, as it is often preponderant when prescribing a fixed or removable retainer.
3. Particularly among young patients, the remaining growth potential and pattern should also be evaluated. In some cases and based on potential growth, prescriptions may be for active retainers, such as maxillary splinters for Class II malocclusions and mandibular positioners for Class III malocclusion.
4. The maintenance of periodontal health is important in all cases. However, in adult patients that presented bone loss before orthodontic treatment, the use of retainers of greater or lower stability and durability should be carefully analyzed before prescribing.

2) Do you believe the results of this study would be the same if conducted elsewhere, in other Brazilian states?

The prescription of a specific type of retainer is often affected by the place where the orthodontist was trained, whether in Brazil or abroad. However, based on the quality of the clinical cases published in the main Brazilian journals in the area of orthodontics, such as the Dental Press Journal of Orthodontics and Facial Orthopedics and the Revista Ortodontia SPO, we conclude that orthodontists have been selecting adequate retainers despite regional differences.

3) How do you explain the fact that most orthodontists prefer the Begg retainer for the maxillary arch and the 3-3 fixed lingual retainer for the mandibular arch?

Mandibular fixed retainers (3-3 wire) are extremely efficient, highly esthetic, and they do not impair speech and mastication significantly. In addition, when guidelines are clear, patients clean the area satisfactorily and, thus, avoid caries and gingival inflammation. The maxillary Begg retainers adapt well to the teeth and palate and do not affect dental occlusion. Some of their inconveniences are the poorer esthetic result and their negative effect on speech and mastication. Therefore, it should be used full time only for a short period and overnight for long-term. The adaptation to maxillary fixed retainers is difficult due to the occlusal contacts on the lingual surfaces of incisors, and the Hawley retainers also affect occlusion.

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Risk variables of external apical root resorption during orthodontic treatment

Maria Carolina Feio Barroso[1], Renan Lana Devita[2], Eugênio José Pereira Lages[3], Fernando de Oliveira Costa[4], Alexandre Fortes Drummond[5], Henrique Pretti[6], Elizabeth Maria Bastos Lages[5]

Introduction: External apical root resorption (EARR) is an adverse outcome of the orthodontic treatment. So far, no single or associated factor has been identified as responsible for EARR due to tooth movement.

Objective: This study investigated the association of risk variables (age, gender, extraction for orthodontic treatment and Angle classification) with EARR and orthodontic treatment.

Methods: The sample (n=72) was divided into two groups according to presence (n=32) or absence (n=40) of EARR in maxillary central and lateral incisors after orthodontic treatment.

Results: There were no statistically significant differences in EARR according to age, gender, extraction or type of malocclusion (p>0.05).

Conclusion: The risk variables examined were not associated with EARR in the study population.

Keywords: Orthodontics. Root resorption. Tooth movement.

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Editor's abstract

External apical root resorption (EARR) is one of the main adverse effects of orthodontic treatment. Due to its irreversible nature, EARR is a huge concern for clinicians and researchers, as losses in root length greater than 3 mm cause a reduction in the supporting periodontium and, in severe cases, can lead to tooth mobility. According to the literature, a number of etiological factors are associated to EARR, such as dental anomalies, abnormal root morphology, type and severity of malocclusion, orthodontic treatment involving extraction, magnitude and duration of the force applied, gender, age and individual variability. The aim of the present study was to assess the association between the presence/absence of EARR and gender, age, orthodontic treatment with/without extraction and type of malocclusion (Angle classification). The sample consisted of 72 individuals with a mean initial age of 15.7 years (±7.3) treated with fixed orthodontic appliance at the Specialization Course in Orthodontics of the Dental School of the Federal University of Minas Gerais (Brazil). Periapical radiographs of the upper incisors taken at the beginning and end of treatment were scanned and analyzed using the ARARA program. For such, the median point of the enamel-cementum junction was determined, which divided the crown and root of the upper central and lateral incisors. EARR of each incisor was determined by the difference between the initial and final root length, multiplied by the ratio between the initial and final crown length, which furnished data on the lengthening or shortening of the roots. Individuals with at least one incisor with EARR ≥ 2 mm were considered affected (32 patients), whereas those with EARR < 2 mm were considered unaffected and made up the control group (40 patients). Data on age, gender, type of orthodontic treatment (with/without extraction) and malocclusion were obtained from the patient charts. For the determination of intra-examiner agreement, the same examiner performed the same measurements on 20 radiographs a second time following a seven-day interval and the data were analyzed using the Kappa test. The Student's t-test, chi-square test and Fisher's exact test were employed for the statistical treatment of the data, with the level of significance set at 5% ($p < 0.05$). The results demonstrated no statistically significant differences between the affected group (EARR ≥ 2 mm) and control group with regard to age, gender, orthodontic treatment with/without extraction or type of initial malocclusion.

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Questions to the authors

1) In a number of studies in the literature, orthodontic treatment with tooth extraction has been associated with the presence of external apical root resorption (EARR) in the anterior teeth. In the authors' opinion, why was this not verified in the present study?

Different factors may have contributed to our present findings:

1. The etiopathogenesis of EARR is unclear and complex, influenced by of numerous risk variables. In the case-control study design, it is difficult to control biases and the causal association can be relatively weak.
2. The subjects analyzed were part of a convenience sample from a Dental School and were, therefore, not representative of a large population.
3. Orthodontic treatment conducted in an academic setting may mean greater care in terms of planning, execution and finalization in comparison to treatment carried out in private practice.
4. Longitudinal studies with larger, representative samples should be conducted to confirm these findings.

2) In orthodontic diagnosis and planning, what characteristics should be considered for the determination of the risk of EARR in the upper incisors?

The etiological factors of root resorption stemming from orthodontic treatment are not yet fully clarified and seem to be complex. Root resorption may result from a combination of individual factors, genetic predisposition and the effect of mechanical factors. The risk factors cited in the literature include a previous history of root resorption, trauma prior to orthodontic treatment, root length and morphology, abnormal root development, genetic factors, systemic factors, asthma, proximity of root to the bone cortex, bone density, root canal treatment, type and severity of malocclusion, age and gender. The literature remains inconclusive regarding the risk of root resorption when such variables are analyzed. The prediction of root resorption considering these risk factors during the diagnosis and planning of treatment is not supported by the literature.

3) In the present study, 44.44% of the patients analyzed had an EARR index equal to or greater than 2 mm stemming from orthodontic treatment. Considering this fact, what conduct do the authors recommend for the early diagnosis of EARR during orthodontic treatment? How should orthodontic treatment be conducted?

Periapical radiographs should be solicited within 6 to 12 months after the onset of orthodontic treatment for the early detection of root resorption. Patients with detectable root resorption in the first six months of active orthodontic treatment are more susceptible to resorption. For patients with positive diagnose for root resorption, a pause of 2 to 3 months with a passive archwire can minimize additional resorption. In cases of severe resorption, the treatment plan should be reevaluated with the patient. Alternatives to extraction may include prosthetics. If severe root resorption is detected in the final radiographs after treatment, follow-up radiographs are recommended until the resorption is stabilized. The stabilization of the resorption activity generally occurs after the removal of the orthodontic appliance. Additional care should be taken when fixing the teeth, as occlusal trauma may occur and lead to extreme resorption.

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Cone-Beam computed tomography evaluation of maxillary expansion in twins with cleft lip and palate

Luciane Macedo de Menezes[1], Fabiane Azeredo[2], André Weissheimer[3], Juliana Lindemann Rizzato[4], Susana Maria Deon Rizzatto[5]

Introduction: The establishment of normal occlusal relationships in patients with cleft lip and palate using rapid maxillary expansion may promote good conditions for future rehabilitation.

Objective: This study describes the clinical case of monozygotic twins with unilateral cleft lip and palate at the age of mixed dentition who were treated using the same rapid maxillary expansion protocol, but with two different screws (conventional and fan-type expansion screw). Results were evaluated using plaster models, intraoral and extraoral photographs, and Cone-Beam Computed Tomography (CBCT) scans obtained before the beginning of the treatment, (T_1).

Methods: The patients were followed up for 6 months after maxillary expansion, when the same tests requested at T_1 were obtained again for review (T_2). T_1 and T_2 results were compared using lateral cephalometric tracings and measurements of the intercanine and intermolar distances in the plaster models using a digital caliper.

Results: The two types of expansion screws corrected the transverse discrepancy in patients with cleft lip and palate. The shape of the upper arches improved at 10 days after activation.

Conclusion: CBCT scans provide detailed information about craniofacial, maxillary and mandibular changes resulting from rapid maxillary expansion. The most adequate screw for each type of malocclusion should be chosen after detailed examination of the dental arches.

Keywords: Palatal expansion. Midpalatal fissure. Cone-Beam computed tomography. Orthodontics.

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Editor's abstract

Cleft lip and palate, a congenital malformation with important clinical and psychosocial impacts, may occur alone (non-syndromic origin) or be associated with multiple congenital anomalies (syndromic origin). Some of the complications that may affect patients with cleft lip and palate are abnormal tooth number and shape, anterior and posterior cross bite, and facial esthetics compromised by maxillary retrusion or mandibular prognathism. Maxillary hypoplasia in individuals with a cleft palate is often not limited to the dentoalveolar segment, but may also involve the paranasal, infraorbital and zygomatic regions.

The establishment of normal intermaxillary relations in patients with cleft lip and palate at the right time using rapid transverse maxillary expansion may ensure good conditions for future rehabilitation. The authors of this study aimed to describe the clinical case of monozygotic twins with cleft lip and palate who underwent rapid maxillary expansion (RME) with two types of expander. Two maxillary expansion protocols were used, one using a tooth-anchored expander and a fan-type ("butterfly") expansion screw, and the other, a modified Haas appliance (palatal mucosa and tooth anchorage) and a conventional screw. Six months after the end of the active phase, new orthodontic investigations were requested, and results were compared with baseline records. Lateral cephalometry, measurement of plaster models, and visual examination of CT scans were used for analyses.

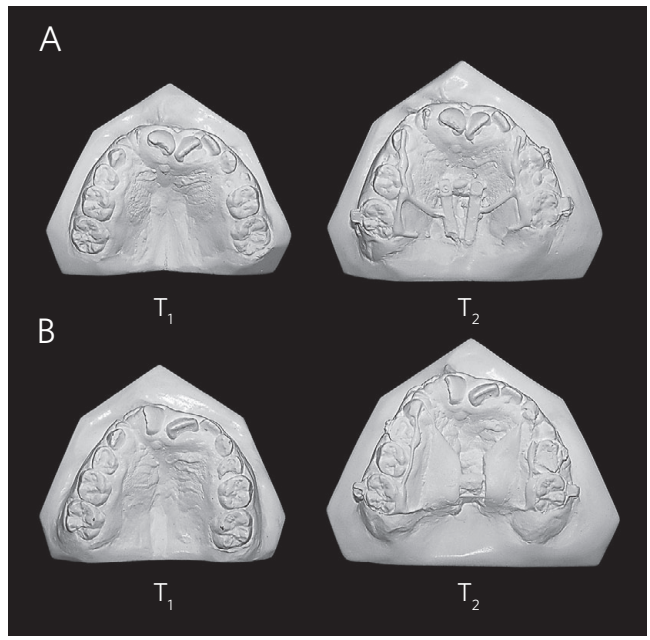

Figure 1 - Comparison between initial models (T_1) and the models obtained 6 months after maxillary expansion (T_2) in patients A e B.

Results revealed that the two types of expansion screws were effective in correcting the transverse discrepancy, and the shape of the upper arches was improved 10 days after activation. CT scans showed the disjunction of the frontonasal, frontomaxillary and frontozygomatic sutures (Fig 1). Therefore, we may conclude that, according to the study results, expansion achieved with the conventional and the fan-type screw effectively corrected the transverse discrepancy in patients with cleft lip and palate and improved the shape of their maxillary arches.

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Questions to the authors

1) Do you think there would be any differences in the results found in your study if acrylic pads were added to the fan-type expander, so that it became an appliance with palatal mucosa as well as tooth anchorage?

This case report compared the action of conventional and fan-type screws by measuring intermolar and intercanine distances. The presence of acrylic pads in the fan-type expander may not change the limited expansion of intermolar distance achieved by the fan-type screw. However, no measurements of dentoalveolar and skeletal dimensions were made transversely to assess and compare the effect of the acrylic pad on both immediate and long-term RME effects. An acrylic pad may be important, particularly after the active phase of RME, during which, according to Haas,[1,2,3] the acrylic pad works as a mechanical protection against possible relapse in the dentoalveolar region during the retention phase. A study with two groups of patients with cleft lip and palate who underwent RME using appliances anchored on teeth and palatal mucosa and who were divided according to type of expansion screw (conventional or fan-type) found that the maxilla moved downwards in both groups and remained so during the retention phase. The conventional screw promoted greater expansion in the posterior region, whereas the effect of the fan-type expander was more marked in the anterior region.[4] However, this issue should be further explored in prospective, randomized clinical trials to evaluate and compare the effects of RME using tooth-anchored appliances or appliances anchored to teeth and palatal mucosa, in which conventional and fan-type expansion screws should be used, and variables should be controlled, such as the number of teeth used for anchorage, standardized position of expansion screws, and the size of the orthodontic wire used to manufacture the appliances.

2) Why were examinations not repeated right after maxillary expansion? Do you believe that results would be different from the results found?

Patients with cleft lip and palate are usually involved in long-term multidisciplinary treatments and often undergo radiographic or CT examinations. The effective cone-beam CT (CBCT) radiation dose varies according to CT scanner manufacturer and the technical specifications set before scanning, such as field of view, exposure time, milliamperes and kilovolts.[5] The amount of radiation is similar to the dose emitted during periapical examination of the complete dentition,[6] or up to 10 times greater than that of a panoramic radiograph.[7] X-ray risks are cumulative, and the patients with cleft lip and palate remain under treatment for a long time, during which more complementary exams the use X-rays will have to be obtained. Therefore, the authors decided that it would be wise not to expose the patients to an extra dose of radiation. Whether there would be differences in the results found, we believe that no, because the appliances remained in the oral cavity. In a recent prospective randomized clinical trial with patients without cleft lip and palate, the immediate effects of RME using both tooth-anchored and mucosa-and-tooth-anchored appliances were similar.[8] Further well-designed clinical studies should be conducted to fully elucidate this issue in cases of patients with uni- or bilateral cleft lip and palate.

3) Based on the statement published in the Discussion Session, "CBCT generates images of the craniofacial complex at submillimeter resolutions..." I ask: It would not be more reliable to make all the measurements directly on the CT images using specific software instead of using lateral cephalometry and making measurements on the plaster models?

In this case report, cephalometric studies were conducted using images that simulate lateral radiographs generated by CBCT. The advantages of such images are the fact that they are not magnified and are similar to conventional cephalometric radiographs. However, the ideal procedure for evaluation and comparison of orthopedic treatments in the maxillofacial region is the construction, superimposition and measurement of distances between surfaces in a 3D model, as described in details in the studies published by the researchers of the University of North Carolina.[9,10,11] However, such technologies remain limited to a few research centers, whereas traditional radiographs and plaster models are still routinely used by most clinical orthodontists.

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4) As it is a case study, would you expand the results to use in the general populations that have the same problem?

Before the effects of a treatment may be applied to the general population, they should be exhaustively studied in well-designed trials, in which the information generated has a high degree of scientific evidence, such as in meta-analyses and prospective randomized clinical trials. Evidence-based Orthodontics is based on the best scientific evidence available associated with professional experience and patient expectations. As a case report has a low evidence level, the effects of RME presented in this study should be interpreted cautiously, as they may not reflect the effects expected for all the patients with cleft lip and palate.

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Dentofacial characteristics of patients with Angle Class I and Class II malocclusions

Rogério Lacerda dos Santos[1], Antônio Carlos de Oliveira Ruellas[2]

Objective: The present study assessed some cephalometric measurements of the soft tissue profile in order to observe the behavior of facial convexity in patients with Class I, Class II division 1, and Class II division 2 malocclusions.

Methods: One hundred and thirty pre-treatment cephalometric radiographs of Caucasian patients aged 10-16 years (mean age of 12.6 years) were selected for study and divided into 3 groups. The cephalometric measurements used in the present study were the following: H.SN, Cx, NLA, MLA, UL-SUL-S, LL-S, IMPA, and 1-SN. Analysis of variance and Tukey's test were applied for measurements H.SN, Cx, IMPA, 1-SN, MLA, and NLA, whereas Kruskal-Wallis and Dunn's tests were applied for UL-S and LL-S.

Results: The results showed statistically significant differences for the measurements H.SN, Cx, UL-S, and IMPA between Groups I, II-1 and II-2 ($p < 0.05$). Measurements LL-S and MLA showed statistically significant difference between Groups I and II-1 only ($p < 0.05$). On the other hand, no statistically significant differences were found for measurement NLA among the 3 groups ($p < 0.05$).

Conclusion: Regarding facial characteristics expressed by measurements H.SN, Cx, and UL-S, one could conclude that Class II division 1 and Class II division 2 malocclusions, both differed from Class I malocclusion. In addition, Class II division 1 malocclusion was found to have facial characteristics expressed by MLA, which differentiate it from the Class II division 2 and Class 1 malocclusions. Class I, Class II division 1 and Class II division 2 malocclusions showed no difference in facial characteristics expressed by the measurement NLA, and measurement LL-S was directly related to eversion of the lower lip.

Keywords: Malocclusion. Cephalometry. Angle's classification.

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Editor's abstract

Over the last hundred years the concept of facial beauty has undergone changes in agreement on esthetic values, especially in this last decade. In the facial profile considered ideal at present, the lips are more outstanding when compared with profiles at the beginning of the 20th Century, when thin, less voluminous lips were desirable, one of the reasons could be that fuller lips tend to demonstrate a more youthful appearance. There have been increasing endeavors to compare, relate and define standards and reliable measures for assessing facial esthetics with the purpose of defining reliability in the evaluation of these profiles. Based on this premise, the authors' purpose in this study was to compare measurements related to facial convexity among patients with Class I, Class II division 1 and Class II division 2 malocclusions, among each other, as well as with the standard measurements. For this purpose a random selection of 130 lateral cephalometric radiographs was made, of caucasian patients in the age-range between 10 and 16 years, mean of 12.6 years. The sample was divided into three groups: (I) 50 individuals with Class I malocclusion; (II-1) 50 individuals with Class II malocclusion division 1, and (II-2) 30 individuals with Class II malocclusion, division 2. The method chosen was comparison among cephalometric measurements. The angular measurements evaluated were as follows: Angle of facial convexity (Cx), H.SN, nasolabial (NLA), mentolabial (MLA), 1-SN, IMPA (Fig 1). The linear measurements used were as follows: UL-S and LL-S (Fig 2). The results obtained demonstrated that the measurements H.SN, Cx, UL-S and IMPA showed statistically significant differences between Groups I and II-1 and between Groups I and II-2 ($p < 0.05$). The measurements LL-S and MLA showed statistically significant difference only between Groups I and II-1 ($p < 0.05$). The measurement NLA showed no statistically significant difference among the three groups ($p > 0.05$). Thus the authors concluded that Class II-1, Class II-2 and Class I malocclusions showed different facial characteristics for the measurement 1-SN. Class II-1 malocclusion presented different facial characteristics when compared with Class II-2 and Class I malocclusions with regard to measurement MLA, and that Class II-1 and Class II-2 malocclusions were differentiated from Class I by the facial characteristics expressed by measurements H.SN, Cx, UL-S and IMPA.

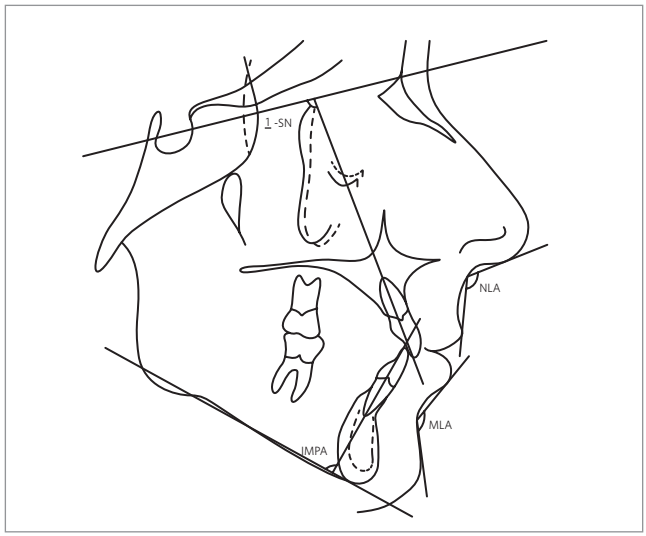

Figure 1 - Representation of the angular measurements for tooth position and labial posture.

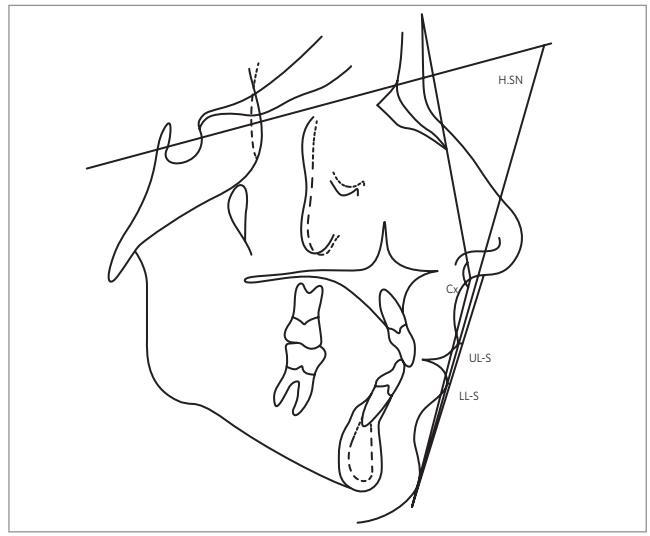

Figure 2 - Representation of angular measurements of facial convexity and linear measurements of labial position.

Questions to the authors

1) Because data were collected in a population from the South East of Brazil, do the authors believe that the results would have differed if the data had been collected in other regions, for example from the North or North East?

Certainly. When considering the facial convexity of individuals with Class I, Class II division 1 or 2, one must consider that this convexity depends on the individuals' ethnic, racial and age factors[1]. A study[2] comparing the pattern of normality of the facial profile of Brazilian individuals from the northeastern region, with those from the southeastern region, showed that individuals from the northeastern region presented less prominent facial middle third, thicker lower lip, more obtuse nasolabial angle, smaller upper lip angle and less protruding maxillary incisors, in comparison with individuals from the southeastern region. These regional evidences are important, not only for diagnosis and orthodontic treatment, but for ortho-surgical planning in these populations.

2) From the authors' point of view, do these results bring anything new to clinical orthodontists?

Over the last hundred years the concept of facial beauty has undergone changes in agreement on esthetic values, especially in this last decade. There are increasing efforts to compare, relate and define patterns and reliable measurements for the evaluation of facial esthetics. In this study it was shown that Class II-1 and Class II-2 malocclusions are differentiated from Class I by the measurements H.SN, Cx, UL-S and IMPA. The revealing result in this study involves evidence that these measurements were not reliable and/or capable of differentiating Class II malocclusions. This reinforces the idea that clinical orthodontists must base themselves on a group of angular and linear measurements that are capable of generating useful and safe information for orthodontic diagnosis of Class I and II malocclusions.

3) What is the next step in this line of research? Are you thinking of evaluating patients with normal occlusion with the aim of determining the measurements of normality in this target population?

There are studies in progress for this target population. But there is a lack of studies in individuals with normal occlusion for the population of the north and northeastern regions. It must be pointed out that the importance of identifying measurements of soft tissue normality in the different facial types arises from the influence that these tissues have on their facial harmony and their dental arches. These measurements are important for individualized orthodontic or ortho-surgical diagnosis and treatment of these regional populations.

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Early cephalometric characteristics in Class III malocclusion

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Objective: Early identification of craniofacial morphological characteristics allows orthopedic segmented interventions to attenuate dentoskeletal discrepancies, which may be partially disguised by natural dental compensation. To investigate the morphological characteristics of Brazilian children with Class III malocclusion, in stages I and II of cervical vertebrae maturation and compare them with the characteristics of Class I control patients.

Methods: Pre-orthodontic treatment records of 20 patients with Class III malocclusion and 20 control Class I patients, matched by the same skeletal maturity index and sex, were selected. The craniofacial structures and their relationships were divided into different categories for analysis. Angular and linear measures were adopted from the analyses previously described by Downs, Jarabak, Jacobson and McNamara. The differences found between the groups of Class III patients and Class I control group, both subdivided according to the stage of cervical vertebrae maturation (I or II), were assessed by analysis of variance (ANOVA), complemented by Bonferroni's multiple mean comparisons test.

Results: The analysis of variance showed statistically significant differences in the different studied groups, between the mean values found for some angular (SNA, SNB, ANB) and linear variables (Co – Gn, N – Perp Pog, Go – Me, Wits, S – Go, Ar – Go).

Conclusion: Assessed children displaying Class III malocclusion show normal anterior base of skull and maxilla, and anterior positioning of the mandible partially related to increased posterior facial height with consequent mandibular counterclockwise rotation.

Keywords: Angle Class III malocclusion. Cervical maturity. Cephalometry.

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INTRODUCTION

The Class III malocclusion shows prevalence around 3%, according to studies carried out in different population groups, including Brazilians[19]. Perhaps because of this low prevalence, early diagnosis, prognosis and the definition of appropriate time and therapeutic modalities suitable for its treatment remains a challenge to the orthodontist.

According to the data gathered from the records available at the Burlington Growth Center, it is possible to observe that in the different age groups analyzed, starting from 3 years of age, the occurrence of patients with Class III malocclusion was around 2%, except in the age of 6, where this percentage increased to about 4%.[14] On the other hand, when the same patients were cephalometricaly analyzed by linear differences between the maxillary and mandibular length, it was observed that until the age of six the occurrence of patients with skeletal relationship Class III demonstrated similar variation. However, starting from this age, the increase in the number of patients with Class III was progressive, until it reached a rate of approximately 12% of the assessed sample.[14] These differences probably are due to so-called natural dental compensation of skeletal discrepancies, that would become more evident after the six years old, on the occasion of the eruption of permanent incisors.[14]

Between the ages of 5 and 15 years, in a sample of Class III patients selected based on molar relationship, 25% present pure maxillary retrusion while less than 20% is related exclusively to mandibular prognathism.[8] Thus, the early identification of craniofacial morphological characteristics, by means of cephalometric data, provides orthopedic segmented interventions to attenuate dentoskeletal discrepancies, which may happen to be partially disguised by natural dental compensation.

A systematic literature review regarding the effectiveness of maxillary orthopedic protrusion to determine the existence of consensus on controversial issues — such as adequate time to treatment — revealed that the most significant orthopedic changes were observed in the earliest ages,[13] being the best stage for skeletal maxillary changes between four and seven years of age.[12] Overcorrected patients to a positive overjet of 4 to 5 mm or more, during the phase of orthopedic treatment, can usually maintain favorable results in long term.[21]

However, the response to treatments performed taking into consideration only the dental and chronological age parameters, becomes poorly predictable, due to the great variability of these patients' skeletal maturity stages. Among the different skeletal maturity indexes, the method that evaluates cervical vertebrae maturation has gotten well-deserved attention. It is based on morphological characteristics of cervical vertebrae at different stages of development, which correlate with different growth rates of the facial structures. This evaluation method presents 5 subsequent stages of maturation, being the mandibular growth peak comprised between the stages II and III.[2] An advantage of using this method lies in the fact that the assessment may be extracted from the lateral teleradiography routinely used for orthodontic diagnosis. In addition, it presents high reproducibility, reaching indexes ranging from 91 to 99%.[2]

The clinical decision to treat a patient who presents early Class III facial characteristics, but that still does not fulfill the criteria for the dental morphological classification could, therefore, find support in the ability to detect, on an individual level, some skeletal predicting characteristics of a developing Class III malocclusion.

The goal of this study is to investigate the craniofacial cephalometric characteristics of Brazilian children with Class III malocclusion in stages I and II of cervical vertebrae maturation and compare them with the ones displayed by Class I controls.

MATERIAL AND METHODS

The present study followed an observational and cross-sectional protocol, performed in the Preventive Orthodontics Clinic at the Medicine School of Petrópolis, Rio de Janeiro. The records of 20 patients with Class III malocclusion (11 females and 9 males, aged between 5 years and 10 months and 11 years and 3 months, mean age of 8 years and 6 months) and 20 control Class I patients matched by the same skeletal maturity stage and sex (ages between 5 years and 8 months and 11 years and 2 months, with a mean age of 8 years and 5 months) were selected from the pre orthodontic treatment records usually requested.

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The inclusion criteria were: (1) Good quality of pre treatment lateral cephalometric radiographs obtained with the same cephalostat, and a focus-object distance of 1.55 m; (2) Class III molar relationship between the second deciduous molars or first permanent molars, determined by the analysis of dental casts of each patient and confirmed clinically by patient manipulation to centric relation ruling out the possibility of functional Class III and edge-to-edge relation or crossbite of incisors; (3) dental development stage of complete deciduous dentition or early mixed dentition; (4) skeletal development stages I or II, according to the index of cervical vertebrae maturation, characterizing the period preceding the outbreak of mandibular growth.[2] Patients with cleft lip or palate or any other dentofacial deformity were excluded.

The inclusion criteria for the control group were the same adopted for the study group, with the exception of the molar relationship which, for this group, became Angle's Class I of the second deciduous molars or first permanent molars determined by the analysis of the dental casts of each patient and clinically confirmed by manipulation of the patients to centric relation.

The lateral cephalometric radiographs were traced by one observer only and the cephalometric points were determined with a mechanical pencil with graphite tip of 0.3 mm on a polyester paper with 0.20 mm thick. The reference points were digitized in a system of X Y coordinates by Radiocef software (Radio Memory, Belo Horizonte, Brazil). The craniofacial structures and their relationships were divided into the following categories for analysis: Skull base, maxilla, mandible, intermaxilary relations and vertical facial relations (Table 1).

Linear and angular measurements were adopted from analyses before described by Downs,[6] Jarabak,[11] Jacobson[10] and McNamara.[16]

The measures found were tabulated and both the mean and standard deviation for each sample variable of Class III patient and Class I controls were calculated using the SPSS statistical software (SPSS Inc., Chicago, USA). The normality of angular and linear variables was examined by the Kolmogorov-Smirnov test, which showed that variables of both groups had normal distribution.

The differences found between means, for each of the selected variables, comparing the Group of Class III patients and the Group of Class I controls subjects, both subdivided according to the stage of cervical vertebrae maturation (I or II), were evaluated by analysis of variance (ANOVA) (Table 1) and complemented by Bonferroni's multiple comparisons test.

Differences which presented a chance lower than 5% of having occurred at random ($p<0.05$) were considered statistically significant. To test the magnitude of the measurement error for the cephalometric variables in this study, the lateral teleradiographies of 15 patients, randomly selected, were measured again through the use of Dahlberg's formula. The error was between 0.29 and 0.81 mm for linear measures and 0.34 and 0.93 for angular measures.

RESULTS

The means for both angular and linear cephalometric variables from the studied groups of patients are arranged in Table 2. This table represents the distribution of mean values and dispersion values (mean ± standard deviation) for linear and angular cephalometric variables for Class I and Class III patients groups, subdivided according to the pre-peak stage of cervical vertebrae maturation that each patient was in. The analysis of variance showed statistically significant differences, between the different groups

Table 1 - Angular (degrees) and linear (mm) cephalometric measures.

Skull base	Maxilla	Mandible	Intermaxillary Relation	Facial Height
S-N (mm)	SNA (degrees)	SNB (degrees)	ANB (degrees)	Ena-Me (mm)
S-AR (mm)	Co-A (mm)	Co-Gn (mm)	Mand. – Max.(mm)	S-Go (mm)
SNAr (degrees)	NperpA (mm)	NperpPog (mm)	Wits (mm)	N-Me (mm)
		Go-Me (mm)		Ar-Go (degrees)

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Table 1 - Distribution of mean and dispersion values (mean standard deviation) of angular and linear cephalometric variables for the studied groups.

Variables	Class I		Class III		p value
	Stage 1 (1) (n = 10)	Stage 2 (2) (n = 10)	Stage 1 (3) (n = 10)	Stage 2 (4) (n = 10)	
Skull base					
S-N (mm)	65.99 ± 2.95	67.70 ± 2.73	65.80 ± 2.34	67.56 ± 3.56	0.329
S-Ar (mm)	31.82 ± 2.69	30.08 ± 3.42	31.01 ± 2.85	32.36 ± 1.90	0.300
N.S.Ar (°)	121.37 ± 6.13	122.37 ± 6.58	123.20 ± 1.75	122.77 ± 4.83	0.876
Maxilla					
SNA (°)	82.79 ± 2.08	79.69 ± 4.71*a	81.87 ± 2.65	83.88 ± 3.14*a	**0.048**
Co.A (mm)	82.86 ± 5.87	82.14 ± 4.33*a	82.23 ± 2.64	86.84 ± 5.40*a	0.100
N – Perp A (mm)	0.80 ± 2.45	0.55 ± 3.12	0.26 ± 2.59	0.92 ± 2.61	0.950
Mandible					
SNB (°)	78.44 ± 2.06	75.58 ± 4.04*a	80.51 ± 2.39*a	82.22 ± 3.24*a	**0.001**
Co – Gn (mm)	104.44 ± 6.96*a	104.93 ± 4.67	105.65 ± 5.97	112.35 ± 7.41*a	**0.028**
N – Perp Pog (mm)	-5.70 ± 5.95	-6.73 ± 6.02*a	-2.17 ± 4.22	-6.21 ± 5.74*a	**0.034**
Go – Me (mm)	65.27 ± 5.24	66.45 ± 3.63	68.30 ± 5.55	72.02 ± 6.16	**0.036**
Intermaxillary relation					
ANB (°)	4.35 ± 1.26*a	4.10 ± 1.49*b	1.36 ± 2.45*a	1.65 ± 2.17*b	**0.001**
Mand – Max (mm)	21.58 ± 3.59	22.75 ± 3.40	23.37 ± 4.07	25.44 ± 4.15	0.166
Wits (mm)	-1.28 ± 2.51	-0.20 ± 3.34*a	-3.96 ± 2.59	-4.15 ± 3.19*a	**0.009**
Facial height					
Ena – Me (mm)	63.38 ± 5.59	65.71 ± 4.63	60.50 ± 4.93	63.41 ± 5.24	0.175
S – Go (mm)	66.88 ± 4.62	66.58 ± 3.98*a	67.02 ± 4.20	72.03 ± 2.62*a	**0.011**
Na – Me (mm)	106.96 ± 7.57	111.88 ± 5.86	104.04 ± 5.65	109.45 ± 8.11	0.860
Ar – Go (mm)	39.58 ± 3.06	39.66 ± 2.27*a	39.15 ± 3.01	43.15 ± 2.89*a	**0.011**

p≤0.05. The groups differing each other by the analysis with multiple comparison test with Bonferroni's means were identified by same letters, *a and *b.

studied, for the mean values found for some angular variables (SNA, SNB, ANB) and linear variables (Co-Gn, N-Perp-Pog, Go-Me, Wits, S-Go, Ar-Go).

The analysis with Bonferroni's multiple comparisons test demonstrated which groups differ from each other (identified by the same letters, a and b).

DISCUSSION

The differential diagnosis of skeletal pattern as well as the dental classification of malocclusion are important factors in planning the orthodontic treatment. In some cases that show natural dental compensation the dental relation does not reflect exactly the actual skeletal pattern. A study evaluating the correlation between facial pattern and sagittal relation between the dental arches demonstrated that pattern III children showed a predominance of Class III but had a fairly heterogeneous distribution of malocclusion, having 48% of children presented Class I and a almost insignificant number of 1.35% presented Class II malocclusion.[20] Thus, the possibility of diagnosis in very early stages of skeletal disharmony that are common in Class III children can play a substantial role in improving early treatment of these patients. This study aimed at identifying which cephalometric measurements has greater power to early classify patients with Class III malocclusion, differentiating those of patients with Class I malocclusion.

It was made the choice for a simplified usage of a combination of Wits,[10] McNamara[16] and Jarabak analyses,[11] in addition to some more conventional and popular standards, as the measurements of Downs.[6] While Wits[10] and McNamara[16] analyses offer an integrated linear assessment of sagittal and

vertical skeletal discrepancies, also relating maxilla and mandible with the skull base; the analysis of Jarabak[11] proposes the possibility of predicting skeletal modifications resulting from growth and/or orthodontic and/or orthopedic treatment.

Just as the prevalence of Class III malocclusion displays variation between the different ethnic and racial groups,[4] the same seems to happen to the skeletal components of this malocclusion1.[5] The results of this study have not demonstrated a significantly lower length of the anterior skull base (S-N) in patients with Class III malocclusion when compared with Class I controls. The deflection angle of the skull base, produced between the anterior and posterior bases of the skull, also did not demonstrated to be reduced in patients with Class III malocclusion when compared to Class I controls. These results oppose to previous studies that suggest that skeletal abnormalities of Class III may be a reflex of alterations in skull base.

The results did not agree to previous findings that demonstrated a high prevalence of maxillary retrognathism composing the global skeletal discrepancy present in patients with Class III. Although there are reports that a hypoplasic midface and poor maxillary growth, associated with a shortened anterior skull base, are the main factors involved in the development of a Class III malocclusion in Asian children,[18] the comparative analysis between Japanese and Americans with European ancestors revealed that the mandibular prognathism was identified as an important component of Class III malocclusion in individuals of European descent.

Opposite to the expected, the SNA angle demonstrated to be increased in patients with Class III when compared to the Class I controls, however this difference was statistically significant only in stage II of cervical vertebrae maturation. The estimation of maxillary growth through the difference of values found for SNA and Co-A in stages I and II of cervical vertebrae maturation has not demonstrated substantial difference in Class I controls. However, an average increase of approximately 2º for SNA angle and 4 mm for Co-A measurement was showed in Class III patients.

Thereby, we can highlight an anterior displacement of maxillary point A in Class III patients, with a substantial increase in the related measures, although not statistically significant between the stages I and II of cervical vertebrae maturation. A possible explanation would be the fact that the point is situated in dentoalveolar region and, therefore, is subjected to anterior displacement due to the attempt of maintenance of the positive overjet in order to offset the preponderance of mandibular growth over the maxilla.

The means found for the measurements related to the length of mandibular body and effective length of the mandible showed rather significant statistical differences between Class I and Class III groups, having the means of Class III patients demonstrated to be superior to those of Class I group. Similarly, for the group of Class III patients it was observed a raise tendency in all means referent to other studied variables related to the mandibular sagittal positioning, however not in a statistically significant way.

Previous studies[17,19] showed that the mandible in patients with Class III malocclusion is found protruded, even in the early stages of the deciduous dentition, becoming more protrusive over time. The data from this study confirm this claim, demonstrating the prevalence of mandibular measurements in Class III group when compared to the Class I control group.

The Class III patients group showed statistically significant differences demonstrating a marked increase in posterior facial height and the height of the mandibular ramus when compared to the Class I control group, indicating a tendency of hypodivergent facial growth in the Class III group. The increase in posterior facial height promotes a counterclockwise rotation of the mandible with a tendency of mandibular protrusion and occlusal relation of Class III.

Thereby, the increase of posterior facial height found in patients of Class III group along with the significant increase of measures related to mandibular length justify the anterior displacement of points B and Pog with consequent establishment of highly significant statistical difference between mandibular skeletal relations SNB and NperpPog in patients of Class I and Class III groups.

These results oppose the previously obtained in similar samples of Brazilian patients where the facial vertical behavior reveals anterior facial height showing statistically significant difference, with the greater values in the group of early Class III

patients than in Class I controls.[19] The widespread use in the past of Downs[6] cephalometric measures for the analysis of skeletal relations between maxilla and mandible and of these with the base of the skull could, therefore, justify previous conducts of proservating the mandibular growth in patients with normal measurements for the SNA and increased measurements to SNB angle, for example, until mandibular setback surgery could be carried out, once the analysis of the results obtained by employing these measures tend to demonstrate a apparently appropriate maxillary positioning and a mandibular protrusion.

Thus, the present study has shown, contrary to the previously demonstrated in Syrian children[18] and similar to the demonstrated in Brazilian children[19] an advanced sagittal position of the mandible in relation to the of the skull in the Class III patients in relation to the one found in Class I controls.

ANB and Wits measurements showed significant statistical differences between groups Class III and Class I patients, even in early stages. Even though Wits[14] measurements can be affected by changes in occlusal plane[5] and ANB measurements by changes in sagittal positioning of nasium point,[9] both measurements has been demonstrated to be effective for the diagnosis of Class III malocclusion.[19]

Although the mean values found for the ANB variable in Class III and Class I groups match respectively to the recognized values for Class I and Class II adults patients, these are in line with the values obtained for this variable when the same groups are evaluated in early ages.[18]

CONCLUSIONS

The results of this study led to the conclusion that Brazilian children with Class III malocclusion, when compared with Class I controls in the same early stages of cervical vertebrae maturation, present as cephalometric craniofacial characteristics: Normal anterior skull base and maxilla, anterior positioning of the mandible and increased posterior facial height.

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Immunosuppressants: Implications in Orthodontics

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Introduction: There are medications capable of affecting bone metabolism and the rate of tooth movement. Among these medications are the immunosuppressants, which act by repressing the action of T lymphocytes, however they can cause bone loss and consequently lead to osteoporosis. Osteoporosis is a common complication following kidney, heart, liver or lung transplantation. The immunosuppressant treatment for preventing organ rejection after transplantation, in general, includes glucocorticoids, cyclosporine, tacrolimus, and sirolimus. All these drugs can have jeopardizing effects on bone mineral homeostasis and consequently influence tooth movement. In recent years, however, the increasing use of immunosuppressants has raised questions about their effects on bone metabolism in patients undergoing orthodontic treatment.

Objective: The objective of this review study was to inform orthodontists about the influence of immunosuppressants on bone metabolism and tooth movement.

Keywords: Immunosuppressant. Tooth movement. Bone.

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INTRODUCTION

There are medications capable of affecting bone metabolism and the rate of tooth movement.[11] Some of these medications are the immunosuppressants inhibitors of calcineurin-phosphatase (cyclosporin and tacrolimus), which are partly responsible for greater survival of transplanted patients and for the reduction in the glucocorticoids doses. However, similarly to the glucocorticoids, calcineurin-phosphatase inhibitors also cause reduction in bone mass, with the greatest bone loss occurring in the first 6 months after transplantation, when immunosuppressant therapy is most aggressive[9]. Even though the present tendency is to use a lower total dose of immunosuppressants, many transplanted patients continue to develop fractures as a complication.[7] Immunosuppressant drugs may be grouped into biologic and chemical categories, according to the location of their action and their effects on lymphocytes.[1] The most frequently used immunosuppressants nowadays are those that affect cytokine synthesis (glucocorticoids, cyclosporin-CsA, tacrolimus-FK506, Sirolimus-RAPA) and those that affect nucleotide synthesis (azathioprine, Mycophenolate mofetil).[1]

Over the last few years, with the growing use of immunosuppressants, questions have arisen about the action of these medications on bone metabolism[9]. The aim of this literature review is to inform the orthodontist about the influence of immunosuppressants on bony tissue and tooth movement.

LITERATURE REVIEW

Glucocorticoids (GC)

Chronic exposure to glucocorticoids constituted the most common cause of secondary osteoporosis, mainly affecting trabecular bone.[4] Bone loss would be greater in the first 12 to 18 months of therapy and is directly related to the dose and duration of treatment.[9] Glucocorticoids have great effects on mineral homeostasis, and may stimulate parathyroid hormone (PTH) secretion both in a direct and an indirect manner.[9] Indirect increase results from diminished intestinal calcium absorption and increase in urinary calcium excretion. In the kidney, there is a reduction in calcium and phosphate tubular absorption. All these mechanisms result in a negative calcium balance, which causes increase in PTH synthesis and secretion, and a consequent increase in bone absorption to maintain the serum calcium level.[24] It is also known that GCs inhibit the transcription of various cytokine genes, particularly two proteins that bind to DNA to activate IL-2 gene transcription: The cytoplasmic factor (NF-ATc) and the nuclear factor (NF-ATn) of activated T cells.[31] GCs have shown *in vitro* capacity to block IL-1, IL-2, IL-3, IL-6, TNFa and IFN-g synthesis, and therefore affect all the stages of the T cell activation process[16].

Sobral[27] observed osteoporosis in the alveolar bone of rabbits 7 days after the application of corticosteroid (Figs 1 and 2); these showed greater tooth movement when compared with normal animals. In 2004, however, Kalia et al[17] evaluated the rate of tooth movement in rats, using short and long term therapies, and demonstrated that bone remodeling appeared to diminish with the administration of larger doses in the acute phase, and tooth movement increased when lower doses were administered in chronic treatment. Clinically, these results suggest that it is possible to treat patients submitted to corticoid therapy with minimal side effects.[11]

Cyclosporin (CsA, Sandimmune®, Neoral®); Tacrolimus (FK-506, Prograf®) and Sirolimus (RAPA, Rapamycin)

CsA is a decapeptide (MW=1.200 Daltons) extracted from the fungus *Tolypocladium inflatum*. Initially described as an inefficient antifungal agent, CsA has been shown to have powerful immunosuppressant activity.[5] Subsequent immunologic studies have demonstrated that CsA acts on auxiliary and cytotoxic T lymphocytes (Th and Tc) blocking IL-2 production, the main trophic factor for these cells, as well as other cytokines production, such as IL-1, IL-3 and IFN-g, while the suppressor T lymphocyte (Ts) would be little affected by the drug.[1] Due to its specific action on lymphokines RNA transcription and synthesis, studies aiming at demonstrating the action mechanisms of CsA have been directed towards understanding the effects of the drug on the regulation of T lymphocyte gene expression.

The binding of CsA to CyP (cyclophiline, cytoplasmic protein of the family of immunophilines) changes its structural conformation, exposing its hydrophilic sites, binding them to the calcineurines A (CnA) and B (CnB), which are serine-threonine phosphatases,

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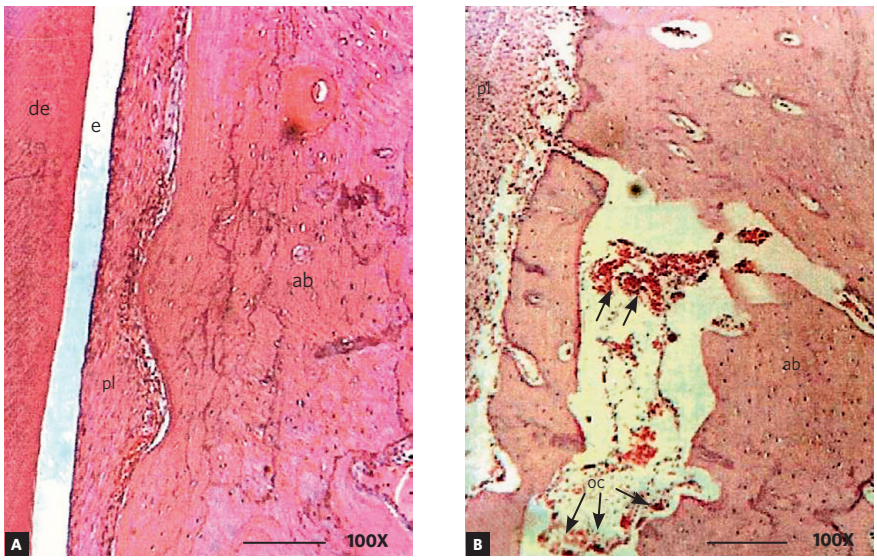

Figure 1 - Photomicrographs of comparative histologic sections between normal bone tissue and tissue with corticosteroid-induced osteoporosis: **A**) normal bone (control animal) **B**) osteoporotic bone – cross section from the region between the maxillary 1st and 2nd molars. Dilated blood vessels; ab – alveolar bone; de – dentin; e – enamel; pl – periodontal ligament and oc - osteoclasts. Staining - HE. (scale: 100μm) (Sobral, 1999).

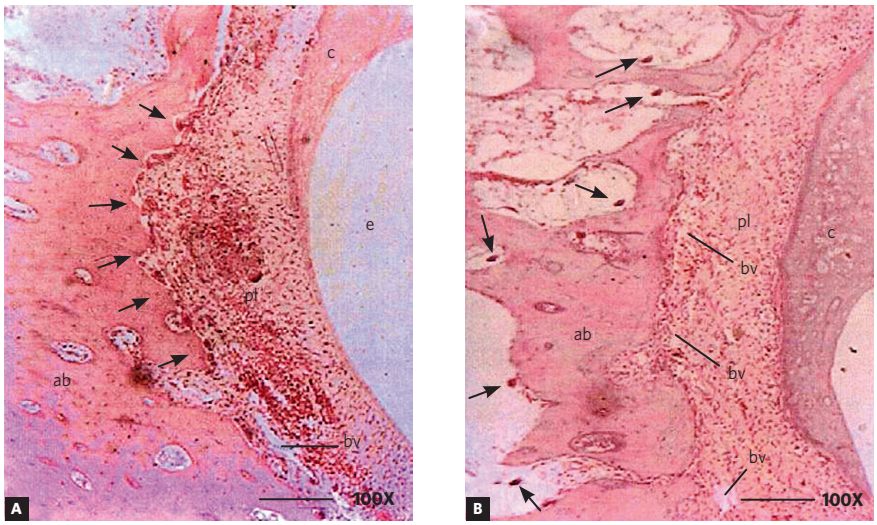

Figure 2 - Photomicrographs of pressure zones (middle third). **A**) control animal; **B**) animal with osteoporosis. ab – alveolar bone; pl – Periodontal Ligament; e – enamel; bv – blood vessels; c – cement; osteoclasts. Staining - HE. (scale: 100μm) (Sobral, 1999).

associated with calcium ions (Ca++) and calmoduline (CaM).[20] The formation of this pentameric complex (CsACyP-CnA-CnB-CaM-Ca) inhibits the enzymatic activity of the phosphatases responsible for the cell activation signals and activation of factors involved in gene transcription regulation that codify the formation of IL-2 and other cytokines. CsA inhibits the NF-AT translocation of activator proteins (AP), regulatory proteins of human gene IL-2, impeding its gene transcription and production.[20]

FK506 is a polycyclic macrolideum (MW=822 Daltons) produced by the fungus *Streptomyces tsukubaensis*; it is effective and has powerful immunosuppressant activity *in vitro* and *in vivo*, even when used in concentrations 100 times lower than those of CsA.[12] Similarly to CsA, FK506 inhibits the intracellular biochemical pathways dependent on the presence of the calcium ion (Ca++) and of its interactions with the cytoplasmic receptor, the coupling protein of FK506 (FKBP12), also a rotamase (cis-trans-prolyl-isomerase) of the family of immunophilines.[20] Although the immunophilines FKBP and CyP are important for the action of FK506 and CsA, respectively, their actions are limited to concentrating the drugs in the cells and altering their structural conformations. Alone, neither the drugs nor their immunophilines

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are able to bind to or modulate the activities of calcineurine, except in the form of the previously described drug-immunophiline complexes.[20] FK506 inhibits the early gene of T cells activation, blocking the expression of the messenger RNA (mRNA) of various inflammatory cytokines (IL-2, IL-3, IL-4 IFN-g).[30]

Recently, Kirino et al[18] investigated the effects of tacrolimus on bone metabolism. In this case-control study, the authors administered tacrolimus to test subjects for 6 weeks and verified that after the initial increase in serum osteocalcin concentration, tacrolimus caused its reduction to levels lower than the basal level; the calcemia remained constant throughout the study in spite of the significant increase in calciuria; in the 3rd week, the serum level of PTH was already significantly higher in the test subjects submitted to the immunosuppressant; and when compared with the control group, the test subjects presented thinner bone trabeculae, and wider medullary cavities in some regions,[18] due to the increase in osteoclastic number and activity. Santos[25] observed an increase in the number of osteoclasts in alveolar bone of Wistar rats after the administration of FK506 for 4 weeks (Fig 3). On the other hand, studies conducted in cell cultures[14] demonstrated that messengers RNA of NFATc1, NFATc2, and NFATc3 were present in osteoclastic precursor cells. Recent studies have also shown that FK506 inhibits mainly the final phases of the life cycle of these cells, by the induction of osteoclastic apoptosis.[14] Taken in conjunction, these findings are in alignment with the notion that the mechanisms by which the agents inhibit osteoclasts and promote osteoclastic apoptosis are similar to those by which the agents inhibit the production of NFAT transcription factor, and the production of inflammatory cytokines in T lymphocytes.

It has been demonstrated that treatment with CsA affects alveolar bone, and that the deleterious periodontal effects may be due to the reduction in bone volume, decrease in number of osteoblasts and increase in osteoclasts.[29] Despite of the contradictory results, studies have demonstrated that CsA and tacrolimus may induce bone loss both in human beings and in experimental animal models,[2] through interleukin gene expression (IL-1, IL-6 and tumor necrosis factor – TNF),[19] cytokines that participate in bone resorption. *In vitro*, the experimental data obtained from animal models have suggested that tacrolimus is an osteopenic agent, nevertheless, less osteotoxic than CsA.[13]

In fact, the results obtained from therapy with CsA-induced in which was observed a marked gingival growth and bone loss in rats,[28] are much more uniform than those observed in man.[13]

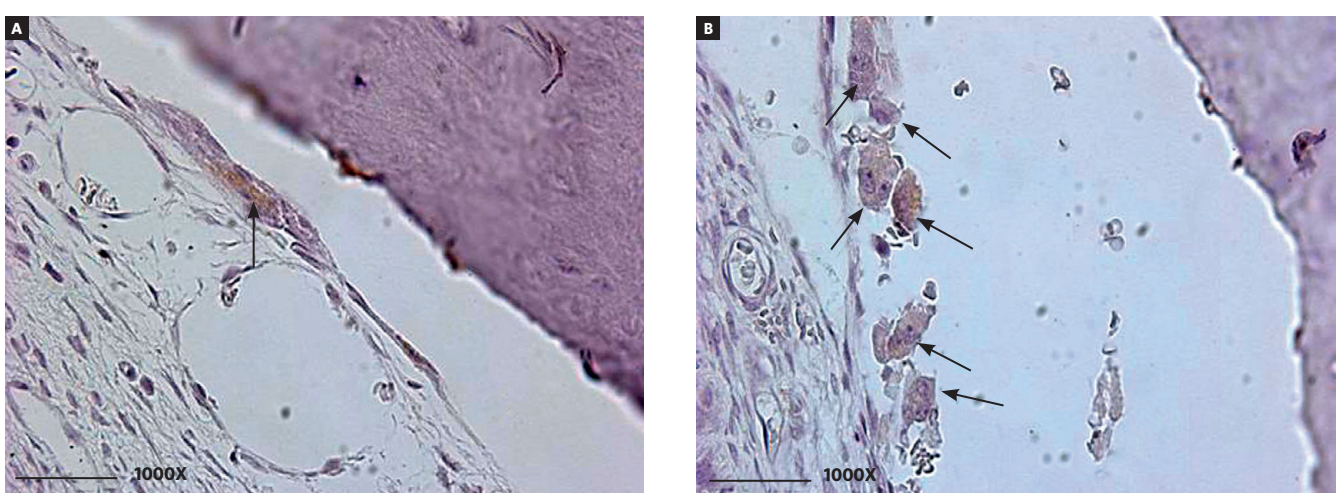

Figure 3 - Photomicrographs of histologic sections in immunohistochemistry (ED1$^+$) in cross section of the region situated between the maxillary incisors for osteoclasts (multinucleated giant cells, located within the alveolar bone or at the bone surface) (arrow) on the control animal's pressure side, without treatment with FK506. (**A**) Animal submitted to treatment with FK506 for 28 days. (**B**) 1000x magnification. Scale: 100µm. (Santos, 2008).

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With a very similar structure to that of FK506,[1] RAPA is a macrolide (MW=914 Daltons) produced by the fungus *Streptomyces hygroscopicus*. Differently from CsA and FK506, RAPA does not affect cytokine synthesis, but impedes the response to these hormones by blocking the transduction signal generated by cytokine receptors, impeding the progression of the cell cycle in phase G1. The RAPA immunosuppression mechanism has been better explained with the knowledge about two important domains in its molecular structure: One domain of bonding to immunophiline FKBP12 and the other to mTOR protein. RAPA blocks T cell protein synthesis, probably by inhibition of 70-KD56 kinases (p7056K).[8]

Some authors have suggested that RAPA has strong anti-angiogenic activity linked to reduction of vascular endothelial growth factor (VEGF), and causes less proliferation of osteoblasts, endothelial cells and periosteal cells; thus, inhibiting cell proliferation and neovascularization.[15]

The use of this immunosuppressant for long periods[6] or in high doses increases bone remodeling and inhibits longitudinal bone growth, reducing growth speed by approximately 30 to 50%,[3] in addition to inhibiting different cell types, including smooth muscle vascular cells and fibroblasts, which do not compose of the immune system.[32]

OTHER IMMUNOSUPPRESSANTS

Mycophenolate mofetil (MPA, Micophenolic Acid, MMF, Cellcept®) and Azathioprine (AZA)

RS-61443 is the semi-synthetic morpholinoethyl ester pro-drug, also known as Mycophenolate mofetil which, when activated by hydrolysis is transformed into micophenolic acid (MPA).[22] After oral administration and absorption, RS-61443 is converted into MPA which is later metabolized in the liver into its inactive form. Regeneration of the active form (MPA) is done by beta-glucuronidase enzymes, which apparently are in elevated concentrations in activated T and B cells and macrophages which, perhaps for this reason, these cells are very sensitive to the action of the drug[23]. Mycophenolate mofetil used in immunosuppressant therapy showed no deleterious effect on bone mineral density.[10]

Azathioprine is an immunosuppressant used with some frequency in post-transplant therapy, together with glucocorticoids and calcineurine-phosphatase inhibitors. Bryer et al[6] have shown that azathioprine does not modify bone mass.

Considering that bone disease is so common on organ transplant candidates, all these patients should be evaluated with regard to the presence of osteoporosis and mineral metabolism disorders. After the transplant, they should be subjected to bone loss prevention therapy, and although there is no consensus, anti-resorptive treatment with bisphosphonates would appear to be the best option.[9]

ANTI-RESORPTIVE MEDICATION

Bisphosphonates

Laboratory studies have demonstrated that tooth movement may be inhibited by the topical application of biphosphonates.[21] In 2004, Liu et al[21] applied bisphosphonate in the subperiosteal molar region in rats subjected to orthodontic forces for three weeks. At the application site there was a reduction in quantity of orthodontic movement, number of osteoclasts and root resorption. Further studies will be necessary before these drugs may be used in Orthodontics.[11] In 2005, Schwartz[26] described an important case of a patient under orthodontic treatment, who was being medicated with Zometa (Novartis, East Hanover, NJ, USA) to control bone metastases related to breast cancer. The premolar extraction space had been orthodontically closed by one third; at the time when this patient began treatment with this medication tooth movement was interrupted.[26]

DISCUSSION

The use of immunosuppressants by transplanted patients and those with auto-immune diseases are partly responsible for their longer survival, however, the use of immunosuppressants may influence bone metabolism[9] and consequently, tooth movement in patients undergoing orthodontic treatment, who use these medications.

Bone metabolism is significantly altered by chronic exposure to glucocorticoids, this being the most common cause of secondary osteoporosis, mainly affecting trabecular bone.[4] Bone loss is generally greater in the first 12 to 18 months of therapy and is directly related to the dose and duration of treatment,[9] as observed by Sobral[27] and Kalia et al[17]

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who showed greater tooth movement in animals subjected to these medications. As occurs with glucocorticoids, Cyclosporine affects alveolar bone causing deleterious periodontal effects that may be due to the reduction in bone volume and number of osteoblasts, and increase in osteoclasts.[29] In rats marked gingival growth and bone loss were observed[28], however more uniformly than those observed in human beings[13] due to environmental and genetic factors.

Recently, Kirino et al[18] in a study with animals submitted to the application of tacrolimus, observed thinner bone trabeculae, wider medullary cavities[18] and increase in the number of osteoclasts.[25] Studies have demonstrated that both Cyclosporin and tacrolimus may induce bone loss both in human beings and in experimental animal models,[2] through interleukin gene expression (IL-1, IL-6 and tumor necrosis factor –TNFα),[19] the cytokines that participate in bone resorption.

Immunosuppressant activity with Rapamicine for long periods[6] or in high doses increases bone remodeling and inhibits longitudinal bone growth, reducing the speed of growth by around 30 to 50%,[3] in addition to inhibiting different cell types, including smooth muscle vascular cells and fibroblasts that are not part of the immune system.[32] Other immunosuppressants such as, Mycophenolate mofetil[10] and Azathioprine[6] showed no deleterious effects on bone mineral density.

Immunosuppressants represent great advancement in the control of different types of diseases, and suppression of the immune response against transplanted organs, however, a large portion of these medications are capable of influencing bone metabolism and tooth movement.

The orthodontist may frequently encounter patients that require prolonged immunosuppressive therapy and orthodontic treatment. Usually, patients in the initial stage of these medications usage may be advised to delay orthodontic treatment, as there would be less bone remodeling, or orthodontic activation appointments should be scheduled at longer intervals. On the other hand, long term medication therapy may accelerate tooth movement, thus orthodontic appliances must be adjusted customarily, or with greater frequency. Medical follow-up with clinical and densitometry periodic exams are necessary in order to obtain more predictable and satisfactory orthodontic results.

CONCLUSION

1) Immunosuppressants that affect cytokine synthesis (glucocorticoids, cyclosporin-CsA, tacrolimus-FK506 and Sirolimus-RAPA) interfere in bone metabolism and may influence tooth movement.
2) Interference in bone metabolism is dependent on the force applied, dose and duration of immunosuppressant therapy, in addition to the individual response of each patient, except to azathioprine and Mycophenolate mofetil that have shown no deleterious effect on bone density.

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General dentist orthodontic practice in foreign legal systems

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Objective: General dentist orthodontic practice is a controversial issue and this paper aims to analyze it comparing foreign laws to Brazilian Legal System.

Methods: Regulations and scientific texts concerning orthodontic practice by general dentists, in Portuguese or English language, were sought.

Results and Conclusion: Portugal clearly forbids general dentist orthodontic practice; United States of America do not clearly forbid general dentist orthodontic practice, but do regulate and promote campaigns to encourage public to seek specialist service; in Australia and England, corrective orthodontics are offered both by orthodontists and general dentists; it was not possible to evaluate how orthodontic services are provided in Eastern Europe; and the fact that general dentists are forbidden to practice corrective orthodontics in Brazilian Legal System is compatible to other countries policy.

Keywords: Orthodontics. Graduation course. General dentist. Legality. Foreign laws.

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INTRODUCTION

History reports that the first dental surgeon focusing his clinical practice in orthodontics was Edward H. Angle, in 1887,[8] and that orthodontics was only regulated as an Dental specialty, by the efforts of Charles H. Tweed, in 1929, who became the first specialist in orthodontics.[27] From this establishment as a specialty, orthodontics started to spread around the world absorbing peculiarities in each country.

In the Brazilian legal system there is a conflict between the principle of legality (permissive) and the principle of human being dignity (impeditive) as regards to the professional practice of orthodontics by the non-specialist dental surgeon.[19] This is a polemic issue involving, basically, legal interpretation. To solve this issue it is adequate to use the Science of Law that according to Gusmão,[15] is a methodically coordinated knowledge resulting from the ordered study of legal standards aiming to understand the objective meaning of these legal standards and to build the law system, as well to discover its historical and social roots.

Maruo et al[19] analyzed this issue by means of the legislation and of the legal decisions of Brazilian courts, and they concluded that using the Theory of Legal Argumentation,[12] the practice of a non-specialist dental surgeon is limited only to preventive and interceptive orthodontics.

However, because of the importance of this subject, the professional practice of orthodontics by a non-specialist dental surgeon must be analyzed through other available tools in the Science of Law, in such a way that it can bring peace to the community, to dental surgeons in general and to orthodontists. One of such tools frequently used by the Law practitioners is the Comparative Jurisprudence.

Ancel[7] states that yet in ancient Greece, Lycurgus in Sparta and Solon in Athens traveled the known world in order to meet legal institutions from other places before creating their own laws. Now for Contemporary Law, Comparative Jurisprudence started following the path of other comparative sciences like comparative anatomy, and its objective was to find in the legal field an equivalent of the organs in anatomy, i.e., similar bodies playing similar functions.[16]

Coutinho[11] supports its importance because Comparative Jurisprudence is based on the comparison and confrontation between different legal models, which is of uttermost importance to the questioning, to put in check some rule, institute, ordinance or legal interpretation. Comparison in most cases involves the act of questioning, of putting in doubt, of taking out the absolute certainty.[11] From this, one can reach a new model, a solution to solve and attend social conflicts.[11]

In this context, the aim of this paper is to analyze the issue of professional practice of orthodontics by non-specialist dental surgeon in Comparative Jurisprudence, to verify if it is or not in accordance to the Brazilian law.

MATERIAL AND METHODS

To carry out this research, a search was performed in the bibliographic and legal writings in portuguese and english languages concerning the practice of orthodontics by non-specialist dentists.

The results were organized and divided according to each country to make its interpretation and comparison easier to the Brazilian law.

RESULTS

United States of America (USA)

Orthodontics as a specialty and science originated in the USA by the efforts of Angle.[8] The USA are known for adopting the legal system of *Common Law* (the custom is the main source and the laws itself are secondary sources) and the capitalist system of free market.[15]

In that country, orthodontics is regulated by the Federal Government in general and more specifically by the Disease Control Centers (DCC); by every State governments — main regulator of the profession — by the Regional Council of Dentistry or state regulatory agency of many health professions which determine the necessary qualifications for practicing orthodontics inside the state, and by professional organizations, like the American Dentistry Association (ADA) and state dentistry associations with their ethical codes and the quality standards acceptable inside the community.[26]

Besides these regulations, some American states create State Licensing Councils to safeguard the public.[26] These agencies are formed by a group of citizens and usually have authority to: 1) Establish necessary

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specific qualifications for initial license; 2) Make examinations and grant license for qualified candidates; 3) Establish more specific practice and conduct standards; 4) Take disciplinary decisions against those acting inappropriately; and 5) enact rules in order to perform their obligations.[26]

In these norms there is no practical objection against the practice of orthodontics by general practitioners, so that researches like the ones of Wolsky and McNamara Jr.[29] and Galbreath et al[14] show that this occurs very frequently.

Nevertheless, several actions are taken by Orthodontic professional associations to stimulate the population to look for a specialized service like the case of American Board of Orthodontics (ABO), founded in 1929, and its campaign to inform people on the reasons for searching a specialist started in May 2006.

1.1 American Board of Orthodontics

The ABO was founded in 1929 by seven important orthodontists under the orientation of Dr. Albert H. Ketcham, who is today the name of the most important award of the Board.[9] To understand their intentions we just need to consider Dr. Ketcham's own words in a letter to Dr. B. F. Dewel:[9]

"We must keep in mind that the object of the *Board* is to elevate the practice of orthodontia. We should not make our requirements for examinations so high that the average orthodontist may not aspire to perfect himself so that he may pass the *Board's examination*. We must remember that our function is different from that of the faculty of an orthodontic school, which gives examinations to students who have all received the same lecture courses and techniques. We must adapt our examinations to the applicant; try to discover if he is safe, whether he has the technical skill and scientific knowledge, coupled with good common sense, good personality, and honesty of purpose, to ensure that he is a good moral risk."

The ABO has been uninterruptedly certifying orthodontists since 1929, with the exception of a period of seven years during the World War II, submitting applicants to various evaluation criteria: Written research and presentation of clinical cases until 1963; as from 1963, the option for research or by written evaluation, besides the presentation of clinical cases; as from 1978 the option for research was excluded and the written evaluation along with presentation of clinical cases was defined. All candidates for ABO should be orthodontists following the standards defined by ADA and by AAO.[9]

In 1960, the AAO and the ABO produced a document for the Conference of National Organizations for practice areas of dentistry, requested by the ADA, clarifying americans about the ABO and the specialty of orthodontics. In this document the goals of ABO were made clear, which are: 1) Stimulate and keep alive the research spirit and the continuous improvement between students and practitioners of orthodontics; 2) establish the competence of the orthodontics experts; and 3) organize, control and conduct exams aiming to evaluate orthodontists skills and grant certificates for those inside the demanded standards of the ABO.[1]

It is from this very same document that Americans draw the characteristics of their orthodontics. Orthodontics specialty and the AAO have the objective to: 1) Promote advances in orthodontics science and art; 2) encourage and support research; 3) struggle for high excellence standards in education and orthodontics practice; and 4) give its contribution to health.[1]

In the undergraduate course the objectives of orthodontics is to allow the formation of a general clinician able to: 1) Anticipate and detect a malocclusion; 2) Make decisions to prevent malocclusion as always as possible; 3) Use this knowledge as a tool in all other levels of Dental practice; and 4) Understand the possibilities of orthodontic treatment.[1]

For this end, the following subjects are essential:[1]

1) A term definition: Concept, diagnosis and discipline. Preventive, interceptive and corrective orthodontics. What orthodontics student should know regarding this;
2) Growth and development — from a preventive point of view;
3) Physiology of the stomatognathic system;
4) Incidence and acknowledgment of malocclusion;
5) Etiology of malocclusion;
6) Diagnostic elements and its interpretation — importance of case analyses to determine preventive, interceptive and corrective conducts;

7) Undesirable sequels of malocclusion;
8) Biomechanical principles of dental movement; tissue response to orthodontics;
9) General principles of orthodontic therapy — description of appliances in use and understanding of treatment methods;
10) Preventive dentistry — The maintenance of normal occlusion;
11) Interceptive orthodontics;
12) Corrective orthodontics — limited to some moderated cases of anterior crossbite, single tooth posterior crossbite, deep bite and functional problems; space control with removable appliances and small fixed appliances, together with restorative dentistry and periodontics; and understanding of advantages and disadvantages of corrective procedures."

Towards orthodontics specialty, AAO and ABO[1] understand:

"Orthodontics considers its major responsibility the supervision of growth and development of the dentition and facial structures associated with maturity and eruption of teeth. Prevention of malocclusion is the major objective of orthodontics. This specialty welcomes the assistance in space maintenance, teeth preservation and correction of habits by the general practitioner and other specialties, but all corrective procedures involving tooth movement requiring functional or mechanical treatment are duties of the orthodontist. These are traditional practice areas of orthodontics along the specialty history."

In this way, the AAO's given suggestion is that graduate courses in orthodontics should be planned with a total of 2985 hours, as follows:[1]

"1) 1035 of basic subjects — Head and neck anatomy, Teeth applied histopathology and support structures; Growth and development; Oral physiology; Oral and cephalometric radiology; Orthodontic materials; Embryology and Human genetics; Biomechanical principles; Treatment and Case analysis; scientific methodology; research; seminars in general.
2) 150 hours of related matters — Speech therapy; Child psychology; Management; Bacteriology of dental caries; Comparative anthropology and anatomy; Congenital facial deformities; oratory; preparation of scientific research; and Dental education.
3) 1800 hours of clinical and laboratory practice."

For evaluating clinical cases, an index was developed.[10] For each criterion the case loses a specified amount of points, and, at the end if a case has lost more than 30 points, the applicant for certification does not pass; if he has lost less than 20 points, the applicant is approved.[10]

Today the ABO certification process is available for orthodontists already practicing the specialty as well as for newly graduated professionals, a re-certification is necessary every 10 years.[22] In phase I, the applicant's curriculum is examined, i.e., if there is a graduate education in orthodontics in the standards demanded by the ADA and the AAO; in phase II a written exam is performed; and, in phase III, the applicant must present 10 cases with initial characteristics required by the ABO for evaluation; for re-certification, the applicant has to present an amount of new treated cases.[22]

1.2 The campaign for public information

Since it was demonstrated that orthodontics is currently practiced by the general practitioner, the AAO started a research in 2005 to develop an advertising campaign to inform the public on reasons to look for a specialist in orthodontics.[2]

This research was performed by a company specialized in marketing campaigns and, it initially realized that the public has doubts on the difference between orthodontic treatment conducted by an orthodontics specialist and by other professionals in dentistry.[2] With these data, the company developed a radio, television, press media and internet campaign and tried it with a selected public. The most effective message was the one focusing that orthodontics specialists have 2 or 3 more additional years of training than general practice dentists, and along this course, they are oriented by specialized professors.[2]

This advertising proposal was initially discussed in the AAO Annual Congress in Las Vegas, from May 5 to 9, 2006. After approved, the campaign "More than a Smile" was launched and started being propagated on television, magazines and internet.[3]

The answer of the public was promising, with many consultations in the AAO's homepage about who were the specialists in orthodontics.[4,5,6]

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2. EUROPE

The European countries can be treated in a single topic, since they essentially followed the teaching of Pierre Fauchard and, later, of Angle.[25]

2.1. Portugal

The law regulating dentistry in Portugal is law nº 40 of 22 August, 2003. In its Article 2 it determines the scope of this law, determining the characteristics of the dental surgeon:

"Article 2
Field of application

1 – Dental Surgeons are the professionals identified in official listings published in official Journal, series 2, number 270, of 22 November, 2002.

2 – The activity of dentistry depends on the possession of dentistry certificate and respective professional portfolio.

3 – The profession of dentistry is residual, it is hereby expressly forbidden any measures aimed at the settlement of future work situations."

And, as regards to orthodontics, it forbids its practice by general clinicians in article 3:

"Article 3
Framework of dental activity

1 – Dentists can execute the following professional actions:

a) Dentistry;
b) Prosthesis;
c) Endodontics;
d) Tooth extraction of erupted teeth and roots are not included;
e) Treatment of dental calculus and polishing;
f) Dental radiology, so long as facilities respect current legislation.

2 – All practices not referred above are expressly prohibited from the scope of activity of dentists, including:

a) The procedures in the field of dental implant surgery;
b) Procedures of fixed or removable orthodontics;
c) All surgical procedures not listed in subparagraph d) above;
d) Procedures in the field of endodontic surgery;
e) The total rehabilitation with fixed prosthesis. Except in situations of Article 4:

"Article 4
Special arrangement

1 - Exceptionally, dentists can practice orthodontic procedures inasmuch as meeting the following terms:

a) Hold a valid licence for dentistry practice issued by the competent authorities prior the accession of Portugal to the European Communities;
b) Have at least 500 hours of specific formation in orthodontics, proven by documents;
c) Be approved in orthodontics examination carried out by the Ethic and Professional Council of Dentistry.

2 - There will be a single exceptional process to verify requirements of previous number, in time and conditions defined by the Ethical and Professional Council of Dentistry."

2.2 England

In England the practice of orthodontics occurs both for specialists and general practitioners, and according to a study by Fox et al,[13] two regions in England were analyzed concerning differences in demand and treatment results. Evaluating models before and after orthodontic treatment, results show that regardless of region, the higher were the orthodontic education, better were the results achieved.

2. Eastern Europe

In Eastern Europe countries, dental service has changed after the fall of the Berlin wall, in 1989, and the fall of communism in the former Soviet Union in 1991.[28] Before dental practice was performed by stomatologist doctors, now private practice by dental surgeons have been increasing gradually.[28] Countries as the Czech Republic, Hungary and Poland offer private health services not including fixed orthodontic treatment, which shows the importance given to this specialty.[28] Available references do not allow to affirm if non-specialist dental surgeons can practice orthodontics.

3 Australia

In Australia, the practice of orthodontics is not legally limited to the specialist orthodontist as noted in some researches.[17,18] Anyway, it was noted that even with a decrease of periodontal diseases and caries, most part of the non-specialist dental

surgeons dedicate only 2.5% of time to orthodontic procedures and only 4.3% to their patients.[17] Besides that, it can be seen that the amount of orthodontic procedures performed was proportional to the hours of training in orthodontics in the undergraduate courses in dentistry.[18]

DISCUSSION

Portugal influenced Dental practice in Brazil while it still was a Portuguese colony.[23] The Portuguese State, according to article 4 of Law nº 40 of august 22, 2003, specifically prohibits the practice of orthodontics with fixed or removable appliances by the non-specialist dental surgeon.

Likewise, the USA — where a large part of scientific production in orthodontics is originated —, even though it does not specifically prohibit the professional practice of orthodontics by general practitioners, it adopts others ways to control this practice. A specific prohibition in the USA is unnecessary because the country adopts the Common Law,[15] i.e., gives privileges to the current customs over very extensive and detailed law texts.

From a technical point of view, by directions given since 1960 by the AAO and the ABO,[1] it is possible to observe that the USA is stricter than Brazil in both undergraduate and graduate orthodontic education. Furthermore, the campaign of the AAO to inform people since 2006[3] with real results,[4,5,6] shows how it is possible to influence patients to look up for specialists in orthodontics to perform orthodontic treatments, without the need of laws with this purpose.

It was not possible to conclude if in eastern European countries there is permission for non-specialists to practice corrective orthodontics. Nevertheless, results in Portugal and England demonstrate that orthodontists offered better quality of treatment in comparison with general practitioners,[13] which suggests a similar tendency in the whole European Community in a larger or smaller degree.

Only in Australia the practice of orthodontics seems to be stimulated to non-specialist dental surgeons.[17,18] This fact is perfectly acceptable, since Australia is a fairly new country in need of manpower to all areas.

The professional practice of corrective orthodontics by a non-specialist dental surgeon is polemic in the Brazilian Legal System.[19] Using Comparative Jurisprudence, we can understand that the corrective orthodontics practice prohibition that exists after analyzing the Brazilian Legal System, also exists in other countries. Since the value of comparative jurisprudence relies in the interpretation of legal normatives,[11] this paper agrees with the work of Maruo et al[19] that after analyzing the legislation and decisions of Brazilian courts, it concluded that the non-specialist dental surgeon can not practice corrective dentistry.

Thus, it is valid to remember that the media,[24] back in 1995, gave alert about the increasing number of victims of orthodontic treatments by non-specialist professionals. Orthodontics is directly related to human health.[21] Damages caused by a badly conducted orthodontic treatment are a violation of the body of the patient and also means a damage to his psychophysical integrity, which is a part of human dignity.[20] Human dignity also is a principle protected by the first article, clause III of the Brazilian Federal Constitution.

CONCLUSIONS

Using Comparative Jurisprudence we can conclude that:

1) Portugal completely prohibits the professional practice of corrective orthodontics by a non-specialist dentists;
2) The USA does not prohibit the professional practice of corrective orthodontics by a non-specialist dentist, but creates policies and campaigns to stimulate people to look for a specialist.
3) In Australia and England corrective orthodontics is practiced both by orthodontists and non-specialists dentists;
4) It was not possible to evaluate the legislation in Eastern Europe towards this subject; and
5) The prohibition of corrective Orthodontic professional practice by non-specialist dentists in the brazilian Legal System is consistent with what is happening in countries around the world.

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Rebonding of unused brackets with different orthodontic adhesives

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Objective: To compare *in vitro* shear bond strength (SBS) of different orthodontic adhesives in bonding and repeatedly rebonding metal brackets, and to evaluate the bond failure site with the adhesive remnant index (ARI).

Methods: Specimens consisted of 90 extracted human first premolars, randomly divided into three groups (n=30). The adhesives Alpha Plast (AP), Concise™ (CO) and Transbond™ XT (TB) were used in each group. Three SBS tests were performed, i.e., one at T_0 (initial) and the other two at T_1 and T_2 (first and second rebondings, respectively), observing a 24-hour interval. The tests were performed in a Shimadzu AG-I (10kN) SBS testing machine, at a speed of 0.5 mm/min.

Results: SBS data were subjected to ANOVA, Tukey's test and Bonferroni test ($p<0.05$). For the ARI, the Kruskal Wallis test was performed, followed by the Dunn test. The results revealed that at T_0 groups AP and CO showed SBS values that were near, but above TB values; and at T_1 and T_2, the highest SBS values were observed for the AP group, followed by the CO and TB groups.

Conclusion: Statistically significant differences were found in SBS between groups AP, CO and TB during bonding and repeated rebondings of unused metal brackets, with group AP achieving the highest SBS value. Regarding ARI, adhesive AP exhibited bond failure at the enamel-adhesive interface, with a higher enamel fracture frequency.

Keywords: Shear bond strength. Brackets. Orthodontic adhesives. Rebonding.

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INTRODUCTION

Orthodontics has made significant improvements in recent decades with the use of new technologies that streamline orthodontic practice. The introduction of enamel acid etching[1] fostered the development of the direct bonding technique, which is currently the method of choice for placement of orthodontic accessories.[2]

Despite significant advances in orthodontic adhesives in recent years, studies regarding bonding show that 5 to 10% of clinical bond failures occur in both self-curing and light-curing composite resins.[2,3,4] Bracket bond and rebonding failures are now commonplace, which can result in treatment delays and increased cost of orthodontic treatment maintenance.[4] Bond failures may occur due to chewing, bonding procedure deficiencies or little retention of some bracket bases. It occurs most frequently in mandibular second premolars.[5]

When bracket bond failure occurs, it can be handled in three different manners: 1) Rebonding the reconditioned bracket, 2) Bonding of an unused bracket, and 3) Using a bracket welded to an orthodontic band in cases of persistent bond failures. Studies show that rebonding an unused bracket provides greater SBS than rebonding a recycled bracket.[6,7,8]

Another aspect that has been addressed in different studies is the recycling of brackets, consisting of removal of the remaining adhesive from their base and reusing them. Bracket reuse, however, has been questioned in terms of biosafety and, from a mechanical standpoint, due to distortion of the bracket slot or base upon removal, which may result in (a) increased friction with orthodontic archwire, or (b) reduced adhesion, respectively. Furthermore, when rebonding brackets, unused or recycled, additional enamel loss may occur during debonding, on removal of adhesive remnant from the tooth surface, or during rebonding procedures.[5,7]

In assessing the rebonding of unused brackets, Bishara et al8 highlighted the effect of repeated rebonding on SBS in a sample of 15 extracted human molars using metal upper central incisor brackets (Victory Series™ - 3M). The brackets were bonded and rebonded with Transbond™ XT adhesive system (3M Unitek) three times using unused brackets. Bracket bonding involved 300 g of pressure prior to light-curing. Shearing test was performed with a Zwick mechanical testing machine at 5 mm/min speed. In all trials, the brackets were debonded 30 minutes after bonding. ANOVA results for the three debonding times showed no significant difference between groups (p=0.104). However, when the total shearing load for each tooth was assessed between debonding sequences 1 and 3, ten teeth exhibited a significant SBS decrease (p=0.001) (4.6 ± 2.5 MPa), and five teeth showed significant increases (2.8 ± 1.6 MPa). These findings revealed that SBS may increase or decrease after second rebonding. Changes in SBS values may be related to changes observed in the morphological characteristics of each etched enamel surface due to adhesive remnant. The adhesive remnant index (ARI) showed no significant difference between the three groups.

Later, in 2002, Bishara et al[9] evaluated the effect of bracket rebonding on the SBS of metal orthodontic brackets bonded and rebonded with two adhesive systems. Thirty-one freshly extracted human molars were used. Unused Victory Series™ maxillary central incisor brackets (3M) were employed in each bonding sequence. Group 1 (n=15) was bonded with Transbond™ XT (3M) and Group 2 (n=16) with SmartBond (Gestenco). A Zwick mechanical testing machine was used at a speed of 5 mm/min. Results showed statistically significant differences. Transbond™ XT (4.4 ± 2.3 MPa) showed a higher SBS than SmartBond™ (2.2 ± 2.6 MPa) in all tests. Overall, the teeth where brackets were rebonded had significantly lower SBS owing to the adhesive remnant on the enamel surface. The authors confirmed that changes in SBS may be related to changes in morphological characteristics of the enamel surface as a result of the presence of adhesive remnant.

The recent economic globalization has significantly reduced the costs of orthodontic accessories, leading orthodontists to rebond unused brackets instead of recycled brackets. Bonding a new bracket seems to be faster and less risky than reconditioning used brackets to bond them anew. The aim of this study, therefore, was to compare the *in vitro* shear bond strength (SBS), using human pre-molars, of different orthodontic adhesives in bonding and repeatedly rebonding unused metal brackets, thereby evaluating and comparing bond failure sites, for each of the tested adhesives, using the adhesive remnant index (ARI).

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MATERIAL AND METHODS

The research design was submitted to and approved by the Ethics Committee of the Ponta Grossa State University (COEP/UEPG) – Report #40/2006, Protocol 06269/06.

This study used 90 extracted maxillary premolars — all extractions indicated for orthodontic purposes — of patients aged between 12 and 14 years old. With the aid of a stereomicroscope magnifier (8x), the teeth were selected based on the following criteria: Intact buccal surface, cracks free, caries, restorations or fractures and not having received any kind of pretreatment with chemical agents. Careful cleaning, storage and selection of teeth were meant to avoid changes that might jeopardize adhesion.

Morelli metal brackets specific for canines and premolars were used. The brackets had a base area of 13.02 mm^2, and a 13.88 mm perimeter. These values were obtained automatically using the SolidWorks Software according to manufacturer instructions.

Ninety specimens were randomly divided into 3 groups (n=30), according to which composite resin was used: Group AP – Alpha Plast Orthodontic Adhesive (DFL), Group CO – Concise™ Orthodontic Adhesive (3M/ESPE), and Group TB – Transbond™ XT (3M Unitek). A prototype device especially developed by the authors for the placement of accessories was used to position all brackets. A 3M Unitek universal positioner and a Morelli dynamometer were modified. With this modification a device was obtained (Fig 1) that positions the bracket and applies pressure evenly (300 grams), according to the method created by Bishara et al.[8,9] Therefore, all brackets were bonded at a standard height of 4 mm and with a composite layer of uniform thickness. Before curing the material, all adhesive excess was removed with the aid of an explorer. All bonding procedures were performed by the same operator. After bonding, each specimen was stored for 24 hours in distilled water at room temperature in plastic containers with lids, separated and identified with specific numbering on the base of the PVC pipe according to each group, which were then subjected to mechanical shear tests. These tests followed the ISO/TR 11405 standard (2003) and were performed in a Shimadzu AG-I (10kN) testing machine at loading speed of 0.5 mm/min, and the breaking loads were recorded in Newtons and converted to megapascal. Three SBS tests were performed for each of the experimental groups at three different times, i.e., T_0 (first bonding), T_1 and T_2, referring to the first and second rebonding, respectively. The interval between rebondings was 24 hours.

The adhesive remnant index (ARI) was observed with a stereomicroscope magnifier (Carl Zeiss, Brazil) with 8X magnification. The amount of adhesive remaining on the enamel after debonding was qualitatively assessed according to the scores used by Artun and Bergland.[10] After recording the ARI at T_0, the adhesive remnants were removed with a special carbide bur manufactured by TP Orthodontics, using high speed and water cooling. After every 10 specimens, a new bur was used to ensure consistent cutting. After recording the ARI at T_1 and T_2, the adhesive remnant removal procedure was repeated and observing a polished enamel surface prior to rebonding, thus completing the experiment. This methodology is simplified in Figure 2.

RESULTS

Table 1 presents the SBS values in MPa, with means and standard deviations for each experimental group under study.

The quantitative variable "shear bond strength" was evaluated taking into account the variation factor "experimental group", in a total of three groups: AP group, CO group and TB group, and time variation factor at 3 times (T_0 – bonding, T_1 – first rebonding and T2 – second rebonding). According to the null hypothesis (H_0) the three materials tested at the 3 times should promote identical shear bond strength. Normal data distribution was confirmed

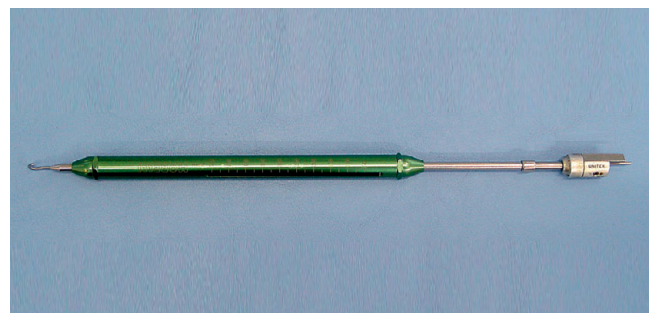

Figure 1 - Prototype of positioner modified by the authors.

Sample	T_0	T_1 (after 24 hours)	T_2 (after 48 hours)
Alpha Plast (n=30)	Initial bonding + shearing + ARI	First rebonding + shearing + ARI	Second rebonding + shearing + ARI
Concise (n=30)	Initial bonding + shearing + ARI	First rebonding + shearing + ARI	Second rebonding + shearing + ARI
Transbond XT (n=30)	Initial bonding + shearing + ARI	First rebonding + shearing + ARI	Second rebonding + shearing + ARI

Figure 2 - Methodology applied to each group.

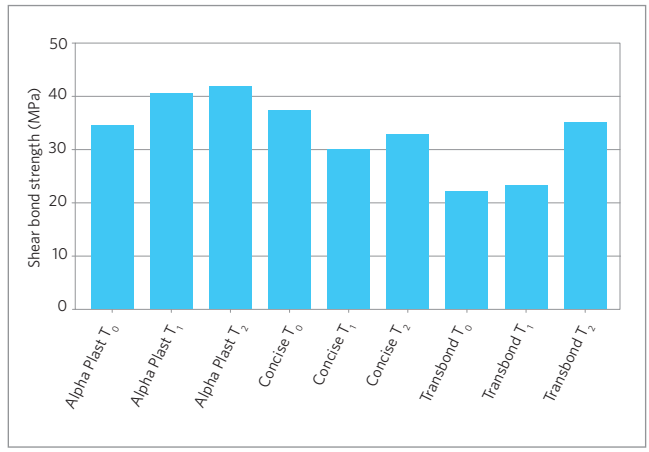

Figure 3 - Mean shear bond strength for each experimental group.

Table 1 - SBS values in MPa, means and standard deviations for each experimental group under study at T_0, T_1 and T_2

	1st Test - T_0			2nd Test - T_1			3rd Test - T_2		
	Groups			Groups			Groups		
Adhesive	AP	CO	TB	AP	CO	TB	AP	CO	TB
Mean	34.18	36.74	22.83	40.28	29.43	23.20	40.71	32.48	25.85
s.d.	13.50	11.25	7.10	11.21	6.54	7.19	8.74	7.79	19.17

by the Kolmogorov Smirnov test, which allowed the parametric ANOVA test to be applied to two fixed criteria. Should the null hypothesis be rejected, the Tukey and Bonferroni (*post hoc*) tests for multiple comparisons would be applied.

Table 1 shows the mean values and standard deviations for shear bond strength (MPa) for each group and experimental period. With the exception of T_0, when the specimens of groups AP and CO showed SBS values that were very near but higher than TB; the highest SBS values were observed in Group AP, followed by groups CO and TB.

ANOVA showed that there was statistically significant difference in the group factor ($p<0.001$); and for the interaction between the time and group factors, ($p=0.007$). However, it did not show differences for the time factor ($p= 0.453$).

By applying Tukey's multiple comparisons test for the group factor, it demonstrated that there were statistically significant differences between the three experimental groups, with the highest SBS values found in the AP group, followed by the CO group and TB group, which exhibited the lowest values for this variable. The data from these tests can be seen in Figure 4.

To assess the qualitative variable "Adhesive Remnant Index" (ARI) the nonparametric Kruskal Wallis test was applied. If the null hypothesis, according to which all groups would show equal ARI values, were to be rejected, the comparison between the mean positions of the samples would be performed using the Dunn test for multiple comparisons in order to detect between which groups existed statistically significant differences. For all tests, a 0.05 level of confidence was adopted. The tests were conducted with the aid of SPSS 13.0 software for Windows and Graphpad Instat version 3.05. The non-parametric Kruskal Wallis test was applied and

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Test	Group	Versus group	Difference between means	Standard error	Level of significance	95% confidence interval	
Tukey	AP	CO	4.4230	1.61479	0.018	0.6123	8.2336
	AP	TB	13.8099	1.59234	0.000	10.0522	17.5676
	CO	AP	-4.4230	1.61479	0.018	-8.2336	-.6123
	CO	TB	9.3869	1.52258	0.000	5.7939	12.9800
	TB	AP	-13.8099	1.59234	0.000	-17.5676	-10.0522
	TB	CO	-9.3869	1.52258	0.000	-12.9800	

Figure 4 - Tukey's test for multiple comparisons for the group factor.

Group	n	Median	Mean positions
Alpha Plast - T_0	30	0	60.76
Concise - T_0	30	1	82.60
Transbond - T_0	30	2	153.48
Alpha Plast - T_1	21	1	124.45
Concise - T_1	24	2	151.73
Transbond - T_1	26	1	126.17
Alpha Plast - T_2	15	1	100.40
Concise - T_2	24	1	82.16
Transbond - T_2	25	2	140.24

Figure 5 - Frequency and median of values obtained for the Adhesive Remnant Index (ARI).

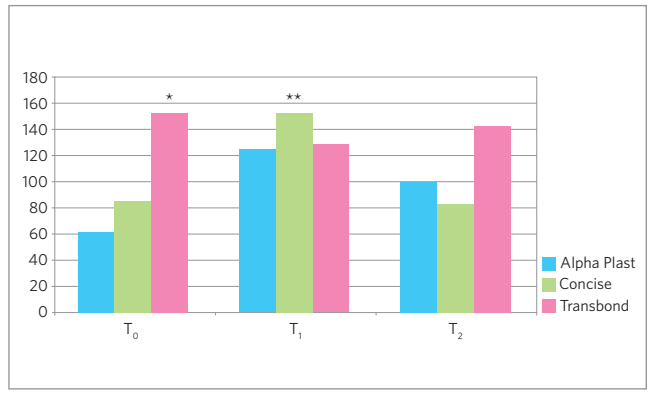

Figure 6 - Mean positions obtained for the Adhesive Remnant Index (ARI) for the Kruskal-Wallis test.
* Statistically significant difference ($p<0.05$) found in comparing groups AP and CO.
* Statistically significant difference ($p<0.05$) found when comparing to group CO.

yielded a value of KW=65.79, with 8 degrees of freedom, considered statistically significant ($p<0.0001$). Thus, the null hypothesis (equal ARI for all groups) was rejected. Figure 5 shows the frequency and median of values obtained for ARI. The comparison between the sample mean positions was made by the Dunn multiple comparisons test, results can be seen in Tables 2 and 3. At T_0 the ARI for Group TB was statistically higher than those of groups AP and CO ($p<0.05$). There were no statistically significant differences between the groups at T_1, whereas at T_2, the ARI for group TB was statistically higher than that of group C ($p<0.05$), with no difference between the other groups, as can be observed in Figure 6.

In analyzing the behavior of group AP at different times, a statistically significant difference was found only between T_0 and T_1, while for group CO statistically significant differences were detected between T_0 and T_1, and also between T_1 and T_2. There was no statistically significant difference between periods T_0 and T_2, and between the three periods assessed for group TB.

DISCUSSION

Bracket bond failures are a frequent occurrence in orthodontic practice. It is jeopardizing as it results in increased treatment time and operating costs, requiring a greater number of appointments[11] which can inconvenience the orthodontist and the patient alike. Identifying the cause of failure can help orthodontists reduce its occurrence, and instruct the patient on how to take proper care in order to avoid repeated bond failures and rebondings.[12] It is also important to understand the bonding mechanism, that involve at least two interfaces: The enamel/adhesive interface and bracket/adhesive interface.[2]

When faced with the need to rebond metal brackets, several options are available: Using the

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Table 2 - Comparison between the mean positions by the Dunn multiple comparisons test.

	T_0 x T_1		T_0 x T_2		T_1 x T_2	
	Difference between points	p value	Difference between points	p value	Difference between points	p value
Alpha Plast	-63.686	p<0.01	-39.633	p>0.05 ns	24.052	p>0.05 ns
Concise	-69.129	p<0.01	0.4333	p>0.05 ns	69.536	p<0.01
Transbond	27.31	p>0.05 ns	13.243	p>0.05 ns	-14.067	p>0.05 ns

Table 3 - Comparison between the mean positions by the Dunn multiple comparisons test.

	T_0 x T_0		T_1 x T_1		T_2 x T_2	
	Difference between points	p value	Difference between points	p value	Difference between points	p value
Alpha Plast X Concise	-21.833	p>0.05 ns	-27.277	p>0.05 ns	18.233	p>0.05 ns
Alpha Plast X Transbond	-92.717	p<0.001	-1.721	p>0.05 ns	-39.84	p<0.05 ns
Concise X Transbond	70.883	p>0.001	-25.556	p>0.05 ns	58.073	p>0.05

same bracket that suffered debonding,[6,7,13-17] using thermocycled brackets,[5,18] or sandblasted recycled brackets,[19] with or without primer[20,21] or using new brackets.[8,9,19,22] This fact establishes the necessity of further scientific research in the pursuit of the most appropriate method.

In this study, shear bond strength (SBS) tests were employed by following the recommendations found in the articles reviewed in the literature[5,8,9,14,16,21,22] with loading speed of 0.5 mm/min. (ISO TR 11405) provided by a mechanical testing machine Shimadzu AG-I with a 10kN load.

The most widely cited light-cured orthodontic adhesive in the literature was Transbond XT, which seems to be the "gold standard." It is a hybrid resin with a fair amount of filler. In this study, this adhesive achieved a shear bond strength (MPa) of 22.83 ± 7.10 in initial bonding; 23.20 ± 7.19 in the first rebonding and 25.85 ± 10.17 in the second rebonding. These values are close to those reported by Mui et al[7], Liu et al,[23] Mondelli and Freitas[17], and Pithon et al,[21] who demonstrated Transbond XT's adequate adhesion to dental structure. These findings differ from the lower values found by Bishara et al[8,9] due to the fact that the SBS reading was performed only 30 minutes after rebonding by these authors.

Concise Orthodontic Adhesive was cited in several studies.[5,13,19,21] This adhesive contains 78% filler and is self-curing, for this reason it is the most often cited in studies assessing chemical-cured adhesives. In this study, this adhesive achieved a shear bond strength (MPa) of 36.74 ± 11.25 at initial bonding (T_0); 29.43 ± 6.54 in the first rebonding (T_1) and 32.48 ± 7.79 in the second rebonding (T_2). These values are close to those reported by Francisconi et al,[5] Quick et al[19] and Pithon et al[21] who demonstrated that this adhesive also features adequate adhesion to dental structure.

In this study of repeated rebondings, unused brackets were used, as this clinical procedure has been common practice for several decades and due to the fact that there are few such studies in the literature.[8,9] It is likely that this is due to the fact that the reuse of debonded[6,7,13,14,19] and sandblasted[15,24] brackets harks back to hard economic times when orthodontists used to import brackets and reuse meant cost reduction.

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But this is no longer true and bracket recycling can affect bonding quality, as shown by Dickinson and Powers[25] as it deteriorates the bracket mesh base, thereby reducing shear bond strength (SBS).

SBS on rebonding remains controversial. In the view of some authors it is inferior to the first bonding[20] whereas others argue that it is comparable to[6] or even superior to the original bonding.[9] This study involved unused brackets and found statistically significant differences in SBS between bonding (T_0) and the first rebonding (T_1) for the Alpha Plast group, whereas for the Concise group the difference was significant between T_0 and T_1 as well as T_1 and T_2. For the Transbond XT group, no statistically significant difference was found between the three periods, in disagreement with Wright and Powers[26] who found no loss in the SBS properties of this adhesive.

The ARI index used in this study was consistent with the results reported in the work of Hirani and Sheriff[20], which showed that the group bonded with Transbond XT had a score ranging between 1 and 2, in the same way, bondings made with Concise also had a score ranging between 1 and 2. Bondings performed with the Alpha Plast showed that ARI scores were concentrated between 0 and 1, indicating that part of the adhesive remained attached to the bracket and part to the tooth. However, this adhesive showed the greatest number of enamel fractures, compared with the other composite resins tested in this study.

The Alpha Plast adhesive system has seldom been used in laboratory experiments and was tested in this study because it is a self-curing adhesive widely used by orthodontists. It shows good bonding results as ascertained by the values achieved in the tests of this study, with values of 34.18 ± 13.50 MPa for initial bonding, 40.28 ± 11.21 in the first rebonding and 40.71 ± 8.74 in the second rebonding. These values are statistically superior to the results found for the Concise and Transbond XT adhesives. This superiority can be due to the finding reported by Dickinson and Powers[25] namely, that composite resin filler content was shown *in vitro* to affect the adhesive force of brackets that rely on mechanical retention. Composites resins with a high amount of filler would provide improved adhesion to metal brackets when compared to low-filler composite resins. However, the elevated SBS of AP adhesive, caused a negative consequence of enamel fracture in most of the times, indicating the necessity of further studies by the manufacturer, in the attempt of keeping the adhesive properties while reducing biological consequences.

CONCLUSIONS

Given the methods used and results achieved in this *in vitro* study, it is reasonable to conclude that:

1 – There was a statistically significant difference in shear bond strength (MPa) between the Alpha Plast and Transbond XT groups, as well as between the Alpha Plast and Concise Orthodontic groups during bonding and repeated rebonding of new metal brackets.

2 – In rebonding with Transbond XT and Concise Orthodontic resins, bond failure sites are unpredictable, whereas with Alpha Plast bond failures occur predominantly at the enamel-adhesive interface, with higher frequency of dental enamel fractures.

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Influence of anatomical barriers on maxillary incisor root resorption after orthodontic treatment with premolar extractions

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Intoduction: Apical root resorption is a frequent and occasionally critical problem in orthodontic patients undergoing induced tooth movement. One of the factors that might influence prognosis, especially in maxillary incisors, which most frequently present resorptions, are the so-called the anatomical barriers; that is, proximity of the buccal and palatal cortical bones to the maxillary incisor roots.

Objective: The purpose of this research was to investigate whether patients with excessive vertical growth really present a small distance between the alveolar cortical bones and the maxillary incisor roots, and whether there is a correlation between this distance and the root resorption index in comparison with patients presenting horizontal growth.

Methods: The sample comprised orthodontic records of 18 patients with extraction planning of first maxillary premolars and treatment by the standard and/or preadjusted edgewise brackets. Their initial and final periapical radiographs were evaluated to determine the amount of root resorption that occurred.

Results: On the palatal side, patients with excessive vertical growth (Group 2 - SN-GoGn ≥ 43º) showed a narrower alveolar bone than the horizontal growth patients (Group 1 - SN-GoGn ≤ 29º). However, the distance between the buccal cortical bone and the central incisor root apex showed no significant difference between Groups 1 and 2;

Conclusions: It was concluded that there are no correlations between the proximity of buccal cortical bone, maxillary incisor roots and the root resorption index.

Keywords: Anatomical barriers. Root resorption. Maxillary incisors. Orthodontic treatment.

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INTRODUCTION

Dental resorptions are tissue damages caused by immunopathological responses resulting from tooth injuries. This may be due to trauma, lesion, extensive dental displacements, orthodontic treatment with tooth extractions, prolonged orthodontic treatments with continuous force, use of inter-maxillary elastics, among other factors.

It is understood that the etiology of root resorption of orthodontically treated patients refers to local factors, such as the morphology of the root and alveolar bone crest. In response to the applied forces, each type of root reacts in a different manner. Therefore, one can predict which tooth will be susceptible to resorption during induced movement, by means of previous analysis of its periapical radiographs.[2]

The quantity of root movement, long roots, narrow roots, abnormal root shape, and the use of Class II elastics appear to be significant risk factors for root resorption. However, no association was found between the type of initial malocclusion, treatment time, use of rectangular wires, root proximity to the palate and root resorption.[6]

Thin alveolar bone can be found in both the buccal and lingual regions of mandibular incisors in patients presenting Class I, II and III malocclusions, with high SN-MP angle, and in a group of Class II individuals with a normal SN-MP angle. Thin alveolar bone may also be found in the lingual region of maxillary incisors in the Class II group with a high SN-MP angle.[4]

In the absence of a history of trauma or resorption before treatment, the dentoalveolar structure cannot be used to identify persons who would be predisposed to a large amount of apical root resorption during orthodontic treatment.[8]

Recently, contact of the root with buccal or palatal cortical bone at the root apex level during an orthodontic movement was related to root resorption. Dentofacial morphology (tooth contact with the cortical bone) was suggested as predisposing certain people to root resorption. Approximation of the root to the palatal cortical bone during orthodontic treatment explains 12% of root resorptions, and maxillary alveolar bone width accounts for approximately 2%.[5]

There are no statistically significant anatomical differences at the level of alveolar bone in the anterior region among dolichocephalic and brachycephalic individuals with different types of malocclusions.[1]

In a study with the purpose of assessing whether the alveolar bone shape and its density could promote apical root resorption, it was demonstrated that the dentoalveolar complex dimensions remained relatively unaltered during tooth movement. The amount of alveolar bone around the root and densities of cortical and trabecular bone showed no significant correlation with the extent of external apical root resorption.[7]

Several factors favor predictability for dental resorption in orthodontic treatment, with emphasis on the morphology of roots and alveolar bone crest, previous history of dental trauma progression, aspects related to the distribution of forces, extent of movement, indication of dental extractions and the use of intermaxillary elastics.[2]

The thickness between the alveolar process of the maxilla and mandible and the patient's age, do not seem to be correlated, but type of malocclusion is dependent on the thickness of the buccal bone in the anterior region of the maxilla. Patients with Class III malocclusion present a higher percentage of buccal bone reduction in the anterior region of the maxilla when compared with Class II patients. Patients who have a tendency toward vertical growth present reduced dimension of the lingual bone of the maxilla and buccal bone of the mandible.[3]

Therefore, the aim of this study was to investigate whether patients with excessively vertical growth indeed have greater proximity of the cortical alveolar bones to the roots of maxillary incisors, in comparison with patients with horizontal growth, and whether there is correlation between this proximity and the rate of root resorption of these teeth.

MATERIAL AND METHODS

Material

Orthodontic records of 456 patients who were treated at the Department of Orthodontics of the University Center of Lavras were evaluated. The sample was comprised of cases treated with maxillary first premolar extractions and with standard and pre-adjusted edgewise brackets.

Initial and final periapical radiographs of 18 patients were assessed to measure the amount of root resorption. Initial and final lateral cephalograms

were also used to analyze the patients growth patterns (vertical or horizontal), based on determination of the SN-GoGn angle, and to evaluate the proximity of the buccal and palatal cortical bone to the roots of maxillary incisors.

Methods

To evaluate the quantity of apical root resorption, a caliper Model DEMEO (Norfol, reading accuracy, 0.1 mm) was used to measure the length of maxillary central incisors in the patients' initial and final periapical radiographs, taken from the root apex up to the incisal edge, along the long axis of the tooth. The quantity of root resorption was obtained by subtracting the value of the final tooth length from the initial tooth length (Fig 1).

Manual cephalometric tracing was used. On each of the initial and final cephalograms, its respective tracing was delimited, which offers a set of variables that allow linear and angular measurements of craniofacial structures to be made for the purpose of research.

By means of cephalometry, the anterior and posterior alveolar thickness to the apex of the maxillary incisors was determined.

Lines and planes (Fig 2)

» SN line: Line that cross through points S and N, situated in the midsagittal plane and at the base of the skull, and extends from one side to the other of the ultraphan paper. The SN line corresponds to the upper measurable limit of the cephalogram.

» Line A Perp: This line is perpendicular to the palatal plane passing through point A. It begins in the palatal plane and ends 5 mm below the edge of the maxillary central incisor.

» Long axis of the maxillary central incisor: It begins at SN line, cross through the long axis of the tooth and ends 5 mm below the incisor edge.

» Mandibular plane (GoGn): Used by Riedel and Steiner. It represents the mandibular body more precisely than the points taken arbitrarily of the most inferior part of the mandible.

» Palatal plane: It starts on the ANS (anterior nasal spine), cross through point PNS (posterior nasal spine) and extends up to the margin of the ultraphan paper.

Angles (Fig 3)

» SN-GoGn angle: Angle formed by the SN line and the GoGn mandibular plane. Considering that GoGn represents the base of the mandibular body, this angle elucidates the behavior of the mandibular base in relation to the base of the skull.

» Angle 1.PP: Angle formed by the long axis of the maxillary central incisor and the palatal plane.

Measurements used in the study (Fig 3)

» AAB (Anterior Anatomical Barrier): Bone anterior (buccal) to the apex of the maxillary incisor. This measurement goes from the buccal cortical bone to the apex of the maxillary incisor; perpendicular to the Line A perp.

» PAB (Posterior Anatomical Barrier): Bone posterior (palatal) to the apex of the maxillary incisor. This measurement goes from the apex of the maxillary incisor to the palatal cortical bone; perpendicular to the long axis of this incisor.

» SN-GoGn: Angle formed by the SN line and the GoGn mandibular plane. Measured in the patient's initial cephalogram.

» 1.PP: Angle formed by the line of the maxillary central incisor long axis with the palatal plane (ANS – PNS).

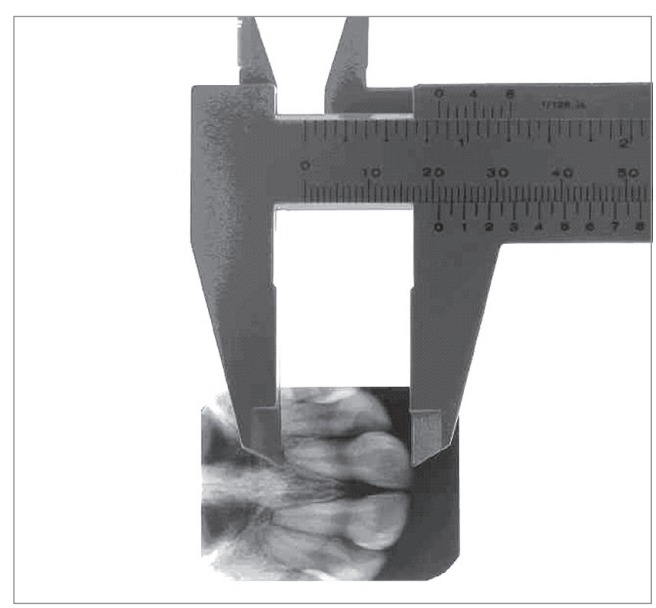

Figure 1 - Measurement of the maxillary central incisors. Caliper measuring the tooth length.

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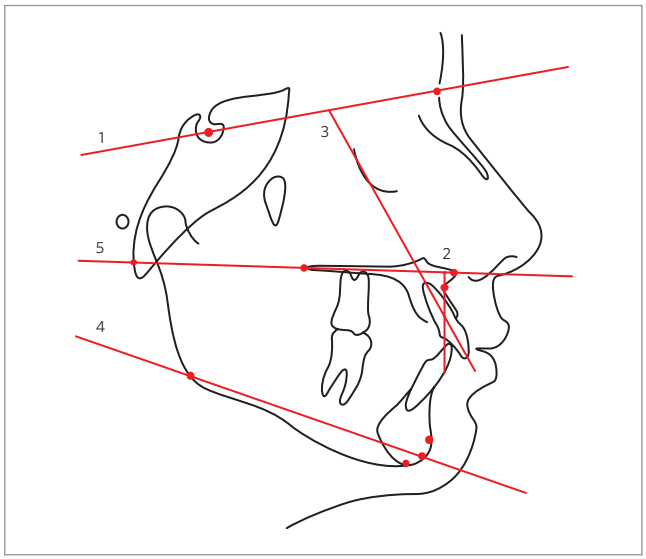

Figure 2 - Lines and planes used in the study. 1- SN line; 2- A perp line; 3- Long axis of the maxillary central incisor; 4- Mandibular plane(GoGn); 5- palatal plane.

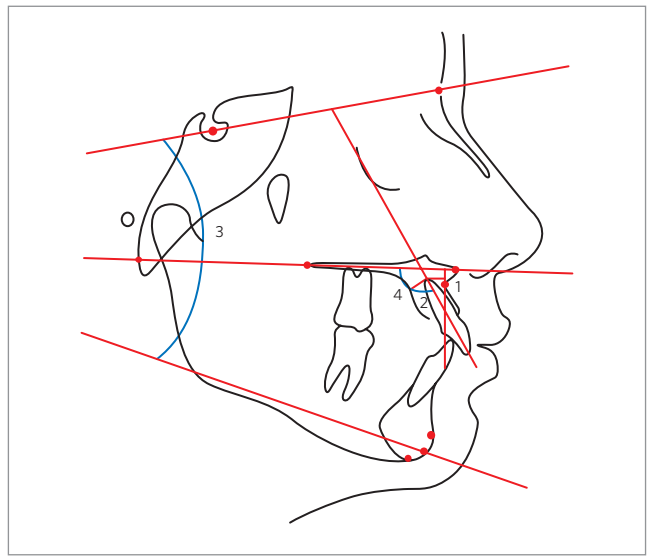

Figure 3 - Angular and linear measurements used in the study. 1- AAB; 2- PAB.; 3- SN-GoGn; 4- 1. PP.

RESULTS

To study the influence of "Anatomical Barriers" in root resorption, it was necessary to first determine groups that would — theoretically — present anatomically narrower alveolar bones, which would be the true anatomical barriers. In this study, the option was to make this analogy in the region of the maxillary central incisors. Starting with this premise, the patients in the sample were divided into two groups, using the facial growth pattern as the criterion.

Thus, patients in Group 1, who presented horizontal growth, had an SN-GoGn angle smaller than or equal to 29º. On the other hand, patients in Group 2, as opposed to Group 1, presented vertical craniofacial growth (angle SN-GoGn greater than or equal to 43º) (Table 1).

In this study, the distance from the posterior alveolar bone to the apex of maxillary central incisor was statistically significant between Groups 1 and 2; that is, patients with excessively vertical growth (Group 2) had a much narrower alveolar bone in the lingual region of the maxillary incisors than patients who presented horizontal growth (Group 1). Whereas the distance from the buccal cortical bone to the apex of maxillary central incisor showed no significance for Groups 1 and 2, which was not expected, since both groups presented quite distinct SN-GoGn angles (Table 2).

In Table 3 it can be noted that in both, Group 1 (SN-GoGn ≤ 29º) and Group 2 (SN-GoGn ≥ 43º), the crowns of the maxillary central incisors showed a palatal inclination, as measured by the reduction in angle 1.PP, being statistically higher in Group 2.

When observing the AAB value (Anterior Anatomical Barrier) and the PAB (Posterior Anatomical Barrier) in the two studied groups, it was noted that there was an increase in PAB and a reduction in AAB, which confirmed the reduction in angle 1.PP (Tables 4 and 5), that is; the apexes of the maxillary central incisors were further from the posterior alveolar cortical bone and closer to the anterior alveolar cortical bone. It was also possible to note that there was a greater reduction of AAB in patients with vertical growth with statistical significance of 5% (Table 4). Whereas, in spite of a greater increase having occurred in PAB in Group 2 (SN-GoGn ≥ 43º) in comparison with Group 1 (SN-GoGn ≤ 29º), it showed no statistical significance (Table 5).

On this point, the two groups were related to each other, with the main object of finding a higher or lower amount of apical root resorption. Although no statistical significance was shown, surprisingly it was verified that the patients in Group 1 (SN-GoGn ≤ 29º) presented a slightly higher rate of root resorption than the patients in Group 2 (SN-GoGn ≥ 43º). To the contrary, it was expected that root resorption would occur to a greater degree in Group 2, in which the alveolar ridge was narrower (Table 6).

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Table 1 - Mean, standard deviation and level of significance of the SN-GoGn measurement for Groups 1 and 2 (in degrees).

	SN-GoGn	
	Group 1	Group 2
Mean	28.1667	45.2500
Standard deviation	1.1690	1.9821
Significance	**	

* Significant at 5%, ** Significant at 1%, ns – nonsignificant.

Table 2 - Mean value of initial AAB (Anterior Anatomical Barrier), initial PAB (Posterior Anatomical Barrier) and level of significance between Groups 1 and 2 (in mm).

	Group 1	Group 2	Significance
Initial AAB (mean)	6	5.4	ns
Initial PAB (mean)	7.44	5.95	*

* Significant at 5%, ** Significant at 1%, ns – nonsignificant.

Table 3 - Mean, standard deviation, calculated "t" and level of significance of Angle 1.PP for Groups 1 and 2 (in degrees).

	1.PP	
	Group 1	Group 2
Mean	-4.6875	-12.3000
Standard deviation	7.5684	9.7929
t-test (calculated)	-1.8056*	
Significance	*	

* Significant at 5%. ** Significant at 1%. ns – nonsignificant.

Table 4 - Mean, standard deviation, calculated "t" and level of significance of AAB (Anterior Anatomical Barrier) for Groups 1 and 2 (in degrees).

	AAB	
	Group 1	Group 2
Mean	-0.7500	-2.3500
Standard deviation	1.6475	1.7803
t-test (calculated)	-1.9572	
Significance	*	

* Significant at 5%. ** Significant at 1%. ns – nonsignificant.

Table 5 - Mean, standard deviation, calculated "t" and level of significance of PAB (Posterior Anatomical Barrier) for Groups 1 and 2 (in mm).

	PAB	
	Group 1	Group 2
Mean	+0.5000	+2.2000
Standard deviation	2.2361	3.6225
t-test (calculated)	1.1586	
Significance	ns	

* Significant at 5%. ** Significant at 1%. ns – nonsignificant.

Table 6 - Mean difference of measurements: 1.PP, AAB, PAB and mean value of the quantity of root resorption between Groups 1 and 2; inter-group differences, "t" test and level of significance.

	Mean value 1.PP	Mean value AAB	Mean value PAB	Mean value of the quantity of root resorption	
				Tooth 11	Tooth 21
Group 1 (SN-GoGn≤29°)	-4.69°	-0.75 mm	0.5 mm	2.18 mm	1.87 mm
Group 2 (SN-GoGn≤43°)	-12.30°	-2.35 mm	2.20 mm	1.68 mm	1.45 mm
Difference between groups	7.61°	1.65 mm	1.85 mm	0.5 mm	0.42 mm
t-test	-1.8056	-1.9572	1.1586	-0.52 mm	-0.47 mm
Statistic (level of significance)	*	*	ns	ns	ns

* Significant at 5%, ** Significant at 1%, ns – nonsignificant.

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DISCUSSION

The literature reports that patients with excessively vertical growth (long face pattern) have a much narrower alveolar bone in the anterior region of the maxilla than patients who present horizontal growth (short face pattern).[4]

Following this line of reasoning, one supposes that patients with vertical growth (Group 2 - long face pattern), because they have a narrower bone, would be more likely to have their maxillary central incisors roots in contact with the alveolar cortical bone, in cases treated with extraction of premolars, and could consequently present a larger amount of apical root resorption.

The literature points out the importance of delineating the limits of orthodontic treatment in adults;[4] therefore, researchers have determined the thickness from the anterior alveolar bone to the apex of the incisors in the maxillary and mandibular arches, because these measurements may represent the anatomical limits of tooth movement. They observed the thinness of the alveolar bone in both the buccal and the lingual regions of the mandibular incisors and the lingual region of the maxillary incisors in patients with vertical growth,[4] confirmed by this study, which presented a narrower alveolar bone posterior to the apex of the maxillary incisor for individuals with a long face pattern.

There were no statistically significant anatomical differences between dolichocephalic and brachycephalic individuals at the alveolar bone level of the anterior region in the different types of Class I, II and III malocclusions.[1] This study is in agreement with Assis[1] with regard to the distance from the buccal cortical bone to the apex of the maxillary incisor, which showed no significance for the groups with vertical and horizontal growth. Similar results were found in other studies,[6,7] which suggested that the morphology of the dentoalveolar complex was not a significant factor in the etiology of external apical root resorption.

Therefore, with the methodology used in this sample, it was evident that there were no correlations between the proximity of the cortical alveolar bone to the roots of maxillary central incisors and the rate of root resorption of these teeth. Other studies with larger samples may perhaps show different results from those found in this study.

CONCLUSION

Based on the analysis of the results obtained, based on the literature and considering the sample used in this research, it could be concluded that:

1) The distance from the posterior alveolar bone to the apex of the maxillary incisor (PAB) was statistically significant between Groups 1 and 2, that is; patients with excessively vertical growth (Group 2 - SN-GoGn ≥ 43º) have a narrower palatal alveolar bone in the anterior region of the maxilla than patients who present horizontal growth (Group 1 - SN-GoGn ≤ 29º), while the distance from the buccal cortical bone to the apex of the maxillary central incisor (AAB) showed no significance for Groups 1 and 2.

2) Surprisingly, the patients in Group 1 (SN-GoGn ≤ 29º) presented a slightly higher rate of root resorption than patients in Group 2 (SN-GoGn ≥ 43º), nevertheless, the values obtained showed no statistical significance between the studied groups, leading to the conclusion that there was no correlation between the proximity of the cortical alveolar bone to the roots of maxillary central incisors and the rate of root resorption of these teeth.

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Temporomandibular disorders and parafunctional oral habits: An anamnestic study

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Objective: To assess the frequency and severity of the signs and symptoms of temporomandibular disorders (TMD), the frequency of parafunctional oral habits and the correlation between the variables by means of the patients' perception regarding their problem.

Methods: One hundred patients diagnosed with TMD, through a clinical examination of their masticatory system, answered the questions of a previously published protocol concerning the signs and symptoms most frequently reported in the literature.

Results: According to the results from the non parametric statistical analysis, the frequency for the following signs and symptoms was significant: Fatigue and muscle pain, joint sounds, tinnitus, ear fullness, headache, chewing impairment and difficulty to yawn ($p<0.01$) and otalgia ($p<0.05$). As to the parafunctional oral habits, there was a significant presence of teeth clenching during the day and night ($p<0.01$) and teeth grinding at night ($p<0.05$). The variable correlation analysis showed that there was a positive correlation between symptom frequency and severity; age was correlated with the presence of otalgia, cervical pain and teeth sensitivity, besides being correlated with muscle and joint pain severity. Habit frequency was negatively correlated with age. TMD duration was also positively correlated with the symptoms of tinnitus, ear fullness, muscle and joint pain.

Conclusion: The study results showed that the anamnestic assessment using ProDTMMulti can predict the severity of the TMD case.

Keywords: Temporomandibular Joint disorders. Signs and symptoms. Habits.

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INTRODUCTION

Temporomandibular disorders (TMD) have been recognized as a common condition of orofacial pain and its clinical manifestation includes a set of signs and symptoms. Among them, pain almost always takes a prominent role, which can impair the functioning of the stomatognathic system and the quality of life.[7,21,36] TMD diagnosis is mainly clinical and maybe supplemented by images.[43] But often what drives the patient to seek treatment is the sign and symptom perception.

Pain in the masticatory muscles and temporomandibular joint (TMJ), difficulty in jaw movement, joint sounds, difficulties related to stomatognathic functions and otologic symptoms are commonly reported by affected subjects.[7,26]

It is believed that habits can act as an important etiologic factor of TMD, as they lead to a traumatic dental occlusion that may affect the teeth and the masticatory muscles and temporomandibular joints, causing the disruption of the functional balance stomatognathic system, or worsening the already installed TMD.[16,19,30,31,32] Thus, some studies have reported that the amount, frequency, intensity and duration of habits can determine the severity of signs and symptoms of TMD, as they relate to fatigue and muscle pain, in addition to joint compression.[13,15,30]

Onychophagy, gum chewing, biting or clenching objects between the teeth, constantly biting cheeks and lips, resting the jaws on the hands, clenching and/or bruxism, among other habits, are commonly reported by TMD patients.[16,31,32]

Studies have shown that anamnestic investigation is valid for the identification of TMD[14] and it may also give positive correlations with clinical findings.[14,28] Previously, our team standardized the patient records about signs and symptoms of TMD, which allowed the definition of the frequency and severity of the condition, as well as verification of the treatment effects.[13]

The objective of this study was to determine the frequency and severity of TMD signs and symptoms and the frequency of deleterious oral habits present in a sample by means of a questionnaire to assess self-perception of symptoms, and to examine possible correlations between the variables: Age of the subjects, severity of symptoms, frequency of signs and symptoms, number of habits, duration of TMD.

MATERIAL AND METHODS

The project was approved by the Ethics Committee of the School of Dentistry of Ribeirão Preto, University of São Paulo (process number 2001.1.266.58.5). All subjects were informed about the objectives of the study and signed an informed consent.

One hundred female subjects, with ages ranging from 11 to 74 years (mean 33.49 years) participated in this study. They were choose because they were the majority seeking for treatment on the waiting list.

Procedures

The patients were called for treatment of TMD, in a waiting list of the university.

The inclusion criterion was to present classification of muscular and/or articular TMD according to Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),[9] applied by a trained examiner. Therefore, the subjects should have TMD signs and symptoms and the presence of pain in the masticatory muscles and/or the temporomandibular joint, limitation or deviation of mandibular movements, TMJ sounds and static and/or unusual dynamic occlusal relationship.[7]

Exclusion criteria were patients with central or peripheral neurological disorders, or who had suffered trauma or tumors in the head and neck.

The subjects were examined while seated in a dental chair with adequate lighting. To check the conditions, morphofunctional evaluation was made of the static and dynamic occlusion. To identify the regions of pain, it was performed palpation of the masseter, temporal, suprahyoid, medial and lateral pterygoid, the insertion of the temporalis muscles (intraoral) and TMJs. The region of TMJ was also palpated during mandibular motion for the identification of joint noises, which were confirmed by auscultation. Clinical examination was carried out based on the criteria required by the protocol RDC/TMD.[9]

To obtain data on the perception of the subjects for signs and symptoms of TMD, it was used the "Protocol for Multidisciplinary Centers for the Determination of Signs and Symptoms of TMD

(ProDTMMulti), which contains 2 parts. Patients answered questions of the first part of the protocol, which admitted only affirmative or negative answers about the signs and symptoms and deleterious oral habits. In the second part, they were asked to express the severity of signs or symptoms questioned according to the situation, that is, at waking up, chewing, speaking and at rest, using a 11-point numerical scale, with the help of a printed graduated scale: Zero was considered complete absence of symptoms or signs, and 10 the greatest severity possible. The severity scale was composed by the sum of the scores assigned to each sign and/or symptoms in the four questioned situations. The procedures were performed individually and patients' responses to each item were marked by the same examiner in the protocol.

To obtain data on deleterious oral habits, subjects were asked about the presence of the following behaviors: Clenching during day and/or nighttime, grinding teeth during day and/or nighttime, chewing gum, biting objects and nails, and some other habit that had not been questioned. The subjects should answer each question with affirmative or negative answers.

Analysis of data

The data were described in terms of frequencies and analyzed using nonparametric statistics. The binomial test was employed to analyze the presence of significance in relation to the absence of signs and symptoms of deleterious oral habits and Spearman correlation analysis for the correlation between the variables: Age of the subjects with the severity of symptoms and the number of habits; severity of symptoms with a duration of TMD, with the frequency of signs and symptoms and the number of deleterious oral habits.

RESULTS

In this study, 65 out of 100 subjects had 21 to 40 years, 11 patients with less than 21 years and 24 subjects with more than 40 years. The time between the first symptoms reported by patients and the first assessment date in FORP/USP ranged from 1 to 23 years.

In this sample, there was significant presence of signs and symptoms of muscle pain, joint noise, fatigue, tinnitus, ear fullness, headache, difficulty opening the mouth, chewing and yawning impairment ($p < 0.01$) and otalgia ($p < 0.05$).

A significant number of patients did not related difficulty to close the mouth. The frequencies and levels of significance are shown in Table 1.

Frequency of deleterious oral habits

Only four sample subjects reported no deleterious oral habits. Thirty-five reported 1 to 3 habits, while 61 subjects reported having 4 to 8 habits. There were reports of significant presence from diurnal and nocturnal clenching ($p < 0.01$) and grinding of teeth at night ($p < 0.05$). The other deleterious habits did not show significant presence in the sample or their absence were significant (Table 2).

Correlations

The age of subjects was positively correlated to the severity of muscle pain ($r = 0.26$, $p < 0.01$), TMJ pain ($r = 0.28$, $p < 0.01$), ear ache ($r = 0.32$, $p < 0.01$), neck pain ($r = 0.27$, $p < 0.01$) and tooth sensitivity ($r = 0.28$, $p < 0.01$). Also the length of the TMD was related to the severity of muscle pain ($r = 0.37$, $p < 0.01$), TMJ pain ($r = 0.28$, $p < 0.01$), tinnitus ($r = 0.21$, $p < 0.05$) and ear fullness ($r = 0.21$, $p < 0.05$).

Table 1 - Frequency of TMD symptoms and noise signs present in the sample.

Binomial Test (n = 100)		
Signs and symptoms	**Presence**	**Absence**
Muscle pain	93**	07
Joint noise	91**	09
Fatigue	84**	16
Tinnitus	81**	19
Ear fullness	76**	24
Headache	76**	24
Difficulty to open mouth	73**	27
Chewing impairment	73**	27
Yawning impairment	67**	33
Ear ache	62*	38
Difficulty to close the mouth	38	62*

Binomial test: *0.05 level of significance; **0.01 level of significance.

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There were positive and significant correlation between the number of symptoms and the severity of each TMD sign and/or symptoms ($p < 0.001$). Sample distribution according to the severity of each sign and/or symptom, and the Spearman correlation coefficients are shown in Table 3.

The frequency of habits was negatively correlated with age of the subjects ($r = 0.24$, $p < 0.05$). There was no significant correlation between the number of deleterious oral habits and TMD severity ($p > 0.05$).

DISCUSSION

The time between the first symptoms reported by patients and the date the first assessment in FORP/USP ranged from 1 to 23 years, indicating that the treatment usually begins at the stage of chronic or recurrent disorder. The duration of symptoms is far beyond the time established by the International Association for the Study of Pain (IASP) in 1994[23] to describe a clinical state of chronic pain, which would be at least 6 months history of pain, and more an attempt to unsuccessful treatment.

By the variety of symptoms present in TMD, it is common that people affected by the problem look different professionals and specialists such as neurologists, otorhinolaryngologists and general practitioners before arriving and/or referred to a specialist service in DTM,[11] which ends up making treatment to be initiated already in a chronic stage of the disorder. This suggests the existence of difficulties in reaching the correct diagnosis and, consequently, to indicate the most appropriate treatment for each case, which in turn may be due to a lack of consensus on the methods of diagnosis, lack of preparation of professionals to recognize dysfunction and difficulty in identifying the etiology.[19,46] In addition, there is the fact that many patients seek treatment only when the disorder is recognized by them due to the increased symptomatology.

Table 2 - Frequency of deleterious oral habits in the studied sample.

Binomial test (n = 100)		
Habits	**Presence**	**Absence**
Daytime clenching	73**	27
Nighttime clenching	66**	34
Teeth grinding (nocturnal)	61*	39
Gum chewing	50	50
Biting objects	38	62*
Onychophagia	33	67**
Teeth grinding (daytime)	23	77**
Other habits (sum)	44	56

Binomial test: *0.05 level of significance, **0.01 level of significance.

Table 3 - Distribution of absolute frequencies of the severity of the TMD signs and symptoms and Spearman correlation coefficients (r) between the number of signs and symptoms and the severity of each one.

Severity of TMD Signs and Symptoms						
Symptoms	**Grade 0**	**Grade 1 (1-10)**	**Grade 2 (11-20)**	**Grade 3 (21-30)**	**Grade 4 (31-40)**	**r**
Muscular pain	03	22	33	24	18	0.45***
TMJ pain	08	22	32	21	17	0.53***
Neck pain	12	25	22	22	19	0.48***
Ear ache	32	33	19	07	09	0.50***
Tinnitus	27	37	18	12	06	0.38***
Ear fullness	22	37	22	11	08	0.29**
Tooth sensitiveness	20	34	14	21	11	0.33**
TMJ noise	10	25	36	16	13	0.53***

0.01 level of significance; * 0.001 level of significance.

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In this study, subjects were selected based on RDC/TMD,[9] which has been widely adopted as a method of classifying DTM.[8,9,42,45] However, this is not the most appropriate method to understand the level of severity. Thus, we used the ProDTM-Multi previously constructed to standardize the records about the signs and symptoms of patients in multidisciplinary clinics, and to identify what are the signs and symptoms that affect the patient and their severity, and what are the most critical conditions on a daily basis.[13]

The significant presence of several signs and symptoms investigated in this study confirms the features found in other populations with TMD,[6,13,19,46] as well as the presence of significant reports of day and nighttime clenching and grinding of teeth at night.[30,31,32] Although these are expected results, because it is a preselected population with TMD, it was interesting to note the patient's ability to affirm or deny what they felt, which complemented the clinical assessments effectively. So this is confirmed as a useful method to identify a dysfunction,[13] which can be easily applied by different health professionals, as is their proposal.

Among the deleterious oral habits, bruxism has been considered an important maintenance factor of TMD.[15,18,31,32,41] The significant presence of diurnal and nocturnal clenching and teeth grinding (nocturnal) in this study, but not other habits, suggests the importance of bruxism on the progression and/or on non-remission of the disorder, being the clenching a more important risk factor than grinding.[6,15,30,31,40,41] And while Choi and Choung Moon[6] have reported that bruxism cannot be a direct risk factor for TMD, there are reports showing that clenching was more often associated with TMJ symptoms and clinically relevant to the occurrence of the same, increasing the risk of manifestation of TMJ pain and noise and losses in the mouth opening.[17,22,24,29,44]

Therefore, a likely association between bruxism and TMD signs/symptoms supports the theory that repetitive loads on the masticatory system can cause functional disorders.[3]

Regarding the positive correlation observed between age and severity of signs and symptoms, it should be considered that only 24 sample subjects had more than 40 years. Therefore, it did not necessarily mean that the more advanced the age of the subject, the greater the severity of the pain present in the TMJ and muscles. As recognized in the literature, the age group most affected by TMD is the young and middle-aged adults.[3,7,10,19,39] Epidemiological studies revealed that, unlike many other musculoskeletal conditions, the TMD has no increase in incidence or prevalence with increasing age.[19,25]

The higher frequency of TMD between 21 and 40 years of age over the older age groups was considered suggestive of the influence of psychological tensions that are inherent to the time of greatest productivity of these individuals, over the painful symptoms of TMD.[5]

The duration of the TMD was correlated with muscle pain, TMJ pain and tinnitus and ear fullness. In the presence of pain and other symptoms, many compensations in the stomatognathic system can occur to allow that chewing, swallowing and speech might be carried out within the limit of efficiency and comfort. However, the actual compensation may have negative medium and long term effects, causing more imbalance and cumulative losses, because such compensations are not necessarily healthy[2,47]. Moreover, the process of chronic pain and the indiscriminate use of analgesics without medical control, as often occurs among patients with TMD, may worsen the case.[20,37]

Significant relationships have been found between the otologic symptoms and other TMD signs and symptoms,[4,38] as well as the functional difficulties of the stomatognathic system.[12]

In the present study, we observed that the perception of severity of ear pain was correlated with the age of subjects. Meanwhile, the consciousness of severity of tinnitus and ear fullness symptoms was correlated with the duration of TMD, suggesting their association with TMD and not age-related ear problems. Earlier studies hypothesized that such symptoms may be caused by anatomical and functional relationships between the TMJ, the muscles innervated by the trigeminal nerve and the structures of the ear.[1,27,33]

The significant correlation between the frequency and severity of signs and symptoms are an indication that the larger the number of signs and

symptoms, the greater the severity perceived by the patient. And, although several authors suggest that the habits accumulation can lead to worsening or contribute to no remission of the present scenario, and deleterious oral habits are among the TMD etiological factors,[15,19,30,31,32] the frequency of habits was not correlated to the frequency or severity of signs and symptoms, according to data analyzed from ProDTMMulti[13] in the current population. In a previous study, it was suggested that, in relation to bruxism, there is an effect of habit in time[30]. Probably the intensity and duration are more important than the number of habits. However, according to the limits imposed by the instrument used in this study, such measurement was not possible.

There were no significant presence of gum chewing habits and onychophagia in our sample, as well as the correlation between habits and age was negative. Research conducted with student populations pointed that gum chewing and onychophagia are the main habits and classified them as juvenile habits.[16,29]

The nature of this investigation allowed us to know about TMD symptoms in the light of who suffers it, revealing the possibility of using the protocol ProDTMMulti[13] as a tool for identification of a potential framework for TMD. Moreover, the possibility to register information about the awareness and consciousness of the population studied in relation to clenching and/or grinding of teeth facilitates the treatment plan, starting at the point of self consciousness to achieve some changes in behavior.[11]

CONCLUSION

Considering the limitations of an anamnestic study and based on the ProDTMMulti data, we conclude that the amount of signs and symptoms and their duration, may be predictive of the TMD severity, according to patients' own perceptions. Symptoms of day and nighttime clenching and nighttime grinding of teeth were significant, revealing the awareness and consciousness of the population studied in relation to them. And yet, the otologic symptoms of tinnitus and ear fullness were correlated with the time of dysfunction and not with age. However, such findings were based mainly on patients answers. A clinical investigation should be performed to confirm and generalize these findings. Furthermore, this study does not provide causal relationship, but only an association between the variables. Future work should be carried out to elucidate each topic individually.

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Treatment of snoring and sleep apnea syndrome with a removable mandibular advancement device in patients without TMD

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Introduction: Among the sleep disorders reported by the American Academy of Sleep, the most common is obstructive sleep apnea-hypopnea syndrome (OSAHS), which is caused by difficulties in air passage and complete interruption of air flow in the airway. This syndrome is associated with increased morbidity and mortality in apneic individuals.

Objective: It was the objective of this paper to evaluate a removable mandibular advancement device as it provides a noninvasive, straightforward treatment readily accepted by patients.

Methods: In this study, 15 patients without temporomandibular disorders (TMD) and with excessive daytime sleepiness or snoring were evaluated. Data were collected by means of: Polysomnography before and after placement of an intraoral appliance, analysis of TMD signs and symptoms using a patient history questionnaire, muscle and TMJ palpation.

Results: After treatment, the statistical analysis (t-test, and the "before and after" test) showed a mean reduction of 77.6% (p=0.001) in the apnea-hypopnea index, an increase in lowest oxyhemoglobin saturation (p=0.05), decrease in desaturation (p=0.05), decrease in micro-awakenings or EEG arousals (p=0.05) and highly significant improvement in daytime sleepiness (p=0.005), measured by the Epworth Sleepiness Scale. No TMD appeared during the monitoring period.

Conclusion: The oral device developed in this study was considered effective for mild to moderate OSAHS.

Keywords: Snoring. Obstructive sleep apnea. Mandibular advancement. Occlusal splints.

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INTRODUCTION

One often hears that when a person is asleep and snoring, it means that they are fast and sound asleep. It couldn't be farther from the truth. A partial obstruction in the upper airway causes snoring while a complete obstruction leads to sleep apnea, which is the total cessation of airflow. These events comprise what is known as Sleep Apnea and Hypopnea Syndrome (OSHAS) and lead to serious consequences such as systemic and pulmonary hypertension, excessive daytime sleepiness, impaired memory, irritability, depression, decreased libido, impotence, burnout, headache and a proneness to workplace and car accidents. Apnea is characterized by an interruption in airflow (breathing) for at least ten seconds. Hypopnea is a 50% reduction in airflow accompanied by a "micro-awakening" or EEG arousal and/or a drop in blood oxyhemoglobin saturation (SaO2) of about 2% to 4%.[4]

It is diagnosed by examining sleep with polysomnography (PSG), which consists of simultaneously recording activities occurring in the organism during a given period and tracking not only the number of apneas and hypopneas during the patient's sleep but also defining OSHAS severity using the apnea-hypopnea index (AHI), which is the sum of apnea and hypopnea events per hour of sleep.[6]

Several authors have confirmed the validity and effectiveness of oral appliances for OSHAS treatment.[1,2,5,8,9,10,16] Appliances that reposition the mandible anteriorly are indicated for primary snoring and mild to moderate OSAHS with an AHI of up to 30 [4,9].

In OSAHS patients this therapy can be effective even in the presence of other diseases such as congestive heart failure and arterial hypertension,[8,19,30] thereby contributing to clinical control.

In treating OSHAS a correct diagnosis is of paramount importance, as well as a multidisciplinary team with training and knowledge of sleep disorders, and a reliable treatment indication for each case. Dentists should be part of this team as they play a key role both in the initial diagnosis, by referring the patient to polysomnography, and in the treatment itself after the examination.

The purpose of this study was to develop an alternative intraoral appliance model for treating OSHAS, evaluate its effectiveness and magnitude of changes in AHI, and observe the side effects and development of potential TMD (temporomandibular dysfunction) signs and symptoms in the follow-up phase.

MATERIAL AND METHODS

The study evaluated 15 patients among those who presented voluntarily at the Clinic of Sleep Disorders located in Bauru, Brazil, reporting excessive daytime sleepiness and/or snoring. Patients had a mean age of 49.9 years.

Initially, patients answered a questionnaire, the Epworth Sleepiness Scale (ESS), designed to measure their daytime sleepiness in specific situations,[15] including patients with ESS scores greater than five. Examination to check for the presence of Temporomandibular Disorders (TMD) began with the patient's clinical history using the Anamnesis Index (AI) questionnaire.[7,11,18] The results were compared with the AI table, which classifies patients' TMD, thus: 0-15, no TMD, 20-40, mild TMD, 45-65, moderate TMD, 70-100, severe TMD. Thereafter, a physical and clinical examination was performed by digital palpation of the right and left TMJs and muscles (superficial and deep masseter, medial pterygoid and temporal). Patient response to TMJ palpation was graded as suggested by Pertes and Gross[21] and as performed by Miranda.[18] Therefore, assessment of the development of TMD signs and symptoms was performed by comparing AI before and after treatment, and also by physical examination, i.e., palpation of masticatory muscles and TMJ.

Exclusion criteria were as follows: AI higher than 15 (since subjects with AI between zero and 15 are considered without TMD, and above 15, with TMD) or presence of TMD signs and symptoms, moderate or severe periodontal disease, lower than 6 mm maximum mandibular protrusion and less than 35 mm mouth opening.

All patients underwent polysomnography (PSG) in the Clinic of Sleep Disorders before and after wearing the appliance. The average time interval between PSGs was five months.

During fabrication, the adjustable mandibular advancement splints were waxed, made with an opening from canine to canine (1.5 mm on average) and processed. Stainless steel wires were also used for mechanical support to prevent the acrylic from fracturing. A 13 mm palate expander screw was

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employed to join the maxillary to the mandibular portion of the splint (Fig 1).

At each visit after splint insertion it was advanced by 0.25 mm until the mandibular advancements reached 1 mm within a two-week period. Patients were monitored on a weekly basis and, after reporting an improvement in snoring and sleepiness, were referred for a second PSG. After approximately six months wearing the splint, the patients were examined again to assess TMD development.

The tests used for statistical analysis of the results included Student's t-distribution test for small samples, with degree of freedom (df) lower than 120 and the "before and after" test which, in simple comparative experiments with samples that have the same origin, ensures greater accuracy than t-test. Both tests were applied to ensure outcome reliability.

RESULTS

Anthropometric data of the subjects who participated in the research are presented in Table 1.

The data were statistically evaluated by Student's t-test and confirmed by the "before and after" test. Assessment results of daytime sleepiness before and after splint use are depicted in Table 2.

All patients exhibited decreased ESS values, noting that the treatment reduced excessive daytime sleepiness in a highly significant manner in 87% of the patients (p=0.005).

It is noteworthy that AI variation was not sufficient to affect the TMD classification of any patient, i.e., it did not increase over 15. On physical examination by muscle palpation 14 patients showed no significant differences after treatment compared to muscle palpation values found prior to treatment.

During mandibular advancement therapy patients 6 and 15 (13.3%) developed morning muscle pain.[10] Treatment included the prescription of oral medication (Celecoxib 200 mg) once a day for three days. The mandibular advancement was halted for a week and then restarted at 0.25 mm per week.[2] The two patients were left with the splint positioned 1 mm below the 75% of maximum protrusion mark. These two patients never again exhibited TMD signs and symptoms.

Table 4 presents the oxyhemoglobin saturation index, number of arousals and number of apneas and hypopneas occurring per hour during the first and second PSG.

On the one-tailed Student's table for p=0.05 and df=14, tc = 1.761 with 95% confidence for the situation "with splint", the amount of oxyhemoglobin desaturation events decreased significantly.

For the one-tailed test tc=1.761 (hence to>tc), the number of arousals "after" is significantly lower than "before."

Snoring, as evaluated by PSG, improved in all patients to acceptable levels and was suppressed or not observed in patients 4 and 15 (moderate frequency level) and in patients 5 and 8 (high frequency).

AHI before treatment had a baseline mean of 18.3 (SD=11.8). After treatment, the AHI displayed a mean of 4.1 (SD=3.8, p=0.001). Thus, the outcome for "after" is significantly less than for "before", i.e., there was a highly significant reduction in AHI.

Figure 1 - Adjustable mandibular advancement splints used in patients with OSAHS.

Table 1 - Anthropometric data of research participants.

Subjects	Gender	Age (years)		Height (m)	Weight (kg)		BMI	
		Before	After		Before	After	Before	After
P1	Male	35	37	1.72	83	80	28	27
P2	Male	39	42	1.69	102	103	36	36
P3	Male	40	43	1.72	78	76	26	26
P4	Female	50	52	1.48	51	52	23	24
P5	Female	59	60	1.61	70	78	27	30
P6	Female	63	64	1.8	97	97	30	30
P7	Male	28	28	1.87	114	116	33	33
P8	Female	54	55	1.57	69	69	28	28
P9	Female	40	42	1.66	63	63	23	23
P10	Female	55	55	1.57	94	94	38	38
P11	Male	63	65	1.68	92	93	33	33
P12	Male	54	56	1.69	79	76	28	27
P13	Male	57	58	1.58	66	66	26	26
P14	Male	56	57	1.67	83	83	30	30
P15	Male	47	47	1.68	75	75	27	27

Table 2 - Results of the Epworth Sleepiness Scale (ESS) before and after splint use.

Subjects	Before	After
P1	8	3
P2	6	2
P3	7	2
P4	11	3
P5	12	6
P6	8	7
P7	14	6
P8	13	10
P9	6	2
P10	6	2
P11	10	5
P12	6	3
P13	10	4
P14	13	3
P15	13	6

Table 3 - Anamnesis Index (AI) results before and after splint use.

Subjects	Before	After
P1	8	4
P2	6	6
P3	15	0
P4	5	5
P5	15	10
P6	13	7
P7	0	0
P8	3	0
P9	0	0
P10	7	7
P11	6	0
P12	0	0
P13	15	4
P14	15	5
P15	15	5

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Table 4 - Oxyhemoglobin saturation index (%) and number of arousals and obstructive events per hour (AHI).

Subj.	Lowest Saturation		Desaturation		Micro-awakening		AHI	
	Before	After	Before	After	Before	After	Before	After
P1	91.0	92.0	1.0	0.0	11.9	1.8	11.3	0.0
P2	77.0	81.0	17.0	7.0	32.8	0.0	26.8	3.3
P3	87.2	89.0	25.0	3.0	20.0	0.0	19.3	6.0
P4	86.0	90.0	4.0	0.0	0.0	0.0	18.8	1.8
P5	87.9	92.0	1.0	0.0	0.0	6.6	8.2	0.0
P6	82.0	83.0	31.0	34.0	0.0	0.0	14.1	5.9
P7	82.0	85.0	12.0	2.0	0.0	0.0	9.7	2.6
P8	86.0	87.0	17.0	1.0	19.4	0.0	20.1	0.8
P9	88.0	94.0	0.0	0.0	9.4	0.0	0.7	1.1
P10	88.9	92.0	0.0	0.0	13.4	10.4	6.3	0.6
P11	69.0	72.0	23.0	25.0	23.7	0.0	17.7	10.2
P12	85.6	88.0	8.0	4.0	64.6	12.5	53.5	9.3
P13	77.0	83.0	47.0	32.0	0.0	0.0	22.1	6.0
P14	77.0	83.0	30.0	1.0	0.0	0.0	19.4	2.7
P15	81.0	82.0	24.0	12.0	30.7	0.0	26.4	11.8

DISCUSSION

The aim of this study was to evaluate the effectiveness of an adjustable intraoral mandibular advancement splint in the treatment of OSAHS.[5,9,19]

Currently, it is recommended that to be considered successful OSHAS treatment using oral splints must comply with the following polysomnographic parameters: A reduction in AHI of at least 50% or a reduction in AHI values below ten.[16]

A highly significant reduction in AHI found in 15 patients, i.e., 77.6% mean reduction, demonstrates that the splints can be indicated for treating snoring, increased upper airway resistance syndrome and OSAHS cases of mild to moderate severity, although some patients with severe OSAHS can also benefit from the therapy, such as patient 12 in this research. When patient 12 was excluded so that the data analysis could be restricted to patients with AHI<30 only, a highly significant improvement in AHI was still found, i.e., a mean 75.9% (p=0.001). Nine (81.8%) out of 11 patients with AHI>10 showed a reduction in AHI to values below ten. It was observed that mandibular repositioning caused a reduction in AHI. Upper airway narrowing due to anatomical factors such as a posterior positioning of the mandible is a risk factor for sleep apnea. In advancing the mandible, the splints widen and stretch the muscles, which concurrently produce an increase in electromyographic activity, widening the airway and improving airflow.[1,2,14,17,19,26]

Thirteen patients (86.7%) exhibited some degree of tooth sensitivity, especially on awakening in the morning. With splint use, five patients (33%) complained of excessive salivation at night and one patient (6.6%) complained of dry mouth at night. In this study, specifically in regard to the development of joint or muscle pain, therapy with splints did not produce definitive or reversible TMD signs or symptoms. Yoshida[29] found these effects in 8.5% of cases and described them as transient. None of the participants was diagnosed with TMD prior to treatment, and after treatment completion (12-month follow-up, on average), no signs or symptoms of TMD-related muscle or joint dysfunction were identified.

It is noteworthy that harmful side effects such as tooth sensitivity (86.7%), dry mouth or excessive salivation (40%) occurred after splint placement but on examination were considered minor or mild.[12,19,23,24,25]

Authors have indicated that the advancement should be between 50% and 75% of maximum mandibular protrusion[2] since such repositioning would be within the measurements of a physiological mandibular protrusion.[22] Six patients had muscle pain and two patients (P6 and P15) presented with moderate pain, which prevented further advancement to 75% maximum protrusion, although the pain was controlled with non-steroidal anti-inflammatory medication. No other changes occurred in AI, indicating no development of TMD signs and symptoms.

The splints were inserted at 60% maximum protrusion and advanced in increments of 0.5 mm to 1 mm within two weeks, unlike other studies, which made weekly advancements of 0.25 mm.[20]

In this study, the mean mandibular advancement was 9.17 mm, ranging from 7 to 12 mm, therefore within what is considered a physiological protrusion length. These results are similar to several studies that proved the effectiveness of splints in mild and moderate OSAHS.[5,9,30]

Advancement was discontinued based on the following criteria: A position that coincided with 75% maximum protrusion and improvement in subjective criteria reported by patients. Clinically, however, defining such criteria can prove elusive. Some authors have therefore suggested an association with objective parameters at the end of mandibular advancement therapy, such as nocturnal pulse oximetry performed at home.[10,28]

Reports of improvement in snoring and daytime sleepiness led four patients (26.7%) to an early referral for a second PSG, but the results showed no change in AHI. This situation showed that the reports of patients and/or of their room-mates are indeed subjective and not a substitute for polysomnography as a therapeutic assessment tool.[9,16] Further advancements were made in these patients and another PSG was performed for each one, except for patient P11, who refused to repeat it and was the only patient who showed no reduction in AHI above 50% (42.4% reduction).

Therapy with the splint caused a direct effect on sleep fragmentation as there was an increase in the lowest oxyhemoglobin saturation index (p=0.05) and a significant decrease in total desaturation and number of arousals (p=0.05). Clinically, improvement in polysomnographic parameters was found to be related to a significant decrease (p=0.05) in ESS.[8,19]

Improvement in snoring levels was observed in all cases and the subjective assessment of spouse confirmed this result. Spouse satisfaction is extremely important since for him or her snoring can cause another sleep disorder, i.e., insomnia.[4]

Long-term studies are warranted to compare the designs and materials used in the splints and to verify the occurrence of any potential desirable or undesirable effects.[3] However, even if significant side effects do occur, a thorough evaluation - pinpointing favorable and unfavorable biological factors - should be conducted and discussed to enable treatment decisions that benefit the patient in the best possible way while gaining control over the important and severe complications of OSAHS. Although treatment using a splint is regarded as a non-invasive therapy, side effects are likely to occur during treatment. Occlusal changes may occur with long-term use, so patients should be strictly controlled.[27]

When patients feel the benefits of therapy using the splint and realize that they are waking up feeling rested, they start wearing it on a daily and continuous basis.[13]

Although this splint was fabricated with materials normally used in dental practice (such as acrylic resin), in light of the limitations of this study and the success criteria adopted for the AHI reduction (above 50%), splint effectiveness was successfully evaluated and the results consistent with those found in the literature.

CONCLUSIONS

Results indicated that the splint developed for this study proved to be a viable alternative for treatment of mild to moderate OSAHS. Therapy using splints did not developed definitive TMD signs and symptoms during the evaluation period. There was a highly significant reduction in AHI above 50% in 93.3% of patients (mean 77.6%) an increase in lower oxygen saturation, reduction in desaturation, decreased number of micro-awakenings or EEG arousals, and subjective improvement in snoring and excessive daytime sleepiness. Undesirable effects were considered minimal and controllable, and no definitive TMD signs and symptoms were found to occur.

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Is orthodontic treatment a risk factor for temporomandibular disorders?

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Introduction: The possibility that orthodontic treatment in childhood might be a risk factor for the development of temporomandibular disorders (TMD) later in life has been an issue of great controversy in dental literature.

Objective: To determine a possible negative or positive correlation between orthodontic treatment and TMD by presenting the results and conclusions from a number of key-papers dealing with this subject.

Results and Conclusion: According to current knowledge, there is no scientific evidence to support that orthodontic treatment is a risk factor for the development of TMD. On the other hand, there is some evidence to support that a proper orthodontic treatment performed in childhood might have a positive effect upon the functional status of the masticatory system later in life.

Keywords: Temporomandibular disorder. Occlusion. Orthodontic treatment.

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INTRODUCTION

The opinion that orthodontic treatment can cause temporomandibular disorders (TMD) is widespread among general dental practitioners. Likewise, this has been frequently mentioned in literature, and some studies done by Franks[1] are often used to support this statement. In this paper, it was reported that 11% out of 751 individuals with joint dysfunction had a previous experience of orthodontic treatment, while only 2% of 326 individuals without dysfunction had received orthodontic treatment in childhood. Several authors have interpreted these results as evidence that orthodontic treatment is a risk factor for TMD later in life. This would be an incorrect assumption since that author wrote on the very same paper that "the great variation on the type and period of the orthodontic treatments performed prevented a formal analysis of these data".

The question about the possible correlation becomes even more confusing since the opposite opinion, that orthodontic treatment can cure and/or even prevent TMD, has also been claimed. It has been stated, for instance, that "if we have the concept of building an occlusion to fit the mandible mechanism, the TMJ pain-dysfunction syndrome can be virtually eliminated in the post-orthodontic patient".[2]

During the years a great number of papers have focused on the possible negative or positive relations between orthodontic treatment and TMD. A search on PubMed using the following keywords "orthodontics" and "TMD" resulted in almost 400 papers. Out of these, the ones dealing with different aspects of orthodontic treatment, morphological malocclusions and TMD were chosen; also only papers in English were used. The papers selected were denying a possible correlation between orthodontic treatment and TMD. However, it should be stressed that due to the large number of papers in this area, it was not possible to review completely the literature in these topics.

LITERATURE REVIEW

Retrospective investigations

Several retrospective papers have compared individuals that underwent orthodontic treatment with untreated individuals in respect of signs and symptoms of TMD. In an early investigation,[3] 23 previously treated individuals were examined for signs and symptoms of TMD 10 years after treatment. It was found that 31% of the patients exhibited mild clinical signs of TMD and 4% showed severe signs. Twenty-seven percent of the patients also reported mild subjective symptoms of TMD. These data was compared to retrospective data from epidemiological investigations, and the authors concluded that there might be only a small increase on occurrence of TMD in patients subjected to orthodontic treatment. This paper has, on the other hand, some major drawbacks. The sample size was very small and no matched control group was included.

In a later study, 51 individuals ageing 19-year-old who had received previous orthodontic treatment, on average 5 years earlier, were compared for TMD signs and symptoms with 47 untreated individuals ageing 19-year-old also.[4] Out of those who had previous treatment, 70.6% showed mild or moderate signs of dysfunction against 53.2% on the controls. This difference, however, was not significant. When asked for subjective symptoms, 70.6% of the treated patients and 91.5% of the controls reported mild symptoms of TMD such as TMJ sounds and feeling of fatigue and/or stiffness in masticatory muscles. This difference was significant, but since only mild symptoms were reported, the authors concluded that there were no substantial differences as to signs and symptoms of TMD between the two groups. These findings are in agreement to other studies[5] with similar design, and the overall opinion is that there seems to be very few reasons to fear an increase in TMD signs and symptoms on patients subjected to orthodontic treatment. On the other hand, some of these retrospective studies suggest that the functional status of treated patients was more harmonious than in controls, and thus, no relation exists between TMD and a well-planned orthodontic treatment.

Prospective investigations

There is always a risk of being misguided when interpreting data from retrospective studies. Moreover, such studies do not supply information about the functional status before orthodontic treatment. During the 90's, the first prospective investigations focusing on orthodontic treatment and TMD were published.

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Among those, there are a series of papers published by Olsson and Lindqvist.[6] They compared signs and symptoms of TMD of 245 individuals in need of orthodontic treatment with 245 matched controls. They found that 52.4% of the patients who were to about to start orthodontic treatment showed moderate or severe clinical signs of TMD, while 16.7% experienced only subjective symptoms. The values for the controls were 29.4% and 4.9%, respectively. Since these differences were significant, the authors concluded that the patients in need of orthodontic treatment appear to be at greater risk of TMD, when compared to controls. The 245 individuals who were in need of orthodontic treatment were followed longitudinally[7] and were treated with fixed orthodontic appliances. The final examination was made on an average of 4 years after the beginning of treatment, when the patients had been out of retention for 3-5 months, and when the occlusion had been stable for at least 6 months. Final data was collected from a total of 210 patients out of the original 245. The data showing moderate or severe signs of TMD had decreased from 45.2% to 20.0%, and the reports of subjective symptoms had decreased from 16.7 to 6.7%. That decrease of both signs and symptoms was significant, and the results were in fairly good agreement with those originally found among the control individuals. The authors stated that "if there is a smaller prevalence of symptoms of TMD, we believe that some credit has to been given to the orthodontic treatment", and they also concluded that such treatment can prevent further development of TMD to some extent, or even cure it.

Longitudinal epidemiological studies

Some longitudinal epidemiological investigations have also focused on possible correlations between orthodontic treatment and TMD. In one study, a total of 402 children in 3 age groups, originally 7-, 11- and 15-year-olds, were followed for 20 years.[8,9] During this time period, approximately one-third of the total sample received some kind of orthodontic treatment. Sixty percent of the treatments were performed by specialists and 40% by general practitioners. At a 10 year follow-up,[8] it was shown that subjective symptom of TMD had increased in all 3 age-groups, but such symptoms were more pronounced in untreated individuals. The signs reported were the same while a decrease was perceived in those who had undergone treatment. At the 20 year follow-up,[9] however, these differences were levelled out, and no difference could be found in respect of signs and symptoms of TMD between treated and untreated individuals. These findings were in agreement with another longitudinal study[10] where a group of patients treated by specialists were compared with a matched control group, with ages from 15 to 18 years old, after treatment.

Extraction versus non-extraction

The possible consequences of orthodontic treatment with or without extractions on TMD have also been discussed in literature, and the results were not conclusive.

In one study,[11] individuals with Class II malocclusions developed TMD after treatment with extraction of 2 upper premolars and retroclination of the incisors with removable appliances. The authors suggested that this was due to a greater than average overbite that resulted from treatment.

In a study by Janson and Hasund,[12] the functional consequences of different orthodontic interventions were investigated. A group of 90 individuals with Class II Division 1 malocclusion were assigned to one of 3 groups: No treatment, orthodontic treatment including extraction of 4 premolars and non-extraction treatment. The results were evaluated after 5 years and it was found that those treated with non-extraction therapy had less signs and symptoms of TMD compared to the other 2 groups, and those treated with extractions showed less signs and symptoms of TMD when compared to controls. They concluded that a non-extraction approach should be aimed for whenever possible.

On the other hand, no difference could be found between the groups in respect of TMD, in a more recent publication[13] comparing non-extraction treatment to treatment with 2 or 4 extractions.

In a more elaborate longitudinal study,[14] 172 treated individuals were followed for 20 years in order to evaluate the effects of extraction or non-extraction on TMD. No differences were found between the groups, and the conclusion was that neither treatment caused differences in signs and symptoms of TMD.

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Orthodontic treatment performed by orthodontists *versus* general practitioners

It is fairly common in Sweden for general practitioners (GPs) to perform orthodontic treatment under the supervision of orthodontists, which is mostly done with removable appliances. The possible difference in functional status after orthodontic treatment performed by orthodontists or GPs has been investigated.

One study[15] showed data from a Swedish population of 1554 19-year old individuals. The more complex cases (60%), with or without extractions, were treated with fixed appliances by orthodontists, while less complex cases (40%) were treated by general practitioners under the supervision. These treatments consisted mostly of removable appliances. After completion of the treatments, the prevalence of both signs and symptoms of TMD were equal between the groups, and their signs and symptoms were also comparable to matched untreated controls.

TMD during orthodontic treatment

The prevalence of TMD signs and symptoms, including tension-type headache, has also been studied longitudinally before, during and after orthodontic treatment.[16,17] The conclusion from these studies is that there is a significant decrease of signs and symptoms of TMD and of the headache during the active phase of treatment, but they tend to increase to pre-treatment levels after treatment is finished.

Functional and morphological malocclusion and their possible relation on the etiology of TMD

The effects of occlusal factors on the function of the masticatory system have been a controversial topic over the years. The several existing epidemiological investigations have not been able to demonstrate any strong correlations between different *functional malocclusions/occlusal interferences* and TMD.[18] However, some weak but statistically significant associations have been found between TMDs and a large sagittal distance between retruded contact position (RCP) and intercuspal contact position (ICP),[19,20] as well as between TMDs and a lateral shift between RCP and ICP.[9,18]

From an orthodontic point of view, the possibility of an effect of the morphological malocclusions in the development of TMD is of great interest, and some specific morphological malocclusions have been found to be associated with TMD variables. Mohlin and Kopp[21] found that anterior open bites and posterior crossbites were more common in TMD patients compared to healthy controls. Studies by Tanne et al,[22] as well as Pullinger et al,[23] also agree with the finding that these 2 malocclusions, as well as a deep bite, are significantly associated with the occurrence of TMD.

Longitudinal studies following the same individuals for 20 years have found that individuals with mandibular deficiency have a much higher risk for tooth wear (odds ratio 7.3) compared to individuals with normal occlusion,[24] and that individuals with posterior crossbites developed two times more TMJ-related problems when compared to normal occlusion (57% and 21%, respectively).[25] Finally, they found that individuals with a deep bite had a much greater risk for developing clinical signs of dysfunction (odds ratio: 12.5) compared to those with no malocclusion.[26]

DISCUSSION

From early retrospective investigations of previously treated patients,[3,4,5] it was concluded that patients that underwent orthodontic treatment do not exhibit more signs or symptoms of TMD compared to untreated individuals. However, from the findings in later prospective studies[4] it can be speculated that the similarities regarding TMD in patients and controls found in the early retrospective studies was in fact the consequence of an improvement of TMD among those patients treated, making them, in respect of TMD, equal to individuals subjected to orthodontic treatment.

Prospective and longitudinal studies[6-10] lend further support to the opinion that individuals who have undergone treatment do not have a higher risk of developing TMD later in life. An alternative view of this issue is that individuals who needed and received orthodontic treatment as children had the same risk for developing TMD, when adults, as untreated individuals.

The literature is inconclusive regarding functional advantages or disadvantage in extractions or no extractions associated with orthodontic therapy.[11-14] The main impression is that a well planned treatment, irrespective if extraction was part of the

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treatment or not, does not have any negative influence on the function of the masticatory system.

An interesting conclusion from literature is that no higher risk exists for development of signs and symptoms of TMD if a GP is performing the orthodontic treatment (in specific cases) compared with orthodontists, or if their patients are compared to untreated controls.[15]

Another finding, which was unexpected, is that both signs and symptoms of TMD decrease during the orthodontic treatment, but tend to return to pre-treatment levels after treatment.[16,17] The reasons for this might be numerous, but the most likely explanation is that the teeth which are being moved become sensitive to occlusal loading, what causes a decrease of the oral parafunctions during the time of active treatment.

Correlations between both functional and morphological malocclusions and signs and symptoms of TMD are, with few exceptions, weak or non-existent.[9,20-23] There is, however, some indications that a large sagittal distance between RCP and ICP, as well as a lateral shift between those positions, might add to a risk for developing TMD.[9,18-21] Thus, these functional malocclusions should, when possible, be treated orthodontically.

Morphologically, the anterior open bite, the deep bite, the mandibular deficiency, and the crossbite involve an increased risk for different TMDs to occur.[20,22-26] It should be emphasized that, with the exception for posterior crossbite, the increased risk is smaller. Thus, an orthodontic treatment should not be accomplished under the argument that it will prevent TMD problems later in life.

Even though the risk is small for the orthodontic treatment to cause TMDs, recording any signs and/or symptoms of TMD before the start of the orthodontic treatment is recommended. One of the reasons for that is to avoid that a patient should claim that symptoms have developed as a consequence of the treatment when they were actually present at start of treatment. Symptoms that should be recorded are frequent headache, pain in the face or mandibles, painful mandible movements, and TMJ sounds.

The procedures on how to perform a functional examination of the masticatory system have been described in TMD textbooks.[27,28] The examination should at least include measurement of maximal mandible opening; registration of palpatory pain on the TMJs, on the superficial part of the masseter muscle, and on the insertion of the temporalis muscle; recordings of TMJ sounds; and painful mandible movements.

It is important to underline that even when there is a clear presence of TMD signs and symptoms, this is not an absolute contraindication to orthodontic treatment because as stated above, the mobility of the teeth during treatment will cause parafunctional activities such as clenching and/or grinding of teeth to diminish or cease.

It is well known from the evidence, in many cross-sectional and longitudinal epidemiological investigations concerning TMD, that the prevalence of both signs and symptoms of TMD increase from childhood through adolescence and into young adulthood, where it seems to level out and decrease.[29] The incidence, or in other words, the number of new TMD cases/year has been found to be approximately 1%.[30]

This increase in TMD signs and symptoms coincide with the age in which the vast majority of the patients undergo orthodontic treatment. Thus, it can be expected that a number of individuals receiving treatment will develop TMD, either during or shortly after the treatment, due to chance. Moreover, even in specific cases it is not possible, most of the time, to judge if a TMD was caused by an orthodontic treatment or not.

If painful TMD symptoms and/or functional impairment should develop during the active treatment phase, it is recommended to modify the treatment, to reduce forces or even to interrupt it for some time. The occlusion should also be checked for large interferences, which, if present, should be eliminated with selective occlusal grinding.

If TMD symptoms should start during or shortly after the retention phase, it is recommended to re-evaluate both the retention appliance and the final occlusion.

It should be strongly emphasized that there is a great possibility that any signs and symptoms of TMD starting during orthodontic treatment might be happening due to a time coincidence rather than because of the therapy.

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CONCLUSION

In agreement with several and previous systematic reviews,[31-35] this paper clearly shows that orthodontics, either with or without extractions, does not cause TMD. Moreover, there is some evidence to support that a proper orthodontic treatment performed in childhood might have a positive effect upon the functional status of the masticatory system later in life.

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Influence of palatoplasty on occlusion of patients with isolated cleft palate

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Objective: This study compared the dental arch morphology of adult patients with isolated cleft palate in order to verify the influence of palatoplasty on occlusion.

Methods: Cast models of 77 patients, 30 males and 47 females, with an average age of 21 years and no syndromes were taken. They were in the permanent dentition and had not undergone orthodontic treatment. The sample was divided into non-operated and operated patients, the latter having been submitted to palatoplasty at a mean age of 2.2 years.

Results: Almost 80% of the sample exhibited sagittal discrepancies in the inter-arch relationship, with a Class II malocclusion prevailing (59.74%) followed by Class III (20,78%), regardless of palatoplasty. Transverse analysis showed a 23% incidence of posterior crossbite also not influenced by palatoplasty. Intra-arch relationship indicated that constriction and crowding on the upper arch were more frequent in the operated group (p=0.0238 and p=0.0002, respectively), showing an influence of palatoplasty on its morphology. The predominant morphological characteristics in patients with isolated cleft palate were a Class II malocclusion, upper dental arch constriction and upper and lower anterior crowding.

Conclusion: The influence of palatoplasty was restricted to constriction and crowding of the upper dental arch, with no interference from the extension of the cleft, except for the upper crowding, which occurred more in patients with complete cleft palates.

Keywords: Dental arch. Cleft palate. Dental occlusion.

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INTRODUCTION

Derived from a fusion failure of the secondary palatal processes in intrauterine life, the isolated cleft palate is established between the eighth and twelfth week of gestation. The morphological manifestation of cleft palate increases in severity from the uvula towards the alveolar ridge, reaching the incisive foramen when is complete (Fig 1). Isolated cleft palate accounts for 25% of all cases of cleft lip/palate and is more severe and frequent in females. Data from the archives of the Craniofacial Anomaly Rehabilitation Hospital of University of São Paulo in the city of Bauru, state of São Paulo, Brazil, on 9821 patients with isolated cleft palate confirm the predominance of females (59.63%) over males (40.37%). While there is an agreement among authors regarding the multifactorial etiology of this type of cleft, current studies stress the polygenic origin in the palate formation process.[23,24] The treatment of a cleft palate begins with a primary palatoplasty at 12 months of age.[25,28] From that point on, non-surgical therapy is then directed mainly towards vocal quality and hearing competence.

In cases of isolated cleft palate, the dentofacial morphology defined by cephalometrics appears to be inherent to the cleft itself and is little affected by palatoplasty.[4,5,20,25,26] Regardless if a palatoplasty was performed in childhood, the cephalometric dimensions in patients with isolated cleft palate translate into small, well related and proportionally retro-positioned apical bases, along with a clockwise rotation of the mandible, denoting a preponderantly vertical growth.[6,8,14] A study on facial morphology through a clinical analysis of the face confirms the cephalometric diagnosis and the small influence of palatoplasty on the final configuration of the face.[28] It can be concluded that the facial morphology of patients with isolated cleft palate is inherent to the individual and undergoes little influence from palatoplasty.

With regards to the occlusion, the literature has shown that palatoplasty in isolated cleft palate affects the development of the upper dental arch, with a reduction in width[11,15,20,29] (Fig 2A) or in width and length[3,7,10,12,14,21,22] with variations depending on the surgical technique[15,20] and on number of surgeries performed.[10] Moreover, the lower arch tends to follow the constriction of the upper arch (Fig 2B).[3]

The dimensions of the alveolar ridge in patients with isolated cleft palate are already reduced before the eruption of the primary teeth, regardless of the extension of the cleft,[7] and remain reduced throughout the three developmental stages of the occlusion (primary, mixed and permanent dentition).[3] Quantitative studies involving study models show that the dimensions of the dental arch in operated cleft patients are

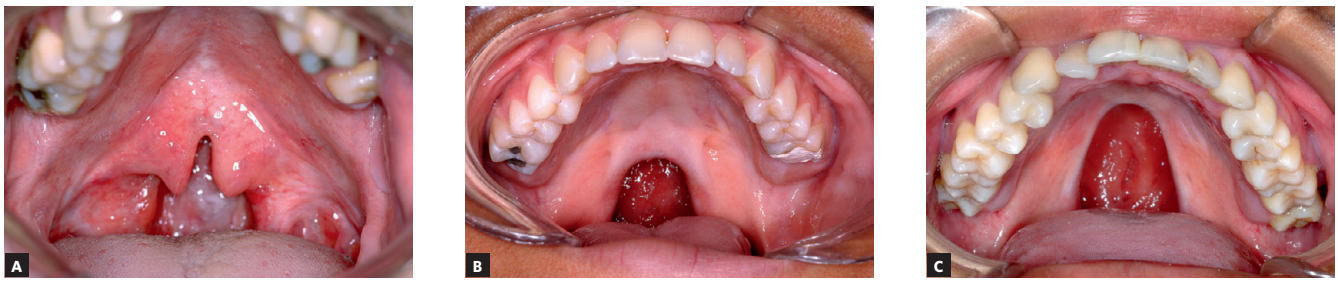

Figure 1 - **A)** Isolated cleft palate: Bifid uvula, **B)** Isolated cleft palate: Soft palate, **C)** Isolated cleft palate: Soft and hard palate.

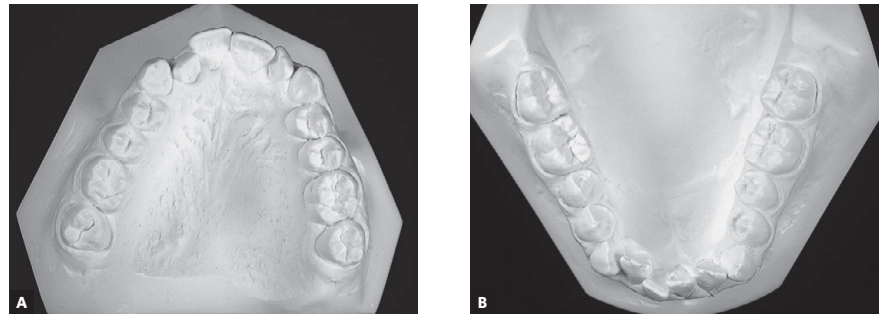

Figure 2 - **A)** Crowding in the upper arch in an isolated cleft palate patient. **B)** Crowding in the lower arch in an isolated cleft palate patient: The lower dental arch tends to accompany the upper arch, demonstrating a reduction in its transverse dimensions.

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reduced in the primary dentition,[12] beginning at three years of age and remaining so through six[20] or even ten years of age,[7] regardless of the surgical technique employed.[21] On the permanent dentition, the palate is narrower throughout its entire length and shallower from the premolars towards the molars.[29] In patients who did not undergo surgery when newborns, the width of the alveolar ridge is influenced by the width of the cleft, with wider clefts leading to larger dimensions in the alveolar arch.[12]

The literature is unclear regarding the influence of palatoplasty on the width of the upper dental arch. Even though more conservative techniques, that expose the palate less, are reported to have a smaller effect on the width of the upper dental arch, at least in the primary dentition phase,[15] this is not a widespread opinion.[7,14] It is also reported that the shape of the upper dental arch may be related to the scar tissue of the palate.[13]

The aim of the present study was to determine the morphological characterization of the occlusion based on the analysis of study models, comparing isolated cleft palate adults that underwent surgery in childhood with those that did not undergo surgery.

MATERIAL AND METHODS

The sample consisted of 77 patients treated at the Craniofacial Anomaly Rehabilitation Hospital of the University of São Paulo (Brazil) with isolated cleft palate (30 males and 47 females) (Table 1). Mean age was 21 years, ranging from 11 years and two months to 39 years and eight months and all patients were in the permanent dentition. Thirty-nine had not been submitted to palatoplasty, while thirty-eight had been submitted to palatoplasty in childhood at a mean age of 2.2 years by different surgeons employing different surgical techniques.

The inclusion criteria were: Brazilian nationality, absence of syndromes, permanent dentition stage, no prior orthodontic treatment and complete or incomplete isolated cleft palate, whether or not having been submitted to palatoplasty. In the operated cases, the first surgery could not have been done after four years of age. Study models of both dental arches were obtained from the subjects and occlusion analysis was performed by two previously calibrated orthodontists, considering the inter-arch and intra-arch relationships.

The following characteristics were analyzed:

» Inter-arch relationship

- Sagittal relationship: Class I, II or III, according to premolars;
- Transverse relationship: Presence or absence of unilateral/bilateral posterior crossbite;
- Incisor relationship: Increased overbite and overjet, edge-to-edge or anterior open bite/anterior crossbite.

» Intra-arch relationship

- Presence or absence of anterior and posterior crowding;
- Arch shape: Normal or constricted.

The sample was divided into two groups (39 patients who had not undergone palatoplasty and 38 patients who had undergone surgery in childhood) and were further subdivided into complete cleft and incomplete cleft (Table 1). Due to a small number of non-operated patients with complete cleft, the statistical analysis did not include the extension of the cleft in the non-operated group. Agreement between the two orthodontists in the evaluation of the occlusal characteristics analyzed was determined using the Kappa coefficient[2] (Table 2).

For comparisons between groups of non-operated patients with isolated cleft palate, operated patients with complete cleft and operated patients with incomplete cleft, the exact chi-square test[1] was used, with the level of significance set at 5% ($p < 0.05$). In cases where $p < 0.05$, a comparison was made between the operated groups with complete and incomplete cleft. When the difference between groups was insignificant ($p < 0.05$), the groups with complete and incomplete cleft were

Table 1 - Distribution of patients with isolated cleft palate according to gender and palatoplasty (in percentages).

		Male	Female	Total
Non-operated	Incomplete	15	18	33
	Complete	2	4	6
	Total	17	22	39
Operated	Incomplete	12	15	27
	Complete	1	10	11
	Total	13	25	38
Overall sample		30	47	77

pooled and the exact chi-square test was performed again considering the surgery factor alone. In cases where $p < 0.05$, all groups were compared using exact chi-square tests, with the level of significance defined as $\alpha = 0.05/p = 0.017$ (Bonferroni correction).[19]

RESULTS

The results (Table 2) show a high level of agreement between the two examiners in the occlusal evaluation, demonstrating the reliability of the study model's analysis as a criterion of morphological analysis in orthodontic diagnosis.

Table 3 displays the comparisons between groups. A significant difference was detected in upper alignment/crowding between non-operated and operated patients with complete cleft ($p < 0.001$). A significant difference in upper arch shape was detected between the operated and non-operated groups ($p = 0.0018$).

DISCUSSION

Among the 77 patients observed, 5 (6.5% of the sample) exhibited normal occlusion (Table 4) while the vast majority (93.5%) exhibited some type of malocclusion. Considering the surgery variable, the prevalence of normal occlusion was 10.25% among the non-operated patients and 2.7% among the operated patients. Despite the small sample size, the greater percentage of normal occlusion among the non-operated patients in comparison to those that underwent palatoplasty in childhood suggests that this type of surgery somehow deteriorates the occlusion.

Even tough malocclusion prevailed in the patients, there was not a typical malocclusion for the isolated cleft palate. Malocclusion characteristics were identified in three dimensions, with a predominance of Class II malocclusion as well as upper and lower crowding.

Table 2 - Kappa confidence intervals for agreement between two examiners.

Variable	Kappa estimate	Confidence interval (95%)	
		Lower limit	Upper limit
Sagittal relationship	0.98	0.95	1.00
Transverse relationship	0.96	0.90	1.00
Overbite	0.98	0.94	1.00
Overjet	0.94	0.88	1.00
Upper crowding	0.96	0.89	1.00
Upper arch shape	0.97	0.92	1.00
Lower crowding	0.98	0.94	1.00
Lower arch shape	0.96	0.88	1.00

Table 3 - Results of chi-square test in comparison between groups.

Variable	p	Comparisons between groups			
		N-Op X Op comp	N-Op X Op inc	Op comp X Op inc	N-Op X Op
Sagittal relationship	0.2322				
Transverse relationship	0.1804				
Overbite	0.1398				
Overjet	0.7994				
Upper alignment/crowding *	0.0002	<0.001	0.0220	0.0343	
Upper arch shape	0.0238			0.5076	0.0018
Lower Alignment / Crowding	0.2891				
Lower arch shape	0.0629				

* Bonferroni correction used for comparisons between ($\alpha = 0.017$).
N-op: Non-operated; Op: Operated; Op incomp: Operated with incomplete cleft; Op comp: Operated with complete cleft.

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Table 4 - Distribution of normal occlusion and malocclusion in sample of 77 patients with isolated cleft palate according to operated and non-operated subgroups (in percentages).

	Normal occlusion	Malocclusion
Overall sample	6.50	93.50
Non-operated cleft	10.25	89.75
Operated cleft	2.70	97.30

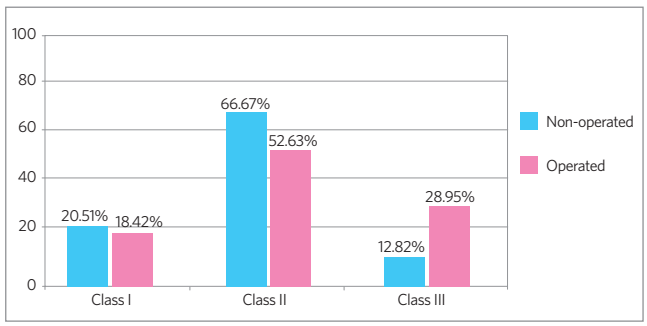

Figure 3 - Percentage distribution of sagittal relationship between dental arches (Class I, Class II and Class III) in sample of 77 patients with isolated cleft palate.

SAGITTAL RELATIONSHIP

A Class I relationship between the arches occurred in only 20% of the patients, whereas 80% exhibited sagittal discrepancies, distributed as 59.74% with Class II and 20.78% with Class III. Distribution was similar when considering the operated and non-operated groups, even though there were more cases of Class III among the operated patients (28.95%) than in the non-operated patients (12.82%). No differences were detected in these groups or in relation to the extension of the cleft (Fig 3).

The larger number of Class II malocclusions may be explained by the condition of the mandible, which exhibits a predominantly vertical growth in cases of cleft as well as morphological, spatial and dimensional abnormalities.[6,8,14] Cephalometric data on the mandible showed a clockwise rotation,[25,28] an increased mandibular plane angle, a retrusion in relation to the cranial base[14] and a reduction on the dimensions of the body and ramus.[8,27,30] The clockwise rotation of the mandible can help to explain the increased incidence of Class II malocclusion in patients with isolated cleft palate.

Class III malocclusion was high (21%) in relation to what is expected in Caucasian patients with no malformations. The fact that palatoplasty had no significant influence over the sagittal relationship between the arches suggests that the Class III relationship was not determined by this surgery, but rather is a part of the morphological condition of the cleft patient. The data suggest that cleft palate has a negative influence over the sagittal relationship between the maxilla and mandible (Fig 3).

TRANSVERSE RELATIONSHIP

The literature shows that the transverse dimensions of the upper arch are small in cases of isolated cleft palate, regardless of the extension of the cleft or surgical technique employed. Studies that quantitatively assess the transverse dimension of the dental arches report a reduction of this dimension on the upper arch during the three developmental stages of the occlusion: Primary,[3,7,11,12,14,20,21,22] mixed[3,7,13,14] and permanent.[3,29] The literature also suggests that the lower arch tends to follow the upper arch, diminishing its transverse dimensions during the primary dentition,[3,12,20,22] on the other developmental stages of the occlusion[3] and on the permanent dentition.[3,11]

On the other hand, posteroanterior cephalometries show that an isolated cleft palate causes a morphological craniofacial condition with increased transverse dimensions, as shown by a greater lateral inclination of the pterygoid processes of the sphenoid bone, by an increase of the distance between the hamular processes, and by a greater width in the region of the tuberosity. Pressure from palatoplasty does not affect the width of the basal portion of the maxilla.[4] Frontal cephalometries also reveal that the surgical technique employed does not affect facial or occlusal behavior.[9]

Based on the data obtained from PA cephalometries, the reduction in the transverse dimension in cases of isolated cleft palate seems to be linked to the upper dental arch and alveolus. This data may also infer that the mid-face does not exhibit the same transverse behavior as that of the dental arch and alveolus.

If the transverse reduction were only present in the operated cases, it could be attributed to the scar tissue of the palatoplasty. Laboratory studies accept the theory that post-palatoplasty scar tissue reduces

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the width of the upper dental arch.[16,17] From the clinical standpoint, however, it is difficult to determine the degree of this interference, even though the shape of the upper arch has been found to be related to the intensity of the scar tissue in the palate.[13] It is likely that the influence of palatoplasty on the upper dental arch is individual.

In the present study, transverse morphological condition was assessed considering the inter-arch relationship, evaluating the presence of posterior crossbite, the intra-arch relationship and the morphology of the upper and lower dental arches. The incidence of posterior crossbite was 23.38%, regardless of the palatoplasty and the severity of the cleft (Table 5). The incidence of posterior crossbite was lower than that reported in the literature for five-year-old children with isolated cleft palate operated between 18 and 24 months of age.[12] In children, the incidence of posterior crossbite was 14.1%, and 19.2% when combined with anterior crossbite, totaling 33.3%. These epidemiological data suggest that the cleft itself in combination with palatoplasty influences the transverse behavior of the occlusion.

Table 5 - Distribution of posterior crossbite (PCB) on 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Normal	PCB
Non-operated	Incomplete	72.73	27.27
	Complete	66.67	33.33
	Total	71.79	28.21
Operated	Incomplete	81.48	18.52
	Complete	81.82	18.18
	Total	81.58	18.42
Overall sample		76.62	23.38

The results on transverse dimension exclude palatoplasty as an interfering variable on the inter-arch relationship. The analysis of that relationship revealed that one-third (76.62%) of the sample had a normal transverse relationship, whereas 23.38% of the overall sample had some type of posterior crossbite (28.21% of the non-operated group and 18.42% of the operated group). If palatoplasty can reduce the width of the upper arch, a greater prevalence of posterior crossbite was expected among the operated patients. The results, on the other hand, reveal that the transverse inter-arch relationship was not influenced by either palatoplasty or by the extension of the cleft.

The incidence of posterior crossbite was low, considering the morphology of the upper dental arch. Approximately 40% of the patients exhibited a constriction of the upper arch (Table 6). The percentage of constriction in the upper arch was larger than that of the lower arch (Table 7). However, this percentage was larger than that of posterior crossbite in this same group (18.42%). There are two important considerations to be discussed: The incidence of Class II (approximately 60%) and the incidence of lower arch constriction (approximately 21%). It can be concluded that the Class II relationship and the constriction in the lower arch contribute toward masking the constriction of the upper arch when diagnosis is made considering the inter-arch relationship.

In regards to the intra-arch relationship, the percentage of constriction in the upper arch was significantly larger in the operated group than in the non-operated group. The same occurred in the lower arch, but without significance. This finding suggests the influence of palatoplasty on the upper arch shape, which reflects on the lower arch's tendency in

Table 6 - Distribution of upper arch shape in sample of 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Normal	Constriction
Non-operated	Incomplete	75.76	24.24
	Complete	66.67	33.33
	Total	74.36	25.64
Operated	Incomplete	48.15	51.85
	Complete	36.36	63.64
	Total	44.74	55.26
Overall sample		59.74	40.26

Table 7 - Distribution of lower arch shape in 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Normal	Constriction
Non-operated	Incomplete	90.91	9.09
	Complete	83.33	16.67
	Total	89.74	10.26
Operated	Incomplete	70.37	29.63
	Complete	63.63	36.37
	Total	68.42	31.58
Overall sample		79.22	20.78

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adjusting itself to the upper arch in the transverse dimension. A higher percentage of constriction was noted in both arches among the patients with complete cleft in comparison to those with incomplete cleft, but this difference was insignificant.

An important aspect of malocclusion is that the transverse problem does not compromise the prognosis of treatment – at least until the end of adolescence. It is possible to correct constriction of the upper arch in the primary, mixed and permanent dentition. The transverse dimension does not determine the prognosis of treatment.

CROWDING IN UPPER AND LOWER ARCHES

Crowding occurred in nearly 50% of the sample, more precisely in 46.75% in the upper arch and 51.95% in the lower arch. A part of the crowding was related to the constriction of both arches. Approximately 40% and 21% of the patients with isolated cleft palate had a diagnosis of constriction in the upper and lower arches, respectively.

On the upper arch, when the surgery factor is considered, crowding occurred in 65.79% of the operated patients and 28.21% of the non-operated patients. This significant difference suggests the influence of palatoplasty on the shape of the upper arch, because 55.26% of the operated patients exhibited constricted arches in comparison to the 25.64% of non-operated patients, also with a significant difference (Table 4).

In regards to the lower arch, no significant difference was found in crowding between groups, but once again there was a tendency towards larger crowding on the operated group (63.16%) in comparison to the non-operated group (41.03%). The same occurred when the lower arch shape is analyzed, with a larger number of arch constriction in the operated group (31.58%) compared to the non-operated group (10.26%).

Despite the lack of significance, more cases of crowding were found on the operated patients with complete cleft in both arches (90.91% for the upper arch and 72.73% for the lower arch), implying that the extension of the cleft is also involved on the shape of the dental arches after the surgical closure of the palate (Tables 8 and 9).

OVERBITE AND OVERJET

Approximately 20% of the patients exhibited increased overbite and overjet. It is likely that these are a part of the Class II malocclusion, while 32% of the patients exhibited an overjet ranging from edge-to-edge (17.72%) to anterior cross-bite (14.28%). When the surgery factor was considered, there was a greater sagittal discrepancy of the incisors on the patients that underwent palatoplasty. This fact is based on the reduction of the overjet and increased incidence of anterior crossbite (ACB) on the operated group in comparison to the non-operated group (Table 10).

The amount of anterior open bites (AOB) was 15%, by adding it to the edge-to-edge (EtE) relationship, vertical problems on the incisors affected 36.36% of the patients. The treatment prognosis is poor, mainly due to the tendency towards vertical mandibular growth in patients with isolated cleft palate. In all the groups studied, normal incisor relationship occurred

Table 8 - Distribution of alignment/crowding in upper arch in 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Alignment	Crowding
Non-operated	Incomplete	75.76	24.24
	Complete	50.00	50.00
	Total	71.79	28.21
Operated	Incomplete	44.44	55.56
	Complete	9.09	90.91
	Total	34.21	65.79
Overall sample		53.25	46.75

Table 9 - Distribution of alignment/crowding in lower arch in 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Alignment	Crowding
Non-operated	Incomplete	60.60	39.40
	Complete	50.00	50.00
	Total	58.97	41.03
Operated	Incomplete	40.74	59.26
	Complete	27.27	72.73
	Total	36.84	63.16
Overall sample		48.05	51.95

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Table 10 - Distribution of horizontal overjet in sample of 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Increased	Normal	EtE+ACB
Non-operated	Incomplete	21.21	54.55	24.24
	Complete	50.00	16.67	33.33
	Total	25.64	48.72	25.64
Operated	Incomplete	14.81	48.15	37.04
	Complete	9.09	45.46	45.45
	Total	13.16	47.37	39.47
Overall sample		19.48	48.05	32.47

Table 11 - Distribution of vertical overjet in sample of 77 patients with isolated cleft palate according to operated and non-operated subgroups and extension of cleft (in percentages).

		Increased	Normal	EtE+AOB
Non-operated	Incomplete	9.09	60.61	30.30
	Complete	16.67	33.33	50.00
	Total	10.26	56.41	33.33
Operated	Incomplete	33.33	29.63	37.04
	Complete	9.09	45.46	45.45
	Total	26.32	34.21	39.47
Overall sample		18.18	45.46	36.36

less in the operated group compared to the non-operated group, as reflected in the greater number of cases of increased overbite and anterior open bite in the former group (Table 11). The statistical relevance was null regarding the effect of the surgery factor and extension of the cleft on the incisor relationship.

CONCLUSIONS

On isolated cleft palate, malocclusions were found to have different manifestations, not only regarding inter-arch relationships (Class I, Class II and Class III) but also incisor relationships (overbite and overjet). The predominant morphological characteristics in these patients included Class II malocclusion, constriction in the upper arch and crowding in both arches. The influence of palatoplasty was restricted to constriction and crowding in the upper arch. The extension of the cleft had influence only over the crowding of the upper arch, which occurred more in patients with complete cleft.

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Evaluation of dry needling and 0.5% lidocaine injection therapies in myofascial pain trigger points in masticatory muscles

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Objective: The purpose of this study was to compare the effectiveness of trigger points injections using lidocaine 0.5% and dry needling without any kind of home-based rehabilitation program.

Methods: Sixteen patients with myofascial pain and trigger points in masticatory muscles were randomly assigned to two groups and received only one application session. The pressure pain threshold (PPT) was recorded before and after the injection: Ten minutes, 24 hours later, 7, 15, 21 and 30 days after the treatment. Visual analogue scale (VAS) was used to in all evaluation periods.

Results: There were no difference between groups for PPT, but for all groups the PPT during the time significantly increased when compared the before treatment. VAS showed differences between groups and during the time. The 0.5% lidocaine had the lowest VAS values when compared to dry needling, but at 30 days there were no differences among them.

Conclusion: Despite the differences in VAS and considering there were no differences in PPT increases, we concluded that, in this study, both groups were able to disrupt the mechanisms of trigger point and relieve the myofascial pain symptoms.

Keywords: Myofascial pain. Trigger point. Needling therapies.

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INTRODUCTION

The myogenic disorders have characteristics such as muscle pain (MP) tenderness, limited motion, weakness, among others. These changes may be reactions of changes not originate in the muscles, or process actually originated in the masticatory and cervical muscles.[27]

One of the conditions affecting the muscles and having a high prevalence is the myofascial pain (MFP). This painful process is originated in points of the muscle and due to local and systemic factors, cause muscle pain on both these points and distant structures.[6] The local muscle tenderness that triggers the process of pain from a distance is called trigger point (TP). The pain it causes in other regions is called referred pain (RP), which can manifest itself in other muscles, teeth, gums, temporomandibular joint (TMJ) and ears.[6,9,21]

The sensitivity of muscle is an important clinical sign, present in most patients with some type of temporomandibular disorder (TMD), reaching a frequency of 88.7%.[21] In the literature, this sensitivity is referred to as the pressure pain threshold (PPT) to be, more specifically, the point at which a patient feels that the increasing pressure becomes unpleasant pain sensation.[5] To assess the muscle sensitivity, the palpation method has been used either manually or with the aid of an algometer.[4,24,29] Studies that demonstrate the application of algometers for determining the PPT show that these devices are reliable sources and the results are in good to excellent reproducibility, and thus a useful tool to evaluate the initial condition of the patient and also the progress of treatment.[13,17] The term MP acquired two meanings. One of them is the regional muscular pain associated with muscle tenderness according to Research Diagnostic Criteria (RDC / TMD), and the other on the MP caused by TP which consist of a hyper-focal muscle irritability.

Studies have concluded that the algometer can reliably quantify and measure the TP sensitivity and the active tip of the algometer is important because if not the correct size, can lead to a misinterpretation and a consequent increase in the values read.[5,22]

Another study determined a pressure capable of stimulating pain response in patients with signs and symptoms consistent with TMD, when compared to a control group. Women in both groups were palpated by a single examiner on the following points: Body of masseter, anterior temporal, middle temporal and posterior temporal. We obtained a specificity of 90.8% for PPT values of 1.5 kg/cm^2 for the masseter, 2.47 for the anterior temporal kg/cm^2, 2.75 kg/cm^2 to 2.77 kg/cm^2 and middle temporal for later time. The authors concluded that palpation proved to be a reliable test for detecting muscle tenderness in TMD patients.[24]

Regarding the treatment of trigger points, there are several studies on the effectiveness of each one, dealing only with the needling, injection of anesthetics, injection of corticosteroids and botulinum injection. Reports of success vary and may or may not be complete remission of signs and symptoms. When this happens, some factors may be associated, such as local twitch response (LTR) during the needling and the subsequent increase in PPT.[8,12,15,16] To sum up, the studies conclude that the injected substances seem to have a role in remission of MP symptoms, always suggesting a more conservative and less costly treatment to patient.[2,7,10,14]

Due to these factors, this study aims to compare, using algometry and visual analysis scale (VAS), the effectiveness of dry needling in the treatment of patients with MFP, when compared to needle injection of anesthetic solution of lidocaine hydrochloride 0.5%.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of the Bauru School of Dentistry, University of São Paulo, under protocol No. 174/2004.

The inclusion criteria were intended to exclude factors that could predispose to TMD.[20] Also excluded were those who presented: History of facial or neck trauma, limitation of movement in the cervical region, active periodontal disease or tooth decay, do not conform to the classification of the RDC / TMD for muscle aches, have made use of anti-inflammatory or analgesic in the last 72 hours, systemic symptoms, physical or mental disability; not agree to participate. After filling out the questionnaire and interview, if the parties did not present any of the above conditions, was carried out physical examination for the diagnosis of TMD.

We collected the personal data of volunteers, chief complaint, history of current condition and medical and dental history. They completed a questionnaire to determine the TMD index, composed of

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10 questions, which allowed the determination of the intensity of the framework of a TMD.

Scores were used: "0" (zero) for no pain, "1" to report mild pain (the patient reports that it hurt a little), "2" for moderate pain (patient responds with eyelid reflex) and " 3 "for severe pain (the patient reacts away from the face). At this stage, if the patient was diagnosed with a TP in the masseter or temporal, it was held to fill the form of RDC / TMD.

Some modifications to the RDC / TMD were performed: replaced the palpation of the lateral pterygoid muscle by palpation of the deep portion of masseter, due to clinical and anatomical impossibility of palpation of this muscle[25,28,29] and digital pressure applied during palpation of the muscles in physical examination was approximately 1.5 kg for extra-oral muscles instead of 2 pounds (0.90 kg) and 1 kg instead of 1 pound (0.45 kg) to the joint and intraoral muscle.[24]

Algometer was used by the examiner for calibration of the pressure exerted during palpation.

Before distributing the patients in the groups and starting treatment, the VAS and the PPT were measured, so that the patients were allocated in groups presenting the same levels of VAS and similar PPT.

By an algometer, PPT was quantified before treatment (baseline). The values of the time required for maintaining the pressure that cause referred pain, area of manifestation and VAS were recorded.

The groups were named according to the type of treatment and recorded in the patient's general form:

» Group I: Patients who underwent needling and injection of the anesthetic lidocaine hydrochloride 0.5%.

» Group II: Patients who underwent dry needling.

The injections were performed using a 3 ml disposable syringes (BD Plastipak™), Luer Lock® with disposable needles 0,45x13 26 G 1/2 (BD PrecisionGlide™). The amount of anesthetic solution injected was 1ml.[27]

PPT measurements were made in the following times after the needling: 10 minutes, 24 hours[7,15,21] and 30 days. A total of seven measurement times were performed. Also, the presence of referred pain and the area of expression were evaluated.

The VAS was assessed before needling (initial) and after, at the following times: 10 minutes, 24 hours, 7, 15, 21 and 30 days.

The patients excluded from the sample or those who still had some symptoms at the completion of the study received the care they need.

All examinations were performed by a single examiner. Before the exams, the examiner underwent training for familiarization with the algometer and standardization of the examination in relation to the rate of force application, pre-set at approximately 0.5 $kg/cm^2/s$.[18,23,24] This step received the supervision of an experienced professional. The examiner was not the same who applied treatment and the patient did not know into which group was inserted.

Statistical analysis

After collecting the results we applied the two-way ANOVA adopting a significance level lower than 0.05. If there were differences, we applied the Tukey test to detect in which groups there were differences.

RESULTS

We examined 423 individuals of which 20 female patients were selected. These patients who consent to participate in this study, were presenting myofacial pain according to RDC / TMD, with the presence of TP in the masseter muscle and referred pain.

After the division of groups, 2 patients expressed wish to not participate further in the study and two others did not appear on the appointed days to return. A total of 16 patients were divided into two equal groups.

PRESSURE PAIN THRESHOLD

We applied the ANOVA to determine whether there were statistically significant differences between groups. No statistically significant differences were present when comparing the PPT before treatment (initial) between groups ($p > 0.05$). The PPT had an initial average of 1.05 kgf/cm^2.

When the period of data collection and tabulation were finished, we applied the two-way ANOVA. There were no differences between groups, independent of time ($p > 0.05$).

By observing the interaction between time, regardless of group, there was a statistically significant difference. Then, the Tukey test was applied for multiple comparisons between the periods analyzed (Table 1).

Statistical difference was found between the time before and immediately after treatment. The same difference was presented between times 24 hours and 7, 14 and 30 days, and between 21 days and

30 days. It means that an increase in the amount of pressure needed to cause pain at the site of palpation was observed (Table 2).

In some patients, the RP process has not been removed, which means the TP structure is still formed. In the group I, there were two patients with RP after 30 days. In group II, there were no patients with RP.

In the VAS evaluation, there was a statistically significant difference between groups and times.

For better understanding, the time difference within each group will be examined initially (Table 3 and 4).

In the comparison between groups within each time, it is seen at the beginning the average of VAS had no differences and significant variation happened between groups over time, but, at the end, there were no differences between the groups I and II.

DISCUSSION

The mean value obtained for the PPT before treatment in patients with MFP in the study was 1.05 kg and are partly according to the literature.[5] There are studies that had higher values, but the areas examined were not the same. However, the authors argue that the PPT is less than in asymptomatic individuals, which agrees with our findings and also with other studies.[9,24] In our study, the results show no statistically significant differences between groups I and II. These findings are not new if we seek some results in literature. Studies conclude the same results can be satisfactory even changing the injected substance, but these were not performed in the masticatory muscles.[8,12,14,26]

In a systematic review,[2] it was found that the nature of the injected substance does not matter in the

Table 1 - PPT among groups over the time.

	PPT_INIT	PPT_IMMED	PPT_24H	PPT_7	PPT_21	PPT_30
	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)
Group I	1.063 (0.133)	1.236 (0.351)	1.139 (0.326)	1.281 (0.434)	1.286 (0.356)	1.560 (0.088)
Group II	1.081 (0.237)	1.194 (0.196)	1.264 (0.121)	1.444 (0.199)	1.550 (0.169)	1.604 (0.164)

Table 2 - PPT over the time regardless group.

Time	Mean PPT
Initial	1.070278 [a]
Immediate	1.197674 [b]
24 hours	1.199236 [b]
7 days	1.305799 [bc]
14 days	1.322986 [bc]
21 days	1.414375 [c]
30 days	1.573924 [d]

Values designated with the same letter are not statistically different.

Table 3 - VAS variance over the time.

Time	Mean VAS
Initial	9.4375 [a]
24 hours	6.8875 [b]
7 days	4.6875 [c]
14 days	1.1625 [d]
21 days	0.125 [d]
30 days	0 [d]

Values designated with the same letter are not statistically different.

Table 4 - VAS variance over the time.

Time	Mean VAS
Initial	9.4 [a]
24 horas	8.533334 [a]
7 days	5.233333 [b]
14 days	5.011111 [b]
21 days	1.433333 [c]
30 days	0.122222 [d]

Values designated with the same letter are not statistically different.

Table 5 - VAS among groups.

VAS		
Time	Group I	Group II
Initial	9.6 [a]	9.4 [a]
24 horas	6.8875 [c]	8.533334 [d]
7 days	4.6875 [e]	5.2333 [ef]
14 days	1.1625 [g]	5.011111 [h]
21 days	0.125 [i]	1.433333 [i]
30 days	0 [k]	0.122222 [k]

Values designated with the same letter are not statistically different.

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final result. Dry needling is as effective as needling with the inoculation of some kind of substance. They found no convincing scientific evidence that needling has an effect beyond placebo in myofascial pain.[2] This study also comments on the limitations of the study as not specify whether patients had TP. Another aspect is in relation to diagnostic criteria, which would be the combination of muscle tenderness in a palpable band of a skeletal muscle and the onset of pain, stating that the effect of the emergence of LTR appears to be more important than the type of substance injected, but this type of analysis was only considered in a single study. The authors[2] conclude by saying that although one can not scientifically say that there is some advantage in using the needle, regardless of whether or not injecting some kind of substance, it is recommended to its implementation, since it is the most safe and comfortable to the patient.[2]

Although there are no differences between the groups when examined separately and over time, while comparing the values of PPT it was noticed an increase in the amount of pressure necessary to have a painful site process. This painful process in most of the time was not accompanied by the presence of RP anymore. Other studies support our findings, in that there be an increased PPT and also in some cases, no change thereof. Relief of TP symptoms occurs regardless of whether or not applying lidocaine. They noted that it was more important to obtain the LTR, as in cases that do not got this answer, no remission of symptoms was perceived. Moreover, in cases that had some type of RP process, may have been stimulation of latent TP, which can occur when we provoke the trauma generated by the needle.[8,11,16] This factor may explain the fact that at the end of the study some patients had the RP process even if the pressure was higher than those recorded in previous periods. Another fact is that only one injection was performed, which may not have been enough to neutralize all satellites TP and also no patient counseling was perform, such as stretching, hot packs or other methods that are cited in literature. Regarding the increase in the PPT immediately observed other studies support it, but often the patient stills reporting the referred pain, which is equal in the experiment.[11,15] This phenomenon can occur because there may be the existence of satellites TP around the injected TP. These points would then not eliminated by the process and due to mechanical trauma, these satellites TP can be activated, which leads to maintenance of the RP and often not change PPT.[8,10,11,16]

The initial PPT averaged was 1.05 kg, and reached the final values of 1.57 kg. This final value is close to normal in healthy individuals, about 1.5 kg for masseter muscle.[24] Other studies also say that healthy muscles have higher PPT than those muscles affected by MP.[16,18,22]

When assessing the results of the VAS of pain, the findings were somewhat different. Regarding the decreased level of pain scored by patients, all groups had a statistically significant decrease over time, and all groups reached values equal to zero, if not close it, or came from the vicinity of the "worst pain imaginable" to close the "no pain". This decrease is consistent with the increase of the PPT, because if there was a remission of symptoms, there was a real effectiveness of treatment and consequent decreased sensation of pain experienced by patients, and this was shown by other studies.[7,11,13] A decrease between 28 and 22 mm on the VAS reading was enough to show the effectiveness of the therapy. These findings may be extrapolated to a population with MFP in general. The decreasing of 20-30 mm in VAS relative to the baseline may be clinically relevant to successful treatment.[3] This finding is confirmed on the results.[1,30]

CONCLUSION

Based on the results that were presented, it is possible to conclude that there are no differences between the applied treatments for the relief of MFP and that all groups decreased the patient's sensation of pain measured by VAS and increased the PPT, even in a short period evaluation. The presence of TP related symptoms in some patients indicates that the treatment may require more than a single approach of injections or interaction with other specialties. It would be interesting in future studies to carry out placebo groups for the verification of its effect on patient response.

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Prevalence of non-nutritive sucking habits and its relation with anterior open bite in children seen in the Odontopediatric Clinic of the University of Pernambuco

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Objective: The aim of this work was to establish the prevalence of non-nutritive sucking habits (pacifier and/or digit sucking) and to assess its relation with anterior open bite.

Methods: The sample consisted of 980 records of children of both genders, with ages between 3 and 12 years, who were treated at the Pediatrics Clinic of the University of Pernambuco (FOP/UPE), from February 2000 trough December 2005, both sexes. Pearson's Chi-square test at 5% level of significance was used for statistical assessment.

Results: It was observed that 17,7% of the sample had some habit at the moment of the anamnesis (9,6% of digit sucking habit, 8,8% of pacifier sucking habit and 0,7% of both habits) and that the prevalence of open bite was 20,3%. The prevalence of sucking habits in girls was much higher than in boys (22,6% and 12,9%, respectively) and this difference was statistically significant (p = 0,000). A correlation between habits and open bite was proved statistically (p = 0,000): Children with sucking habits had 8 times more chances of developing anterior open bite.

Conclusions: Anterior open bite was associated to the presence of non nutritive sucking habits; sucking habits were more prevalent in girls and in children between three and six years of age.

Keywords: Habits. Open bite. Suction. Prevalence.

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INTRODUCTION

Suction is a primitive and innate reflex, which starts on the 29th week of intrauterine life and is one of the earliest patterns of behavior exhibited by the newborn.[33] It is crucial for the survival of the newborn and is responsible for the first emotional link with the mother.[8]

In the early years of life, muscle exercises carried out by suction during breastfeeding promotes the correct development of the structures of masticatory system, through the balance of muscular forces of inner and external containment.[4]

Whenever there is a disturbance of these forces, dentofacial deformations will occur in regions of atypical pressures. It is what happens in the presence of non-nutritive sucking habits, bringing a series of disorders to the stomatognathic system, i.e., a reduced vertical growth of the anterior portion of alveolar process, upper incisors proclination and anterior displacement of maxilla due to horizontal force. The lower incisors can undergo proclination or even retroinclination, in owing to the tension of lower lip, to the tongue during swallowing and/or to the presence of the digital pressure.[35]

Therefore, the dental arch form depends on a harmonious balance between all the soft tissues that surround it. Any change in this muscular balance, along with the other causes, may cause a malocclusion, especially when this balance is broken by a detrimental oral habit.[2] The habit, on its turn, is originated by the repetition of an act, which becomes unconscious and starts to be incorporated into the personality of an individual.[29]

Some oral habits are part of the behavior of small children, however they may become harmful or damaging when occurring in a extensive or inappropriate way. Nevertheless, the harmful effect of prolonged sucking habits in the development of occlusion and facial growth of the child depends on some parameters like: Duration, frequency and intensity of sucking habits (Graber's triad), position of the pacifier in the mouth, age when the habit was ceased and growth pattern of the child.[11,16]

The extensive duration of non-nutritive sucking habit has been strongly associated with anterior open bite,[1,9,15,18,23,37,42,43] which is defined as the presence of negative overbite existing between the incisal edges of upper and lower anterior teeth.[31]

Children in pre-school age, presenting non-nutritive sucking habits, have four-fold risk in developing open bite compared to children not presenting such habits[41]. Worth noting, however, is that the self-correcting of this malocclusion is observed if the deleterious habits cease during the period the deciduous dentition and beginning of mixed.[18,22,27]

Within this context, This study aimed to verify the prevalence of non-nutritive sucking habits and its relationship to anterior open bite in children assisted in the clinic of Pediatric Dentistry, Faculty of Dentistry of Pernambuco (UPE/FOP).

MATERIALS AND METHODS

The sample consisted of 980 records of children from 3 to 12 years of age, of both genders, who were treated at the pediatric clinic of Dental School of the University of Pernambuco (FOP/UPE) from February of 2000 to December of 2005. The legal guardians of the patients signed a free and informed consent allowing the analysis and publication of data collected.

The database was composed of information about gender, date of birth, year of anamnesis, presence or absence of non-nutritive sucking habits, type of sucking habit (pacifier and/or digital sucking), type of dentition (deciduous or mixed), and presence or absence of anterior open bite. In order to simplify data analysis, it was decided to divide the sample into age (3 - 6 years, 7 - 9 years and 10 - 12 years).

The results were analyzed using the software Statistical Package for the Social Sciences (SPSS), version 11.0. Pearson's Chi-square test (x^2) and Fisher's exact test, whenever x^2 couldn't be performed, a significance level of 5% were used for data analysis.

RESULTS

The sample consisted of all patients seen in the Pediatrics Clinic of FOP/UPE, from 3 to 12 years old with the purpose of obtaining a representative sample.

After data analysis it was verified that 17.7% of children were exposed to non-nutritive sucking habits (9.6% digital sucking, 8.8% pacifier sucking and 0.7% digital and pacifier sucking) and that 20.3% presented anterior open bite.

In this study there was difference between

genders regarding the prevalence of non nutritional sucking habits, with the girls showing a higher prevalence of sucking habit (Table 2).

In Table 3, the prevalence of sucking habits according to age group can be seen. It was significantly greater in the age group between 3 and 6 years of age (p = 0.022) and there was a reduction of habits prevalence with age increase.

A significant association could be observed (p = 0.000) between sucking habits and the previous open bite.

The anterior open bite was more prevalent in females (24.4%) than in males (16.3%), and this difference was statistically significant (Table 5).

Table 1 - Prevalence of anterior open bite and non-nutritive sucking habits.

Variables	Present	Absent	Total
	n (%)	n (%)	n (%)
Anterior open bite	199 (20.3)	781 (79.7)	980 (100.0)
Sucking habit (digital and/or pacifier)	173 (17.7)	807 (82.3)	980 (100.0)
Digital sucking	94 (9.6)	886 (90.4)	980 (100.0)
Pacifier sucking	86 (8.8)	894 (91.2)	980 (100.0)
Digital and pacifier sucking	7 (0.7)	973 (99.3)	980 (100.0)

Table 2 - Prevalence distribution of sucking habits, according to gender.

Gender	Sucking habit			p Value
	Present	Absent	Total	
	n (%)	n (%)	n (%)	
Male	64 (12.9)	433 (87.1)	497 (100.0)	p = 0.000(1)
Female	109 (22.6)	374 (77.4)	483 (100.0)	

(1) By Pearson's chi-square test. OR = 0.507; IC = 0.362 - 0.711.

Table 3 - Prevalence distribution of non-nutritive sucking habit according to age.

Age	Pacifier sucking habit			p Value
	Present	Absent	Total	
	n (%)	n (%)	n (%)	
3 to 6 years	76 (22.1)	268 (77.9)	344 (100.0)	p = 0.022(1)
7 to 9 years	62 (16.1)	323 (83.9)	385 (100.0)	
10 to 12 years	35 (13.9)	217 (86.1)	251 (100.0)	

(1) By Pearson's chi-square test

Table 4 - Association between anterior open bite and non-nutritive sucking habits.

Sucking habit	Anterior open bite			p Value
	Present	Absent	Total	
	n (%)	n (%)	n (%)	
Present	94 (54.3)	79 (45.7)	173 (100.0)	p = 0.000(1)
Absent	105 (13.0)	702 (87.0)	807 (100.0)	

(1) By Pearson's chi-square test. OR = 7.955; IC = 5.535 - 11.453.

Table 5 - Anterior open bite prevalence, according to gender.

Gender	Anterior open bite			p value
	Present	Absent	Total	
	n (%)	n (%)	n (%)	
Male	81 (16.3)	416 (83.7)	497 (100.0)	p = 0.002(1)
Female	118 (24.4)	365 (75.6)	483 (100.0)	

(1) By Pearson's chi-square test. OR = 0.602; IC = 0.439 - 0.826

DISCUSSION

Digital and pacifier sucking habits have been the subject of research for many years. In this study, the prevalence of sucking habits was lower than what other have reported,[21,23] this was probably due to the wide-range of ages in the studied sample, since children from 3 to 12 years of age were evaluated.

Girls showed a higher prevalence of sucking habits than boys. These results agree with other papers which point out the existence of a cultural feature of differentiation between genders in relation to sucking habits.[19,25,32,34]

Studies show that the non-nutritive sucking habits are common among children in pre-school age.[6,23,40,41] These data have been ratified by the results found in this study. It was possible to see a reduction of habits prevalence with age increase, indicating a natural tendency of the children to cease such habits.[1,18,22]

The results of this study clearly showed the influence of non-nutritive sucking habits in the presence of anterior open bite. Children with sucking habits had almost 8 times more chance of showing anterior open bite.

There is a consensus on the literature, that non-nutritive sucking habits increase the risk factors for skeletal malocclusions, particularly on the anterior open bite.[1,5,6,10,14,17,23,24,37,40,41,43] The presumable cause of anterior open bite in children with sucking habits is the vertical growth inhibition in the anterior part of alveolar process, but if the habit ceases during the growth phase, the possibility of spontaneous correction could be very satisfactory.[28] A gradual reduction in the prevalence of anterior open bite was observed, possibly due to occlusal development itself by the maturation of the individual, what facilitates the elimination of deleterious habits by the adenoids size decrease and by the establishment of a normal adult swallowing, due to the removal of external causal factors.[7,13,38]

Differences were found between the genders in regards to the prevalence of malocclusion, differing from the findings of other authors.[20,36] This difference can be explained by the higher prevalence of sucking habits observed in girls, since the presence of malocclusion was strongly associated with such habits.

Due to the transversal nature of this study, it was not possible to verify if children without sucking habit and that showed anterior open bite had some kind of sucking habit before the examination.

Given the results found and in regards to preventive measures, an early intervention on these habits is suggested. This can be done through guidance and awareness of patient and/or guardians,[44] in order to prevent or intercept the appearance of unwanted occlusal changes, which can become more complex and may involve more expensive treatments.[39] Moreover, the elimination of sucking habits between four and six years of age can allow a self-correction of anterior open bite.[3,12,22,26,30]

CONCLUSIONS

Based on obtained results it can be concluded that:

- The prevalence of digital and pacifier sucking habits were 9.6 and 8.8%, respectively.
- Non-nutritive sucking habits were more prevalent in females, in children ranging from three to six years of age.
- The anterior open bite was associated with the presence of non-nutritive sucking habits and was more prevalent in females.

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Photometric study of divine proportion and its correlation with facial attractiveness

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Objective: The aim of this study was to evaluate if there is correlation between perception of facial esthetic and divine proportion, verifying if most attractive faces are closer to and less attractive faces are more distant to this proportion.

Methods: Standard facial photographs (frontal and lateral) in natural head position were taken of a sample of 85 Brazilian Caucasian women, with mean age of 23 years and 9 months. The photographs were evaluated by 5 orthodontists, 5 artists and 5 laymen and were classified, according to their subjective analysis of facial esthetic, in pleasant, acceptable and not pleasant. Frontal photographs were evaluated by divine proportion analysis using the computerized method.

Results and Conclusions: According to subjective analysis the sample consisted 18.8% of pleasant, 70.6% of acceptable and 10.6% of not pleasant faces. After statistical analysis, a lack of agreement was verified in esthetic facial preferences among the three groups of observers. It was also possible to verify that in this research there was no correlation between perception of facial beauty and divine proportion.

Keywords: Divine proportion. Facial analysis. Golden section. Facial esthetic.

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

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INTRODUCTION

It's known that the main reason that moves a patient to seek orthodontic treatment is the search for improved facial esthetics[10,23] and, in this regard, evaluation of soft tissue is of the utmost importance for orthodontic planning.[1] So, as the orthodontists have increased their ability to modify the face, the need to understand what is beautiful or not has been intensified[1]. This perspective requires orthodontists to approach the expectations of their patients, considering facial esthetic and the smile as the main treatment objective.[23]

Due to limitations in the evaluation of soft tissue through cephalometric analyses and the complexity involving facial esthetics, several researchers began to advocate the use of numerical and proportional facial analysis directly on the face of patients[1] or through the study of photographs.[2,3,7,10,11,17,20,25,27]

The direct clinical examination of the face of patients has limitations as the sensitivity of some tissues and the compression of others, that lead to technical errors[2] and makes measuring more difficult, and also does not allow future diagnostic comparisons or researches.[22] Thus, the photograph becomes a basic tool for facial analysis,[2] having the advantages of not exposing patients to ionizing radiation, being of low cost and providing a better assessment of facial harmony.[5] However, in order to allow for the use of this method in a scientific way, the standardization for obtaining photographs became necessary.[10,15,22]

With this purpose, the Natural Head Position (NHP) has been employed for being a standardized and reproducible position[7,16] in an erect posture with eyes focused on a point located at the same level, implying a horizontal visual axis, which can be more effectively achieved by using a mirror.[4]

Because of the variations that exist between genders and ethnic, racial and demographic differences, the use of proportional assessments stands out for the study of facial esthetics rather than absolute values pre-established as is observed in numerical facial analysis.[12] In this way, facial proportion analyses emerged, including the divine proportion.

Divine proportion applications, which can also be called the golden section, are known since antiquity. This theory states that humans, for some reason, has esthetic preference for objects, geometric figures, buildings, among others, presenting this proportion or at least very close to it.[8] This relationship can be observed on the face and in the relationship between the smile and face[14] therefore, several authors have used and advocated the use of the golden section in facial[8,19,25] and cephalometric[8,9,11,19,25,26] analyses.

The golden section is obtained through asymmetric division of a line in order to maintain a proportion such that the largest segment is to smallest as well as the sum of both is for the largest.[26] The largest portion of this line is always 1,618 times the smaller size and this corresponds to 0,618 times the length of larger.[25]

In the 80's, Ricketts[24,25] was a great divine proportion enthusiast, studying and publicizing its connection with facial harmony. Since then, researches using this concept were developed in order to individualize orthodontic diagnosis.[9,19]

The divine proportion does not adhere to populational means obtained in researches carried out in specific groups. In this way, it can be applied to anyone regardless of gender, age, ethnicity, race and demographic differences. The easiness and rapidity of its execution are other advantages attributed to this analysis. In this way, for the development of this research we employed the divine proportion facial analysis in frontal facial photographs, taking as reference the studies of Ricketts[25] in 1982.

Therefore, this work aims to contribute to orthodontic diagnosis through facial analysis, proposing to:

1. Characterize the sample through subjective analysis of facial esthetics performed by a board of evaluators, in esthetically unpleasant, esthetically acceptable and esthetically pleasing.
2. Verify if there is a correlation between orthodontists, lay people and visual artists on the evaluation of facial esthetics and if an intergroup lack of agreement is found, check what is the trend of judgement between the three different areas of professional activity composing the board of evaluators.
3. Check the possible association between the perception of facial beauty and the divine proportion, in this way determining, if the subjects considered most attractive present this proportion and the less attractive are different from it.

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MATERIAL AND METHODS

Material

The sample used for the preparation of this study comprised 85 randomly selected women, Brazilian, Caucasian, with an average age of 23 years and 9 months ranging from 18 years and 7 months to 30 years and 3 months, which have not undergone any type of plastic surgery in the head and neck region and that were willing to voluntarily participate in this survey.

Only women were selected in order to characterize and individualize the sample. Furthermore, this work was part of a series of surveys conducted to study feminine facial esthetics through many facial analyses, both numeric and proportional.

A prior orthodontic treatment was not an exclusion factor for the participation in this research, and occlusal issues were not considered in the selection of the sample, because good facial esthetics may be associated with malocclusions and normal occlusions.[5] Neither was the objective of this survey to relate facial esthetics with the occlusion.

The photographic records of the sample were made using: Canon EOS Rebel XT digital camera, macro lens 100/35 mm circular flash Canon Vivitar tripod, a plumb and line as true vertical reference, a rectangular mirror, a projection white screen for background standardization and a strip of fabric to hold the hair.

The program used for the method was the Radiocef Studio 2® (Radio Memory Ltda., Belo Horizonte, Brazil) in a HP Pavilion dv6000 computer.

METHOD

Photographic record

Standardized frontal and lateral facial photographs were carried out. The individuals were photographed seated, maintaining an upright position, natural and normal, with both arms hanging freely along body, corresponding to the natural head position (NHP) of Broca,[7] and this is the position in which the individual remains daily.[29] To assist in achieving the NHP, a mirror was positioned on the height of the eyes of the individuals so that they could fix the gaze on their pupils. A projection white screen was placed for the background, in such a way that the environment would not influence the evaluation, and as a true vertical reference, a plumbline[16] was tied to the screen support so that it was visible in the photograph.

The camera remained fixed on a tripod. The focal distance was 1.70 m, the shutter speed 1/200 and the lens aperture F29. As a source of light, a circular flash was used. In order to view all points of reference for the proposed facial analysis (in special *Trichion*) a hairband was used on all participants.

All photographs were printed in color, matte paper, 10 cm x 15 cm in size, at the same time and in the same photo lab, QLab standard (Kodak international standard quality).

No method was used to measure the distortion between the actual size of the face and the size of the photo, since only proportional measures were studied and in this way, size variations makes no difference in the final result.[25]

Sample classification method

For sample classification by facial esthetics subjective analysis, a board was selected consisting of 15 individuals divided into three groups of professional activity, as follows: 5 orthodontists; 5 visual artists, professors from the Faculty of Fine Arts of Paraná; 5 lay persons to dental area and not involved in any artistic activity, all residents in the city of Curitiba.

Each evaluator received a set of 170 photos corresponding to frontal and sides shots of 85 individuals from the sample, with each one receiving just one score.

The participants of the board were instructed to analyse all photographs at the same time and to classify individuals according to their own criteria for facial esthetics, giving scores between 1 and 9,[15,22] considering the score 1 the lowest and 9 the greater degree of attractiveness.

From these scores, the sample was divided into three groups: Esthetically unpleasant, esthetically acceptable and esthetically pleasant.[15,22]

Individuals with average grades 1, 2, 3 and 4 were classified as esthetically unpleasant (Group I); with average grades 5 and 6, as esthetically acceptable (Group II) and with average grades 7, 8 and 9 as esthetically pleasant (Group III).

Analysis of frontal facial divine proportion

The frontal facial photos were analyzed through the program Radiocef Studio 2® on a flat panel monitor. The analysis of frontal facial divine proportion was created through the Mixcef

tool provided by the software, where all necessary points are generated, and then 8 vertical and 3 lateral segments were determined, and through mathematical expressions gave rise to 8 factors. These were numbered of "Φ 1 to Φ 8" and corresponded to 6 vertical measures of frontal facial divine proportion and 2 transversal, which will be described later.

Photometric reference points

Photometric employed points (Fig 1) were proposed by Ricketts[25] in 1982:

TRI - (Trichion) - point determined by the hairline on the forehead midpoint in young subjects;

LCr - (Lateral Canthus right) - point located in the lateral corner of right eye;

LCl - (Lateral Canthus left) - point located in the right corner of left eye;

LNr - (Lateral Nasal right) - point located on the external portion of the right wing of the nose;

LNl - (Lateral Nasal left) - point located on the external portion of the left wing of the nose;

ALr - (Right Alar Edge) - point located on the top edge of the right wing curvature of the nose;

ALl - (Left Alar Edge) - point located on the top edge of the left wing curvature of the nose;

CHr - (Right Chilion) - point located in the outermost portion of the labial commissure, in the right angle of the mouth;

CHl – (Left Chilion) – point located in the outermost portion of the labial commissure, in the left angle of the mouth;

ME – (Tegumentary Menton) – point located on tegumentary menton in correlation with the osseous menton point.

Due to peculiarities relevant to the program used, in the vertical frontal facial analysis all points were orthogonally projected over the true vertical line (TVL) and proportional measures were performed on it by the point to point distance. For the proportions that involved lines formed by the union of two points, the midpoint between them was found and then was projected over the TVL (Fig 1).

Vertical frontal face measures of divine proportion

The vertical frontal face analysis of divine proportion was performed employing a selection of measurements proposed by Ricketts,[25] 1982 (Fig 2).

Φ 1. Trichion - Lateral Canthus // Lateral Canthus - Menton;

Φ 2. Menton - Alar Edge // Alar Edge - Trichion;

Φ 3. Lateral Canthus - Alar Edge // Alar Edge - Menton;

Φ 4. Chilion - Menton // Chilion - Lateral Canthus;

Φ 5. Alar Edge - Chilion// Lateral Canthus - Alar Edge;

Φ 6. Alar Edge - Chilion // Chilion - Menton.

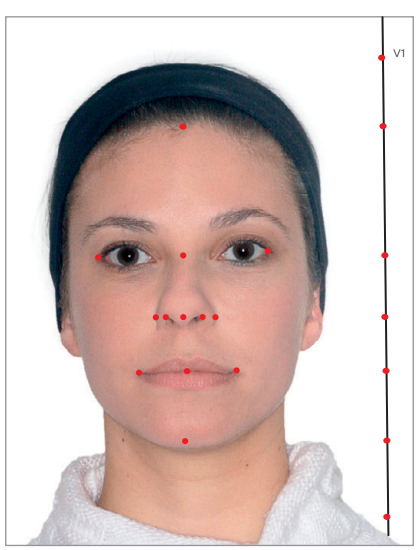

Figure 1 - Reference points used in the analyses of the frontal facial divine proportion. The TVL was determined by the union of the points V1 and V2.

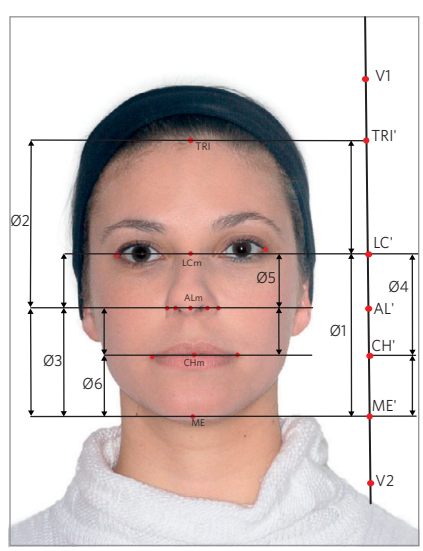

Figure 2 - Measurement of the vertical frontal facial divine proportion.

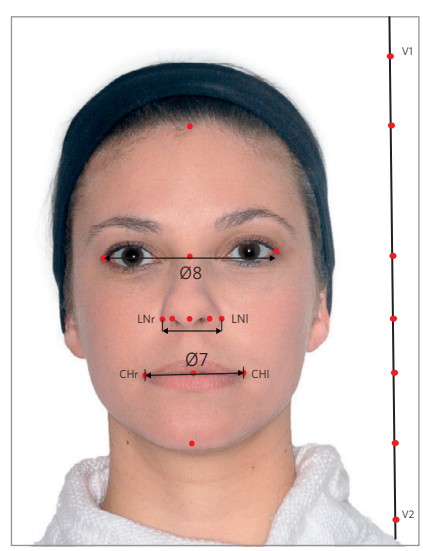

Figure 3 - Measurement of the transversal frontal facial divine proportion.

Transversal frontal face divine proportion

For the analysis of the divine proportion in transversal frontal face photographs two variables proposed by Ricketts[25] were verifyed (Fig 3).

- Φ 7. Right Lateral Nasal - Left Lateral Nasal // Right Chilion - Left Chilion;
- Φ 8. Right Chilion - Left Chilion // Right Lateral Canthus - Left Lateral Canthus.

To verify if quantities analyzed were or were not in the divine proportion, we used the method described by Gil and Medici Filho,[9] that is based on the following concept: A couple of measures (a, b) is in the golden ratio if a/b = b/(a+b), where a < b. The difference between ratio |a/b = b/(a+b)| is called delta and this will be null when the pair of measures is in divine proportion.

Statistical analysis

Through statistical analysis the information corresponding to the sample, mean, standard deviation, minimum and maximum value observed, median and coefficient of variance, was obtained. The level of agreement among the three groups of observers on subjective analysis of facial esthetics was calculated by the Kappa index and by the percentage of evaluators in agreement, always by pairwise comparison of groups.

For the statistical evaluation of frontal facial analysis of divine proportion, the median value was used because the coefficient of variation found was high. Therefore, a non-parametric test for paired data was applied, in this case, the Kruskal-Wallis test. The significance level used was less than 5% (p<0,05).

The reliability of measures used (error of method evaluation) was analyzed by selecting, at random, 20 photographs in which new tracings were performed with one week interval. For casual error analysis, we applied the Dahlberg's formula. For the evaluation of systematic error, the data obtained was subjected to the non-parametric Wilcoxon test.

RESULTS

The results obtained were subjected to statistical analysis and are presented in Tables 1, 2, 3 and 4.

DISCUSSION

Despite the eminently subjective character for beauty perception,[1,6,13,18] it becomes necessary to acknowledge and study facial esthetics, to bear in mind the concept of "normality" serving as a guide during orthodontic treatment planning. It is in this sense that extensive research has been developed, seeking to find standard average values, both numeric and proportionate, to obtain an objective facial analysis.

This survey was conducted in order to evaluate the facial pleasantness and its relationship with divine proportion in frontal images. With the results of subjective analysis of facial esthetics it was observed that 18.8% of the sample studied was classified as

Table 1 - Subjective concept of facial esthetics.

Concept		Number	Percentage
Unpleasant	(Group I)	16	18,8
Acceptable	(Group II)	60	70,6
Pleasant	(Group III)	09	10,6
TOTAL		85	100,0

Table 2 - Kappa coefficient of agreement between observers.

Observers			% Agreement	Kappa	Interpretation[1]
Lay	X	Visual Artists	41.2	0.2026	Slight
Lay	X	Orthodontists	18.8	-0.0507	Poor
Visual Artists	X	Orthodontist	45.9	0.2795	Regular

Table 3 - General average score by different groups of observers.

Mean score	Lay		Visual Artists		Orthodontists		Total	
	n	%	n	%	n	%	n	%
1, 2, 3, 4	26	30.6	21	24.7	06	7.1	53	20.8
5, 6	55	64.7	53	62.3	58	68.2	166	65.1
7, 8, 9	04	4.7	11	13.0	21	24.7	36	14.1
TOTAL	85	100.0	85	100.0	85	100.0	255	100.0

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Table 4 - Descriptive statistics of facial analyses factor of divine proportion in the studied groups.

Data	n	Mean	Standard deviation	Min	Max	Median	p value*
Φ 1) TRI-LC // LC-ME"	85	0.08	0.08	-0.09	0.28	0.08	0.627
• Unpleasant	16	0.07	0.11	-0.09	0.24	0.08	
• Acceptable	60	0.08	0.08	-0.09	0.28	0.08	
• Pleasant	09	0.10	0.06	0.01	0.19	0.10	
Φ 2) ME"-AL // AL-TRI	85	0.04	0.08	-0.14	0.24	0.04	0.392
• Unpleasant	16	0.05	0.10	-0.09	0.24	0.06	
• Acceptable	60	0.04	0.07	-0.14	0.18	0.05	
• Pleasant	09	0.00	0.07	-0.09	0.10	-0.01	
Φ 3) LC-AL // AL-ME"	85	-0.13	0.09	-0.29	0.14	-0.13	0.506
• Unpleasant	16	-0.14	0.10	-0.29	0.01	-0.15	
• Acceptable	60	-0.13	0.09	-0.27	0.14	-0.14	
• Pleasant	09	-0.10	0.08	-0.24	0.03	-0.11	
Φ 4) CH-ME" // CH-LC	85	0.07	0.06	-0.09	0.22	0.06	0.510
• Unpleasant	16	0.07	0.08	-0.07	0.21	0.07	
• Acceptable	60	0.07	0.06	-0.09	0.22	0.06	
• Pleasant	09	0.05	0.07	-0.04	0.17	0.04	
Φ 5) AL-CH // LC-AL	85	0.19	0.17	-0.27	0.49	0.19	0.672
• Unpleasant	16	0.19	0.15	-0.03	0.43	0.17	
• Acceptable	60	0.19	0.17	-0.27	0.49	0.19	
• Pleasant	09	0.14	0.17	-0.14	0.35	0.15	
Φ 6) AL-CH // CH-ME"	85	0.04	0.10	-0.23	0.25	0.05	0.909
• Unpleasant	16	0.03	0.08	-0.12	0.15	0.05	
• Acceptable	60	0.04	0.11	-0.23	0.25	0.05	
• Pleasant	09	0.03	0.13	-0.23	0.24	0.05	
Φ 7) LNr-LNI // CHr-CHI	85	0.12	0.07	-0.02	0.30	0.11	0.104
• Unpleasant	16	0.13	0.07	0.00	0.25	0.13	
• Acceptable	60	0.12	0.07	-0.02	0.30	0.12	
• Pleasant	09	0.08	0.05	0.00	0.16	0.08	
Φ 8) CHr-CHI // LCr-LCI	85	-0.11	0.05	-0.20	0.00	-0.12	0.528
• Unpleasant	16	-0.12	0.06	-0.20	0.00	-0.12	
• Acceptable	60	-0.11	0.05	-0.20	-0.01	-0.12	
• Pleasant	09	-0.10	0.05	-0.19	-0.04	-0.09	

NOTE: For very high s.d. it is recommended to use the median. * Kruskal-Wallis.

esthetically unpleasant, 70.6% esthetically acceptable and 10.6% esthetically pleasing, in this way we verified the prevalence for the acceptable standard (Table 1).

These findings corroborate with other researches demonstrating the preponderance of the acceptable pattern[15,22] in the samples. The smallest group found in this work was the esthetically pleasant, making evident the rigidity of esthetic ideal imposed by today's society.

To esthetically classify sample in a reliable manner, reducing individual influences, we sought to select a larger and more heterogeneous board as possible, composed by evaluators belonging to different areas of professional activity. This selection followed the tendency found in the literature, where we found that several authors select orthodontists, visual artists, laypersons or the combination of two, or even three groups,[5,15,18,20] to analyze the degree of facial attractiveness of the samples.

In assessing the degree of correlation between the three groups that composed the board of observers, we noticed the low correlation in esthetic conception between them. The lowest correlation occurred between

laypersons and orthodontists being considered poor by the Kappa index (-0.0507), which indicates a low percentage of agreement (18.8%).

Between laypersons and artists the correlation was considered slight (Kappa = 0.2026) with 41.2% of agreement and, finally, between visual artists and orthodontists we observed a regular result (Kappa = 0.2795) representing 45.9% of agreement (Table 2).

In this way, it highlights the need to take into account the patient's own expectations in relation to facial esthetics, since his appreciation of beauty can differ from that of orthodontists.

The results obtained were similar to those found in other researches,[3,15,17,18] which suggest that the criteria of the evaluators are eminently subjective, where the more diverse the area of expertise of the evaluators the lower the correlation between them.

In this paper, it may be noted that the group of laypeople had a tendency to be more demanding in facial esthetic judgment, the second group was of visual artists and the less critical were the orthodontists (Table 3).

The discrepancy found is due to, probably, the fact that the professionals dealing with the face or with the study of art have in mind the facial limitations and a greater understanding of the balance between the parts, where, while examining an individual, they look for a good relationship between parts and not just the initial esthetic aspect, as occurs with the lay. It was therefore verified that if the observers were more specialized in the study of the face greater was their degree of tolerance in relation to the assessment of facial esthetic.[20,21,28]

It is remembered that more conclusive results regarding the assessment of the degree of correlation between the observers, as well as the tendency of esthetic judgment between the different areas of professional activity, the ideal would be to use a board consisting of a number of evaluators larger than the one employed in this study.

Regarding to the frontal facial analysis of divine proportion, results differ from those obtained by Ricketts,[25] in 1982. Statistically, none of the evaluated relations presented divine proportions (Table 4), despite some measures used, such as the Φ 2, for the pleasant group presented median values close to the zero delta value, the eight evaluated ratios are away from this value, in addition none of them has exactly this number.

An important factor to be emphasized is that when Ricketts[25] performed his studies he employed the golden compass directly over the facial photographs, which probably, allows to obtain only approximate values. In this research, a analysis of divine proportion was developed through a computer program, establishing and marking each photometric points of reference, in this way we obtained exact measurements. Another important factor, is that in this work standardized facial photographs were used and, in contrast, the author[25] performed his measures in photographs obtained from magazine covers.

In the descriptive statistic analysis it was noticed that there was no significant difference in the medians of the divine proportion deltas between groups esthetically unpleasant, esthetically acceptable and esthetically pleasant, demonstrating that for the studied sample, "pleasant" individuals did not tend to have higher values in golden proportion than "acceptable" or "unpleasant" individuals.

Results corroborate with previous studies,[3,17] that also did not find significant difference in the medians of the deltas within the categories of pleasantness, noting that individuals regarded as more attractive do not have more measures in golden proportion than those considered less attractive.

In this way, it may be noted that faces considered beautiful may not display the divine proportion and vice versa,[2] and therefore not always facial esthetic improvement at the end of treatment should be related to the patient's facial measurements proximity to the golden section.[27]

On the other hand, presented results disagree to those found by Santos[26] and Kawakami, et al.[11] These authors observed that the human face has numerous structures in golden proportion relating themselves in many ways giving esthetic balance. Gil[8] affirms that divine proportion is a translation of "good sense" or "common sense" in beauty evaluation, advocating that this analysis should be based on the measures proposed by Ricketts,[25] in 1982.

We emphasize that facial analysis is essential in orthodontics and orthognathic planning, nevertheless, the evaluation of beauty seems to be mostly

subjective and personal. In this way, one should take into consideration the expectations and the esthetic concept of their own patient, associating, of course, to the orthodontic scientific knowledge on human face. It is believed that individual facial esthetic characteristics, and not only proportions, give major influence in beauty perception and, as in cephalometric analyses, facial analysis of divine proportion also have certain limitations.[27]

Therefore, if divine proportion will be employed in orthodontic or orthognathic planning, this should be employed only as a guideline working together with other methods already established.

CONCLUSIONS

With the development of this study, we can conclude that:

1. Subjective analysis of facial esthetic classified the studied sample in 18.8% as esthetically unpleasant, 70.6% as esthetically acceptable and 10.6% as esthetically pleasant, in this way verifing the prevalence of the acceptable standard.
2. A low grade of agreement in facial esthetic evaluation was observed between the three groups of observers in this research,. The more skilled in facial study was the evaluator, higher was the grade of tolerance on esthetic evaluation, being the lay group the most demanding and the orthodontists the less critical.
3. There was no statistically significant difference in delta medians of divine proportion between groups esthetically unpleasant, esthetically acceptable and esthetically pleasant.

In this way, it could be verified that in this research there was no association between the perception of facial beauty and divine proportion.

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Aspects and clinical procedures of eruptive changes of permanent upper canines

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Introduction: Even though the upper canine is the tooth that presents most eruption anomalies, after the third molars, canine retention prevalence in the population is quite low. Local, physiologic and pathologic factors can provide difficulties for the tooth eruptive process. The correct diagnosis in trying to prevent upper canine retention with ectopic eruption is fundamental to choose the ideal treatment, which can be performed by various methods.

Objective: The present paper has the purpose of approaching aspects related to impacted upper permanent canines by a literature review, including localization and treatment conducts.

Keywords: Impacted upper canines. Etiology. Tooth impaction.

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INTRODUCTION

The eruption of teeth is a physiological process that occurs in a sequence established by nature to fulfill one of its major functions: Mastication. However, in some occasions this mechanism fails or is interrupted, and there is a missing tooth or teeth, usually the upper canines, which are fundamental to the esthetics, harmonious smile and stomatognathic system of a patient.[3,8,13]

The upper canine presents the longest and most tortuous development period starting before the first molar and incisors calcification.[2] In addition, it takes twice the time to complete its eruption in relation to the first molars and the central incisors and, therefore, making it more susceptible to changes in the path of normal eruption resulting in a clinical problem frequently observed: The ectopic eruption or a buccal or palatal impaction.[1,2,3,11,12,13]

There are several treatment alternatives which must be examined in accordance with the particularities of each case. To obtain positive results the diagnosis and treatment of this problem require careful assessment in everyday orthodontic practice, as well as cooperation of professionals of different areas, such as the general practitioner, the pediatric dentist, the bucomaxillofacial surgeon, the periodontist and the patient collaboration.[2,8,11,15]

REVIEW OF LITERATURE

A canine is considered retained when it is not in the dental arch and does not present eruption potential because its root is completely formed. The term "dental retention" means that a tooth at the physiological time of eruption presents one impediment to accomplish eruption.[8,11]

Any tooth presents chance of impaction, the upper canines are those which are most frequently under these conditions with the exception of third molars. The retention of upper canines covers a small portion of the population ranging, according to the authors, from 0.9 to 2.5%[1,2,3,6,8,12,16] occurring two to three times more in females than in males (although the reason is unknown, there is an assumption that this occurs due to a lower transverse dimension of the upper arch in females) and usually occurs unilaterally (75 to 95% of cases) and palatally (60 to 80%),[8,12,15] and in 8% of cases they are bilaterally impacted.[16,17]

Excellence in orthodontic treatment results in correction of occlusion, harmony of smile, periodontal health and stability post-treatment. To obtain these conditions, the maintenance of canines is essential. Thus, to ensure both esthetics and function, it is important that the professional is aware about its placement along the eruptive path so that it is possible to detect aspects of abnormality in eruption providing patient diagnosis and the right treatment plan.[3,12]

The diagnosis and treatment of this problem usually requires careful evaluation of the orthodontist, as well as cooperation of professionals from different areas such as the general practitioner, pediatric dentist, buccomaxillofacial surgeon and the periodontist. These treatments may involve:

1) Extraction of the tooth, which is the radical treatment; 2) ulectomy, with or without osteotomy (tunnel of eruption); 3) surgical exposure and tooth loop with steel wire; 4) surgical exposure and perforation of enamel to steel wire passage; 5) autogenic transplants; and 6) surgical exposure and accessory bonding for traction.[2,5,15,16]

Before, however, deciding by traction of impacted tooth one should make the correct (clinical and radiographic) localization of the tooth position and once diagnosed examine carefully the indication and the opportunity for intervention.[2,3,14]

CLINICAL CONDUCTS

Location

The diagnosis of the absence of a canine, as well as its location, occurs through clinical (inspection and palpation) and radiographic examination.[1,2,3,9,12] The clinical examination must be careful, evaluating the placement of the teeth in the arch and its conservation status. One should analyze the space for eruption, which must be at least equal to the mesiodistal diameter of canine crown or impacted tooth.

At the stage of permanent dentition, the clinical absence of one or both canines, without a prior history of extractions, suggests that they are retained, once the agenesis of canines is rare. At the stage of mixed dentition, assessment must be criterious, noting clinical and radiographic signs that make possible an early diagnosis of retained upper canines. A clinical sign of abnormality is the position

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of the incisors crowns during the stage of "ugly duckling". An excessive angulation to mesial or distal suggest tooth impaction.[4,12]

Regarding the occurrence of impaction, often the prolonged retention of deciduous canine is observed followed by the presence of a palatal or buccal volume. The lateral incisor and occasionally the first premolar may be displaced or with rotation, due to the pressure exerted by the canine crown against the roots of teeth. Palpation of a palatal protrusion indicates that the tooth is not very deeply positioned.[2,13,14] There are authors who argue that the ectopic position of canine is associated to genetic factors.[3]

Another feature of ectopic eruption or impaction of canines is the absence of the canine volume in the alveolar process, at the distal of the lateral incisor during the mixed dentition or the presence of this volume in the palatal side. In 70% of cases the not erupted teeth can be palpated.[4,9,12]

The location of the canine by means of images must be technically the best possible. To do so, occlusal radiographs may be used (Fig 1), standard frontal and lateral cephalometric radiographs, CAT scans (Figs 2 and 3), panoramic X-rays (Fig 4), although in most cases, the periapical films are sufficient for this purpose.[3,8,11,12,15,16] The Clark technique performed with the periapical films (Figs 5 and 6) indicates only if the tooth is buccally or palatally displaced.[3,4,10,12] More recently rapid prototyping can be used, a technique that involves the use of various technologies that apply data from computer-aided design files (CAD; abbreviation for "computer aided design") to produce physical models by a process of material addition. There are various rapid prototyping technologies and, among them, the most accurate and of better quality are laser sintering (SLS), stereolithography (SLA) and PolyJet.[6,7]

In these radiographic examinations, the outline of the lamina dura of the root process of non-erupted tooth is searched; suggestive images of apical disruption; of the relationship of the root apex in the osseous space limited by the cortical bone of the maxillary sinus; the canine crown relationship with the roots of neighboring teeth; tooth positioning in the arch and presence of pathological processes.[11] Prototyping, on its turn, aims besides diagnosing an included maxillary canine impaction, create a specific accessory for tooth tractioning and assisting the surgeon

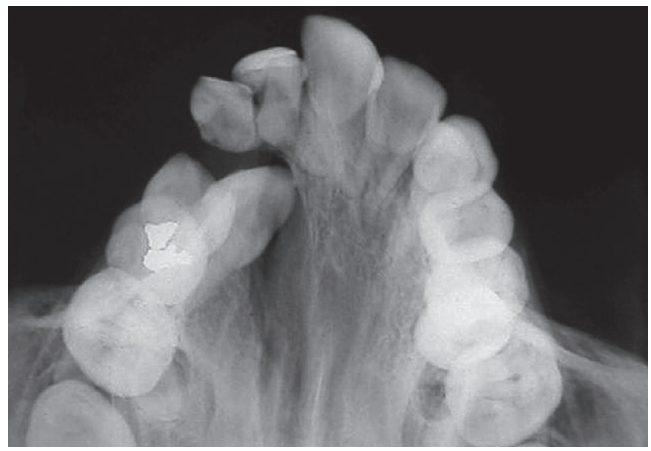

Figure 1 - Occlusal radiograph of impacted canine due to cleft palate.

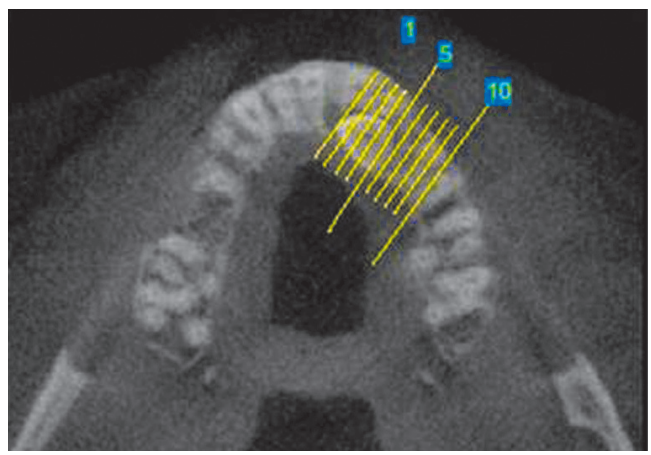

Figure 2 - CT scan for localization of the impacted canine.

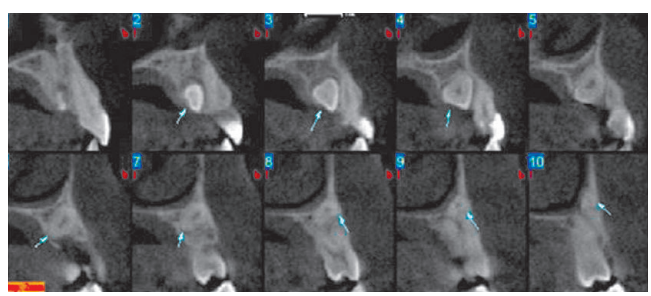

Figure 3 - CT scan for localization of the impacted canine.

Figure 4 - Panoramic radiograph with bilateral canine impaction.

Figure 5 - Localization of periapical radiograph using the technique of Clark.

Figure 6 - Periapical radiograph positioning using the Clark technique with displacement for canine buccal or palatine position evaluation.

in intraoperative tooth exposure and individualized accessory bonding.[6,7]

Canine location is of primary importance for the determination of access to the tooth and appropriate surgical procedure, as well as the direction of orthodontic force application.[11]

Treatment alternatives

After individual assessment of malocclusion and with the various current mean of diagnosis available, it is possible to prevent or even avoid the impactions and/or ectopic eruption of canines, being this a relevant fact in clinical planning.

In this way, conducing an ectopic tooth to its proper position in the dental arch is regarded as ideal for health, function and patient's esthetic and the clinician can consider various options for treatment, including:

a) Follow up where only periodic controls should be performed to verify the occurrence of pathological conditions; b) autogenic transplantation of canine; c) extraction of impacted canine and movement of premolar into its space; d) ulectomy, with or without ostectomy (eruption tunnel); e) coronary surgical exposure of tooth for bonding of orthodontic accessories, bonding with steel wire or perforation of the enamel for steel wire passage for later orthodontic traction; f) prosthetic rehabilitation for canine replacing[1,2,3,5,6,9,10,11,17]

Autogenous transplantation

Surgical procedure which extracts the retained canine and immediately transplants it to an artificial alveolus in the alveolar ridge. There is frequent risk of pulp necrosis, root resorption and loss of transplanted tooth.[8]

Extraction of retained canine

Should be considered when it is ankylosed and prevents the realization of a transplant or a tractioning; or with external and/or internal root resorption; or with severe root disruption; or with a severe impaction for example, with the canine located between the roots of central and lateral incisors; or if the occlusion is acceptable, with the first premolar occupying the place of a canine; or, with pathological changes such as cysts or infections, and if the patient refuses to undergo orthodontic treatment.

In some of these cases, patient rehabilitation is required for treatment complementation after extraction. Orthodontic rehabilitation can be performed promoting space closure by the movement of neighboring teeth since the premolar is on the same axial position of the canine, the prosthetic orthodontic treatment recovering space for the installation of dental prosthesis, or simply if there is enough space, the placement of a fixed prosthesis.[8,10,11]

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Extraction of deciduous canine

Is indicated when the permanent canine has the potential of eruption, or is with half of its root formed and being not so much horizontal.[8,10]

Orthodontic tractioning

Currently, with the possibility of early diagnosis and the development of orthodontic-surgical techniques, the more conservative treatments are more desirable, such as the orthodontic surgical tractions, followed by leveling and alignment of teeth in the arch until enough space is obtained to accommodate the canine. This treatment represents the preferred procedure in the permanent dentition and consists of the surgical access to the retained canine for fixation of the orthodontic accessory, by which a force is applied to perform its traction until the correct positioning in the dental arch.[1,3,5,8,9,10,16,17]

Orthodontic-surgical approach of buccally and palatally impacted canine

Surgical access for tooth exposure depends on the definition, by radiographic examination, of the position in which the tooth is located in the arch.[9] There are several methods for surgical exposure of impacted canines and tractioning in order to lead them to occlusion. The methods most commonly used are:

1) Surgical exposure, allowing the natural eruption (apically repositioned flap); and 2) surgical exposure and placement of an orthodontic accessory (Fig 7), for further tractioning (gingival flap repositioned in its original position). Orthodontic forces are subsequently applied to move the impacted teeth.[1,11]

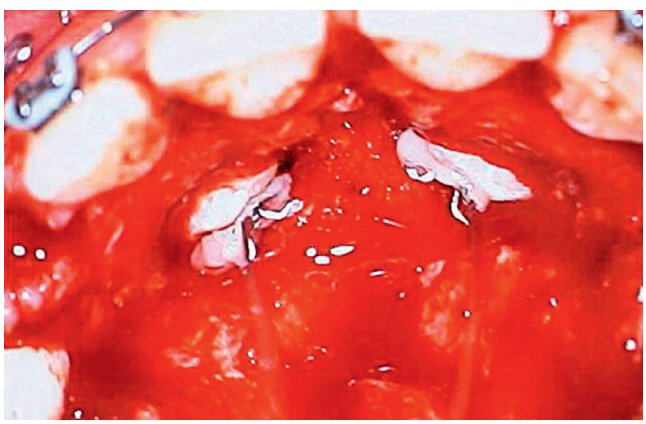

Figure 7 - Bonded accessory during surgical procedure.

The first option is used when the canine presents with a favorable axial inclination, not needing to be uprighted during its eruption. The canine eruption is monitored by means of X-rays, using some reference points as the neighbouring teeth or the orthodontic archwire. The disadvantage of this procedure is about the time, because the eruption is slow and spontaneous, prolonging treatment time. The second option consists of surgical exposure of the tooth and the placement of an auxiliary device. Therefore, direct bonding buttons and orthodontic brackets for traction of impacted teeth have become the preferred techniques because, in addition to the easiness, it requires minor tissue removal and surgical extension to access the tooth crown. However, as a disadvantage, there is the risk of accessory debonding because of the difficulty in drying the operating field with consequent deficient bonding, needing another surgery for new fixation in case of the non-use of hydrophilic primers.[1,2,3,5,11]

The buccal impaction is less frequent and usually caused by insufficiency in arch length. As a result, the canine is in a higher position in the alveolar bone and erupts ectopically in the alveolar mucosa (Figs 8, 9 and 10). Teeth buccally impacted in a favorable vertical position must be treated by simple surgical exposure and natural eruption of the tooth and in some cases, with orthodontic tractioning.[2,3,9,10,11,13,17]

Force system

The buccally impacted canine should be to extruded in order to obtain arch alignment and the force system necessary to get this type of movement is a simple application of extrusive force on the canine. This force system can be easily achieved by using a cantilever so that the posterior teeth experience an intrusive force and a anterior tipping moment, while canines erupt.[1,17]

The main objective in the treatment of buccal impacted teeth consists in creating and preserving a inserted functional band gum. This inserted gum can be achieved by means of an retail repositioned by apical or laterally, or when it is necessary, for a inserted graft gum free, thus avoiding future gingival recessions and marginal alveolar bone loss.[11]

Palatally impacted canines need to erupt and move buccally. The force application on the canine

is accompanied by a system balance with an intrusive force and anterior tipping moment on the posterior teeth. Buccal canine tipping is achieved by applying a simple force in brackets. When moving the canines buccally the molar tips lingually and undergoes a mesial rotation toward the palate. It is recommended to use cantilevers on the molar tube connected to the canines to promote the eruption of palatally impacted canines.[1]

During buccal or palatal impacted canine traction, one must be careful with the direction of the applied force, because this should not promote traction towards the roots of neighbouring teeth, to avoid causing trauma and external root resorptions. It is recommended, initially, to obtain space in the dental arches before the traction and also the use of force of low intensity (no more than 60 g) and the employment of archwires of sufficient rigidity (0.018 x 0.025-in) to avoid deflections which may undermine the movements.[1,2,3,5,9]

Traction methods

Several therapeutic approaches have been employed and presented in the orthodontic literature to obtain the appropriate positioning of impacted canines in proper alignment and levelling of dental arches. Among them, we highlight orthodontic loops built with reduced size wire (0.6 mm) which can be bonded to the palatine arches or buccally with Adam's clasps in removable appliances, also on second-order bends, introduced in leveling arches, as well as elastic wires with shape memory and elastomeric chains.[2,3,5,17]

a) Use of superelastic wires — obtaining space for the placement of the impacted canine can be reached by the use of nickel titanium superelastic loop (Fig 11). This loop can be kept in this position as a stabilization method.

After initial leveling and alignment, the upper arch was stabilized by means of rectangular archwire 0.019 x 0.025-in and lingually interconnecting the right and left side molars by a transpalatal bar. Then canine surgical exposure and accessory bonding is performed. The main stainless steel arch is removed and the NiTi superelastic archwire is positioned (Fig 12), occurring deflection until it properly fits into the slot of the bracket on the canine.[1]

b) Use of removable appliances — after the exposure of the canine the working model for the removable appliance construction is obtained, which must include Adam's and drop type clasps for retention in premolars, in addition to a buccal support structure with a hook for the use of 3/16 diameter elastic from the hook to the canine accessory.

The disadvantage of this system is the employment of intermittent force and, therefore, patient cooperation is necessary in how to use the appliance and change elastics to keep the traction force.[1,2,3]

Another system that can be used in buccal canine traction is the incorporation of loops welded to the horizontal bar of the Adam's clasp. The force intended for canine traction will be due to this loop activation and must be applied on the accessory bonded to the tooth.[1]

c) Use of cantilevers — systems that provide the proper control for canine movement, associated with a smaller commitment of anchorage units. It is built with titanium-molybdenum wire (TMA) 0.017 x 0.025-in. Loop activation must focus on activation points contained in the loop shape and observing the pre-activation bends. The big advantage found in this method consists in the possibility to work with a defined force system.[1]

Figure 8 - Right side view of ectopic upper canine.

Figure 9 - Frontal view of ectopic upper canines.

Figure 10 - Left side view of ectopic upper canine.

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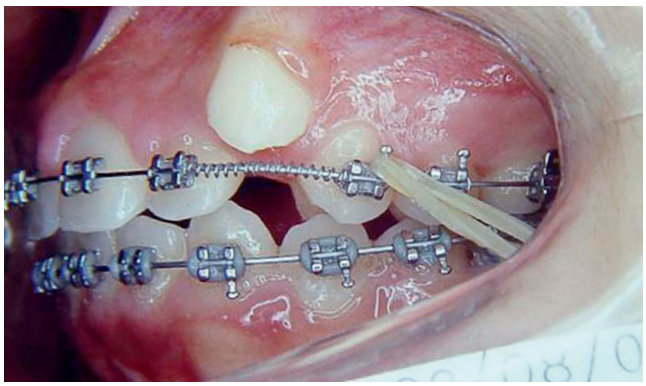

Figure 11 - Upper canine space recovery using NiTi loop.

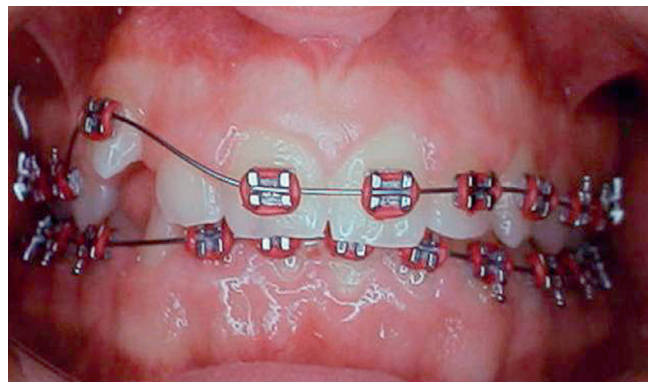

Figure 12 - NiTi superelastic wire traction canine.

d) Use of elastomeric chains — system that provides control over the magnitude and direction of the force applied to the tooth to be tractioned.[2,3,4] Orthodontic traction to bring the impacted tooth to the arch should start as soon as possible after surgery.[3]

DISCUSSION

The upper canine despite being the tooth of most frequent eruption anomalies after third molars, was considered by most authors as one of the most important teeth of the dental arch, and a correct diagnosis and clinical approaches are necessary in cases where it is impacted. Their retention covers a small portion of the population ranging, according to the authors, from 0.9 to 2.5%[1,2,3,6,8,11,12,16] and it occurs two to three times more in females than in males (although the source is unknown, there is an assumption that this occurs due to a lower transverse dimension of upper arch in female gender), it generally occurs unilaterally (75 to 95% of cases) palatally (60 to 80%)[8,12,17] and in 8% of cases are impacted bilaterally.[16,17]

In general, most authors advocate that for a good treatment prognosis the conduct for canine location must be accomplished through clinical and radiographic evaluation (teleradiographies, periapical, occlusal computed tomographies and, more recently, rapid prototyping) and treatment alternatives analyzed according to the particularities of each case after careful evaluation of the orthodontist and professionals of distincted areas.[2,3,4,8,15]

The orthodontic-surgical conduct is one of the most used options in cases where there is buccal or palatal impaction.[2,3,9,10,17] Most employed methods are surgical exposure allowing natural eruption,[10] surgical exposure for bonding of an orthodontic accessory and further traction.[1,3,11]

Various methods are suggested for the traction and alignment of impacted canines, among them the orthodontic removable or fixed appliances, the use of anchorage in the same arch or opposite arch.[2,3,5,15,17] The use of the lower arch as anchorage makes it difficult to control the direction and magnitude of the force applied. Another form of treatment would involve the use of a removable device at an early stage and subsequently install of the fixed orthodontic appliance for case finishing.

The use of a removable device presents some advantages as transferring anchorage to the palate[1] or lower arch[15] a more vertical component when supported in the lower arch, but despite these advantages the orthodontist must bear in mind that this type of device depends on the cooperation of the patient and so the completion of the case can be compromised.[1,2,3,15] The fixed orthodontic appliance provides greater control and effectiveness of the force applied, and in most cases there is a need to correct some other type of associated malocclusion and to open and keep the space for the tooth to be tractioned, using specific accessories as loops.

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With regard to the force system for traction of buccally or palatally impacted canines, one must be careful with the direction of the applied force, because this should not direct traction to the roots of neighbouring teeth, not to cause trauma and external root resorptions. It is recommended, initially, to gain space in dental arches before traction and also the use of force of low intensity (no more than 60 g) and the employment of sufficiently rigid archwires (0.018 x 0.025-in) not to deflect which may undermine movement control.[1,2,3,5,9]

CONCLUSIONS

1) The permanent upper canine presents a high prevalence of impaction, and this anomaly occurs more frequently in the palate and in the female gender.
2) The correct diagnosis of the position of an impacted tooth, in addition to the essential clinical examination, must be followed of a meticulous radiographic examination.
3) The adequate time for surgical and orthodontic intervention is when the tooth presents more than half of its root formation.
4) Surgical exposure of the dental crown should be conservative and the flap must be completely repositioned allowing tooth eruption.
5) The support for the traction force is preferably anchoraged over retangular orthodontic wire, in order to occur minimal deflection and the least amount of undesirable effects.

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Cephalometric evaluation of skeletal alterations induced by Herbst appliance during mixed dentition

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Objective: The present prospective clinical study was designed in order to evaluate horizontal and vertical skeletal alterations induced by the use of Herbst appliance in individuals with Class II, division 1 malocclusion during mixed dentition stage.

Methods: The sampling consisted of 15 pre-pubertal individuals (12 boys and 3 girls; initial age 9 years and 6 months), who were treated with Herbst appliance for a period of 7 months. The effects of the treatment were compared to a group of 15 individuals with Class II, division 1 malocclusion (8 boys and 7 girls, initial age averaged 9 years and 1 month), orthodontically untreated, who were followed up for a period of 12 months. Statistical analysis was performed with Student's t-test with significance level at 5%.

Results: It was showed that the treatment with Herbst appliance in mixed dentition stage has restricted maxilla growth. Mandibular and palatal planes have not undergone significant alteration; however, anterior and posterior facial heights have increased significantly. Facial convexity and maxillomandibular relationship were altered positively. Mandible has positioned significantly forward and its effective length increased 2.5 times more than the increase observed in control group.

Conclusion: It was possible to conclude that Herbst appliance was able to provide satisfactory results in individuals during mixed dentition stage.

Keywords: Herbst appliance. Class II malocclusion. Early treatment.

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

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INTRODUCTION

Among the proposed treatment methods for the Class II malocclusion which are intended to stimulate the growth of mandible, Herbst appliance has its prominence. Initially developed in 1905 by the German Emil Herbst, it was popularized by Hans Pancherz in the end of the 70's.[13] This appliance is characterized by presenting a bilateral telescopic mechanism that keeps the mandible anteriorly positioned on continuous basis during the rest, and also all mandibular functions.[25]

With respect to the ideal time for beginning the treatment of Class II malocclusion, the literature highlights the moment near the peak of growth, at the beginning of the permanent dentition stage. The optimization of the results might be related to the magnitude of the orthopedic response and to the long-term stability of changes induced, being this factor conditioned to the degree of intercuspation obtained after treatment.[5,6,14,16] These studies have shown that the orthopedic effect is more significant, overcoming dental compensation, when appliance is installed at the time of the peak of height growth. However, we can see that in the literature there are diversified opinions in terms of treatment time of mandibular deficiency with the Herbst appliance. The use of this appliance in young permanent dentition, at the time of circumpubertal facial growth has been suggested by some authors.[15] In case of severe Class II malocclusions, the Herbst appliance has been recommended[28,29] yet in deciduous dentition stage. Other authors[8,22] have used this appliance even after adolescence.

However, the severe Class II malocclusions are considered a concern factor for orthodontists due to the numerous esthetic and psychological problems that may be caused to the child, besides increasing the risk of fractures in the teeth, specially of maxillary central incisors.[25] The main advantage of the early treatment in class II malocclusions due to mandibular deficiency is the consequent psychosocial relief of the patient and parents. Moreover, it reduces the risk of trauma in maxillary incisors and achieves a class I relationship in early age.[25] The disadvantage would be the prolonged follow up. Despite the active stage of treatment be quick, ranging from 6 to 12 months, it is necessary the use of removable functional appliances as retainers until the end of the growth period, in order to minimize the potential relapse.[25]

During the past 20 years, many studies have been conducted to assess the effects of Herbst appliance over craniofacial skeleton, during the Class II treatment. However, only a few studies have evaluated the effects of Herbst appliance in mixed dentition stage.[1,3,28,29] The vast majority of researches investigated the effects of treatment in permanent dentition. For these reasons, this prospective clinical study aimed to measure the horizontal and vertical skeletal effects induced by Herbst appliance in the early treatment of Angle Class II malocclusion.

MATERIAL AND METHODS

Characterization of the sample

The treated group was composed of 15 Caucasian children (12 boys and 3 girls), ranging in age from 8 to 10 years (average initial age of 9.4 years and standard deviation of 0.64; average final age of 10.1 years and standard deviation of 0.64). Individuals were selected based on the following criteria: Class II facial pattern, associated with mandibular retrusion; Class II division 1 malocclusion; permanent maxillary and mandibular central and lateral incisors erupted or in eruption; mixed dentition; absence of severe crowding in the lower arch and the absence of transverse problems. Facial morphological pattern was determined by the Facial Height Ratio of Jarabak. In this study, 60% of individuals presented mesofacial pattern, 33.33% brachyfacial pattern and 6.66% dolichofacial pattern. This study has been approved by the Ethics Committee in Research (protocol 73/04).

To determine the Class II facial pattern and the Class II malocclusion, both face and occlusion were clinically analyzed. In this way, there was a certain subjectivity, because measurable data obtained from facial radiographs were not used. In facial analysis were observed some characteristics that helped to determine the Class II facial pattern, like morphological evaluation of the nasolabial angle (straight, obtuse and acute) and length of mentocervical line. In this way, individuals who have a convex profile, straight nasolabial angle or slightly acute and short mentocervical line, were classified as Class II facial pattern (Figs 1A and 1B). The Class II division 1 malocclusion was determined by the sagittal position of permanent

molars and permanent or deciduous canines, and by the overjet. Individuals with molar and canines in Class II, equal to or higher than the half of a cusp, and overjet equal to or greater than 4 mm, were included in the sample (Fig 2).

Patients were treated with modified Herbst appliance (Fig 3), where permanent maxillary first molars were banded and united to each other by a transpalatal bar, welded to bands with a 2 mm distance from palate[7] (Fig 4A). For mandibular anchorage was used a Nance modified lingual arch, constructed with 1.2 mm steel wire welded to permanent mandibular first molars bands. A cantilever with extension up to the region of deciduous or permanent canines was welded in the buccal surface of the mandibular first molars bands. The link between the cantilever and the lingual arch was made in the region of canines and deciduous first molars or permanent canines and first premolars, using a 0.9 mm wire in order to avoid occlusal interferences[18] (Fig 4B).

Figure 1 - Initial extraoral photographs: **A)** profile, **B)** frontal.

Figure 2 - Initial intraoral photographs: **A)** right side; **B)** frontal; **C)** left side; **D)** overjet; **E)** upper occlusal; **F)** lower occlusal.

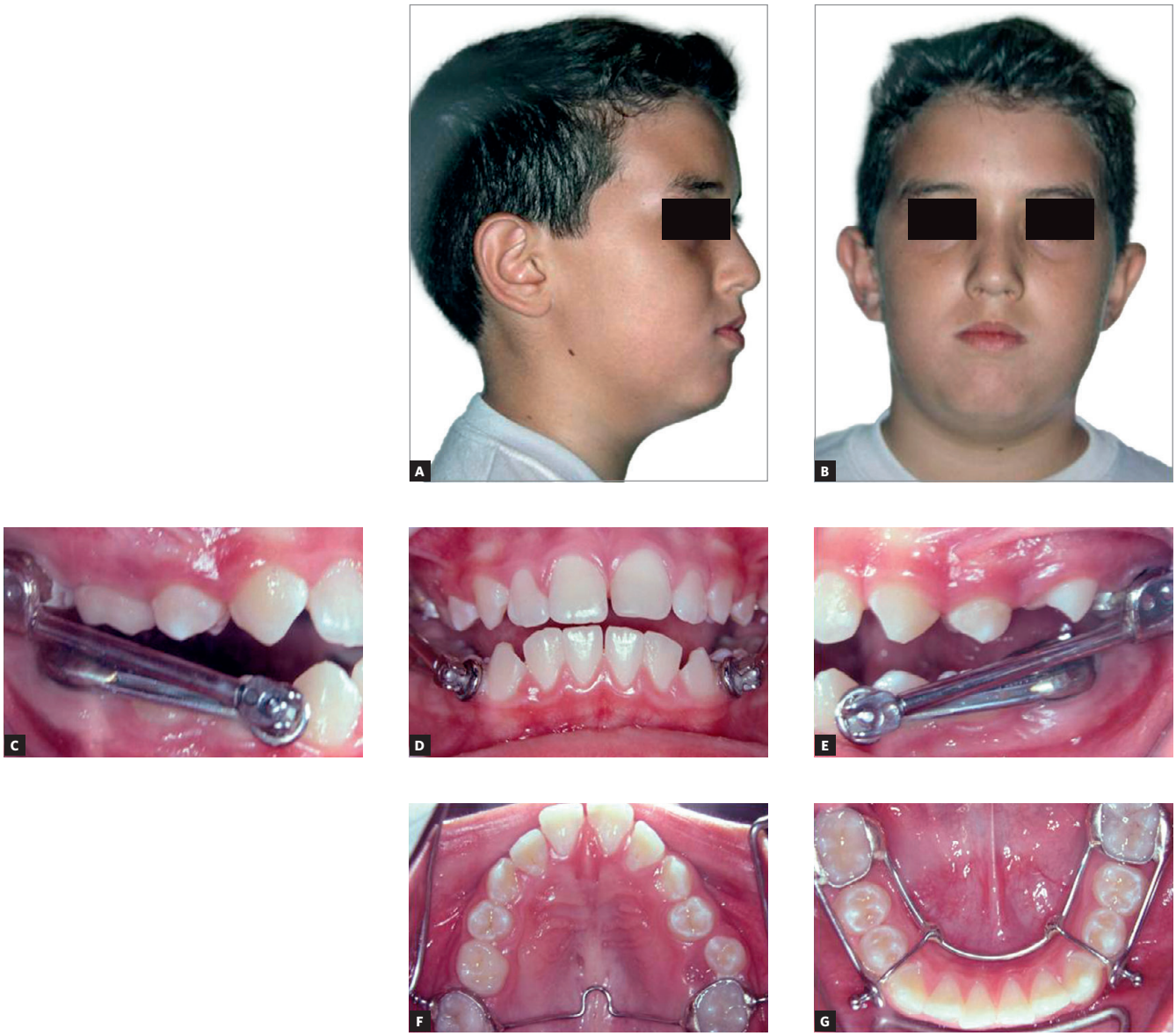

Figure 3 - Extraoral photographs of the patient with the Herbst appliance installed: **A)** profile, **B)** frontal. Intraoral photographs of the Herbst appliance installed: **C)** right side, **D)** frontal, **E)** left side. Occlusal photographs of the anchorage system used: **F)** upper, **G)** lower.

Figure 4 - **A)** Upper anchorage; **B**) Lower anchorage; **C**) Single mandibular advancement.

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The anterior projection of the mandible with the Herbst appliance, was performed according to Pancherz,[14] i.e., single mandibular advancement until the incisors were in an end-to-end relationship (Fig 4C). The appliance was used for a period of 7 months (Fig 5). At the end of the active stage of treatment it was verified that the centric occlusion was coinciding with the maximal intercuspation in all patients.

The control group, selected from the files of Burlington Growth Centre, located at the University of Toronto, Canada, involved 15 children (7 girls and 8 boys). The criteria for selection of the control group

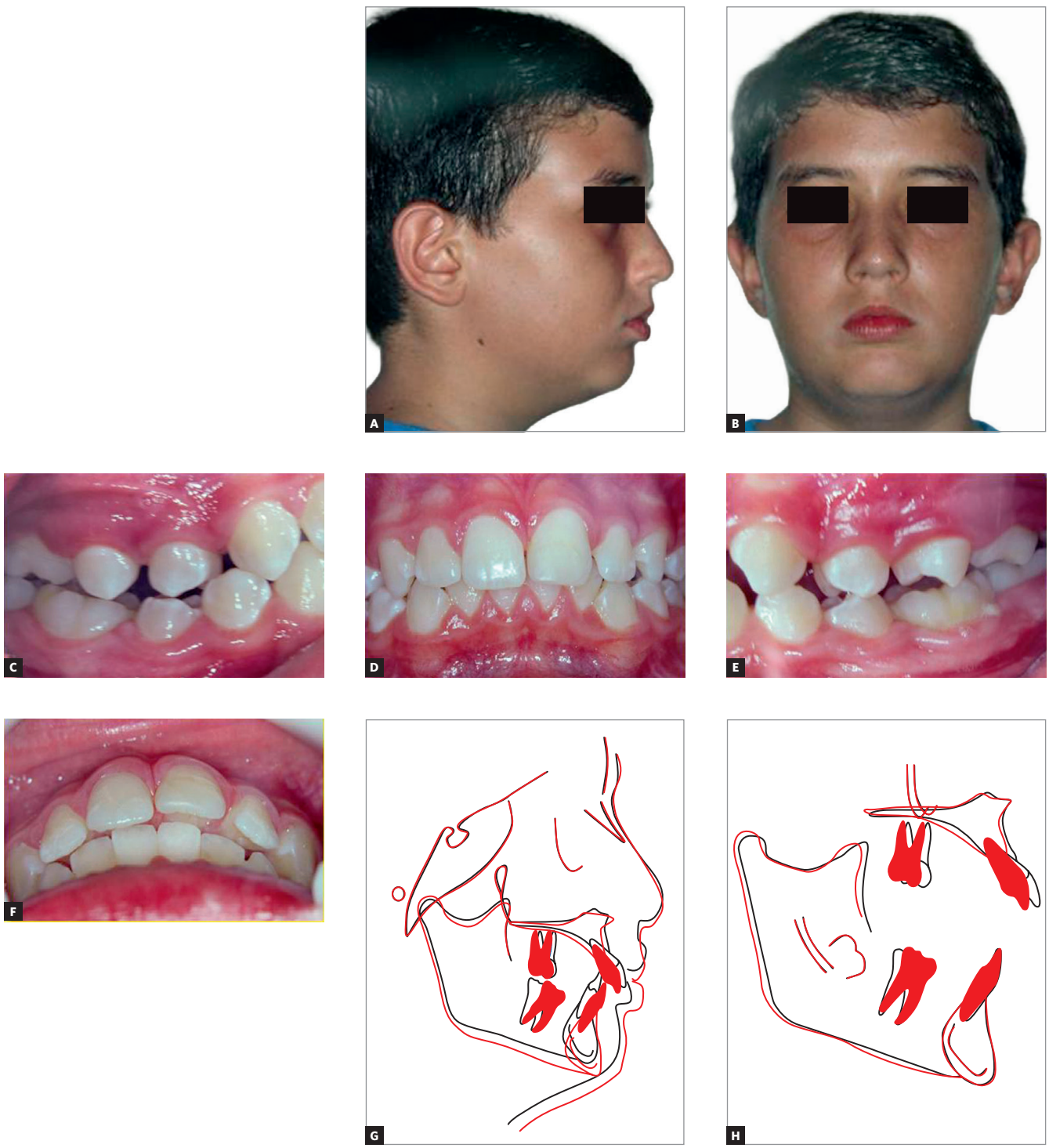

Figure 5 - Final extraoral photographs: **A)** profile, **B)** frontal. Final intraoral photographs: **C)** right side, **D)** frontal, **E)** left side, **F)** overjet. Cephalometric tracings superimpositions: **G)** total, **H)** partial superimpositions of the maxilla and mandible.

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were: Class II facial pattern, associated with mandibular retrusion; Class II division 1 malocclusion; erupted permanent maxillary and mandibular central incisors; mixed dentition and absence of previous orthodontic treatment. The mean initial age of the control group was 9 years and 1 month (standard deviation 0.09) and the mean final age was 10 years (standard deviation 0.05). In relation to facial morphological standard of the control group, 73% of individuals presented mesofacial pattern, 20% brachyfacial pattern and 7% dolichofacial.

The skeletal age of both groups was verified through radiographs in lateral standard, determining skeletal maturation stage using cervical vertebrae.[10] The determination of bone age was performed by the same operator blind to the patient status, which reduces the effect of subjectivity of this evaluation. Individuals in this study were located in the stages 1 and 2 of maturation, i.e., before the peak of pubertal growth.[2,12]

Two profile radiographs in maximal habitual intercuspation were obtained for each individual in the experimental group, named T_1, at the beginning of treatment and T_2, 7 months after the treatment. The X-rays were carried out using an X-ray machine (Rotograph Plus, model MR05, regulated to 85 Kvp and 10 mA and exposure time of 0.5 seconds). For the control group were obtained two profile radiographs in maximal intercuspation, named: T_1, at 9 years of age and T_2, at 10 years of age. The radiographs were obtained with equipment of brand Keleket™ set to 120 Kpv, 25 mA and exposure time of 0.3 seconds.

Although these radiographs were obtained by different X-ray machines, the correction of image magnification was not conducted. The magnification of the image, i.e., the percentage of magnification on the experimental sample was 10%, representing a magnification of 0,1000 cm (1,000mm)[23]. In the control group, the percentage of magnification reported was of 9.84%, according to the records of Burlington Growth Centre.[17] The magnification percentage difference between samples would be 0.16%, what would not affect the comparison of variables obtained from radiographs taken in the different X-ray machines. This difference in magnification would correspond to a difference in magnification between X-rays of 0.0016 cm (0.016 mm). All radiographs were traced manually by a single operator. The points were typed into Numonics AccuGrid digitizer and evaluated by means of Dentofacial Planner Plus 2.01 computer software to obtain the cephalometric measurements (Fig 6).

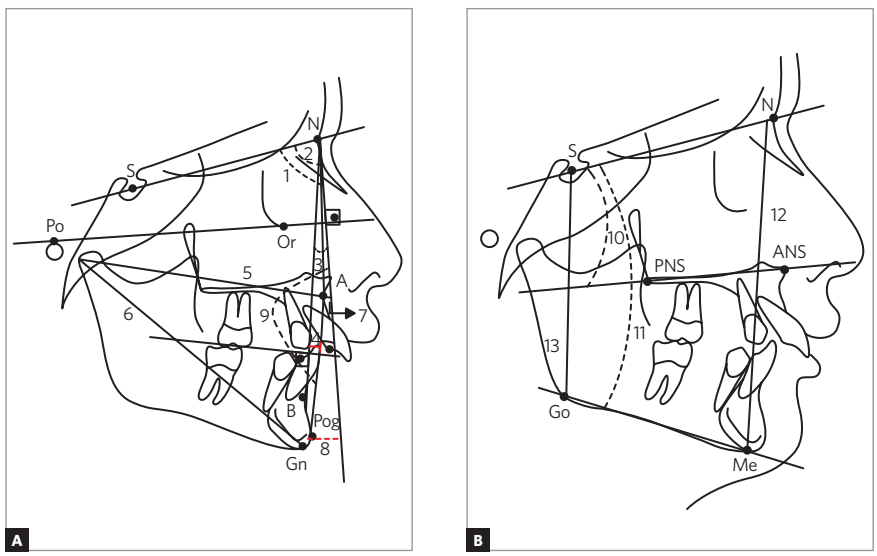

Figure 6 - **A)** Horizontal skeletal measurements: 1= SNA; 2= SNB; 3= ANB; 4= AO-BO; 5= Co-A; 6=Co-Gn; 7= A-Nperp; 8= Pog-Nperp; 9= NAPog. **B)** Vertical skeletal measurements: 10= SN.PalP; 11= SN.GoMe; 12= S-Go; 13= N-Me; 14= SGo/NMe.

RESULTS

To assess the possible occurrence of measurement errors, all tracings were typed again and measured by the same operator, with a range of 2 weeks between the first and second evaluation. It was used intraclass correlation coefficient (ICC) to evaluate the error of method (reproducibility). The results indicated that the measurement process was highly accurate because the expected value of the ICC was, at least, 0.983 and for most variables the ICC was above 0.99.

To compare the measurement changes, with and without treatment, it was necessary to eliminate the time difference effect between measurements made in the experimental and control group. To do so, measurement changes were annualized.

To assess the data, the following statistical tests have been conducted:

a) Student's t-test for the average equality of two independent populations — to examine the hypothesis that the average of each measurement of control group is equal to the experimental group at the beginning of treatment (Table 1).

b) Student's t-test for average equality of two populations with independent samples — to examine the hypothesis that the mean changes observed in a cephalometric measurements between times 1 and 2 are equal in the control group and the experimental group (Table 2).

The assessment of equivalence between control and experimental groups, regarding the measurements of interest at the beginning of the study, (Table 1) showed that there is little cephalometric difference before treatment between groups, with only 3 of 14 variables showing statistically significant differences.

DISCUSSION

a) Sagittal skeletal changes

After the one-year assessment period of the treated group, we noticed that the maxillary growth-related variables (SNA and A-Nperp) presented a decrease of 1.3°/year and 1.2 mm/year, respectively, which was not statistically significant. When comparing these changes with those observed in the control group, that was just 0.21°/year and 0.26 mm/year, it can be stated that the Herbst appliance presented a tendency to restrict the anterior growth of maxilla. These data are in accordance with other studies in the literature[13,15,18,27,30], since they have shown that the Herbst appliance provides a limited skeletal effect on the maxillary complex. However, when one considers the variable Co-A, we noted that there was a significant growth constraint of 2,23 mm/year in maxillary growth, while in the group without treatment there was a tendency to increase the effective length of the maxilla. This result confirms the fact that there was a restriction of the maxillary growth. Another study[29] reported that the maxilla was affected by the treatment with the Herbst appliance associated with the extraoral appliance, since the position of the point A was changed in the posterior direction about 1.5 mm in individuals with mixed dentition. Similarly, other authors[3] concluded that early treatment with Herbst appliance restricted the anterior sagittal displacement of point A about 1.2 mm.

Even considering the probable skeletal changes, SNB, Pog-Nperp and Co-NG measurements were assessed, to identify the effect of the appliance in the mandibular bone. While the control group showed a decrease on SNB angle (0.06°/year), the experimental group showed a statistically significant increase of 1.8°/year, which indicated that the use of this orthopedic appliance intensified the effect of the forward displacement of the mandible in relation to the base of the skull. When assessing the measurement Pog-Nperp, we found a significant reduction in the degree of retrusion of pogonion to the Nperp line of 3.01 mm/year. Meanwhile, the control group showed a reduction of only 0.21 mm/year. With respect to the effective length of the maxilla (Co-NG) is was noticed that both experimental and control groups showed a significant increase of this measure. Nevertheless, the experimental group (4 mm/year) showed an increase 2.5 times greater than the control group (1,57 mm/year). Thus, in our study of Herbst appliance was able to induce an additional mandibular growth. These results confirm the findings found in the literature[4,9,11,13,14,15,18,26,27,28,30] with regard to immediate mandibular skeletal effects induced by Herbst appliance.

One of the questions of this study was the possible interference of the Herbst appliance in the mandibular growth potential of individuals in early stages of occlusion development, i.e., does the amount of increase in mandibular length is similar to that of those individuals treated with the Herbst appliance

Table 1 - Mean and standard deviations in the experimental and control groups and mean differences between measurements before treatment, and Student's t-test for the difference between measures.

Measure	Experimental group		Control group		Mean of differences	p
	Mean	sd	Mean	sd		
SNA	82.38	3.30	79.90	2.98	2.47	0.040
A-Nperp	-0.63	3.08	-2.89	2.75	2.26	0.043
SN.PalP	6.10	2.42	8.32	2.53	-2.22	0.020
Co-A	88.87	4.71	87.23	3.40	1.64	0.284
SNB	76.69	2.79	75.27	1.94	1.43	0.115
Pog-Nperp	-10.88	5.94	-12.38	3.68	1.49	0.415
SN.GoMe	33.61	3.61	34.80	3.53	-1.19	0.369
Co-Gn	104.88	5.12	104.84	3.53	0.04	0.982
ANB	5.68	2.19	4.65	1.70	1.03	0.163
AO-BO	3.06	1.79	1.92	2.51	1.14	0.165
NAPog	169.85	5.71	171.92	4.11	-2.07	0.265
S-Go/N-Me	64.32	2.52	64.23	2.32	0.09	0.923
N-Me	109.85	7.97	105.36	4.56	4.49	0.071
S-Go	70.60	5.08	67.67	3.35	2.93	0.072

Table 2 - Means and results of Student's t-test of equality of means in the Experimental group and control group, each of the variables under study.

Measure	Means		p
	Experimental group	Control group	
SNA	-1.30	-0.21	0.182
A-Nperp	-1.20	-0.26	0.217
SN.PalP	0.59	-0.27	0.222
Co-A	-2.23	0.93	0.002
SNB	1.80	-0.06	0.002
Pog-Nperp	3.01	-0.21	0.012
SN.GoMe	0.16	-0.05	0.791
Co-Gn	4.10	1.57	0.008
ANB	-3.09	-0.17	0.000
AO-BO	-4.60	0.16	0.000
NAPog	6.03	0.34	0.000
S-Go/N-Me	0.76	-0.15	0.221
N-Me	4.11	1.70	0.001
S-Go	3.53	0.92	0.001

at the adolescence period? Significant short term increases in the length of the mandible have been reported in adolescents in approximately 2.2 mm[13,14] and 3.4 mm.[30] The literature has shown favorable and clinically significant mandibular growth in individuals treated with the Herbst appliance, who started the treatment in stages 3 and 4 of skeletal maturation of cervical vertebrae, i.e., at the peak of pubertal growth.[5] According to the analysis of skeletal maturation using cervical vertebrae in our study, all patients started treatment before the outbreak of pubertal growth. Thus, it is worth mentioning that the magnitude of skeletal mandibular effects in our study was similar to that found in individuals treated around the peak of pubertal growth, when one might expect a more significative orthopedic effect.[8,9,15,16,19]

Due to the restriction of maxillary growth and the effect of mandibular growth stimulus, we observed a significant reduction in maxillomandibular relationship (ANB: 3.09º/year; AO-BO: 4.6mm/year). When the results of the evaluated groups were compared, we noticed that the experimental group presented a similar alteration to the control group, however in a larger magnitude, what denotes a positive effect of use of this device in terms of improving sagittal maxillomandibular relationship. Croft et al[3] when comparing the ANB angle change in mixed dentition patients treated with Herbst appliance and others monitored without treatment, they obtained a reduction of maxillomandibular relationship of 1.4º greater than the experimental and control group. Reduction in ANB angle of 3.26º and of 1.3º in 12 months of treatment with the Herbst appliance has been described in the literature.[9,18]

When evaluating the behavior of facial skeletal convexity, it was identified an increase in the NAPog angle of 6.03º/year, leading to a decrease in the facial convexity. The changes observed in the experimental group were similar to the control group, nevertheless, on a larger scale. Our result is in agreement with other studies[3,18] that observed a reduction of 4.23 and 2.2º in this angle in a sample treated with Herbst appliance.

Thus, according to the results of our study, there was a significant improvement in the sagittal relation between apical bases. The reduction of about 4.6 mm in the maxillomandibular relationship (AO-BO) can be explained by the significant restriction of 1.2 mm in the maxillary growth (A-Nperp) and by the anterior displacement of 3.01 mm of Pogonion (Pog-Nperp). This fact is confirmed when assessing the ANB angle, that showed a decrease of 3.09º, represented by maxillary growth inhibition (SNA: -1.3º) and by the anterior displacement of the mandible (SNB: 1.8º).

b) Vertical Skeletal Changes

The influence of functional or fixed appliances in the vertical relation of the bone bases is a controversial subject in literature.[3,9,18,20,21,28] In cases of hyperdivergent growth pattern patients, functional appliances are not recommended because these appliances can cause a subsequent clockwise mandibular rotation[20] and, consequently, may worsen the facial esthetics. On the other hand in patients with mesofacial growth pattern, the mandibular plane angle, on average, does not seem to be affected with the Herbst appliance.[1,3,9,11,18,19,28,30] However, some authors found no significant differences regarding the magnitude of vertical skeletal changes in hypodivergents and hyperdivergents patients treated with the Herbst appliance[21,24,30].

Our study showed a significant increase in the anterior (N-Me: 4.11 mm/year) and in posterior facial height (S-Go:3.53 mm/year). The changes observed in the experimental group were similar to the control group, however, in a larger magnitude. Increase of facial height as a result of treatment with the Herbst appliance was found on some researches.[9,28] However, a study[1] related the absence of significant changes in anterior and inferior facial height in individuals treated with Herbst appliance. It is interesting to observe that despite the increased facial height in our study that is favorable to the esthetic of the patient, the mandibular plane angle (SN.GoMe) did not change significantly in the treated (0.16º/year) and in the untreated group. These data are in accordance with the findings of literature.[1,3,4,9,11,18,19,26,28,30] The results of this study showed that the use of the Herbst appliance did not change the pattern of rotation of mandibular plane.

In relation to the palatal plane, our results showed that the treated group did not show a significant increase (0.59º/year) of this plane from the base of the skull. The change observed in the experimental group was not similar to the control group. This variable in the control group also presented a significant change. Our results are consistent with other papers[1,5,6,13,19] that also did not observe changes in palatal plane in patients treated with the Herbst appliance.

According to the results of vertical skeletal changes in our study, we could verify that the mandibular plane presented a similar behavior to the palatal plane, that is, a tendency toward maintenance of initial values, in a comparable way to the control group. As for anterior and posterior facial heights, our study showed that there was a significant increase in the use of this appliance, indicating a harmony in the increase of vertical dimensions. These data suggest that the use of Herbst appliance in patients with excessive facial height should be performed with caution, since this appliance might increase even more the facial height. In this way, when a professional uses the Herbst appliance in patients with increased facial height, it would

be wise to use an anchorage structure with occlusal coverage in order to obtain a better control of the vertical growth of bone bases.[5,9,24,27,30]

The results of this study showed that the Herbst appliance was able to satisfactorily treat Class II malocclusion in pre-puberty subjects. However, it is worth to notice that the choice of the ideal time to begin the treatment of Class II it is still a critical point in orthodontic planning. Therefore, the advantages and disadvantages of early treatment should be carefully considered before starting treatment. In case of early treatment, it is worth to notice the importance of the prolonged monitoring these patients to mitigate the potential for relapse.[3,25,29] Thus, this makes necessary the use of functional removable appliances as retainer until the end of the growth stage,[3,25,29] with the goal of keeping the orthopedic correction and lead the tooth eruption during the transition from mixed to permanent dentition.

CONCLUSION

Skeletal effects produced by Herbst appliance at the stage of mixed dentition in this study were:

- Restriction of maxillary growth.
- Greater anterior position and increase of the mandibular length.
- Positive change in relation to facial convexity and the maxillomandibular relationship.
- No significant change in mandibular and palatal plane.
- Significant increase in anterior and posterior facial height.

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Asymmetric extractions in orthodontics

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Introduction: Extraction decisions are extremely important in during treatment planning. In addition to the extraction decision orthodontists have to choose what tooth should be extracted for the best solution of the problem and the esthetic/functional benefit of the patient.

Objective: This article aims at reviewing the literature relating the advantages, disadvantages and clinical implications of asymmetric extractions to orthodontics.

Methods: Keywords were selected in English and Portuguese and the EndNote 9 program was used for data base search in PubMed, Web of Science (WSc) and LILACS. The selected articles were case reports, original articles and prospective or retrospective case-control studies concerning asymmetrical extractions of permanent teeth for the treatment of malocclusions.

Conclusion: According to the literature reviewed asymmetric extractions can make some specific treatment mechanics easier. Cases finished with first permanent molars in Class II or III relationship in one or both sides seem not to cause esthetic or functional problems. However, diagnosis knowledge and mechanics control are essential for treatment success.

Keywords: Asymmetric extraction. Mechanics. Treatment. Orthodontics.

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

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INTRODUCTION

The main goal of orthodontic treatment is to obtain a normal relationship of the teeth with facial structures. Edward H. Angle emphasized that the preservation of all dental units was necessary to achieve facial balance, harmony and esthetics. However, subsequent studies related to the stability of treatments pointed the necessity of teeth extractions in order to correct certain types of malocclusions. The lower incisor inclination revealed a great importance in diagnosis and orthodontic treatment planning. The orthodontists realized that maintaining all dental units in order to correct some kinds of malocclusions was not always possible.[9,25,26,29] Besides, space closure due to extractions should be under total control of the professional. In cases of dental position asymmetries, this control would ensure functional and adequate occlusion of the teeth at the end of treatment.[3,18]

Therefore, many authors have suggested that asymmetric extractions would be necessary and important to correct midline deviation, favoring unilateral movement of the posterior teeth, reduce treatment time and tooth movement, facilitate orthodontic mechanics and obtain more stable and functional results.[6,8,15,18,23,30] This study aims to conduct a literature review about asymmetric extractions, emphasizing the importance of this procedure for orthodontics.

MATERIALS AND METHODS

Selected keywords in English (asymmetric, extraction, treatment, orthodontics, mechanics) and Portuguese (extrações assimétricas, tratamento, ortodontia and mecânica) were used in EndNote 9 software, searching for studies in the following databases: PubMed, Web of Science (WSC) and LILACS. These keywords should be present in one of the following parts of the articles: Title, keywords, abstract or text. Following, inclusion / exclusion criteria were determined in order to select the papers. Studies reporting teeth agenesis or pathologies, systemic diseases, syndromes, cleft palate, orthognathic surgery and conventional extractions of first premolars were excluded. Papers including case reports, original articles, case-control studies involving prospective or retrospective mechanical or asymmetric extractions of permanent teeth were selected. A total of 30 articles were chosen for the literature review and discussion.

LITERATURE REVIEW AND DISCUSSION

The perfect symmetry is a theoretical concept and rarely found in nature. The facial and dental asymmetry is a common phenomenon often observed when comparing right and left sides.[1,25] According to Lundström,[19] the asymmetries of the arches could be classified as quantitative or qualitative. Imbalanced numbers of teeth on each side of the arch would be included in the quantitative asymmetries. Differences in teeth size and position, associated to dental arch relationships to the skull and to themselves would be grouped in qualitative asymmetries. The treatment of quantitative asymmetries, for example, could be accomplished by prosthetic rehabilitation or fixed orthodontics.[1] Stripping, single incisor extraction and asymmetric extraction of permanent teeth followed by asymmetrical mechanics would be good options for treating qualitative asymmetries.[1,2,6,8,16,30]

Garn, Lewis and Kerewsky[7] observed that asymmetries in tooth size generally did not involve an entire side of the arch. Teeth of the same morphological class tend to have the same asymmetry. If the first right premolar is larger than the left, the same trend could be expected between the second premolars. Melgaço et al[20] measured the mesiodistal widths of all permanent teeth (excepted 3rd molars) of 500 dental casts and found no statistically significant differences between right and left sides. Other authors also found similar results.[5,17]

Therefore, in cases of qualitative or quantitative asymmetries, the extraction of teeth should be considered as a treatment option to achieve facial balance and occlusion stability at the end of the treatment. However, extracting teeth is still a challenge for orthodontists, especially in choosing which tooth should be extracted.[16] In these cases, Rheude et al[22] emphasizes the importance of the plaster casts for orthodontic treatment planning in order to perform asymmetric extractions.

Thus, the Bolton analysis determines the ratio of the mesiodistal widths of maxillary versus mandibular teeth.[2] This tooth-size discrepancy allows a

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Figure 1 - Patient presenting a Bolton discrepancy with anterior excess. Treatment performed with extraction of only a lower permanent incisor.

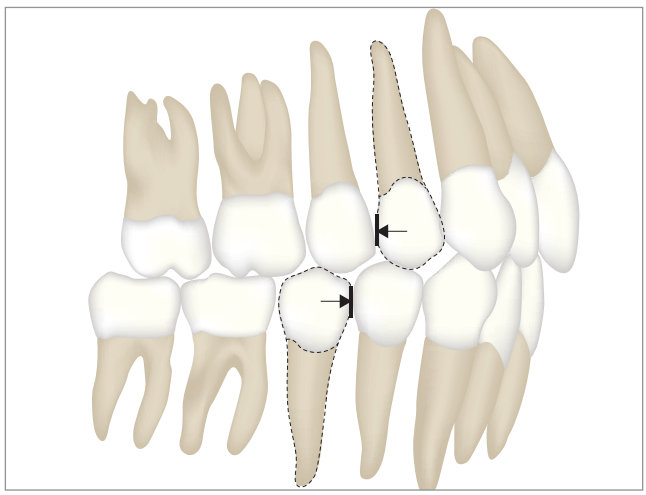

Figure 2 - Asymmetric extractions: First premolars and second premolars.

further option of extraction: Removal of one lower incisor. According to Klein[16] this option can provide satisfactory results in some specific cases, as observed in Figure 1.

In Class II malocclusions cases with small lower anterior crowding or slight protrusion of the lower incisors, the extraction of lower second premolars and upper first premolars is a good treatment option (Fig 2). This favors the correction of the protruding upper anterior teeth (if present) and favors the correction of lower anterior crowding or some slight protrusion of the lower incisors, without great facial impact. The correction of molar relationship would be achieved by more anchorage loss in the mandible. The use of Class II elastics would facilitate this process, associated with a face-bow or a transpalatal arch to avoid maxillary anchorage loss. However, patient's collaboration would be essential for the success of this kind of therapy.[21,28.29] The removal of a first premolar on one side and the second premolar on the other can also occur, depending on arch discrepancy location.[28,29]

The most discussed and common cases about asymmetric extractions refer to Class II subdivision malocclusions with lower dental midline deviation. The solution in these situations arises from symmetrical extraction of four first premolars or asymmetric extractions of only three premolars. However, the first choice requires greater collaboration of the patient, since the use of intermaxillary elastics become necessary. On the other hand, extraction of two upper premolars and only one lower premolar (opposite to the midline deviation) results in asymmetrical molar relationship at the end of the treatment (Class I and Class II).[10-13,21,27] Thus, in these situations it would be easier to achieve midline correction and obtain better vertical control. Treatment considering three premolars extraction protocol in Class II subdivision cases requires less treatment time, providing more satisfactory results.[10,12] Janson et al[10] also state that the asymmetric extraction protocol is best suited for promoting minor changes in the profile.

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However, the authors described an extrusion of lower incisors in cases treated with three premolars extraction protocol and affirmed that better vertical control of the anterior teeth is accomplished when symmetrical extractions are performed. They also concluded that an asymmetry in the position of the first permanent molars is inevitable in these cases. This was also confirmed by Janson et al[11] and Johnson and Smith.[14] Other authors state that asymmetric extractions (first premolar on one side and second premolar on the other) could help to correct midline deviations, anterior crowding and reduce the protrusion of the lower incisors in Class II subdivision malocclusions.[25,30] However, Gianelly et al[8] reported that the extraction of four first premolars would have the advantage of using an easier mechanical anchorage control, and to preserve the contact point between the second premolar and first molar (more anatomically correct and preferable than the contact of the first premolar with the first molar).

Based on these assumptions, Burstone[4] defined three types of space closure control in extraction sites:

» Type A – the teeth anterior to those extracted would occupy all or almost all of the extraction sites.
» Type B – space closure would be a result of both anterior retraction and posterior anchorage loss.
» Type C – the teeth posterior to those extracted would occupy all or almost all of the extraction sites.

These space closure controls must not be identical on both sides of the dental arch. In asymmetrical malocclusions, for example, it would be required a type C space closure on the right side and a type A space closure on the left side. These differences in mechanics would be essential to achieve treatment goals as midline correction, appropriate anteroposterior positioning of the teeth, improving facial profile and dental stability.[3,18] As stated before, asymmetric extractions could result in asymmetrical position of the molars. The final molar relationship could be Class II or III only in one side or in both sides[21,30] (Fig 3).

However, space closure in asymmetric extraction cases is difficult due to anchorage control. A gap in extraction sites could persist even after correction of midline, solving anterior crowding and improving profile. In these cases, molar mesialization should not change the final position of the lower incisors nor affect facial harmony. The closing loop bends or elastic ligatures could deviate the midline or compromise canine relationship.[8,30] Fiorentino and Melsen[6] agreed that space closure in the posterior region of the arch is a difficult procedure, especially in Class II malocclusions. Thus, Bishara, Burkey and Kharouf[1] suggest the use of unilateral Class II or Class III elastics, associated with oblique anterior elastics to produce asymmetrical forces. In order to have total control of the mechanics, the system and braces used must deliver the correct and precise forces needed to facilitate tooth movement, causing minimal tissue damage and discomfort to the patient.[3,18]

Asymmetric extractions could resolve cases that would require the use of prostheses or implants.[6] Slavicek[24] postulate the use of orthognathic surgery or asymmetric extractions of upper first premolars as an alternative treatment for severe Class II malocclusion cases with retruded mandible and no growth potential. In these cases, the mechanics should favor the retraction of maxillary anterior teeth and the final molar relationship would remain in Class II on both sides. However, normal canine relationships would be present (Fig 4).

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Figure 3 - **A, B, C)** Finalization with first permanent molars in Class III relationship. **D, E, F)** Finalization with first permanent molars in Class II relationship.

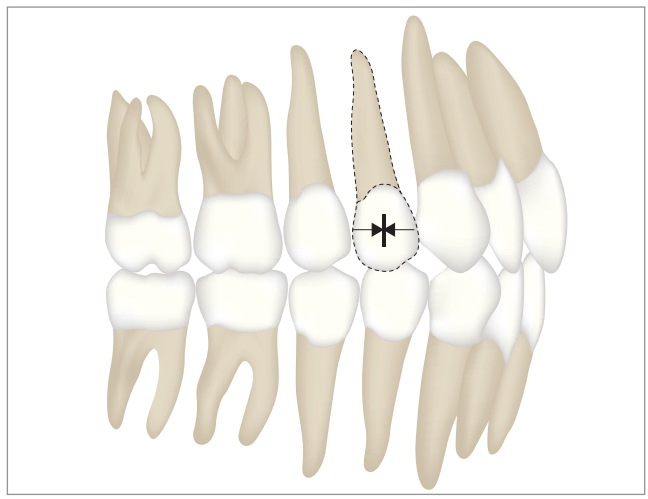

Figure 4 - Asymmetric extractions: only upper first premolars.

FINAL CONSIDERATIONS

According to the reviewed literature, asymmetric extractions could simplify and facilitate orthodontic treatment and mechanics in some specific cases. As a result, first molars relationship could differ for right or left sides and this asymmetry would not bring functional or esthetics problems. In cases of Bolton discrepancy, a lower incisor extraction option should be considered. However, the orthodontist must have total control of the mechanics used to achieve the best final results at the end of the treatment.

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Calcium, amylase, glucose, total protein concentrations, flow rate, pH and buffering capacity of saliva in patients undergoing orthodontic treatment with fixed appliances

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Objective: To evaluate qualitative and quantitative changes in the saliva of individuals undergoing orthodontic treatment with fixed appliances.

Methods: Salivary samples were collected from 50 individuals divided in two groups: Experimental Group – patients with fixed orthodontic appliances (n=25); and Control Group – subjects with no orthodontic appliances (n=25). Salivary flow rate, pH, buffering capacity, amylase activity, concentrations of total proteins, calcium and glucose were measured in all salivary samples.

Results: There was a reduction in salivary pH and buffering capacity and an increase in the concentration of calcium ions in the experimental group ($p<0.05$); there was also an increase in glucose, amylase and protein concentrations in the saliva of the Experimental Group, but the differences were insignificant. There was insignificant correlation between calcium ion concentration and salivary flow or between buffering capacity and salivary flow.

Conclusion: The saliva of individuals with fixed orthodontic appliances had lower pH, buffering capacity and calcium concentration than that of individuals without any type of orthodontic appliance. These oral changes are enough to cause tooth demineralization. Patients with orthodontic appliances should adopt additional oral hygiene procedures.

Keywords: Saliva. Corrective orthodontics. Demineralization.

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INTRODUCTION

Saliva is a complex mixture of fluids produced by the salivary glands and the gingival crevice, as well as bacteria, leukocytes and exfoliated epithelial cells.[6,9,10,11,13,29] Its composition varies according to the flow, nature and duration of stimuli, plasma composition and time of the day when it is collected.[25]

Water (99%) is the main component of saliva, and the remaining 1% is of inorganic and organic components.[13] The inorganic elements that play the most important role in osmolarity of saliva are sodium, potassium, chloride and bicarbonate. Saliva is always hypotonic in relation to plasma. The main organic elements are salivary amylase, proteins (lysozyme, lactoferrin, secretory immunoglobulins, peroxidase and agglutinins), peroxidase complex (peroxidase and myeloperoxidase) and agglutinin. They have antimicrobial functions, inhibit calcium and phosphate precipitation, have bactericidal or bacteriostatic effects, and segregate bacteria, which facilitates their removal.[11]

The diverse composition of human saliva explains its several functions, such as the contribution of salivary amylase to digestion, protection of hard and soft tissues, cleansing of the oral cavity, neutralization and buffering of acids found in foods, and participation in bacterial metabolism, demineralization and formation of pellicle. Saliva is also responsible for maintaining the biological balance in the oral cavity since the salivary flow continuously removes bacteria from the teeth surfaces and mucosa. Another important salivary function is maintenance of a relatively neutral pH in the oral cavity what is mostly done by the bicarbonate system.[10,20,27]

Saliva is a fluid that may be easily collected by stimulation, and has been used in medicine as a diagnostic tool for certain diseases.[20] In dentistry, it has been studied as a tool for periodontal diagnosis,[15] to monitor patients with final stage kidney disease[17] and to assess the risk of caries in orthodontic patients.[30] Salivary tests are useful both in planning preventive measures and in the evaluation of the results of treatment.[25]

Orthodontic treatments using fixed appliances in a healthy oral cavity may induce the continuous accumulation of bacterial biofilm, which compromises oral hygiene, affects oral microflora, produces lesions in the oral mucosa, worsens periodontal diseases and consequently causes infection.[3] These factors may promote dental enamel demineralization and biofilm formation,[24] which increases the risk of caries.[7]

In particular, metal brackets and orthodontic bands induce specific changes in the oral environment, such as decreases in pH and increases in the amount of biofilm.[2,4,8,23]

The protective characteristics of saliva against caries are a result of the salivary flow, of its buffering capacity and of its calcium and phosphate concentrations, and well as of several antibacterial systems.[6] The process of eliminating sugar is affected by the salivary flow. The increase in salivary flow results in faster dilution of substances in the oral cavity.[18]

The evaluation of the risk of developing caries or forming dental calculi depends on the salivary composition of each individual. These diseases may lead to serious complications for the patient and may put at risk the esthetic, functional and health benefits of orthodontic treatments, requiring a premature removal of the appliances. Therefore, the characteristics of saliva of individuals under treatment using fixed orthodontic appliances should be studied.

This study evaluated whether the saliva of individuals being treated with orthodontic fixed appliances undergoes qualitative and quantitative changes. The following factors were evaluated: Salivary flow rate (SFV), salivary pH, salivary buffering capacity (SBC), amylase activity, total proteins, calcium and glucose.

MATERIAL AND METHODS

This study was evaluated and approved by the Ethics in Research Committee for Studies with Human Beings of Pontifícia Universidade Católica do Paraná (PUC-PR) under no. 1818/08.

Fifty people (18 male and 32 female) aging from 15.8 to 25.2 years were selected among individuals that sought dental care at the Dental Clinic of PUC-PR. The Experimental Group was composed of 25 individuals that were currently under treatment with fixed orthodontic appliances, and the Control Group was composed of 25 individuals with no orthodontic appliances. Patients, in the 3 months immediately before the beginning of the study, that were diagnosed with debilitating diseases, that were under current treatment with drugs, that smoked, that were users of mouthwash or that had dental prosthesis were excluded from the study.

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The saliva sample was collected in the morning (between 8 and 11 a.m.) to avoid circadian rhythm variations, and was collected through the method of spitting. The saliva was collected after mechanical stimulus by chewing a piece of sterile latex tubing. During a controlled time, the subject continuously chewed and spat saliva into a sterile universal container.

The containers with the samples were placed in a Styrofoam box with ice and sent to the Biochemistry Laboratory of the Center for Biological and Health Sciences of PUC-PR for the salivary tests.

To evaluate saliva, colorimetric enzymatic kits (Labtest Diagnóstica®, Lagoa Santa, Brazil) were used according to the instructions of manufacturer to prepare biochemical samples. Readings were made using a Bio Plus spectrophotometer (Perkin-Elmer, Norwalk, CT). The following parameters were evaluated: Salivary flow rate (SFV), salivary pH, salivary buffering capacity (SBC), and concentrations of glucose, total proteins, calcium and salivary amylase.

All variables in both groups were analyzed for normality. Upon normality distribution, Student's *t* test for independent samples was used, but when at least one of the variables was not normally distributed in both groups, Mann-Whitney's *U* test was used.

RESULTS

Table 1 shows the mean values, standard deviations and the statistical analysis of the variables studied. Mean values of protein concentration, salivary flow and glucose in the control group were lower than on the experimental group.

The Kolmogorov-Smirnov test for normality was used for all variables. In the experimental group, the variable calcium was not normally distributed, and in the Control Group, the variable buffering. For the variables protein, amylase, pH, salivary flow and glucose, which had a normal distribution in the Experimental and Control groups, the Student's *t* test for independent samples was used (Table 1). The group without fixed orthodontic appliances had an average of pH greater than the group with appliances ($p<0.05$).

The Mann-Whitney's *U* test was used for the variables calcium and buffering capacity, which were not normally distributed in the experimental and control groups (Table 1). In the Control Group, mean calcium concentration and buffering capacity were greater than in the experimental group ($p<0.05$).

DISCUSSION

Saliva plays an important role on caries development because of its participation in the dilution of substances in the oral cavity, mechanical cleansing, post-eruptive maturation, demineralization and remineralization of dental enamel, pellicle formation, antimicrobial action and buffering of acids produced by biofilm and foods.[1,11,21]

Table 1 - Mean and standard deviation values of the variables of the control and experimental groups and statistical analysis.

Variable	Experimental group	Control group	p Value
Proteins	0.189 (0.076)	0.184 (0.095)	0.8307
Amylase	7.861 (0.035)	7.857 (0.045)	0.7015
Calcium	2.186 (0.734)	4.865 (1.334)	0.0000*
pH	6.885 (0.268)	7.104 (0.298)	0.0089*
Buffering capacity	2.346 (0.533)	2.698 (0.526)	0.0126*
Salivary flow	0.785 (0.353)	0.754 (0.235)	0.7207
Glucose	0.241 (0.158)	0.189 (0.064)	0.1343

* Significant differences ($p<0.05$).

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The saliva buffering capacity, defined as salivary resistance to pH changes, is assigned to carbonate-bicarbonate systems, phosphates and proteins.[6,25] The bicarbonate system is responsible for about 85% of the buffering capacity in the pH range of 7.2 to 6.8. When the salivary flow rate increases, the concentration of bicarbonate ions also increases.[9,10,11,25]

In the group using orthodontic appliances, there was a significant decrease in salivary pH and buffering capacity ($p<0.05$). These results are similar to those reported by Kanaya et al,[14] who found a pH decrease in individuals that underwent orthodontic treatment. On the other hand, Chang, Walsh and Freer[7] suggested an increase on the salivary buffering capacity after the placement of orthodontic appliances, but their subjects had appliances for a shorter time.

Patients under orthodontic treatment may be more prone to tooth demineralization since the mean salivary pH and the buffering capacity were diminished on the experimental group. Consequently, preventive measures should be taken since there is a direct association between pH and salivary buffering capacity decreases and increased risk of caries.

The concentration of calcium ions in saliva was different between the groups ($p<0.05$) and lower on the Experimental group. Individuals with a low calcium concentration in saliva have a lower pH and, therefore, a greater susceptibility to demineralization than individuals that have higher concentrations of calcium.[1]

The calcium concentration in saliva is highly dependent on pH and salivary flow rate. According to Jenkins,[13] there is an increase in the concentration of saliva of calcium ions when the flow rate is higher. However, some other authors have found that the concentration of calcium ions decreases as salivary flow rates increase.[11,18] In our study, there was no significant correlation between calcium ion concentration and salivary flow rate or between salivary flow rate and buffering capacity.

Some authors[7,12,14,30] found an increase in the salivary flow rate of individuals with fixed orthodontic appliances. In our study, the experimental group also had a greater salivary flow rate, but the difference was insignificant.

A positive correlation between salivary flow rate and buffering capacity has been reported by several authors.[5,11,16,22,28] Our data differ from their results since an insignificant correlation was found between the groups studied. Laine and Pienihakkinen[19] also did not find any correlation between these two variables. Moreover, a greater glucose concentration was found in the saliva of the experimental group, even though this difference was not significant, in accordance with reports by Forsberg, Oliveby and Lagerlöf[12]. These finding may be associated with the increased salivary flow rate.

Salivary amylase, an enzyme that has the main function of starting the digestion of starch and proteins (the main organic components of saliva[11]) was elevated in the experimental group. However, when compared with the control group, this increase was insignificant.

The factors associated with the risk of caries, such as buffering capacity, concentration of the calcium ions and salivary pH, were altered in the group with fixed orthodontic appliances, what suggests that orthodontic treatment may have an effect the intraoral environment. Because of the long time that fixed appliances remain in the mouth, our findings suggest that preventive measures, such as hygiene, diet advising, topic fluoride application and prophylaxis should be adopted for orthodontic patients.

CONCLUSION

In this study, individuals with fixed orthodontic appliances had lower salivary pH, buffering capacity and calcium concentration than individuals without appliances. Patients with fixed orthodontic appliances had oral changes that might result in tooth demineralization and, therefore, should adopt additional oral hygiene procedures.

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Skeletal and dental Class II malocclusion, with anterior open bite and accentuated overjet*

Márlio Vinícius de Oliveira[1]

Open bite is defined as a deficiency in normal vertical contact between antagonist teeth and may manifest in a limited region, or more rarely throughout the entire dental arch. If the lack of contact between teeth is located in the incisor and/or canine region when occlusion is in centric relation, it is called anterior open bite (AOB). Some studies have demonstrated that AOB is strongly associated with non-nutritional sucking habit. This article relates the treatment of a female African-Brazilian patient, with 20 years and 7 months of age, who presented Angle's Class II, division 1 malocclusion, AOB, accentuated overjet, lingual interposition during swallowing and difficulty with pronouncing some phonemes. Orthodontic treatment began by mounting an Edgewise Standard fixed appliance system, with a fixed palatal crib appliance and extraction of maxillary first premolars. This case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics (BBO), as part of the requisites to become a BBO Diplomate.

Keywords: Angle's Class II malocclusion. Open bite. Tooth extraction.

*Clinical Case Report, Category 7, approved by the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

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

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INTRODUCTION

The patient, a 20 years and 7 months Afro-Brazilian girl, presented for the initial exam in a good state of general health. Her medical and dental history contained no significant records. Her oral hygiene was good and her third molar had been extracted. During anamnesis the patient reported that she had used a pacifier until she was eight years old. Her chief complaint was the "difficulty with pronouncing some words".

DIAGNOSIS

The patient presented a symmetrical face, convex profile (upper lip – S line = 7 mm, Lower lip – S line = 7 mm), acute nasolabial angle, lip sealing with contraction of the perioral muscles and chin muscle, lingual interposition when swallowing and difficulty with pronouncing some phonemes. Her smile, in spite of AOB, was pleasant, with a good contour, as well as an adequate exposure of the maxillary incisors.

Regarding her dental aspect, she presented Angle's Class II division 1 malocclusion, 5.5 mm overjet, a 3 mm anterior open bite, coincident upper and lower midlines, triangular-shaped maxillary arch and parabolic mandibular arch, both presenting symmetry in the anteroposterior and transverse directions. The patient presented no arch perimeter and Bolton discrepancy (Figs 1 and 2).

Figure 1 - Initial facial and intraoral photographs.

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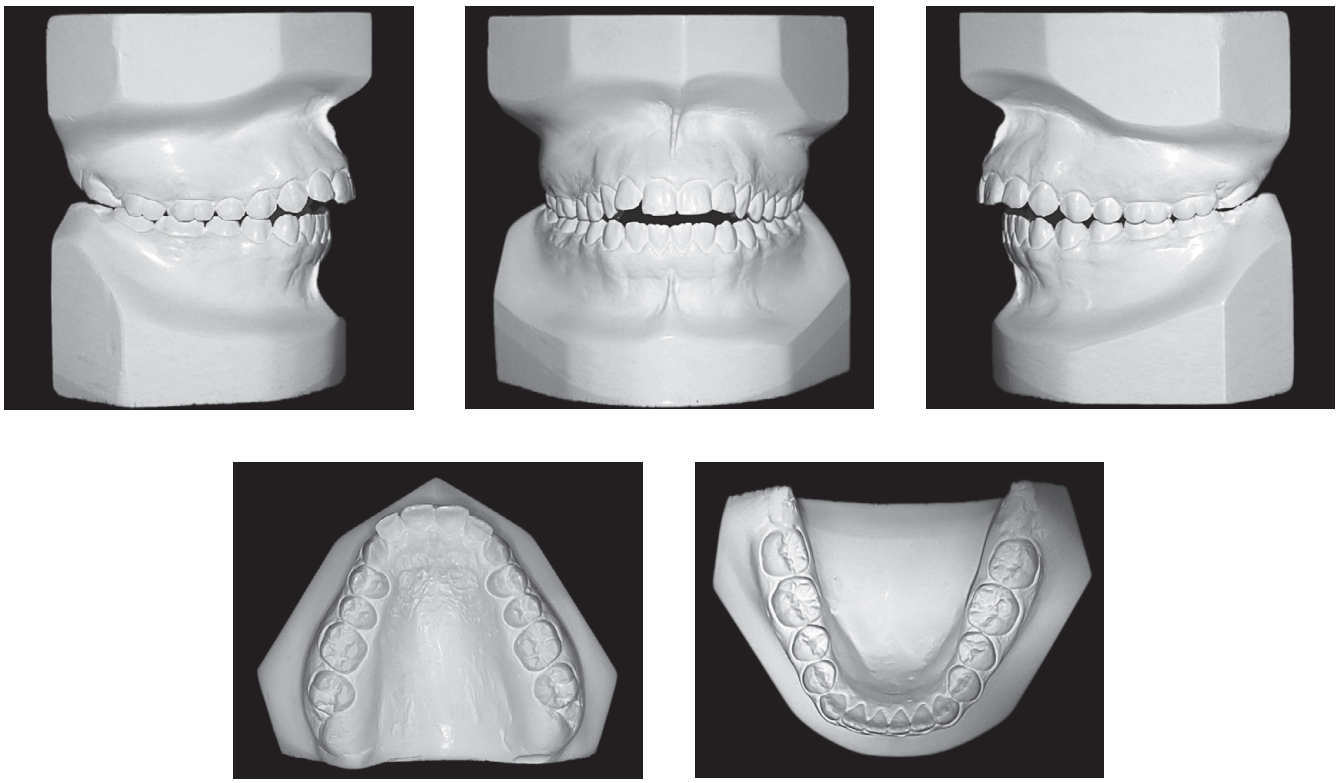

Figure 2 - Initial models.

The periapical and panoramic radiographs disclosed a normal bone, absence of third molars and a good root parallelism. With regard to the skeletal pattern, she presented a 5° ANB angle (SNA=79° and SNB=74°), showing evidence of disharmony between the bony bases, according to Steiner's analysis. From the vertical aspect, there was an accentuated inclination of the mandibular plane (SN-G. Gn=40°) (Fig 4).

TREATMENT GOALS

The treatment goals were to establish canine Class I occlusion, correct the AOB, overjet and attain ideal functional occlusion. For this purpose extraction of the maxillary first premolars was necessary. In addition, after closure of the OAB, and speech therapy, facial esthetics were expected to improve as well as the pronunciation of some sounds articulated by the teeth, lips and tongue.

TREATMENT PLAN

The plan was to correct canine Class II relationship and extract the maxillary first premolars. Regarding anterior open bite, the option was to use the fixed palatal crib during the alignment, leveling and canine retraction phase. When incisor retraction began, the crib was removed and a lower spur was bonded on the lingual face of the incisors. At this time, when AOB and overjet had diminished, the patient was referred for speech therapy treatment.

The fixed appliance used was of the Edgewise Standard type, slot 0.022 x 0.028-in, stainless steel arches from 0.014 to 0.020-in were used for alignment and leveling, and maxillary canine retraction began in 0.018-in arch. For incisor retraction a 0.019 x 0.025-in rectangular stainless steel arch with "bull" loops was used distal to the lateral incisors.

For finishing, a rectangular 0.019 x 0.025-in maxillary and mandibular arches were used, with first and third order bends, individualized according to the needs of the case. After the active treatment stage, upper and lower retention appliances would be placed.

TREATMENT PROGRESS

Orthodontic bands with brackets welded on the buccal region and lingual tubes were adapted to the first maxillary molars. Transfer impressions were taken in order to fabricate the crib appliance.

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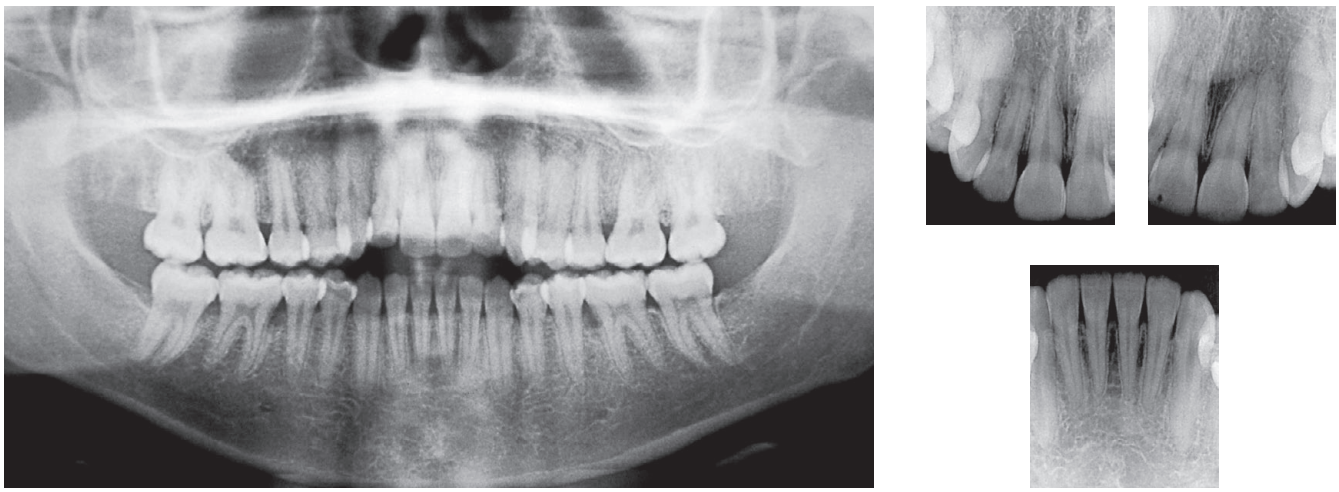

Figure 3 - Initial panoramic and periapical radiographs.

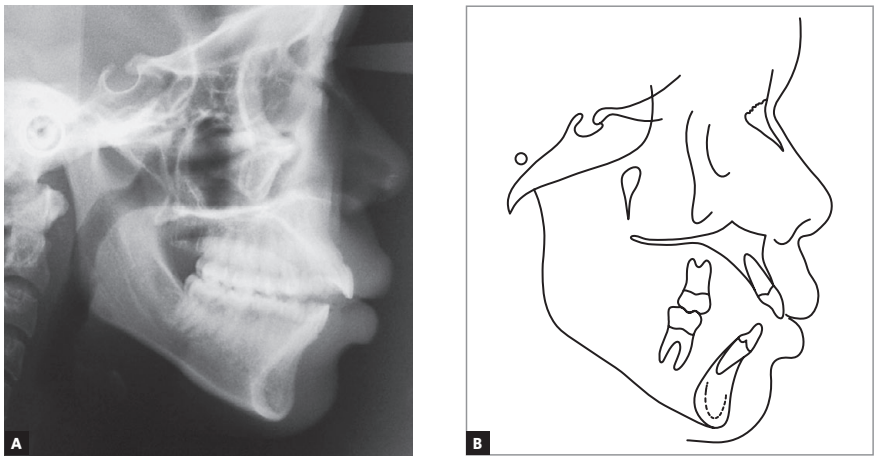

Figure 4 - Initial cephalometric profile radiographs and cephalometric tracings.

After cementation of the orthodontic bands, the crib was fitted into the lingual tubes and tied with metal ligatures (Fig 5). The remainder of the fixed appliance was installed on the maxillary and mandibular dental arches, Edgewise standard system with slot 0.022 x 0.028-in.

After the appliances were installed, extraction of the maxillary first premolars was requested, and in sequence, round stainless steel arches (0.014 and 0.020-in) for alignment and leveling were inserted.

In the maxillary arch, the posterior teeth were tied together, on both sides, using 0.018-in wire. Elastic chains were placed from the second premolars to the canines to distalize them. After canine distalization, the stainless steel 0.019 x 0.025-in arch made of a rectangular section with bull loops located in the distal region of the lateral incisors for retraction of the canines. At this stage the fixed palatal crib was removed and spurs were bonded on the lingual surface of the mandibular incisors to control tongue position (Fig 6). The patient was referred to speech therapy.

During orthodontic finishing, rectangular 0.019 x 0.025-in maxillary and mandibular arches were fabricated, with first and third order bends, individualized according to the needs of the case. At this stage, Class III intermaxillary elastics were used on the left side supported on a maxillary sliding jig for anchorage loss of teeth #25, #26 and #27. Anterior vertical intermaxillary elastics were used, bilaterally, to favor adequate overbite (Fig 8). After the active treatment phase, a maxillary removable wraparound retainer was used, and in the mandibular arch, a fixed retainer bonded from canine to canine was made with a 0.028-in wire.

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ACHIEVED RESULTS

When evaluating the patient's records after the end of active treatment, it was observed that the main goals had been attained. Facial esthetics was enhanced by the reduction in lip protrusion, functional balance between the lips resulting from closure of the AOB and speech therapy. The smile remained pleasant in spite of the small increase in exposure of the maxillary incisors (Fig 7).

The maxillary arch shape improved, SNA angle

Figure 5 - Fixed palatal crib.

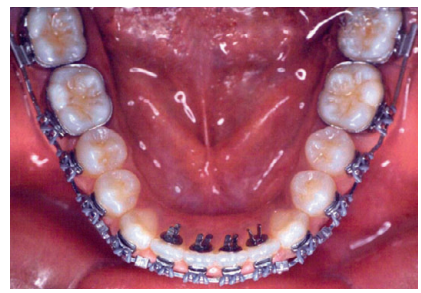
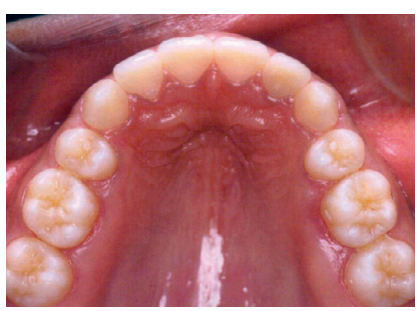


Figure 6 - Bonded mandibular spurs.



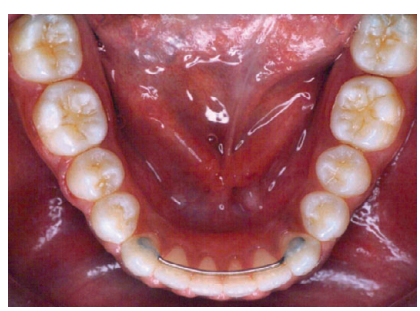


Figure 7 - Final facial and intraoral photographs.

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remained unaltered even with retraction of the incisors. The mandibular position remained vertically unaltered, however, SNB angle increased by 2 degrees, demonstrating a more anterior position at the end of treatment (Fig 10 and Table 1). This anticlockwise rotation of the mandible, verified in the total superimposition of the initial and final tracings (Fig 11), may have occurred as a result of the improvement in the cusp-fossa relationship at the end of treatment, and/or as a result of the loss of anchorage of the maxillary molars.

In the radiographic evaluation discrete apical rounding of the incisors could be perceived, compatible with orthodontic movement (Fig 9). With regard to final occlusion, a Class II molar relationship and Class I canine occlusion were obtained. All the other characteristics of an ideal functional occlusion were verified before the appliance was removed (Fig 8).

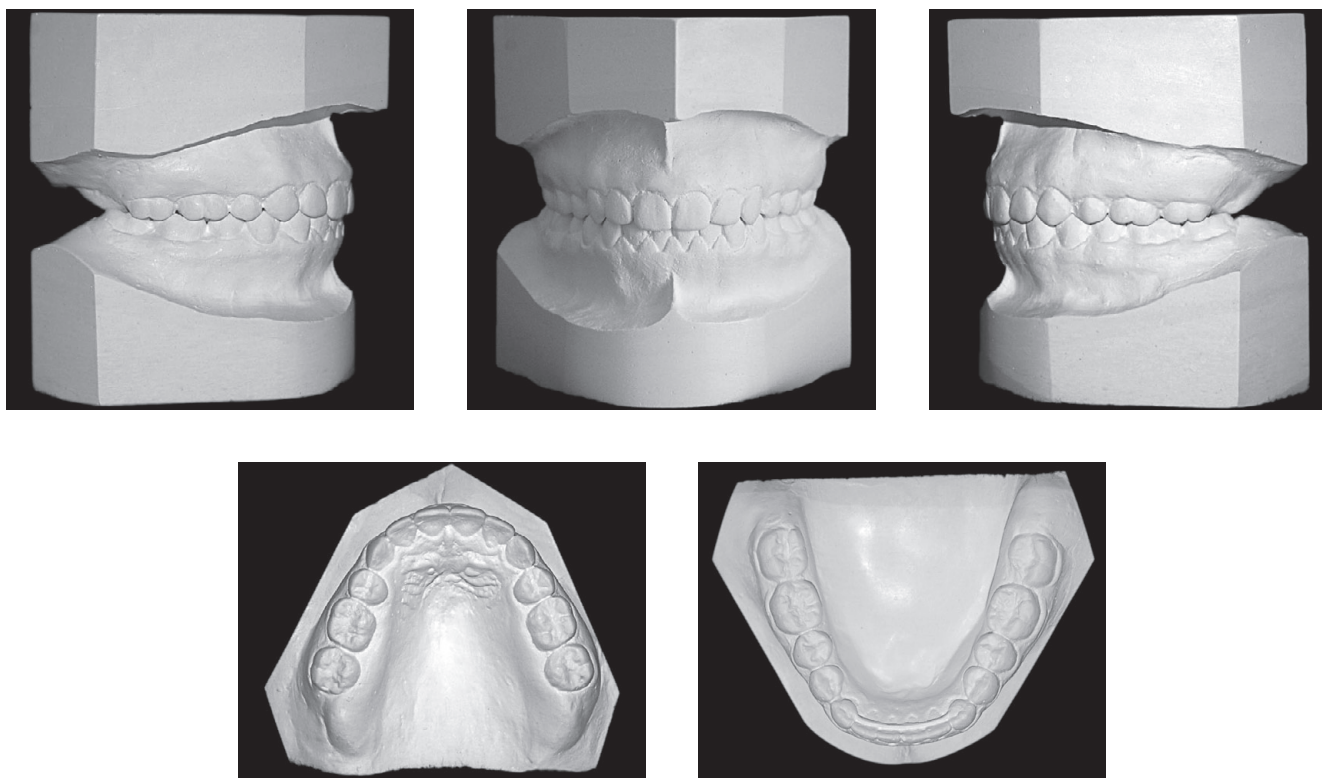

Figure 8 - Final models.

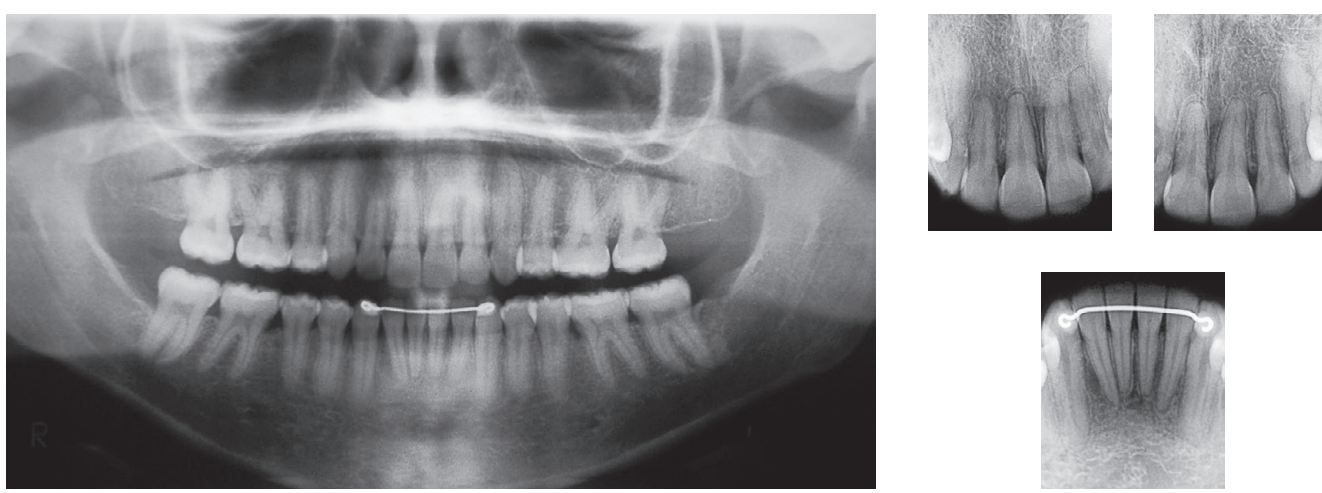

Figure 9 - Final panoramic and periapical radiographs.

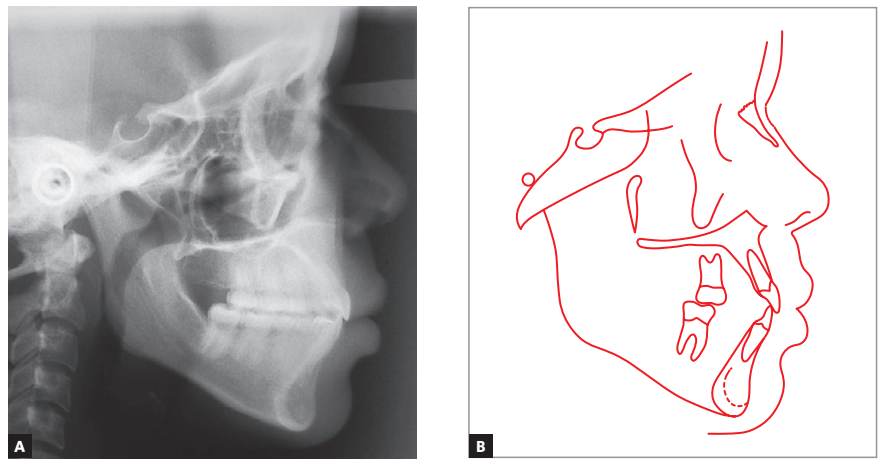

Figure 10 - Final cephalometric profile radiographs and cephalometric tracings.

Figure 11 - Total (**A**) and partial (**B**) superimpositions of initial (black) and final (red) treatment phases.

Table 1 - Summary of cephalometric measurements.

	Measures	Normal	A	B	A/B Difference
Skeletal pattern	SNA (Steiner)	82°	79°	79°	0
	SNB (Steiner)	80°	74°	76°	2
	ANB (Steiner)	2°	5°	3°	2
	Convexity angle (Downs)	0°	10°	6°	4
	Y axis angle (Downs)	59°	61°	66°	5
	Facial angle (Downs)	87°	87°	83°	4
	SN-GoGn (Steiner)	32°	40°	40°	0
	FMA (Tweed)	25°	29	35°	6
Dental pattern	IMPA (Tweed)	90°	94°	88°	6
	$\underline{1}$-NA (degrees) (Steiner)	22°	31°	22°	9
	$\underline{1}$-NA (mm) (Steiner)	4 mm	9 mm	6 mm	3
	$\bar{1}$-NB (degrees) (Steiner)	25°	31°	25°	6
	$\bar{1}$-NB (mm) (Steiner)	4 mm	8 mm	7 mm	1
	$\frac{1}{1}$ - Interincisal angle (Downs)	130°	109°	130°	21
	$\bar{1}$-APo (mm) (Ricketts)	1 mm	5 mm	5 mm	0
Profile	Upper lip - S line (Steiner)	0 mm	7 mm	5 mm	2
	Lower lip - S line (Steiner)	0 mm	7 mm	6 mm	1

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FINAL CONSIDERATIONS

Open bite is defined as a deficiency in normal vertical contact between the antagonist teeth, and may be manifested in a limited region, or more rarely, throughout the entire dental arch.[1,2] If lack of contact of the teeth is located in the region of the incisors and/or canines, when occlusion is in centric relation, then this is denominated anterior open bite.[1,3]

Some studies have shown that anterior open bite is strongly associated with non-nutritional sucking habit.[4,5,6] In the case of this patient, who reported having used a pacifier up to the age of 8 years, it is believed that the open bite was maintained by lingual interposition after pacifier removal. Regarding the functional alteration caused by the anterior open bite, it was planned to use the fixed palatal crib at the beginning of treatment, and afterwards, when the open bite had been reduced, mandibular spurs would be bonded to the lingual surface of the incisors and the patient would be referred for speech therapy.

In this patient, the option was to extract the maxillary first premolars to correct the overjet and Class II canine relationship. Treatment of Class II without extractions requires extensive distal movement of the maxillary posterior teeth, which frequently becomes complicated, particularly in adult patients[7]. Recent studies have demonstrated that for the same age and degree of severity, the protocol for Class II malocclusion treatment with extraction of the two maxillary premolars is more efficient than the treatment protocol without extractions.[8,9]

Regarding stability, it is consensus that anterior open bite is ranked among the most challenging treatments and its end results have been shown to be less stable. However, it is believed that with the establishment of a correct overjet, over bite and muscular balance between the lips and tongue there will be no relapse of the malocclusion.

As may be seen in the record obtained after the end of active treatment, all the goals were attained from both a functional and facial esthetic point of view.

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The role of friction in orthodontics

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Introduction: Sliding mechanics is widely used during orthodontic treatment. One of the disadvantages of this mechanics is the friction generated at the bracket/archwire interface, which may reduce the amount of desired orthodontic movement obtained. Due to the application and great acceptance of this type of mechanics, the role of friction in Orthodontics has been of interest for both clinicians and scientists.

Objective: Therefore, this article discussed how friction affects orthodontic tooth movement, with an approach to its clinical implications as well as the evolution of dental materials and its properties regarding resistance to sliding.

Keywords: Orthodontics. Orthodontic brackets. Dental materials.

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INTRODUCTION

The friction present during orthodontic sliding mechanics represents a clinical challenge to the orthodontists because high levels of friction may reduce the effectiveness of the mechanics, decrease tooth movement efficiency and further complicate anchorage control.[1] One of the primary focuses of the search for ideal conditions for orthodontic tooth movement (OTM) is the reduction of friction at the bracket-wire-ligature interface in certain stages of treatment[2]. Therefore, lower but still sufficient to promote OTM forces could be used.[3]

Orthodontics, as part of modern sciences, is also influenced by the rapid and constant technological development observed in today's society, most particularly, in regards to dental materials. According to Kusy,[4] an important researcher on this topic, the knowledge about biomechanics and orthodontic materials complement each other. Therefore, a good comprehension about biomechanical concepts is very important for the development of innovative orthodontic materials and such innovations may result in new biomechanical principles.

In this context, one of the major goals of the orthodontic manufacturing companies is the search for new products that would generate less friction during sliding mechanics. Over the last two decades, major efforts have been made to develop the so called low-friction brackets, wires and ligatures. In order to carefully determine the real cost-benefit of these products, the orthodontist must critically understand the role of friction during sliding mechanics. Therefore, the objectives of this article are to: (1) Discuss the clinical implication of friction on OTM; (2) debate which variables and how some orthodontic materials may affect friction during sliding mechanics and, finally; (3) consider the real clinical application of the new low-friction brackets, wires and ligatures.

FRICTION AND SLIDING MECHANICS

Orthodontic tooth movement during space closure may be performed with two different types of mechanics. The first is the "Segmented Arch Mechanics" (SAM), which consists in bending loops on stainless steel (SS) or titanium molybdenum (TMA) wires. When SAM is implemented, the tooth or group of teeth move due to the force to moment ratio generated during the activation of the loops. SAM is also called "frictionless mechanics" because the brackets and tubes do not slide along the archwire[5]. The other space closure mechanics used in Orthodontics is the Sliding Mechanics (SM), which involves the actual sliding of brackets and tubes along the wire.[6]

Although SAM provides excellent control of tooth inclination during space closure, it is not as popular as SM. The possible SAM disadvantages are the need for a refined biomechanics understanding to properly activate the springs and closing loop archwires, as well as the increased chances to cause patient discomfort when these loops are not adequately adjusted.[6] Conversely, the probable SM advantages are the simpler archwires used, the shorter chair time and lower chances to cause patient discomfort[7]. However, SM also presents disadvantages such as the higher chances to generate dental tipping and the friction generated at the bracket-wire-ligature interface.[8]

Friction is the force that resists against the movement of one surface in relation to another and that acts on the opposite direction of the desired movement[1]. When two surfaces slide one over the other, two force components are created: Frictional Force (FF), tangent to the Contacting Surface (CS) and Normal Force (N), perpendicular to the FF and to the CS[8] (Fig 1). FF is directly proportional to N and dependent on the friction coefficient of both contacting surfaces. This coefficient is a constant closely related to the superficial characteristics of each material involved.[1,8]

There are two types of FF: Static Friction (SF) and Kinetic Friction (KF)[9]. SF is the smallest force needed to initiate a movement between two solid bodies that were static in relation to each other. Kinetic friction is the force that resists against the sliding movement of a solid object against another at a constant speed. SF is always greater than KF since it is harder to change a body from its inertial situation than to maintain it moving.[1,8] When an orthodontist tries to slide a tooth along the archwire, the tooth is subjected to an alternate movement of tipping and uprighting, thus moving in a sequential number of small and consecutive movements.

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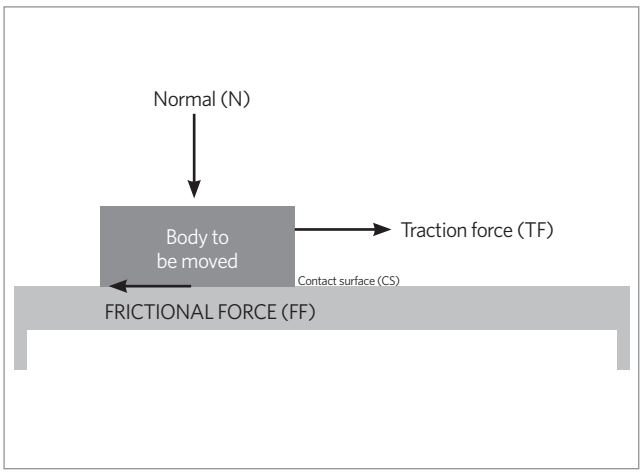

Figure 1 - Different forces acting over a body under traction on top of a surface. Body to be moved, contact surface (CS), Traction force (TF), Friction force (FF).

Therefore, SF is more important than KF during space closure.[8]

The application of the retraction force during space closure with SM generates a moment on the tooth's crown that causes an initial crown tipping and later root uprighting. This moment is determined by the location of the point of force application in relation to the center of resistance of the tooth or group of teeth. A number of successive crown tippings and root uprightings take place in the same plane of space towards the direction of the applied force. When the tooth inclines, the orthodontic wire binds against the edge of the bracket slot ("binding effect"), increasing friction and further restricting OTM. Greater frictional forces mean that an increased number of tipping and uprighting must take place. Thus, friction should be minimized to achieve a more efficient sliding movement of the tooth along the arch wire.[8]

When the orthodontic wire slides through the bracket slot and the tubes, some resistance to sliding always takes place at the bracket/wire interface. This phenomenon is observed during leveling and alignment, space closure and even during torque expression at the end of treatment.[10] A percentage of the orthodontic force applied to the teeth is lost as static friction and the rest is transferred to the tooth and its periodontium, generating the actual OTM. Kojima e Fukui[11] evaluated the influence of friction on OTM using the finite element method and reported that approximately 60% of the orthodontic force applied to a tooth is lost as SF. Thus, the biological tissue response to the mechanical stimulus takes place only if the force is strong enough to overcome SF. Therefore, higher levels of friction during sliding mechanics require the application of higher orthodontic forces and may compromise the amount of OTM obtained as well as complicate anchorage control.[5-8]

Despite the undesirable effects that friction may cause in some stages of the orthodontic treatment, there are other clinical situations in which the presence of friction is beneficial such as when the orthodontist wants to use a group of teeth as a larger anchorage unit or during torquing at the finishing stage of treatment.[1,2,8] Therefore, a good understanding of how friction may impact the clinical development of the orthodontic therapy, the variables that increase friction and how they can be better controlled is very important to the orthodontist who wishes to improve his or her clinical skill and consistently provide better services to the patients.

VARIABLES THAT MAY INFLUENCE FRICTION DURING OTM

The variables affecting the role of friction during orthodontic treatment could be divided in two large groups: Biological and mechanical. The major biological factor influencing SF seems to be the presence of saliva, which acts as a lubricant and plays an important role in friction reduction.[12] This information may be important when treating patients presenting xerostomia or those who regularly take medications that reduce the production of saliva. The influence of saliva in friction reduction may also be relevant when an orthodontist consider the clinical application of *in vitro* laboratory studies. Some of these experiments do not simulate the presence of saliva and neither point out this methodological limitation.

The accumulation of debris on the surface of orthodontic wires also appears to be a significant variable that may increase friction throughout the orthodontic treatment. Significant deposits of biofilm were registered on orthodontic archwires after only 8 weeks of intraoral use.[13] The number of adult patients seeking orthodontic care has been

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increasing in the past decades and these patients have higher tendencies for calculus formation. Therefore, the orthodontist who constantly treats adult individuals should pay attention to the presence of debris on the archwires that may be used for several months. Stainless steel archwire cleaning following clinical use with ultrasound for 15 seconds or with steel wool sponge for one minute were efficient methods to decrease the static friction of used archwires.[14]

The third biological variable that may be clinically relevant is the biodegradation that the orthodontic materials suffer throughout the orthodontic treatment. A recent evaluation of some important properties of brackets and elastic ligatures after their use brought some light to some of the questions related to the biodegradation of orthodontic materials.[15,16] The examination of metallic brackets post-orthodontic treatment revealed alterations such as corrosion, structural fatigue and plastic deformation. Different levels of biofilm were registered at the surface of these products and carbon, oxygen, calcium and phosphorus were found superficially. Commercially available brackets of two different manufacturers presented up to 20% more friction than their out of the box correspondents.[15] Differently than the brackets, elastic ligatures showed similar levels of friction both brand new or after different times of intraoral use.[16]

The physical and mechanical properties of orthodontic brackets deserve special attention when the effects of friction on OTM are considered. In this context, the type of material used to construct the bracket is the first property to be evaluated. Metal brackets present lower friction coefficients than ceramic and plastic brackets and they are considered the golden standard to perform sliding mechanics.[17] Plastic brackets showed lower values of friction than polycrystalline ceramic brackets.[17] Others studies investigated possible static friction differences between poly and monocrystalline ceramic brackets and no significant differences were registered.[12,18] Omana et al[9] reported that scanning electronic microscopy evaluations showed no major surface roughness differences between the two types of ceramic brackets and this property could not be pointed out as the cause for different levels of friction between mono and polycrystalline ceramic brackets. The first group presented a slightly smother slot surface, but the levels of friction were very similar between the two groups.[9]

The insertion of a metal slot in ceramic brackets has showed relatively good success to reduce the levels of SF on this type of esthetic orthodontic brackets. This structural modification aimed to combine the esthetic of a ceramic bracket to the clinical performance of metal brackets[4]. Ceramic brackets with metal slots did show lower levels of SF than pure ceramic brackets. However, their levels of SF remained higher than those registered with metal brackets.[19] This difference may be due to the different ceramic and metal expansion coefficients,[4] or to the presence of a gap between the ceramic bracket body and the metal slot[20] what could be responsible for an inaccurate adaptation between these two major components, compromising its clinical performance.

Bracket size, slot depth and width also influence the amount of friction registered during sliding mechanics. Wider brackets present higher frictional forces than brackets with reduced width due to the greater area of surface contact between the bracket and the wire. In addition, a greater angulation of the wire in relation the bracket slot is also related to an increased resistance to sliding.[21]

The type of orthodontic wire used will also influence the amount of friction during the different stages of treatment and the wire alloy, its cross section and diameter as well as the surface roughness should be taken into consideration. Cacciafesta et al[22] evaluated the amount of friction related to the most commonly alloys used in orthodontic archwire manufacture: Stainless steel (SS), nickel-titanium (NiTi) and TMA. 0.016-in, 0.017 x 0.025-in and 0.019 x 0.025-in wires were tested and the results showed that SF increases when thicker wires of the same alloy were tested. TMA wires presented higher frictional resistance than SS and NiTi wires of same diameter. According to Omana et al,[9] the influence of the wire size on friction increases because thicker wires fulfill the bracket slot and the amount of force needed to cause orthodontic tooth movement is also increased. Saunders and Kusy[18] also reported higher frictional values with

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TMA wires, followed by the NiTi arches. They suggested that the increased TMA surface roughness and the greater elasticity of the titanium alloys as the reasons for such findings.

Another mechanical variable that plays an important role in friction formation at the bracket/wire interface, constantly present in daily clinical orthodontics is the method of wire ligation to the bracket. Steel or elastic ligatures may contribute differently to friction increase depending on how they are used.[23] Steel ligatures influence resistance to sliding according to the intensity of the ligation. They can generate higher amounts of SF than elastic ligatures if they are tightly used. However, if they are loosely inserted, small gaps between the wire and the bracket slot remain present and smaller SF values may be registered[24]. The amount of SF may also vary depending on the type of elastic ligature used to ligate the archwire to the brackets. Hain et al[24] reported that elastic ligatures with decreased surface roughness generated lower amounts of friction.

Elastic ligatures tied as the number 8 generated increased levels of SF with all ligatures tested.

The high number of variables that may influence friction complicates the determination of the exact variables acting in all different clinical scenarios especially when all possible types of bracket/archwire/ligature combinations are considered. The search for new materials that decrease the amount of friction continues and it has actually increased in recent years, as discussed below.

RECENTLY INTRODUCED ORTHODONTIC MATERIALS TO REDUCE FRICTION

The golden standard materials to perform sliding mechanics is the combination of stainless steel brackets and wires[1,4]. The main technological innovations that have been tried to create low-friction orthodontic materials could be divided in design innovations and surface treatments. Among the various attempts to change the bracket design to reduce friction, the use of self-ligating brackets (SLB) has been the most tested.

During the past decade, SLB have been advertised as the new great innovation in Orthodontics. However, like some other "innovations", the idea of having a self-ligating bracket is actually not that new. The first report of a SLB was the Russell Lock appliance in 1935.[1-4] Other brackets with similar concepts have been introduced in the market and a few of these SLB have been consistently available since the early 80's[25]. SLB present a clip incorporated to its buccal surface that locks the wire within the slot and transforms the bracket in a tube-like device, thus eliminating the need for elastic or steel ligatures.[2,3] Passive SLB present a clip that does not press the arch wire against the internal walls of the bracket slot (Fig 2A). Conversely, active or interactive SLB present a spring clip that pushes wires of greater diameter against the bracket slot (Fig 2B).

There were no significant differences between the amounts of friction registered when passive and active SLB where tested with round wires, However, when heavier rectangular wires were implemented active SLB showed more resistance to sliding than passive SLB.[26] Ehsani et al[27] performed a systematic review of the literature on SLB and reported that based on the evaluation of the papers published until august 2008, there were no evidence to support that SLB brackets generated significantly less friction than conventional brackets in the following clinical situations: (1) when rectangular stainless steel wires were used; (2) with marked dental tipping or torquing and (3) when treating complex malocclusions. The fracture of the buccal clip, the difficulty in using elastic chains and the cost up to ten times higher than conventional brackets of the same manufacturer have been reported as other limitations of SLB.[2,4] However, the authors of this manuscript acknowledge that the orthodontic companies have been heavily investing in SLB both on research and in advertisement. Therefore, as further laboratory and clinical studies take place, improvements may decrease the current SLB limitations, reduce their cost and if all advantages suggested by the manufacturers are confirmed, the use of SLB as the golden standard for orthodontic brackets may became truly evidenced based.

A polyurethane elastic ligature presenting a very creative design (Slide®, Leone Ortodonzia e Implantologia, Florence, Italy) is another "new"

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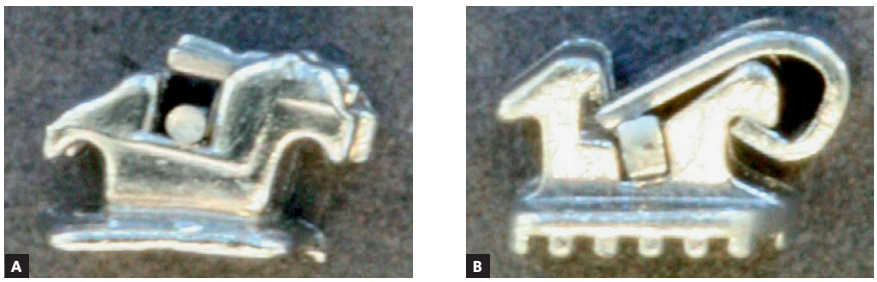

Figure 2 - **A**) Passive SLB: The buccal clip does not touch the arch wire, **B**) Active SLB: The buccal clip may press the wire against the internal surfaces of the slot depending on the wire cross section and diameter.

low-friction material recently introduced in the market. This ligature combined to a conventional bracket forms a tube-like structure (Fig 3). Baccetti e Franchi[28] reported significant lower resistance to sliding with the Slide® ligature than with conventional elastic ligatures. They concluded that this newly-designed elastic ligature may be used to generate a low-friction system when conventional brackets were used. Another possible advantage of this system would be the possibility to selectively use this ligature in one tooth or in some teeth were lower levels of friction were desired.

Finally, the efforts to discover technological innovations to decrease friction in Orthodontics are not limited to design modifications. The use of different superficial treatment of orthodontic materials has also been explored. A new type of elastic ligature that incorporated a technology named Metafasix® (Super Slick Elastic Modules®, TP Orthodontics, La Porte, IN, USA) was recently introduced. According to the manufacturer, the engineering process is similar to the one implemented to fabricate stents used to treat coronary heart disease, consisting of a water resistance polymeric coating, thus making the elastic ligature extremely slippery in the presence of saliva. Hain et al[24] reported approximately 60% of friction reduction when these elastic ligatures were used.

Diamond-like carbon (DLC) surface coating of SS and NiTi orthodontic wires have been suggested to decrease static frictional force.[29] These ions were incorporated to the surface of wire during the manufacturing process, increasing the wire hardness and significantly reducing SF when compared to the conventional orthodontic wires. The same technology was recently tested to improve the clinical performance of stainless steel brackets. The initial *in vitro* results were very promising for both increasing the superficial hardness and reducing the resistance to sliding.[30]

CONCLUSION

1. The resistance to sliding in Orthodontics is multifactorial. It is directly influenced by the types of materials used and affects orthodontic tooth movement efficiency. The presence of friction is unfavorable in many clinical situations. However, it may be very important in others.
2. The biological variables influencing friction seem to have been overlooked by orthodontists. Simple factors such as the accumulation of debris over the wire surface and the brackets' biodegradation registered after intraoral use may be as important as the type of material used when friction in Orthodontics is considered.
3. The physical or mechanical variables that influence friction formation during OTM are more frequently researched than the biological variables. They should be carefully taken into consideration during the different stages

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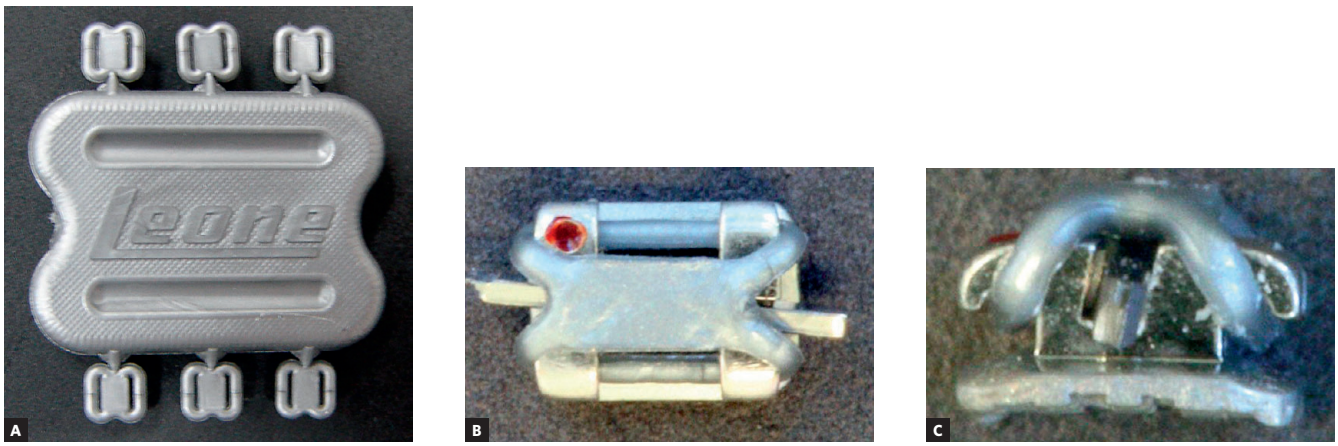

Figure 3 - **A**) Slide® elastic ligature, **B**) Frontal view of the ligature tied to a conventional metal bracket, **C**) Lateral view of this low-friction system, where there is no pressure on the orthodontic wire.

of the orthodontic treatment to increase efficiency in different clinical situations.

4. The technological innovations used to develop new low-friction materials such as the design alterations and the surface treatments seem to present good potential to reduce friction in specific clinical situations. However, the cost of these materials is still significantly higher than the traditionally used materials and their real cost to benefit remains scientifically questionable.
5. The need to increment orthodontic materials research especially performing studies with greater direct clinical application is undisputed. These studies would help clinical orthodontists to better understand the performance of all materials available and to critically follow the new products introduced in the market. Therefore, the orthodontist would be able to identify which of these new materials may actually contribute to diminish the clinical limitations of some orthodontic materials.

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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;
- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

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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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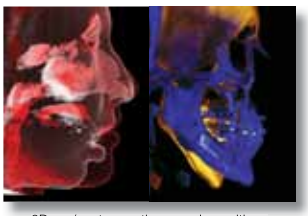
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