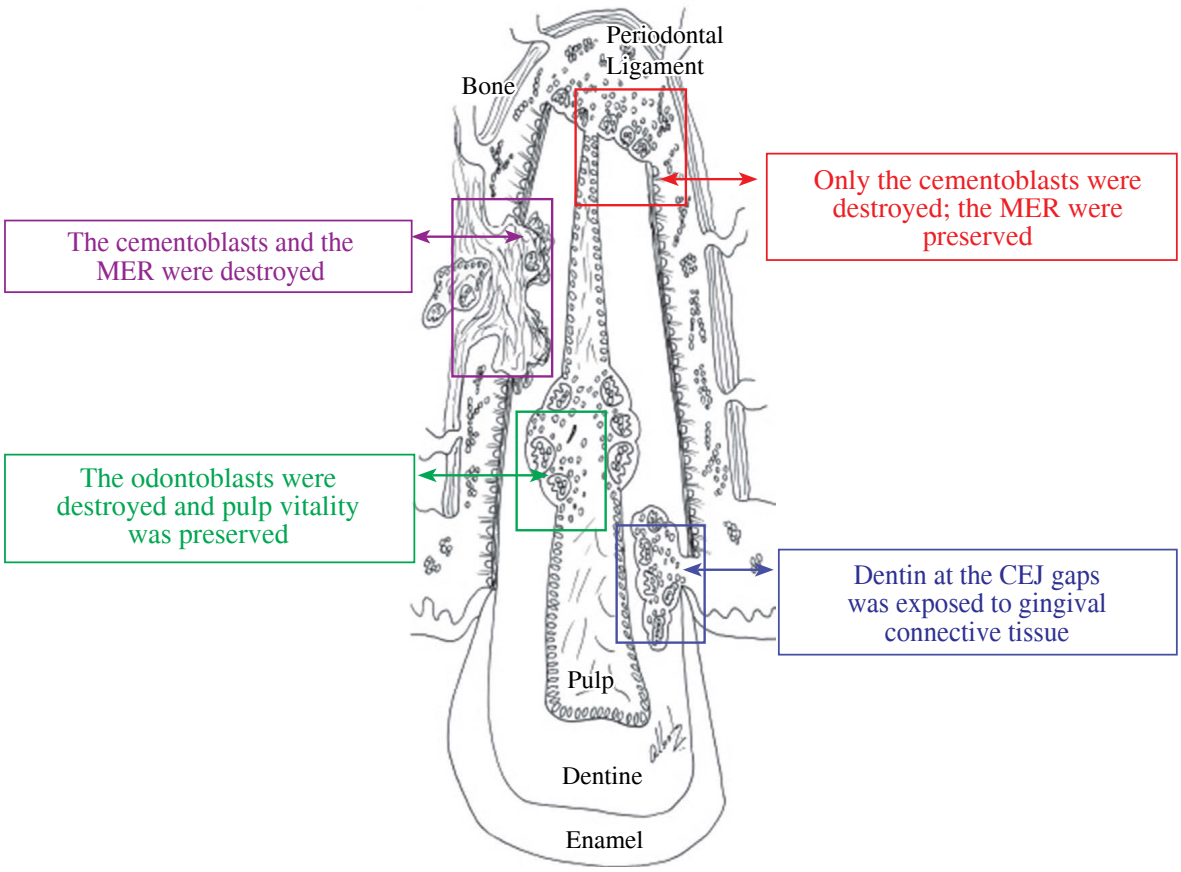
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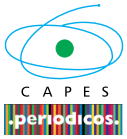
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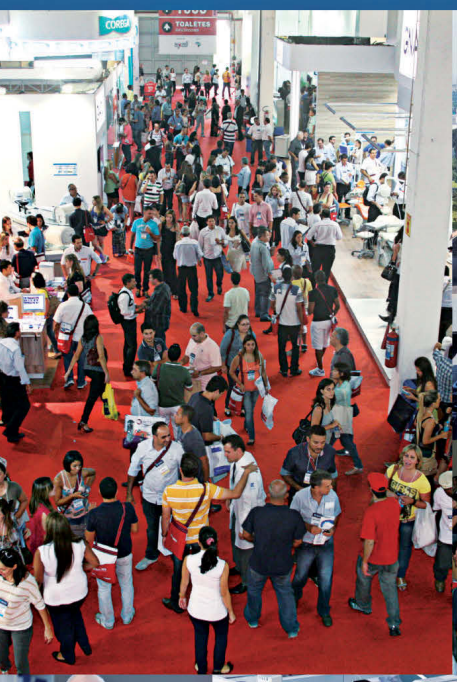



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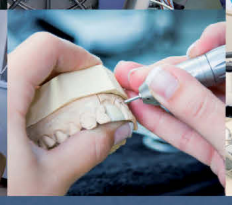











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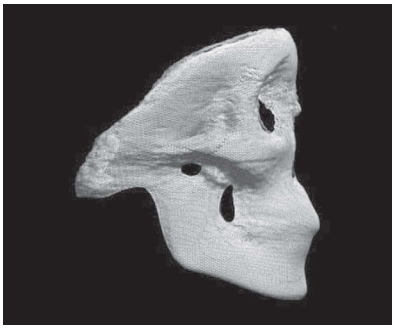
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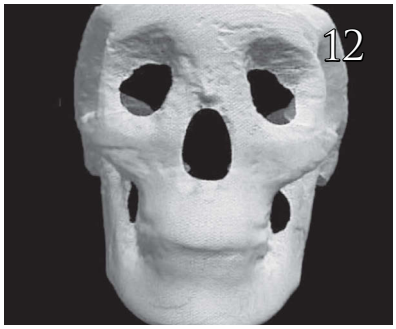
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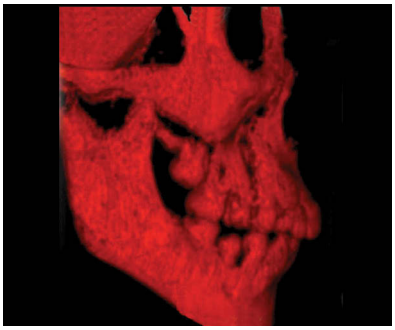
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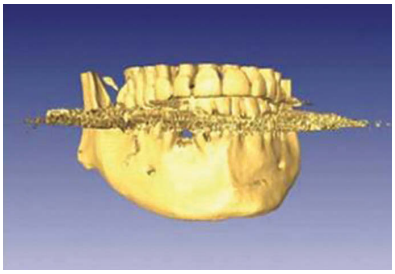
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Orthodontic brackets – between passion and science

Passion is an unbalanced love.
Science is an investigative love.
Truth is love which perpetuates.
(Chico Xavier)

In Orthodontics we grew up with passionate discussions around brackets. During Orthodontic's childhood we contemplated brackets systems that have been stamped as the "last and best" — to paraphrase Angle — but that vanished even before we reached Orthodontic's adolescence. Topics such as slot dimensions, influence of manufacturing material and, recently, the ligation system, are eloquently debated. Leaving alone high-spirited discussions, the lack of scientific information regarding the influence of the bracket system on treatment efficiency is frightening. It is important to understand efficiency as good results with short treatment time.

While there are few studies which would offer us good scientific background on bracket slot (0.018-in or 0.022-in) or prescription (Straight-Wire or Standard Edgewise) choice, orthodontic science has produced an enormous amount of clinical trials to prove the efficiency of self-ligating brackets.

At the beginning, a great number of laboratory studies have demonstrated friction reduction with self-ligating brackets compared with conventional ones. However, the power of these studies, as with this editorial, isn't enough to justify the system choice or the treatment speed. There are limitations in this study design in representing what really happened in the oral environment.

A question arises here regarding the reliability of the study designed to investigate the effectiveness of self-ligating brackets on orthodontic treatment. The gold standards for health clinical studies are randomized trials. How are they designed? Why are they ideal for researches?

For randomized clinical trials researchers select patient groups with similar characteristics regarding malocclusions, called inclusion criteria. Treatment type (conventional or self-ligated for example) is determined randomly, most of the time by a computer program. Even the orthodontist that will treat the case is chosen in the same manner, in order to eliminate the operator effect. In this way, neither the patient, nor the professional will have any influence on the treatment choice and result.

Once patients have been allocated randomly into their respective groups, the cases are monitored to the end. Data such as treatment time, quality of results, patient abandonment and other variables are collected. It is assumed that differences shown at the end of the study are an exclusive consequence of the treatment option.

I am not aware of any randomized clinical trial showing how Straight-wire brackets are more effective then standard Edgewise or how 0.018-in slots are better than 0.022-in ones. Would metal brackets produce better results than the ceramic ones?

What about self-ligating brackets? Are there any randomized studies about their efficiency? Yes, there are. What kind of information do they offer? These studies are consistently — and uniquely — showing no benefits in using self-ligating brackets to reduce treatment time with quality final results. There are plenty of studies proving this and by the time this article reaches you, there will be even more.

Unfortunately, in Orthodontics, very frequently products are launched by the industry without scientific proof. This is unaccepted in Medicine. Based on this fact, the belief in a bracket-wire system that promises to answer our patient's key question — "When am I taking the brackets off, Doctor?" — is surprising.

Even though passion persuades us to hear a sweet answer, science remind us that truth is yet to come, and seems not to be hidden in metal clips or slide ligatures.

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We are left with the need to dive into science, to find the answers to shorten treatment time. In the meanwhile — and science always has space for an appealing "while" — there is no reason to change our bracket system with the goal of treatment time reduction.

However, there is always something good to take from different systems. With self-ligating brackets there is enough clinical and scientific evidence that they reduce chair time since the opening and closure of bracket clips is faster than changing elastic modules by about 2 minutes. If you have a busy practice, this will make a difference at the end of the day. But apart from this it can't be counted as an advantage.

Another reason to choose self-ligating brackets is to avoid the inconvenient discoloration of clear elastic ligatures, a constant issue for patients with esthetic brackets.

With regard to its convenience for orthodontists, there is a strong feeling that self-ligated brackets constitute a one-way street in Orthodontics. Treatment costs are significantly reduced, however, orthodontic science hasn't confirmed them as a tool to reduce treatment time. Unfortunately, many young orthodontists who believed, or still believe, in this promise will later realize the power of the message in the epigraph.

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BBO good seeds and the specialty excellence

From now on, the Dental Press Journal of Orthodontics begins an important collaboration with the Brazilian Board of Orthodontics and Facial Orthopedics (BBO). This significant partnership between Dental Press and BBO allow readers of this renowned journal to follow the breakthroughs and remarkable work of the BBO.

I was invited by the current BBO president, Dr. Sadi Flavio Horst, to write this editorial, a space that will annually be occupied by a member of the Board. Just as a beautiful smile gives a wonderful impression at first sight, I would like to underline what the BBO represents to our specialty in the new millennium. I hope this first impression can awaken a desire to know the Board better. This is our goal with the first BBO editorial hosted in this DPJO issue.

The Brazilian Board of Orthodontics and Facial Orthopedics (BBO) was born from the initiative of the Brazilian Association of Orthodontics and Facial Orthopedics (ABOR) to create 'Quality standards for clinical excellence' in this field. BBO Diplomate orthodontists are recognized as professionals that were evaluated by a strict and renowned examining committee, demonstrating to have great knowledge and skills in the art and science of Orthodontics.

With the establishment of the BBO on the 2nd of September 2002, Orthodontics became the first health specialty in Brazil to have a certification process for specialists. Orthodontics was the first specialty in global dentistry to create a board in 1929 during the 28th American Society of Orthodontia meeting in America — the American Board of Orthodontics (ABO). In 1950, the Council on Dental Education of the American Dental Association (ADA), recognized the ABO as the official certifying agency in Orthodontics.

Having a board certification demonstrates the specialist's commitment to the necessary knowledge to treat patients with the highest quality standards. Everybody benefits by this arrangement: The society gains with the option of counting on recognized well prepared professionals; science is supported by high standard studies and breakthroughs; representative orthodontic associations are elevated as they improve standards to meet the needs of their associates. For orthodontists, in particular, having the board certification has a significant impact on their ethics and values of conduct. The demand for excellence is a way of achieving seriousness, respect and commitment to the best results for patients.

BBO certification is a demonstration of the right direction, namely, the highest level of quality work. Looking for excellence in each action is a sign of kindness and gentleness with our own life. A quote by Willian Lyon Phelps, an American writer, uniquely communicates the importance of seeking for knowledge and wisdom: "*Every time you acquire a new interest, even more, a new accomplishment, you increase your power of life.*" In the same way, we can increase our power of life by becoming better, doing more, offering the best of our capacity and potential to our patients. Regarding the principle of desiring the best, Gilberto Amado remind us that, "*Wisdom is the art of climbing higher inside ourselves.*" Wisdom is looking for the best, it is to take a step forward, becoming an expert, walking where few are willing to go. It is a hard way, but all the rewards we have achieved so far reassure us that it is worth it.

The Board can rise the spirit of constant update and, also, offer references and parameters of the specialist work to the general public. Board candidates are assessed by their knowledge in diagnosis, treatment plans and orthodontic therapeutics. The exam gives the opportunity for candidates to review their skills, consider the importance of taking good records, mechanics control during treatment, and commitment until the end of treatment.

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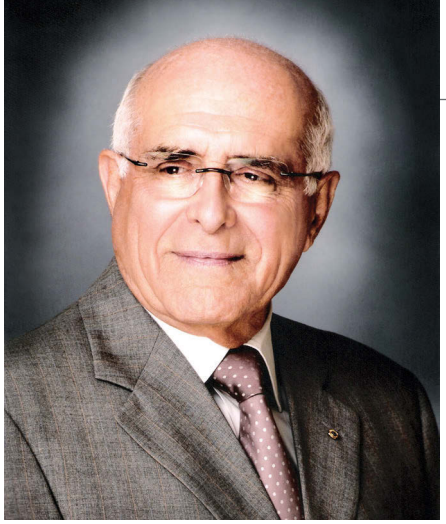
Among the benefits of having the certification, it is worth highlighting the changes in professional conduct — shown by patient's satisfaction — and the safety of working with good quality standards, with records taken from the beginning to the end of treatment. Also, candidates have the opportunity for self-assessment via a strict and detailed review of their clinical practice. Therefore, the certification process represents an important step on the way to improve Orthodontics quality.

Board certification implies that orthodontists become life long students. Learning experiences with the Board are crucial and there is no progress without apprenticeship. Orthodontists have a need for continued learning and the Board represents a good way of doing this. In March 2014, as an example of ABO, BBO launches the recertification process, as its bylaws sets out. This is an important tool to validate continued competency.

Upon the creation of the BBO, I said that the one who works only with the hands is just a worker, the one who works with the hands and head is an artisan, and the one who works with the hands, head and heart is an artist. It is important though to understand Orthodontics as science and art, to became a daily artist. It is well known that every artist needs dedication, studying, training and commitment. Talent is not magic, one has to work hard to achieve excellence. BBO gives the tools, conditions and parameters for this continued specialization. As BBO's certification is not mandatory to practice orthodontics, the consolidation of its best goals (excellence in practice) comes with time and propagation of its principles and philosophy. This resembles the seeds a farmer sows with faith in its results. This is the mission of the Brazilian Board of Orthodontic and Facial Orthopedics today: to sow the good seeds of desire and consciousness to orthodontic specialists as to become more prepared and capable of making their patient's face and smile more beautiful and better.

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Prof. Dr. Décio Rodrigues Martins

Goodbye, Dr. Décio. We deeply thank you!

"Perseverance is the key to success, nothing is impossible for the man impelled by intrepid believes!"

Décio Rodrigues Martins, in interview for Dental Press (October, 1996).

With a life marked by happiness, delight and accomplishments, Dr. Décio Rodrigues Martins rested after an intrepid journey. He passed away on the 29th of May, after five years of an unceasing battle trying to keep alive a heart that made many others beat fast, in a rhythm of intensity and enthusiasm. Innumerable people in his family, students, colleagues, followers and friends, remain full of gratitude for the intense life this man lived, accomplishing his mission in his "own way" — as in the lyrics of his favorite song.

By paraphrasing Socrates, he claimed to be satisfied with his journey: "The secret of having a happy death is having a happy life!" Being face-to-face with death, he repeated many times: LIFE, I THANK YOU VERY MUCH!

Dr. Décio always claimed that what we take from this life is the good we do to others and the emotional ties we build along the way. Professor Décio leaves a valuable legacy of personal and professional values.

He was oftentimes excessively demanding, unseasonable, impetuous, tempered and brave. If he was demanding towards his children, grandchildren and students mainly, it is because he had always dedicated himself considerably. Should he not see the development of one's potential, he would become furious. He had a lot to give. Valuable exchanges between him and his students truly fed his professor's soul which was combined with a father, provider, and protector figure.

He overwhelmed everyone he met not only with his family ties which were beyond blood ties, but also with the science and the art of Orthodontics. Nevertheless, he emanated and taught excellence in teaching by means of valuing discipline, severity, good domain of Portuguese and general culture, always improving his intellect, his reason and his way of living: with wisdom and humbleness, especially when acknowledging his own mistakes. He always had plenty of love and generosity to give, as these were peculiar to him.

He was pleased and proud to say that many Brazilian orthodontists had been his students or students of his former students. Therefore, they were his "children" and "grandchildren", directly or indirectly. Along with his great partners, pioneers in Brazilian Orthodontics (Dr. Muler de Araujo, Dr. José Édimo Martins and Dr. Décio's closest friend, Dr. Sebastião Interlandi), Dr. Décio Rodrigues Martins has directly or indirectly influenced the lives of many generations of professionals.

I once read a quite old text written by Dr. Interlandi, which impressed me very much. In his text, he expressed his wish to make Orthodontics available to barefoot boys. We owe the popularization and diffusion of Brazilian Orthodontics to these four men who were at our disposal to teach Orthodontics beyond their clinics, democratizing their clinical practice and allowing competition to improve quality and promote research and education initiatives.

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Within a global context, Brazilian Orthodontics is surely one of the best in the world. I would dare to claim that no other country makes good orthodontic treatment available for such reasonable price.

We will miss Dr. Décio's first classes, in which he used to present the history of both national and international Orthodontics. We felt we were very privileged pupils who were inserted in an invincible and indefatigable militant group of "sculptures in vivo"! At first, he would congratulate us for having chosen the Orthodontics field, convincing us that we would have a magnificent professional future — following the steps of those who had established our path and taking care of the legacy to which these great men devoted their lives, leaving their sublime example to us.

When I became aware of my grandfather's case, knowing that it was irreversible and that it had been aggravated in the past days, I called Dr. Interlandi who went to visit him in hospital. Their friendship as well as their closeness was always heartwarming. But in the end, at this last moment, the feelings they had for each other opened the doors to what my grandfather meant by "what we take from life". A remarkable moment, inexpressible in words. There are fissures in time and space, moments when only silence may express what words cannot. Nevertheless, at this moment, I attempt to share my feelings towards the last lesson I learnt from these two partners who have strongly influenced our lives in many respects.

Keeping Dr. Décio company in hospital was an extremely significant lesson! He gave classes while he was sleeping! He asked questions such as: "What are the mouth appendages?" I answered: "The teeth!" He was given excruciating injections in his abdomen and when the nurse entered the room saying it was time to do so, he said: "Let's go for it!" He underwent physiotherapy as if he was working out, until his last day. He was so humbly gallant. His last words to me were: "I have noticed I am getting worse, but we must remain resolute until the end!"

A colleague of his mentioned on Facebook, where many heartwarming farewell tributes were rendered, in capital letters: BRAZILIAN ORTHODONTICS IS IN MOURNING! How should we go into mourning, face our sadness for losing and missing him, and move forward with Dr. Décio's vivacity?

Quoting the philosopher Antisthenes, Dr. Décio used to say that: "Gratitude is the memory of heart". We are certain that he lived his life completely and happily, and this comforts us. The steps we have to follow are strong and the legacy he left us is extremely valuable. His thunderous voice shall echo forever in our affective memory, making many hearts beat fast, freeing us from inertia, encouraging us to improve in personal and professional matters, acting as the propelling spring of Brazilian Orthodontics.

We affectionately surrender to the Lord this great source of inspiration, great father, grandfather and great-grandfather of many students and followers, someone who has contributed to the lives of many. Everything that could have been done was done. Everything that could have been said was said. All hugs were given. The journey comes to an end with plenitude and peace!

The opportunity of paying tribute to Dr. Décio, preserving and keeping his memory in Brazilian Orthodontics is the best way of being in mourning for Dr. Décio as he would like us to do. Dental Press Journal of Orthodontics is indeed the most appropriate place to do so. For being one of the main supporters of this Journal, Dr. Décio was the first person to be interviewed.

He lives in every person who was inspired and welcomed by his life. We have never felt more fraternized by his lessons, his example, the impression he has left on our lives, the valuable legacy he has left to us, by our pride for having him as our preceptor and certainly, by his absence.

Deep is our mourning because incommensurable is our lost, but immense is our love. Gratitude is certainly the greatest feeling we have: GOODBYE, DR. DÉCIO. WE DEEPLY THANK YOU.

Maria Fernanda Martins-Ortiz Posso

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The four mechanisms of dental resorption initiation

Alberto Consolaro*

The aim of this study is to present a classification with a clinical application for root resorption, so that diagnosis will be more objective and immediately linked to the source of the problem, leading the clinician to automatically develop the likely treatment plan with a precise prognosis. With this purpose, we suggest putting together all diagnosed dental resorptions into one of these four criteria:

1) Root resorption caused by cementoblast cell death, with preservation of the Malassez epithelial rests.
2) Root resorption by cementoblasts and Malassez epithelial rests death.
3) Dental resorption by odontoblasts cell death with preservation of pulp vitality.
4) Dental resorption by direct exposure of dentin to gingival connective tissue at the cementoenamel junction gaps.

Keywords: Dental resorption. Root resorption. Tooth movement. Internal resorption. Cervical resorption.

Dental resorptions are traditionally classified according with the mechanism of maintenance and evolution into:

a) Inflammatory.

b) By replacement.

Inflammatory dental resorptions[1] are maintained by inflammatory mediators that stimulate BMUs — Bone Multicellular Units — where clastic cells gradually resorb the dentin surface free of cementoblasts and odontoblasts, eliminated as a consequence of the resorption process. The therapeutic principle of these dental resorptions is based on the identification and elimination of its cause, therefore, the resorption process will evolve to the repair phase. This is how we see inflammatory resorption related to orthodontic movement in each activation period.

Dental resorptions by replacement[1] are maintained by systemic and local mediators of bone tissue which regulate the remodelling process or turnover. This resorption occurs always as a consequence of alveolodental ankylosis because of the death of Malassez epithelial rest cells — induced by dental trauma, especially by daily concussions. Since there is no way to eliminate the local mediators for bone turnover, the prognosis of dental resorption by replacement almost always involves tooth loss. It is important to highlight that orthodontic movement and occlusal trauma does not induce Malassez epithelial rests death.

To facilitate the clinical and etiological understanding of root resorptions, it was proposed a classification for each case, using as criteria its mechanism of induction and initiation of the process. Figures 1 and 2 illustrate and explain it.

[1] Full Professor, FOB-USP. Full Professor of the Post-graduation program, FORP-USP.

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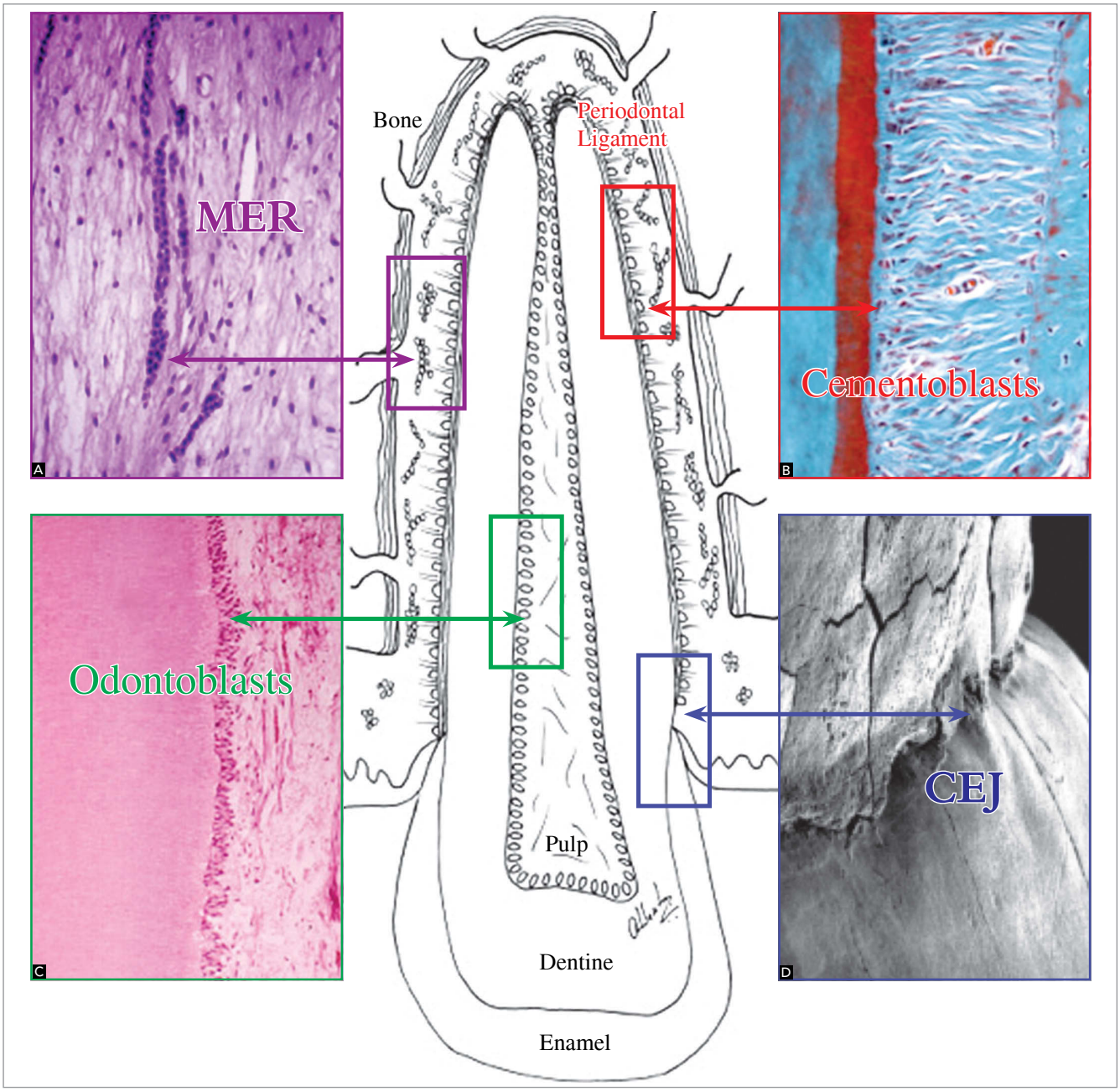


Figure 1 - The four tooth protective structures against resorption: Malassez epithelial rests, (MER), cementoblast cells, odontoblast cells and cementoenamel junction (CEJ). Resorption process is triggered by destruction or local exposure of these structures (**A** =H.E., 160X; **B** = T. Mallory, 160X; **C** = H.E., 40X; **D** = MEV, 100X).

Using this classification in each clinical case allows a direct and precise diagnosis, immediately linked with its cause, leading to an automatic reasoning of the likely treatment plan with an accurate prognosis.

Root resorptions are grouped as follows:

1. Root resorption by cementoblast cell death with maintenance of Malassez epithelial rests

» Inflammatory root resorptions during orthodontic movement.

» Apical Inflammatory root resorption in chronic periapical lesions.

» Inflammatory root resorption by mild and /or contaminated trauma.

» Inflammatory root resorption by occlusal trauma.

2. Root resorptions by cementoblast and Malassez epithelial rests death

» Resorption by replacement in dental trauma.

» Resorption by replacement in periodontal ligament atrophy of unerupted teeth – especially canines.

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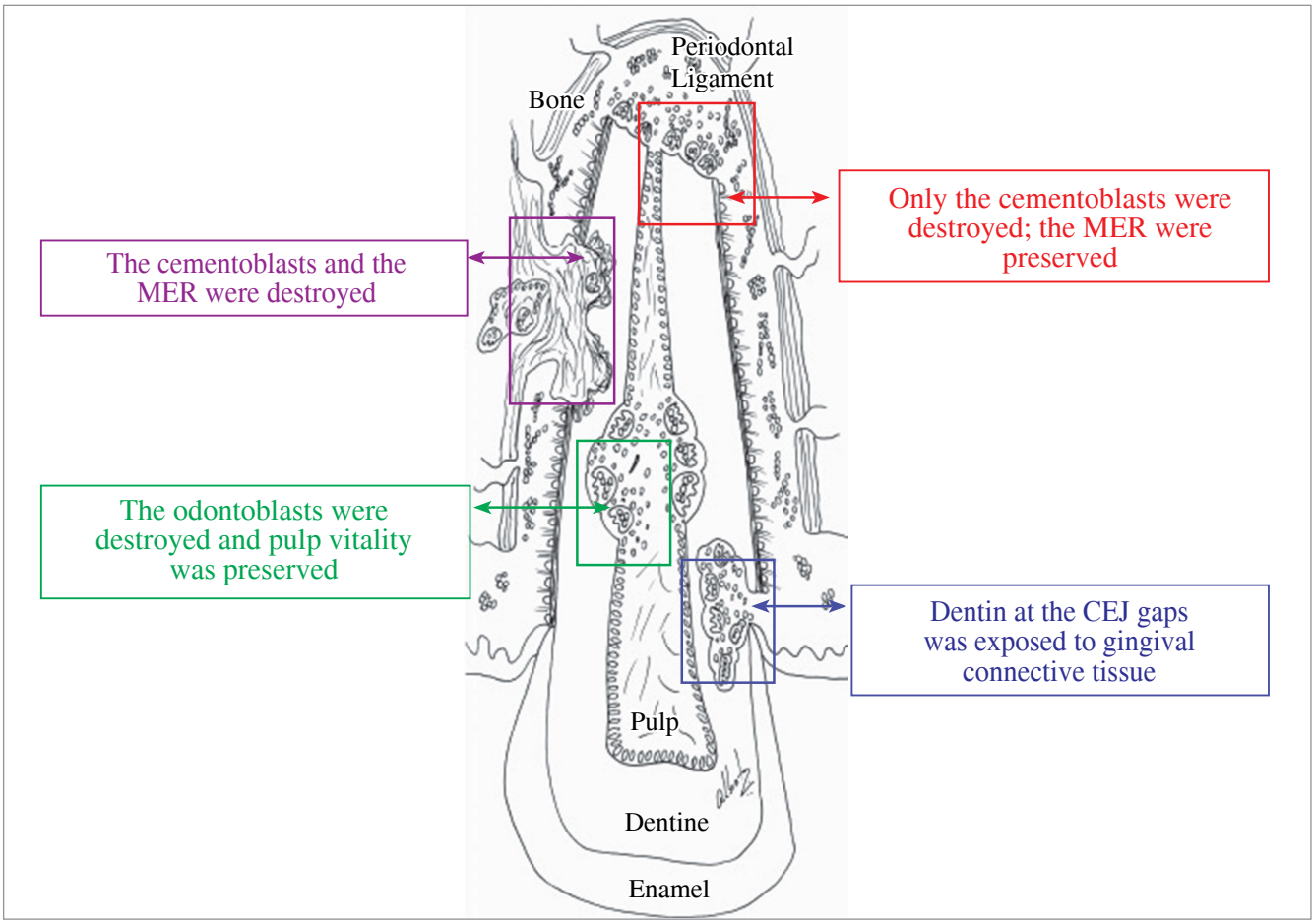


Figure 2 - Destruction or local exposure of the four protective structures of the tooth are the initial phenomena of the four different types of resorption processes leading directly to its cause, treatment plan and prognosis in each clinical case, as represented in this figure.

3. Root Resorption by odontoblast cell death with maintenance of pulp vitality
   - » Internal Inflammatory root resorption by dental trauma.

4. Root resorption by direct exposure of dentin to the gingival connective tissue at the cementoenamel junction gaps
   - » External cervical inflammatory resorption by accidental trauma, especially concussion.
   - » External cervical inflammatory resorption by trans-operative dental trauma as in impacted canine traction and during intubation in general anesthetic procedures.
   - » External cervical inflammatory resorption in association with internal whitening procedures.

FINAL CONSIDERATIONS

The application of the proposed classification for dental resorption to every clinical case will help the development of a direct diagnosis promptly linked with its cause. This will lead to a treatment plan with a precise prognosis.

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Matheus Melo Pithon*

MINI-MAXILLARY PROTRACTOR APPLIANCE: A NEW OPTION FOR CLASS III TREATMENT

The search for an esthetic appliance to treat Class III malocclusion has intrigued researchers for years. More recently, emphasis has been laid on the early correction of this malocclusion with the use of skeletal anchorage, associated with intermaxillary elastics with Class III orientation. Although this technique has revolutionized Orthodontics, there is still a need for surgical intervention. Some patients have accepted this proposal well, and others have not. Therefore, the initial problem goes back to "*square one*", raising a new question. How to treat this malocclusion without surgical intervention, but at the same time, without the appliance being anti-esthetic? In seeking improvement in the esthetics of protractor appliances, an infinite number of new designs have appeared, among these the mini maxillary protractor appliance (Fig 1). But would this appliance with reduced dimensions be effective in protracting the maxilla? Searching an answer to this question, Turkish[1] researchers conducted a clinical study, in which they verified the effectiveness of this appliance, in comparison with a control group. The results obtained were encouraging, seeing that this device with reduced dimensions was capable of applying traction to the maxilla, leading to dental and facial skeletal changes. Therefore, this device has become another option for the orthodontist in the early treatment of Class III malocclusion. It is worth pointing out that long term studies must be conducted due to the great potential for relapse of this type of malocclusion.

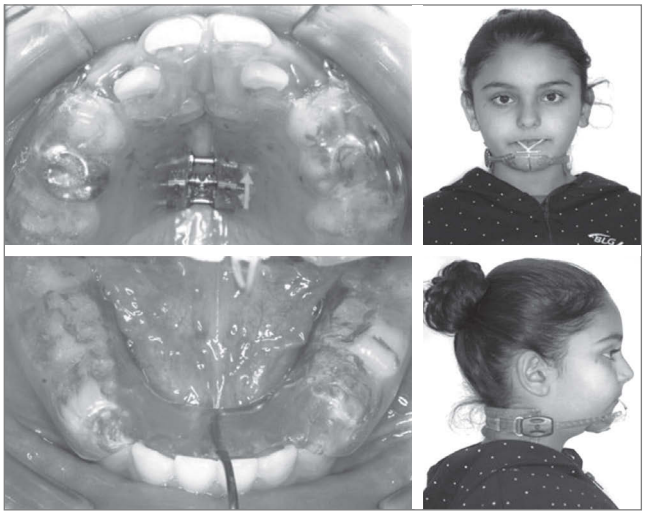


Figure 1 - Intra and extraoral photographs of the mini maxillary protractor appliance used in the study (Source: Celikoglu M, Oktay H[1]).

MINI-IMPLANT REMOVAL IS A SAFE PROCEDURE AND DOES NOT CAUSE SYSTEMIC BACTEREMIA

In contemporary times we come across patients in a wide variety of age-ranges, malocclusions and health conditions. Years ago, the prevalence was for only young patients with all their teeth present, and in good health. This reality has changed, since adult patients have invaded dental offices, and with them, the most diverse types of local and systemic problems. With these patients, special care must be taken, since systemic problems may be aggravated by intraoral interventions. In this context, special mention is made on patients with cardiac compromise, with whom special care must be taken, particularly with regard to contamination — the so-called transitory bacteremia — while performing dental procedures. The literature has established that in these individuals, when performing more invasive procedures, the use of prophylactic antibiotic therapy is imperative. When we think of Dentistry, it immediately brings to mind that the insertion and removal of mini-implants, undoubtedly is the most common and crucial procedure. But would this procedure be capable of causing bacteremia in the patient, leading to a risk of systemic compromise? In an endeavor to elucidate this question, Greek, Swedish and Dutch[2] joined to conduct a multicentre clinical study, in which they evaluated bacteremia occurring with the removal of mini-implants. The results found in this study demonstrated that the removal of mini-implants does not lead to bacteremia. This result brings us a certain

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measure of comfort, but one must not underestimate the potential of the procedure to cause bacteremia, and each case must be analyzed individually. It is worth pointing out that the authors evaluated only the removal of mini-implants, leaving a gap to be researched, which would be with respect to whether or not bacteremia occurs at the time of their insertion.

DOES THE HEIGHT OF THE HYRAX EXPANDER SCREW INFLUENCE THE TYPE OF DENTAL MOVEMENT?

Palatal expansion is an established procedure in orthodontic literature. As we know, its most precise indication is for the correction of posterior crossbites caused by transverse maxillary deficiency. Among the expansion appliances used are the Hass and Hyrax types; the latter with the proposal of facilitating cleaning. However, many dentists attribute a greater dental tipping movement to the Hyrax type. Would it be possible to minimize this dental effect? Could the screw height influence the inclination? To evaluate these questions Brazilian[3] researchers developed a study using finite elements to evaluate the influence of the expander screw height on the dental movement achieved. The height evaluated was below, at the level, and above the center of resistance (Fig 2). The results obtained in this study demonstrated that dental movement is altered according to the expander screw height. The authors pointed out that when more extensive orthopedic results were necessary, the ideal position of the screw would be a little above the center of resistance of the maxillary first molars.

SELF-LIGATING BRACKETS DO NOT PROMOTE LESS PAIN AND MAKE ORTHODONTIC TREATMENT FASTER

At present, we are experiencing a flood of commercial advertising that alleges the superiority of self-ligating brackets in comparison with conventional brackets. The superiority of these is attributed to a lower level of pain, chair time, and treatment time in general. Many of the advantages attributed to these devices have aroused the interest of orthodontists and patients all over the world. But is there scientific proof of all these advantages? In seeking a response to all these questions, Austrian[4] researchers conducted a systematic review of the literature to verify whether or not there is scientific proof of these parameters. The authors used exclusion and inclusion criteria of the sample, giving priority to the most well designed studies. After an extensive literature search, they arrived at the conclusion that the superiority of self-ligating brackets to conventional ones could not be affirmed with respect to initial pain, chair time and final orthodontic treatment, because there are no strict scientific studies that support these affirmations. Therefore, it is always important to seek serious scientific references when one thinks about changing conducts in the dental practice.

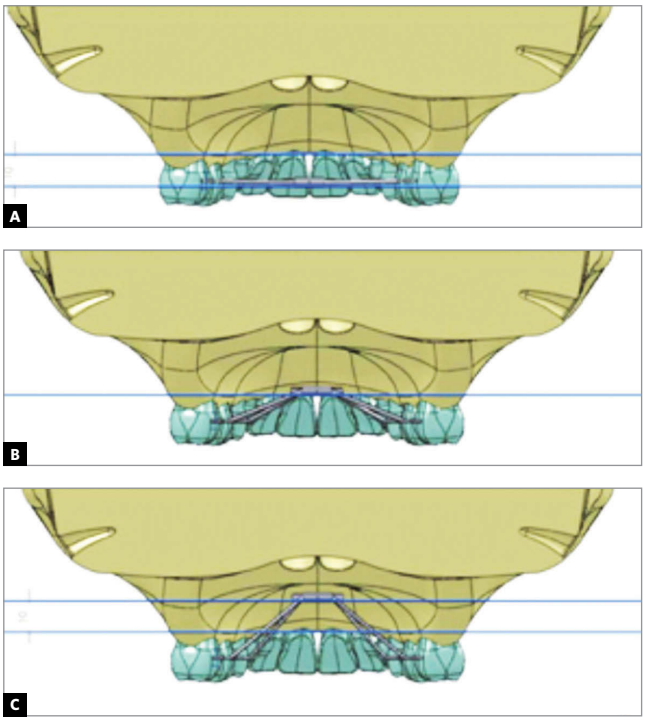


Figure 2 - Expansion appliance in: **A**) low position (positioned parallel to the occlusal plane that cuts the crown of the maxillary teeth in their middle portion); **B**) intermediate position (higher, between the plane of the first model and the palate), and **C**) the highest position (closer to the palate).

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An interview with

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» Harvard School of Dental Medicine, DMD, 1989.
» University of California, Irvine, BS in Mathematics, 1984.

All in life have a positive side. In 2010, I was studying for my Doctorate in Orthodontics in UNESP-Araquara, Brazil, when for some personal reasons I had to drop my academic activities and return to Salvador city for a while. Luckily or by divine providence I received a great gift: The opportunity to meet Dr. Won Moon while he was visiting Brazil to present a lecture in the specialization course in Orthodontics at the Federal University of Bahia. It was admiration and friendship at first sight. A second opportunity to enjoy the contact with Won occurred in 2011, when I was taking part of my sandwich PhD at UCLA. Perceiving his qualities more closely became a motivation for new learnings. Won is a role model teacher and this is exemplified by the many tributes received by his students. His clinical aptitude is striking! In various challenging circumstances I have heard from his residents the following: "Cases like that only Dr. Moon handles...". There is no need for long descriptions concerning the excellence of his career as an international lecturer. After he has visited the most important centers of Orthodontics worldwide you all will be able to appreciate this aptitude by your own! I did not take so long to notice that his qualities go beyond the professional sphere. Despite being blessed for having a very special family, he still manages his time for practicing radical sports such as climbing and mountaineering. Always accompanied by his wife Miran and his daughter Crystal, there is no lack of stories of trips around the world. It is clear the complicity of a marriage that began in their adolescence! Given the proper introduction of our distinguished interviewee, I also give my cordial thanks to the friends Sergei Rabelo, Richard Kulbersh, Greg Huang and Barry Briss, for accepting the invitation to actively participate of this interview. I also thank to Dental Press for the granted honor to conduct this experience. I wish all the readers a moment as pleasant and rich as the scientific path that led us to this interview.

André Wilson Machado

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

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Could you please provide us some of your dental and orthodontic background?

I grew up in Southern California since 1976, and I initially pursued my education in Mathematics at a local university, UC Irvine (UCI). After earning a Bachelor of Science (BS) degree in Mathematics, I changed my career path. I left home for the first time, and I pursued a degree in Doctor of Dental Medicine (DMD) from Harvard School of Dental Medicine (HSDM) in Boston. After acquiring a dental license from the Northeastern Regional Dental Board during my last year in dental school, I volunteered as a Peace Corps member and helped building a dental clinic in the city of Above Rocks in Jamaica. This project came to a halt because of Hurricane Gilbert, which caused historical destruction. After an early return from Jamaica, I participated in the Licensed Practitioners Clinic at HSDM as a general dentist before moving back to California in 1989 for a post-doctoral orthodontic residency program at the UCLA School of Dentistry. While pursuing orthodontic education, I also entered the Master of Science (MS) program in Oral Biology at UCLA. During my dental and orthodontic education, my interest in clinical research proliferated, and I successfully produced and defended three theses.

Since graduation in 1991, I worked at a private orthodontic clinic in the suburbs of the Los Angeles metropolitan area. In 2002, I became a Diplomat of the American Board of Orthodontics. In 2003, I joined the UCLA School of Dentistry, Section of Orthodontics, as a faculty member. Since then, I have served UCLA as the Program Director for Combined Pedo-Ortho Residency Program, Director of Advanced Continuing Education, Director of International Affairs, Clinic Director for the Section of Orthodontics, and Director for Preceptorship Program. During that time, I also served as the Program Director and Assistant Director for the Southern Region, Pacific Coast Society of Orthodontists (PCSO). In 2012, I decided to phase out the private clinic after 21 years of orthodontic practice and join UCLA as a full-time professor. I was appointed as the Program Director for the orthodontic residency program at UCLA, and I also hold the position as the Director of International Affairs.

I am currently involved in various research topics, and they include the Accelerated Tooth Movement, Genome-wide Association Study of Craniofacial Phenotypes, Finite Element Model Study, 3-D Image Analysis, and Micro-Implant Study. As you can easily see, it is evident that my mathematics background plays a major part of my research area.

What orthodontic technique do you use in your practice? What is the UCLA's teaching philosophy?

Since Dr. Edward Angle developed the edgewise technique in modern orthodontics, we have gone through a number of facelifts in our treatment philosophy: extraction versus non-extraction,[1] growth modification versus surgical orthodontics,[2] headgear versus functional appliance,[2] centric occlusion versus centric relation versus neuro-muscular bite,[3,4] etc. We can easily find numerous research findings arguing back and forth claiming the superiority of one philosophy over another through many decades, which only proves that there are many different ways of providing orthodontic treatment with satisfactory results. The advent of new tools and appliances such as micro-implants, clear-aligners, self-ligating brackets, and CBCT images only adds fuel to the fire. Traditionalists continue to claim that the fundamentals of orthodontic biomechanics cannot be changed, whereas the more progressive practitioners routinely defy old tradition. As an advanced institution of education that should respect evidence-based science, but also has an obligation to nurture novel concepts, where do we stand? We are definitely in the business of teaching the evidence bases of orthodontics; however, we should also put just as much effort in the evidence building. Without those pioneers in our profession, we will not be able to progress.

UCLA has a unique teaching philosophy. We refuse to brand the way we do orthodontics. Understanding that there are many effective ways of providing orthodontic and orthopedic treatments, we try to create an educational environment that is a true melting pot of diverse ideas. We have over 35 part-time clinical faculty educated from over 20 different institutions, some from the overseas, with various orthodontic techniques. We continue to proactively recruit national and international lecturers with different educational backgrounds in order to diversify our teaching philosophy. We also recruit the international students and scholars from all over the world in order to facilitate this effort.

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As you can imagine, this is a daunting task. It is hard enough to teach one technique, not to mention deal with all the above. Fortunately, we are able to recruit the best of the brightest students each year. We put them through extremely rigorous curriculum with enormous amount of resources at UCLA. In simple terms, we throw everything at these incredibly smart individuals, and see what sticks. At the end of their residency, each student will have his/her own brand of orthodontic technique that works the best for him/her. This teaching philosophy has worked very well for us, and we continue to produce highly competent orthodontists every year.

Diagnosis is a vital step for the success in orthodontics. What is your opinion on the role of 2-D conventional Cephalometrics in contemporary orthodontic diagnosis?

Dr. B. H. Broadbent's contribution in orthodontics cannot be measured.[5] He brought objectivity into our diagnosis by introducing cephalometric images. Since then, many have developed cephalometric analyses to aid in diagnosis, and they have propelled the level of modern orthodontics. However, these measurement systems were largely limited to the simple linear measurements comprised of angles and distances. Although they have established the norm and gave us baseline information, these linear measurements have inherent shortcomings. The linear measurements are adequate in measuring regular structures such as desks and table tops, but they are severely inadequate in measuring irregular structures such as the human skull. The word linear comes from the Latin word *linearis*, which means resembling a line. The human morphology is far from resembling a line. Thus, nonlinear equations and functions are of interest to engineers, physicists, and mathematicians because they can be used to represent many natural phenomena and irregular structures. When measuring from point A to point B, the information between these two points is lost with a linear measurement system (Fig 1). In this illustration, two buildings with very different morphologies will have similar measurement values when we use the linear measurements. This type of function should not be applied in analyzing the morphology of irregular structures.

Moreover, linear measurements often ignore spatial relationships. Figures 2 to 5 illustrate some of the many problems we face using cephalometric analysis that many of us are accustomed to. These problems arise because the reference points, such as nasion, sella, orbital, basion, and PT points are highly variable in space.[6] In truth, cephalometric analyses such as in Steiner and Ricketts are 1-D analyses applied to 2-D images extracted from 3-D structures. The 2-D image requires a 2-D analysis for adequate quantification.

During my orthodontic residency at UCLA (1989-1991) we explored the possibility of developing a true 2-D analysis utilizing the Elliptical Fourier's Descriptor (EFD).[7] By utilizing this mathematical equation, we can describe any irregular curved line in a 2-D space. Figure 6 illustrates the application of this approach to a lateral cephalogram. This is a true 2-D analysis that accounts for spatial relationships, and it also is completely quantifiable since the outline of the skull is described by a mathematical equation. That means we are able to generate a graphic illustration of the norm by calcu-

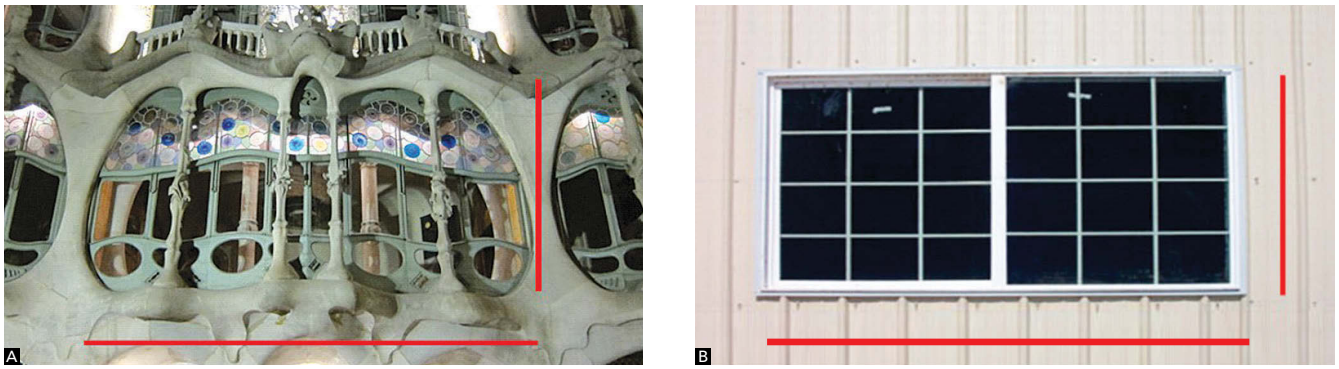


Figure 1 - The window on **A** was designed by Antoni Gaudi, and it has similar linear dimension to the modern building window on **B**; however, they do not resemble each other morphologically.

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lating an equation that represents an average of many individual equations. Numbers are not necessary, and the superimposed images of the norm and a patient can illustrate the discrepancies between them in any given point that lies on the outline of the skull. This approach was largely ignored by orthodontists because of a lack of desire to learn the new method of evaluating cranial structure; however, it had more impact in the field of anthropology.[8] I have learned that it is hard to change the minds of traditionalists, especially something as sacred as cephalometric numbers. The IMPA of 90 degrees was etched in everyone's brain back in 1991.

Based on these problems listed before regarding the conventional cephalometric analyses, how do we deal with the 3-D images in orthodontics?

It took twenty years for us to finally realize to a full scale how deficient conventional cephalometric analyses were. With the advent of CBCT, we faced more complex problems in quantifying 3-D structures. Many investigators are still utilizing the linear measurements to describe a 3-D human skull, applying 1-D measurement system to irregular 3-D images.[9] Some compress these 3-D structures to 2-D images, and apply conventional 1-D analysis. This is analogous to playing a high

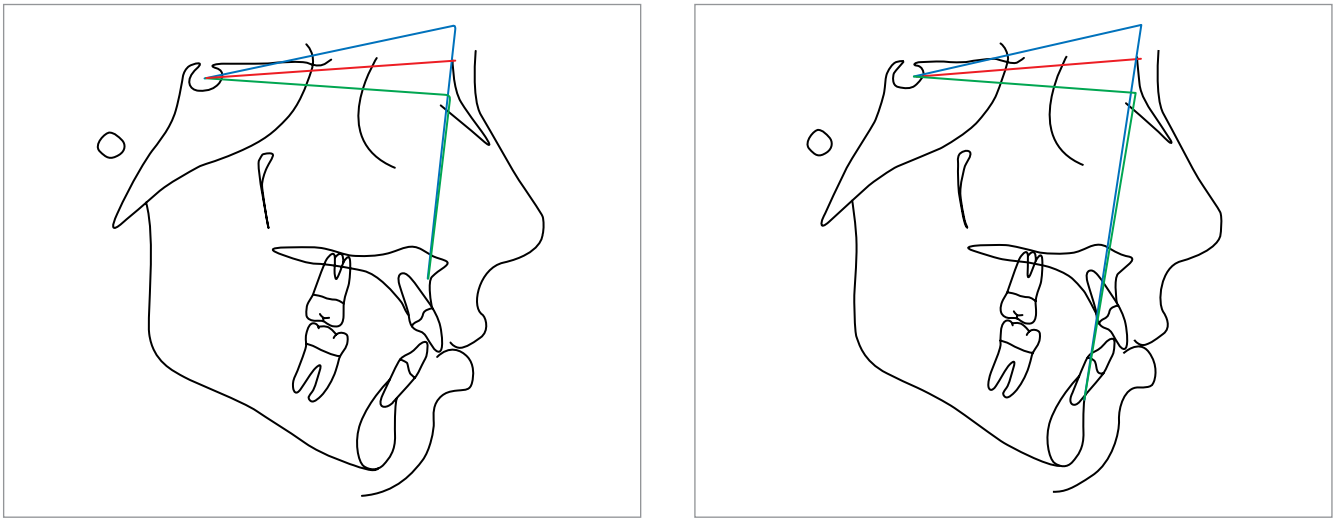


Figure 2 - A relatively high Nasion position makes maxilla and mandible more retrusive.

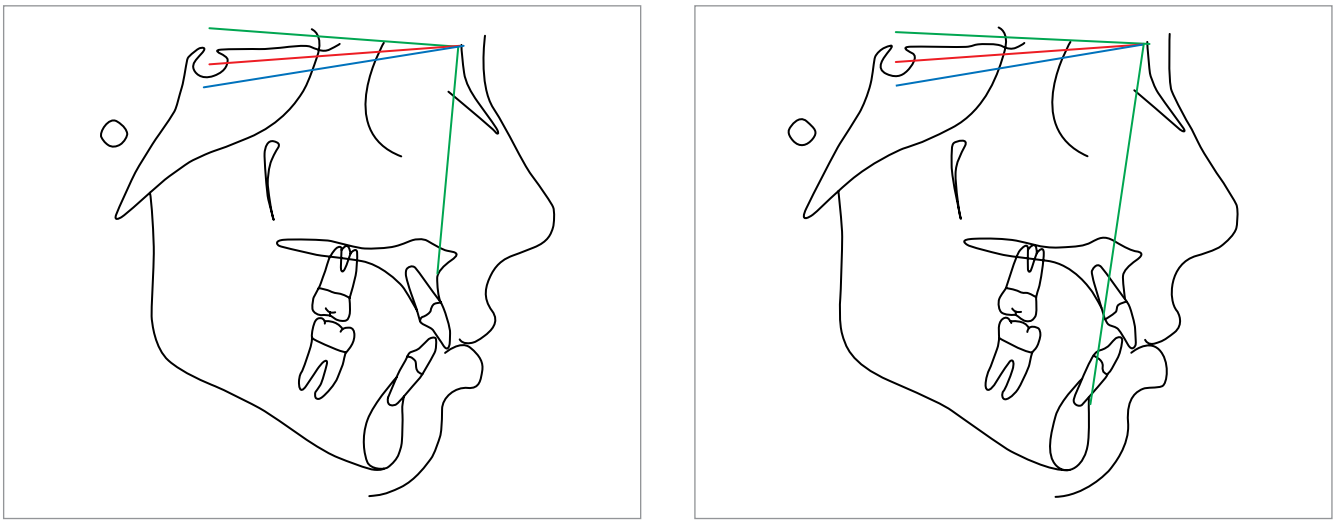


Figure 3 - A relatively high Sella position makes maxilla and mandible more protrusive.

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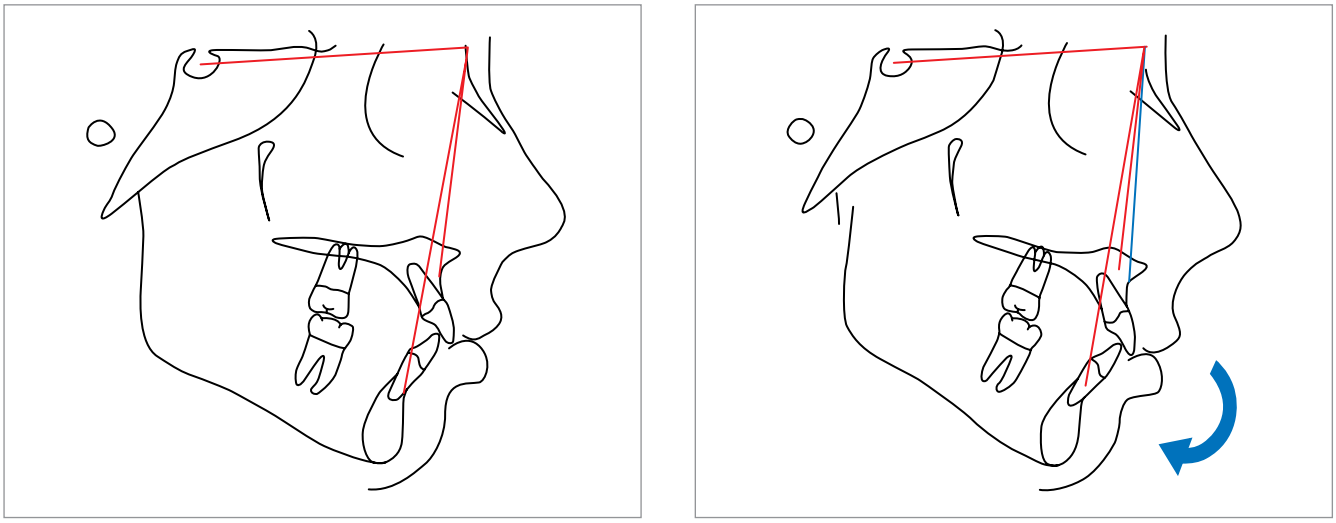


Figure 4 - A clockwise rotation of maxillomandibular complex creates more of a Class II relationship.

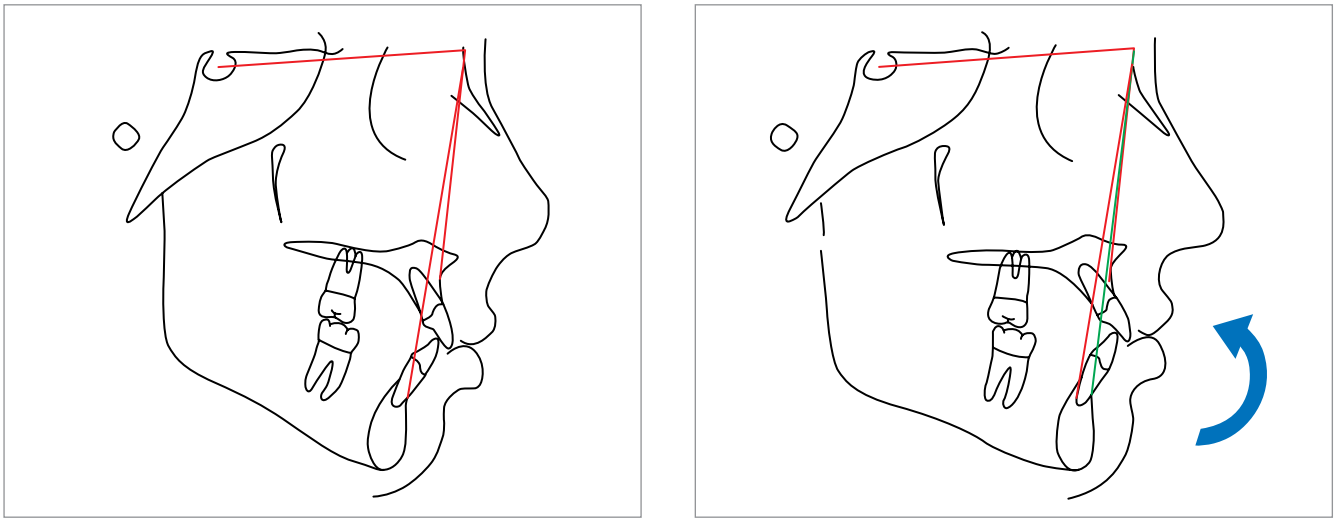


Figure 5 - A counter-clockwise rotation of maxillomandibular complex creates more of a Class III relationship.

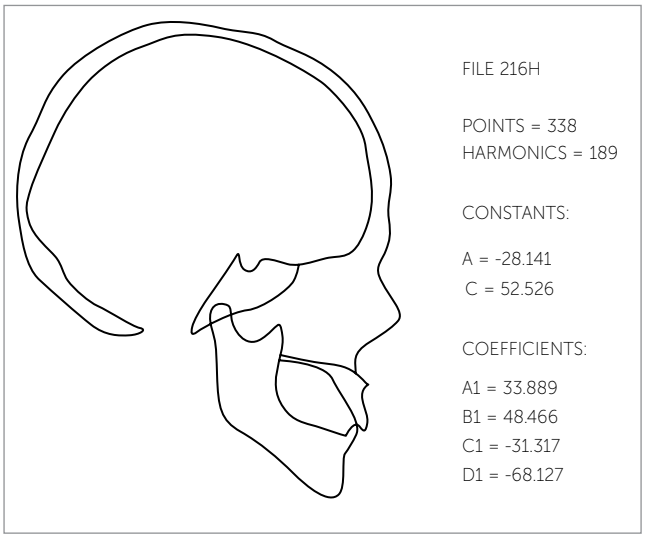


Figure 6 - A true 2-D analysis using the Elliptical Fourier Descriptor.[7]

quality CD digital music through an analog tape deck. This new 3-D imaging technology requires a new 3-D analysis method that deals with 3-D structures, and we desperately need a new approach.

Initially we thought that we could expand the EFD to a 3-D space. This means that we can describe any line in a 3-D space mathematically. In fact, this was tried in 1993 utilizing the dry skull of a rabbit.[7] The boundary information can be quantified accurately by this function. However, this approach has an inherent deficiency in contrast to 2-D analysis. The surface contour bound by the line cannot be described by the EFD. In order to address the above concern, we are developing a surface mapping function, illustrated in Figure 7. This function converts surface information into a series, which we make into a

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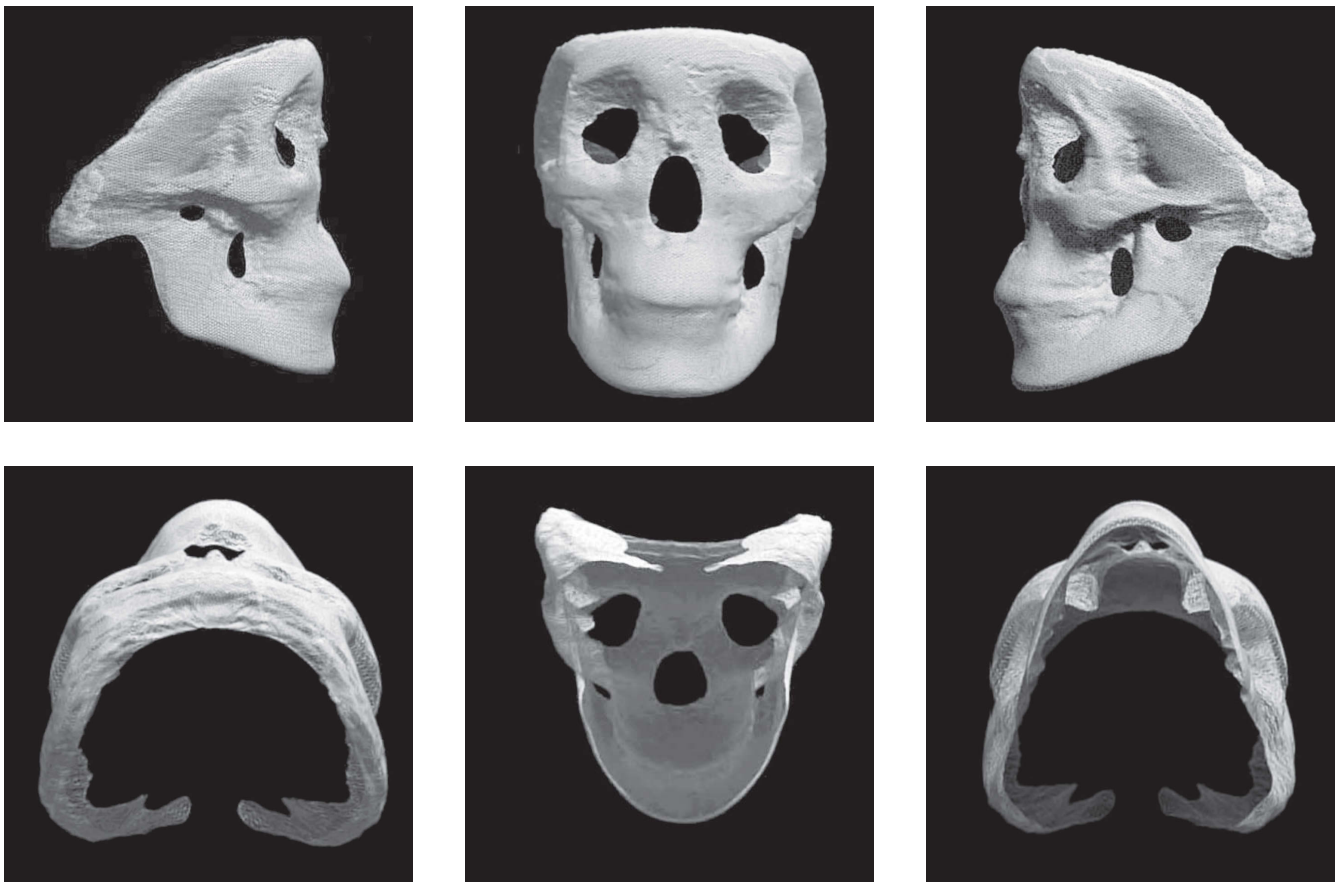


Figure 7 - A surface mapping function generated from a CBCT image: an average of 67 skulls.

quantitative mathematical matrix. A total of 67 3-D skull images were converted to surface mapping functions, and the average of these functions was calculated and plotted in this illustration (Fig 7). Figure 8 is a colorized displacement map when the 67 skull average function and an individual skull function are superimposed. In this image we can visually understand the regional discrepancies between the average skull and an individual patient skull without the confusing numerical data that the linear measurement system provides. However, this function also has inherent deficiencies: the internal structures such as the sella and PT points are missing, and the boundary is not clean. By combining this function with EFD and conventional landmark points, the final 3-D analysis will provide both surface and boundary information, and this will allow retroactive comparison with the previous data prior to the 3-D era. Figure 9 illustrates this combined function. My research team at UCLA already has made significant progress in this area, and we hope to have true 3-D analysis within a couple of years.

In the future, will it be practical to use such complex formulation in clinical orthodontics? In other words, the 2-D cephalometric analyses are simple to use even with its shortcomings. Will the 3-D analysis be user friendly?

I do not think that our current cephalometric analysis — which is more like 1-D or 1.5-D at best — is all that simple to use if you are looking for accuracy. At UCLA we use a minimum of three different analyses for each case in order to fully understand the dento-skeletal relationship. Very often, these analyses disagree with each other: Which of the three analyses shown in Figure 10 is correct? Some orthodontic programs choose to only look at one analysis and avoid this confusion, but that does not mean they are operating with the correct information. Some may be able to identify the reason for this disagreement based on their experience and adjust their thinking accordingly, but this hardly is an objective means to deal with the problem.

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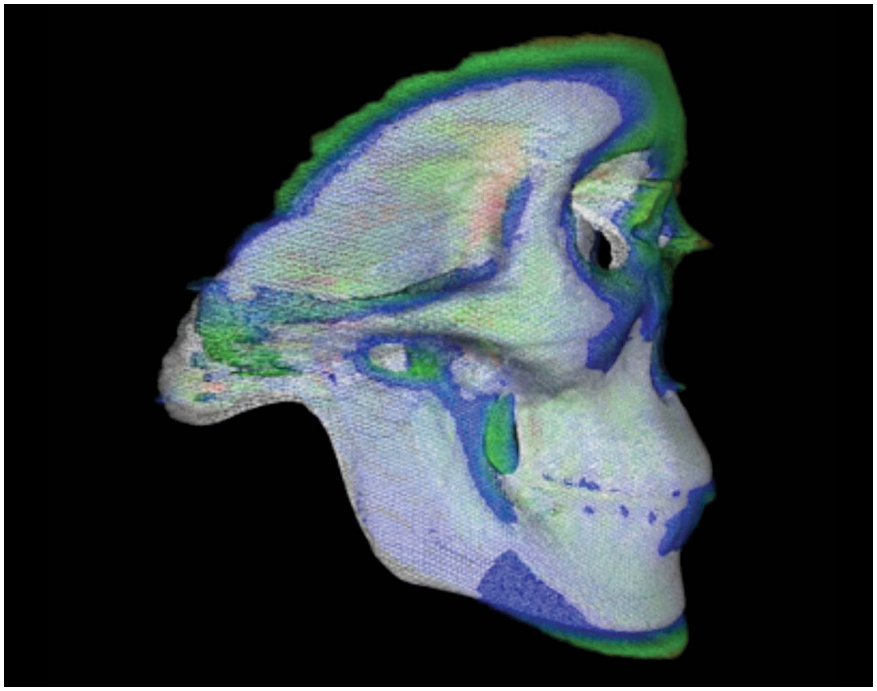
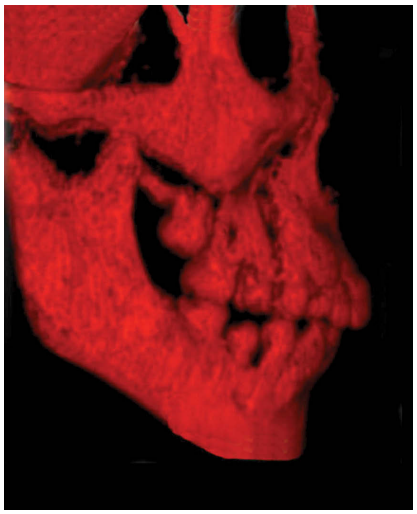
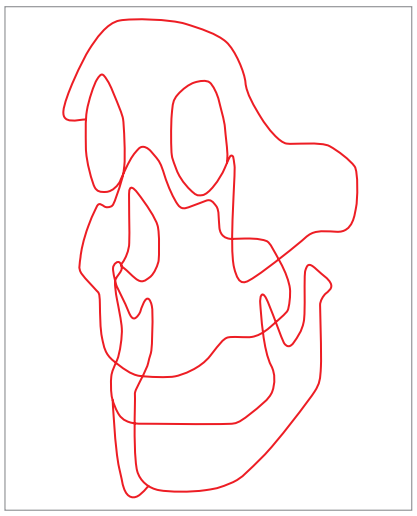


Figure 8 - A colorized Displacement Map: This is a superimposition of a 67 skull average function vs. an individual skull function.







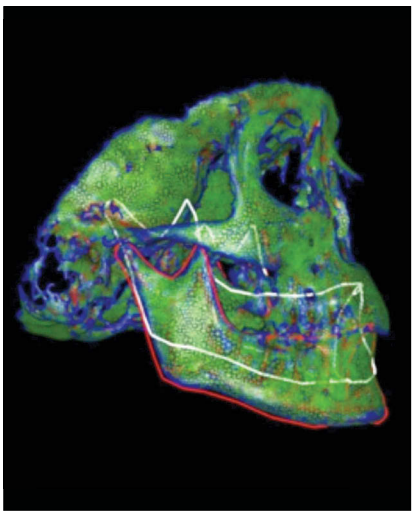


Figure 9 - A surface mapping function combined with the EFD generated from a CBCT image.

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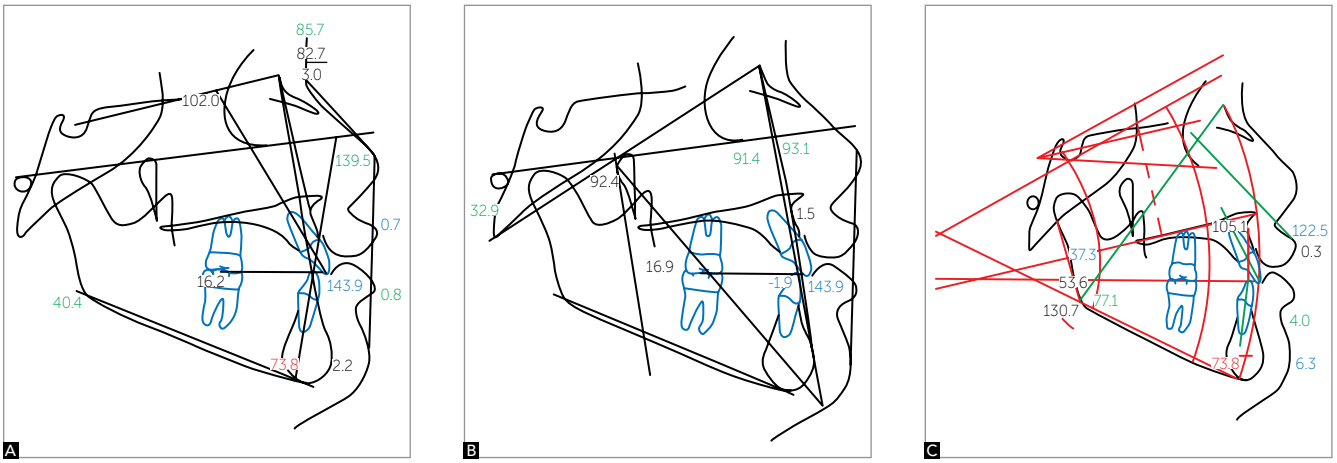


Figure 10 - Three different analyses were applied for the same patient. The Steiner analysis (**A**) showed a Class II relationship, the Ricketts analysis (**B**) showed a Class I relationship, and the Sassouni analysis (**C**) showed a Class III relationship.

On the other hand the previous example of true 2-D analysis using the Elliptical Fourier Descriptor is much more accurate and visually descriptive (Fig 6). Eliminating the numerical values and visualizing the plotted line make it much easier for the operator. This is also true with the true 3-D analysis method we are currently working on (Fig 8). Evaluation of the data is unequivocally simple. However, the potential problem in user friendliness may come from the data entry. Dealing with a 3-D structure requires labor intensive data entry process.

The answer to this problem will largely depend on the ability for the software program to identify the morphological shape, process the DICOM data,[10] and automate the steps involved. This part of development may take some time, but we will eventually get there.

Do you think that orthodontists will use a 3-D analysis in the near future, and will this alter our orthodontic diagnosis and treatment outcome?

I have no doubt that we will be using 3-D analysis in the future. The question of how soon mainly depends on the user-friendliness of the software. Also, the biggest hurtle will be orthodontic politics. As with anything, there will be a battle between the traditionalists and the early adaptors.

Your second question is a much more interesting one. This really is the ultimate question when we have a new tool. Will this new and fancy system change how we see things and what we do? Old habits are hard to break, and here we are clearly dealing with human behavior. Let's say there is a man with an old car he has been driving for 20 years; it is an old car but a reliable one. One day this man decides to get a new toy; he buys himself a brand-new fancy car with all of the bells and whistles. It comes with all of the latest safety features, an automatic climate system, a hi-fi sound system, a voice recognition system, a programmable seat position, and the latest GPS navigation system that illustrates traffic flow and potential detour routes. Would this car change the way this man goes to work and comes back home? Would it change his driving habits? Initially, he will continue to drive his new car the same way he drove his old car for the last 20 years. As he gets more familiar with the new features his new car provides, he will slowly change. Now, he listens to a satellite radio with no commercial interruptions, enjoys the auto climate system, and relies on the rear view camera when he backs up. As he gets used to his new navigation system, he has now discovered many shortcuts to his work, and he often take detours recommended by the navigation

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system in order to avoid dreadful traffic during commuting hours. Yes, his driving habits will change gradually for a more efficient way. That is exactly how 3-D analysis will take over the orthodontic diagnosis and treatment planning: Slowly but surely.

What do you think about the ideal cone beam protocol for orthodontic patients? With the radiation concern, do you think we should request a 3-D scan for every orthodontic patient?

The recent article by the New York Times brought many concerns for both patients and practitioners regarding increased radiation dosage associated with cone beam images.[11] This concern was also echoed by some orthodontists. We are dealing with risk and benefit analysis. If we look back at the history of radiographic usage in dentistry, we have come a long way. With the development of digital enhancement capability, we were able to cut the dosage to a fraction of what we were accustomed to.[12] When you consider the amount of radiation our patients are subjected to when the CBCT is used, it is much lower than the full mouth x-ray series general dentists take annually or a conventional panoramic x-rays orthodontist ordered routinely a few decades ago before the digital radiograph became the norm. One may argue with a good justification that if this amount of radiation were accepted to be safe in the past, then it must be safe today.[13] On the other hand, the thresholds for acceptable radiation dosage have been reduced drastically in the recent years due to modern inventions.

Does this mean that we should not worry about the radiation associated with CBCT? Since it is well documented that radiation exposure lasts over a lifetime, we should always try to minimize exposure whenever possible.[14] This means that any radiation, including the conventional x-rays we routinely order, should be avoided when it does not provide a significant benefit in diagnosis and treatment. Then how do we set the guidelines for the use of radiographs? Who should decide what the acceptable risk is? My personal feeling is that it should be the doctor's decision to assess which patient can benefit from what type of radiographic images since the risk to benefit ratio almost entirely depends on the doctor's ability and knowledge to interpret the images. If one is not capable of getting valuable information for a particular patient from the radiograph, whether it is a standard lateral cephalometric film or a more complex CBCT, it should not be ordered. Too often, we order the standard set of x-rays regardless of the patient's needs or the operator's ability to evaluate the images. On the other hand, if one has an extraordinary knowledge in extracting valuable information from CBCT that could potentially help in achieving a better diagnostic and treatment outcome, I think that ordering CBCT routinely can meet the standard of care for this doctor. By not doing so, the patient's care may be undermined. I was asked if the CBCT changes my treatment plan from the days when it was not available: It does not always change my treatment plan. However, this question should not be the criteria in deciding on the overall usefulness of CBCT. Dr. Angle was able to provide orthodontic treatment without the help of cephalometric x-rays. During the initial diagnostic exam of the patients, most of us formulate how we would approach the treatments of these patients, and the x-ray findings merely confirm that our initial thinking was correct in the majority of the cases. This fact does not negate the necessity of the images we want to acquire. The use of CBCT is very much like this example. It gives us more precise and accurate information.

In short, my answer to your question is that it depends on the operator's knowledge in utilizing CBCT. As there will be further developments in the utilization of this data, such as the 3-D analysis, 3-D growth prediction, and 3-D superimposition, the advantages in utilization of the 3-D image will exponentially proliferate in the future.

We just discussed some of the cutting edge technology related to orthodontic diagnosis. Now let's talk about the current orthodontic technique that may have changed our practice: The micro-implants. How do you think the micro-implants have changed the orthodontic treatment planning?

Micro-Implant (MI) is slowly changing the face of orthodontics. Initially, they were used mainly as anchorage devices yielding the uninspiring name TAD (temporary anchorage device). Many still believe that MI does not change the landscape of orthodontics, and that it is just another type of anchorage device. However, there have been countless case reports pushing the boundaries of conventional orthodontic belief.[15,16,17] Now, we can distalize molars more than we have ever imagined, and we can intrude molars to correct skeletal

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open bite cases. It does not stop there; we now can incorporate MI for skeletal corrections. We can expand the maxillary arch without buccally tipping the dentition, allowing for more skeletal expansion. We can increase inter-canine width without compromising the labial plates. We can utilize MI in orthopedic corrections of patients with skeletal imbalance. We can safely treat patients with extremely high mandibular plane angles, and we can manage patients with deep bite and gingival smiles. The MI also has changed the biomechanics to a certain degree since our current biomechanics rarely deal with an absolute anchorage.[18]

There is no doubt that MI has an enormous impact in orthodontic treatment planning by providing possibilities that have not been fully explored yet. It is not MI that has changed the orthodontics; it is rather how one can apply MI that has made the difference. In the last five years, the World Implant Orthodontic Conference (WIOC) has been at the forefront of this effort to promote international collaboration of ideas. This meeting has been growing steadily, and it now attracts audiences from all over the world. Over 50 international speakers have participated in these meetings, and your very own Dr. Jorge Faber from Brasília (Brazil) was one of the renowned speakers. This sort of forum will continue to advance MI utilization in orthodontics, and a brighter future is approaching more quickly.

How do we modify growth with micro-implants? Does it mean that some surgical cases can be treated without the surgery by this approach?

Growth modification has been controversial in orthodontics, with many conflicting clinical and research findings.[19,20] This conflict cannot be resolved easily because the skeletal changes in patients who have been treated with orthopedic devices — such as HG, FM, RPE, FA, etc. — are difficult to isolate because orthopedic force is applied to the dentition. Dentoalveolar changes are almost always present in these patients, and they mask and limit true skeletal changes. During the last five years, I have tried to isolate the skeletal changes by eliminating the dentoalveolar changes during the orthopedic correction, and the results were profoundly different than those of the previous studies. Not only we were able to eliminate these unwanted changes, but we were also able to reverse the existing dental compensation, and maximize the skeletal correction.[21] In many of the Class III cases, the dental de-compensation occur spontaneously as the skeletal relationship improves, supporting the functional matrix theory.[22] I have enclosed two clinical situations here supporting the above statements.

Figure 11 illustrates a Class II malocclusion being treated by fixed functional appliances and micro-implants in a thirteen-year-old boy. Mandibular dentitions were retracted against the micro-implants placed in the posterior region as the mandible was pushed anteriorly by the fixed functional appliance (FA). This mechanic prevents the lower incisors from flaring forward when the functional appliance is fully activated to achieve a Class I occlusion. Sometimes, two additional micro-implants can be placed in the maxillary alveolar bone if the distal movement of the maxillary dentition is a concern. The micro-implants allow true skeletal corrections without dental movements, and it also allows higher magnitude of orthopedic correction by eliminating pre-existing dental compensations.

The cephalograms shown in Figure 12 illustrate that the mandible grew significantly more than the maxilla after twelve months of FA treatment. When we compare the FA treatment outcome, it is important to make sure that the patient has the same condylar position (illustrated with thin red arrows in Fig 12). As the mandible grew in a forward direction, the airway also enlarged. Figure 13 shows the superimposition of the tracings generated from these radiographs. A significant differential growth was noted between the two jaws. The lower incisors were decompensated with micro-implant supported retraction as the mandible grew forward assisted by the functional appliances. However, the maxillary dentition moved in a posterior direction because the micro-implants were used on the lower jaw only, and the posterior force generated from the functional appliances drove the maxillary dentition posteriorly. As I have mentioned earlier, this movement can be offset by utilizing micro-implants in the maxillary arch. In this particular case, the posterior movement of the maxillary dentition was desired due to patient's protrusive upper lip.

Figure 14 is a superimposition generated after ten months without the functional appliance treatment. The black tracing was generated before the functional appliance treatment, the red tracing was generated right after terminating the twelve months of functional

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Figure 11 - A Class II malocclusion treated with the fixed functional appliance and micro-implants: A forward movement of mandible by the fixed functional appliances (red arrow) and retraction of the mandibular dentition using the micro-implants (black arrow).

appliance therapy, and the green tracing was generated ten months thereafter. Surprisingly, the mandible continued to outgrow the maxilla and the lower incisor position became more upright as the jaw relationship changed. Moreover, the maxillary incisor started to procline as well, cancelling the previous posterior movement during the FA treatment. This phenomenon is in full support of Moss's Functional Matrix Theory.[22]

All the years of controversy related to FA therapy can be put to a rest if we can isolate the orthopedic changes without the dental side effects. After treating many patients with Class II malocclusion, I am optimistic that we can create true orthopedic changes. Obviously, the long-term follow up is necessary to legitimize this claim, and results will be coming.

A similar concept can be applied to the Class III malocclusions as well. Figure 15 illustrates the modified Hyrax for orthopedic correction. The body of the Hyrax is fitted closely to the palatal vault, and four MI were used to fixate it to the palate on either side of the midpalatal suture. As the Hyrax is activated, the expansion force is localized near the midpalatal suture and causes a maxillary expansion, and this force may disarticulate the circummaxillary sutures.[23] This apparatus also has two face mask (FM) hooks attached to the molar bands, and the protraction force generated by the face mask will be directed mainly at the maxilla. Because the apparatus is firmly attached to the palatal bone, the vertical dental movements are controlled. This means that even a high-angle Class III patient can be treated without the fear of creating an anterior open bite. The high-angle Class III patients are considered to be the most challenging problem in orthodontics by many, and I will present a high-angle Class III patient who was treated using the above treatment protocol.

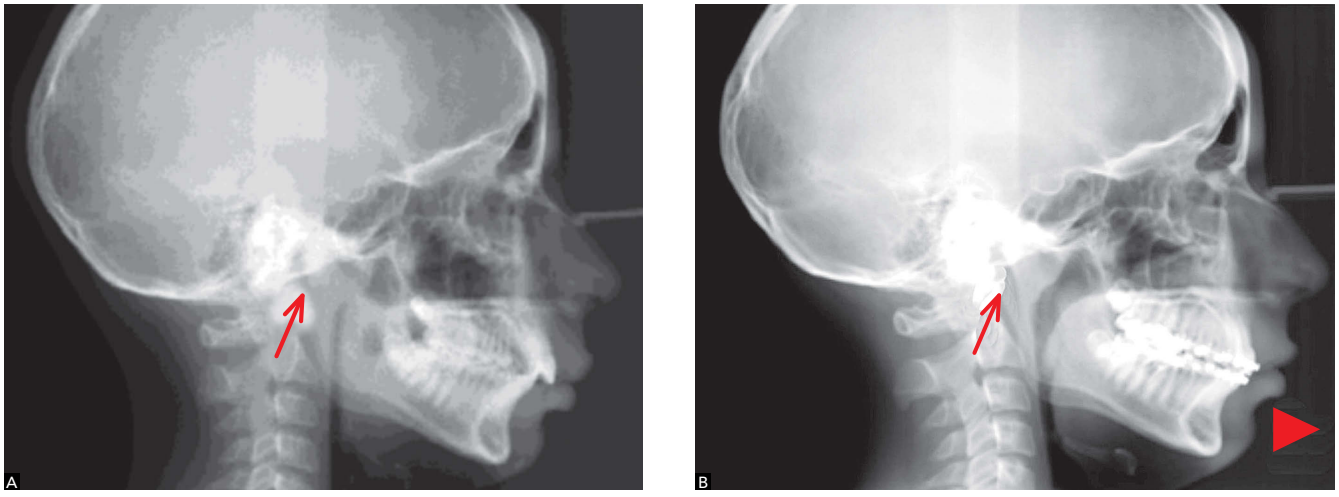


Figure 12 - Before the functional appliance therapy (**A**), after twelve months of functional appliance therapy (**B**).

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Figure 13 - Superimposition of the tracing generated from the radiographs taken before (black) and after (red) the functional appliance therapy for twelve months.



Figure 14 - Superimposition: before the FA treatment (black), after twelve months of FA treatment (red), and ten months after terminating the FA treatment (green).

This patient presented with a MP-FH angle of 31.4 degrees (norm: 24.5) and a Wits measurement of -20.8 (norm:-1.0). She was an eleven-year-old female patient presented with a high-angle Class III skeletal relationship with anterior and posterior crossbite. After a fourteen-month FM treatment, both the skeletal and dental relationships have improved (Figs 16 and 17).

The superimpositions shown in Figure 18 illustrate that the maxilla grew forward significantly more than the mandible during the fourteen months of FM treatment. More interestingly, the maxillary and mandibular incisors retroclined and proclined respectively as the skeletal relationship improved. Despite the fact that none of these teeth had any orthodontic appliance, they spontaneously decompensated as the jaws were aligned. Although her face grew in forward and downward direction, the mandibular plane angle did not change. Table 1 confirms the above statements.

Again, we must ask if these results are stable. Figure 19 shows a seven-month follow up after terminating the FM treatment. It seems that maxillary growth from the FM treatment held stable, but the mandible grew a bit more than the maxilla. This reaffirms the previous study that skeletal Class III patients are predisposed to grow in a Class III manner.[23] Some authors suggested an overcorrection in order to compensate for the future growth.[23] It is important to closely follow these patients until their growth rests.

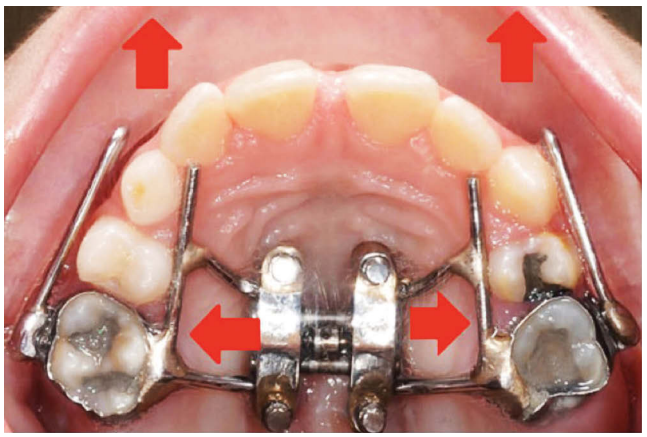


Figure 15 - The Hyrax with MI and FM hooks.

Do you think we can use the same strategies for adult patients?

In non-growing patients, this approach would not work. However, there have been reports of success in expansion of maxillary width, much like in Surgically Assisted Rapid Palatal Expansion (SARPE).[24] At UCLA, we experienced good success in splitting the midpalatal suture in adult patients using the Micro-Implant Assisted Rapid Palatal Expander (MARPE) as shown in the Figure 20. Dr. Eric Liou and others have demonstrated some success in loosening the maxilla from the surrounding bone by

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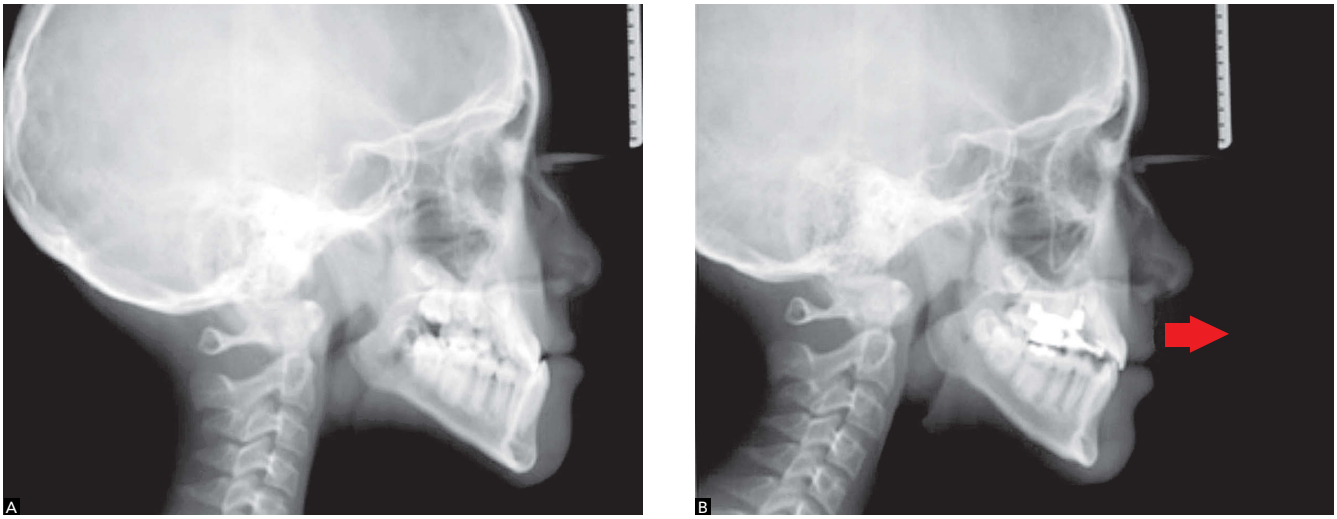


Figure 16 - Before the FM treatment (**A**), after 14 months of FM treatment (**B**).

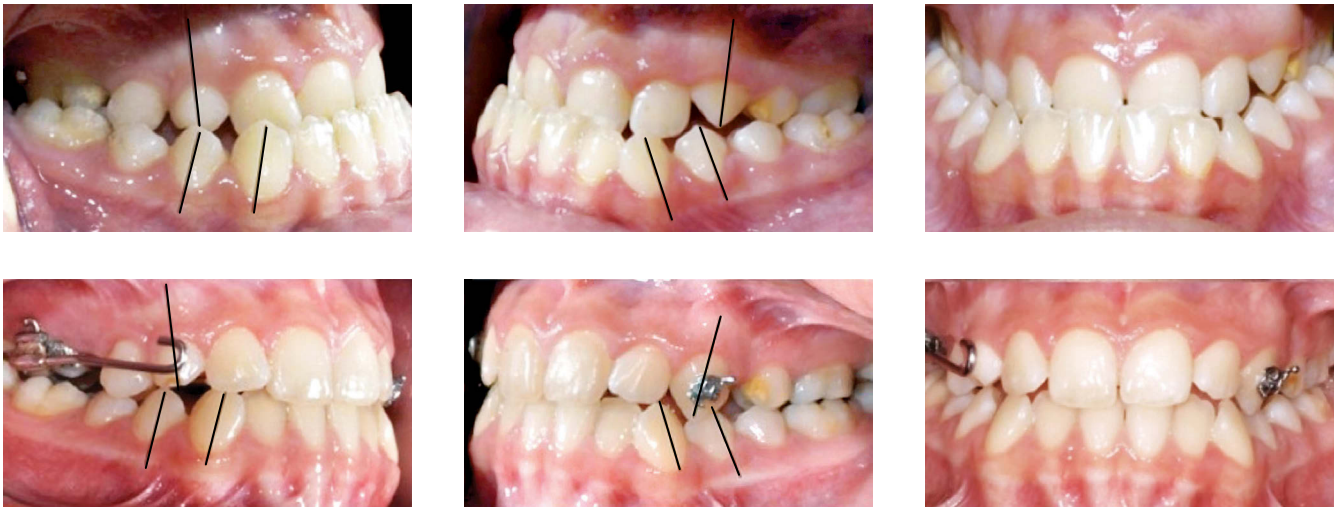


Figure 17 - The MI supported FM treatment for 14 months.

expanding and constricting the maxillary suture repetitively using the MI supported expander.[24] This process simulates the distraction osteogenesis and the maxilla can be rapidly protracted. This may lead us to a breakthrough, but currently the sutural growth in adult patients sounds too good to be true. As far as Class II adult patients with retrognathic mandibles are concerned, I have not heard of any ground-breaking ideas yet.

Based in your vast experience with micro-implants, can you briefly discuss the important factors related to the stability of MI?

The stability of MI can be divided into the primary and secondary stabilities. The primary stability comes from the mechanical interlocking between the MI and the surrounding bone.

The factors involved in the primary stability can be further divided into biological and mechanical factors. Bone density, bone volume, tissue thickness, type of gingival tissue, vital structures and others, constitute the biological factor. The mechanical factors largely depend on MI design, and they include diameter, length, shape, thread density, thread pitch, thread count, etc.[25] It should be also noted that the cortical bone is responsible for the MI stability and cancellous bone plays a minor role. The biological factors are inherent to our patients, and it is not easy to change them. We should try to find the MI placement site carefully in order to maximize stability. However, the most stable position may not be the most advantageous for orthodontic biomechanics, and one may choose to settle for a less stable site. Since MI stability is the most frustrating problem we face, I suggest

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Figure 18 - Superimposition generated from tracing before the FM treatment (black) and after (red)

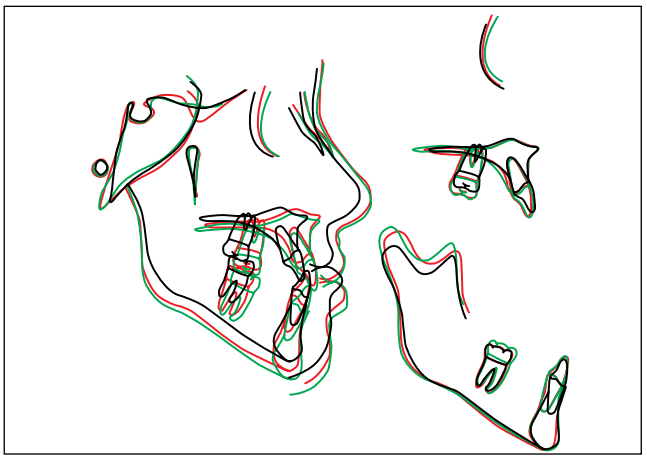
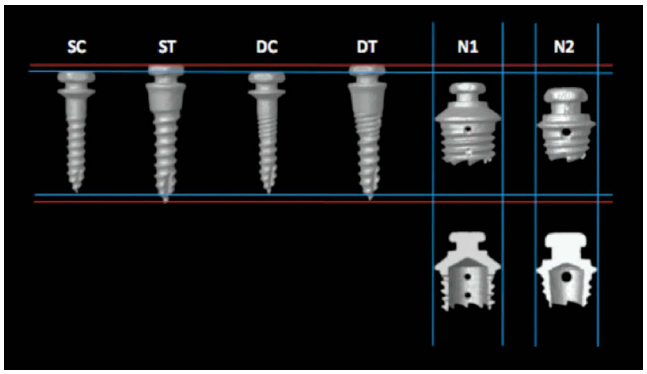


Figure 19 - The superimposition generated from the tracings before the FM treatment (black), after the FM treatment (red), and seven months after the termination of FM treatment (green).

Table 1 - Comparison of cephalometric measurements.

Measurement	Initial	Phase I (20 months with facemask)
SNA (degrees)	81,4	85.1
SNB (degrees)	83,0	82.4
ANB (degrees)	-1,6	2.8
Wits (mm)	-28,0	-6.3
U1.SN (degrees)	106	103
L1.GoGn (degrees)	74	83
FMA (degrees)	31	30
SN.GoGn degrees)	35	36



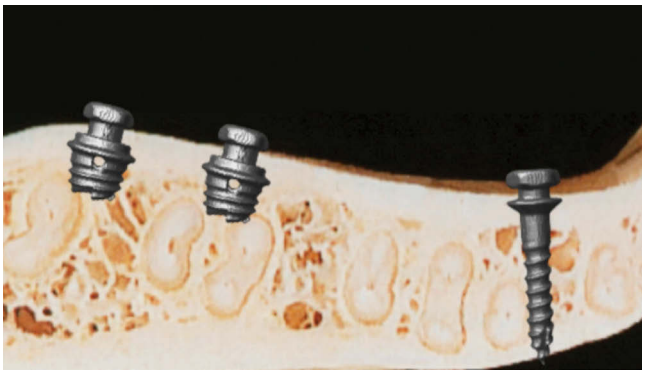


Figure 20 - A novel micro-implant design.

finding the most stable site for MI and working out the orthodontic mechanics instead of settling for a less stable site. Being creative with orthodontic biomechanics is critically important. The mechanical factor is where we have much more control because we can manage these variables. There are numerous MI designs available in the marketplace, and understanding the factors associated with each design will help in choosing the right MI for a particular circumstance.[25]

The secondary stability comes into picture as the osseointegration takes place. As the bone remodels around the MI, the large part of primary stability attributed by the tightness facilitated by the mechanical interlocking and bone compression (often seen in the tapered designs)

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becomes irrelevant. The osseointegration may play a much more significant role in the stability after bone remodeling takes place in the surrounding area. Secondary stability also can be divided into biological and mechanical factors. Bone metabolism, bone density, etc. influence the biological factors, and MI design contributes to the mechanical factor. As with the primary stability, the mechanical factors are easier to control. More surface area of MI is in contact with the bone, more osseointegration can be established, and the surface texture and surface treatment can facilitate osseointegration as well.[26]

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

Any new procedure should be used with caution. The safety of MI has been well established, but there have been reports of surrounding tissue damages as well. The decision to use MI should follow after the risk and benefit analysis as with the CBCT. If MI can be placed safely without tissue damages, there is no reason to avoid its usage. If MI has to be placed in the area with a risk, every precaution should be considered. Generally speaking, the majority of the problems are related to root injury, and this problem can be largely eliminated by choosing the site carefully and selecting the proper MI design. The recent trend is utilizing the palatal area and using the MI with small diameters in attempts to reduce the root contact.[27]

I heard that you have developed a new micro-implant design. Can you briefly describe this new project?

The objective of this novel design was to avoid the vital structures, to maximize the bone contact area within the cortical bone, to reduce the insertion torque (for easy placement), to maximize the removal torque (for stability), and to maximize the osseointegration (for the secondary stability).[28] This MI is only 2.0 mm in length, to avoid contacting the root and neurovascular bundles, but 3.0 mm in diameter to maximize stability (Fig 20). It is hollow inside in order to reduce insertion torque and to increase bone contact. The total surface area in contact with cortical bone is larger than in conventional MI. The internal chamber is reverse-tapered to facilitate insertion. The bone trapped inside the chamber will undergo remodeling process and fill the void. This creates a mechanical trap within the cortical bone and more osseointegration with MI internally, aiding in the secondary stability. Our studies, part 1 and part 2, were published in The Angle Orthodontist journal,[28] and they illustrate, in vitro, the stability of this Novel MI. Our most recent in vitro study also demonstrated its superior stability in various clinical simulations. We are now ready for a clinical trial of this design at UCLA.

The orthodontic community got excited with the idea of decreasing treatment time by using the self-ligated brackets, but after evaluating recent papers, it was found that one cannot treat patients any faster. What are your thoughts on this?

It is well established that the self-ligating brackets do not significantly reduce treatment time.[29] I am troubled by the recent trend in "appliance-based thinking".

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All around us, there are advertisements promoting appliances, such as Invisalign, Damon brackets, and Incognitos. I understand that the manufacturers of these products are trying to convince the public because they have to sell these products. Many of us caved into public pressure and provide the services that the public demands, which often may not be the best treatment choice. It is also sad to see many orthodontists mindlessly promoting the talking points of these manufacturers, claiming that these products are superior and/or more efficient without concrete scientific evidence.

I strongly believe that we all should go back to skill-based orthodontics and treat these new systems as mere tools to achieve our goals. I use MI extensively and sometimes achieve treatment goals that would not have been possible in the past, but it is not the MI that treated patients. It is what I do with this novel tool that matters. If you are looking for a good meal, you will look for a restaurant with a great chef, and you would not care much what kind of knife this chef uses. It is what the chef does that matter, not which tools the chef uses.

If we truly want to reduce treatment time, we have to consider both factors, biomechanics and bone biology. The orthodontists have a tendency to focus more on biomechanics than bone biology. Over the years, a large volume of work has been produced on biomechanics of orthodontics, and they have advanced science. Perhaps that is why we sell our souls to these new devices that claim to make orthodontics easier and more efficient. New hi-tech arch wires, new appliances, and new materials have improved our treatment protocols, but I realize that the improvement in treatment speed has been marginal at best. No matter what new devices we may have, we cannot move teeth any faster than the rate of bone remodeling.

Here are my thoughts on reducing treatment time. It would be far more efficient if we can affect the bone remodeling process. The Wilco brothers introduced accelerated tooth movement, and the results were unmatched by any biomechanical invention to this date.[30] The key is "how do we achieve Wilco-like results without such an invasive procedure?" Accelerated tooth movement (ATM) is one of my research projects at UCLA, and we hope to have good news soon.

An interesting analogy could be associated to micro-implant cases: Do you think we can decrease treatment time by using micro-implants?

That is a common claim I hear from many. I disagree with this blanket statement. In cases that require patient cooperation, maximum anchorage, asymmetric anchorage control, vertical control, etc., MI can aid in efficiency and control. However in many cases, MI can be used to correct the problems that could not to be corrected with conventional mechanics: severe canting, severe open bite, maxillary vertical excess, long lower face height, significant crowding in non-extraction case, periodontally compromised cases, skeletal imbalance, etc. Because we are now able to correct such difficult problems, treatment often takes much longer than typical orthodontic cases. It is not necessarily the reduction in treatment duration we should celebrate, but the ability to provide more optimal treatment results in extremely challenging cases through the use of MI.

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Sagittal changes in lower incisors by the use of lingual arch



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Objective: The objective of this study was to evaluate a sagittal variation on the lower incisors with the use of the lingual arch on the transition from mixed to permanent dentition.

Methods: The sample was constituted of 44 Caucasian patients (26 girls and 18 boys), divided in two groups: CG, control group, monitoring the lower arch space with no orthodontic/orthopedic treatment during the rated period (n = 14); EG, experimental group, presenting anterior inferior mild crowding and installation of the lingual arch for space maintenance (n = 30). The position of the lower incisors was analyzed on computerized cephalometric tracings performed at the beginning of the monitoring (T_1) and at the and, on the permanent dentition (T_2). In order to evaluate the position of the incisors it was used Tweed and Steiner measurements: IMPA, 1.NB and 1-NB. The alterations were analyzed through the "t" test for paired samples, while the differences between the groups were analyzed through the "t" test for independent samples, as for sexual dimorphism.

Results: The values in T_2 were greater in relation to T_1 for all measurements on EG (IMPA, $p = 0.038$; 1.NB, $p = 0.007$ and 1-NB, $p < 0.0001$). On comparing the differences (T_2-T_1) between CG and EG, it can be gauged differences significantly superior for measure 1.NB ($p = 0.002$) and 1-NB($p < 0.0001$) on EG. There was no difference significantly statistic between genres.

Conclusion: It was concluded that the lower incisors were projected after using the lingual arch to control the space on the transition from mixed dentition to permanent, however, within acceptable standards, not having difference between genres.

Keywords: Incisor. Orthodontics. Cranial circumference.

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

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INTRODUCTION

The origin of the lingual arch was assigned by Dewey[3] to Dr. Lourie in 1904, however, Mershon[14,15] was the responsible for the popularization of the referred appliance. Originally it was used to expand the lower arch and posteriorly Nance[16,17] described the indication of the lingual arch for the treatment on mixed dentition, suggesting its use only on the maintenance of the distance between permanent incisors and molars in specific cases.

The lingual arch, as an appliance of passive application, similar to the recommended by Nance,[16] is widely used in orthodontic clinics until the present day. Its main utility is on controlling the perimeter of the lower arch, maintaining the distance between the first permanent molars and the lower incisors after the loss of deciduous molars. It can also be used as assistant for intraoral anchorage on the permanent dentition, from the mixed dentition. This type of appliance shows efficiency on the maintenance of the lower arch perimeter, preventing the molars movement to mesial and the incisors lingual inclination.[22]

The maintenance of the perimeter on the dentition development is fundamentally important because the use of the Leeway Space for eruption of premolars guarantees space for the correct alignment of the lower teeth in up to 80% of the patients with mild crowding.[1,6,10,18]

If not provided with adequate space for alignment of the permanent teeth, it may be necessary a less conservative conduct when the corrective orthodontic treatment is performed.

This way, the lingual arch installed on appropriate moment can reduce the number of future premolars extraction, lower arch stripping and other procedures to restore the space for adequate alignment of teeth.[6]

The cognition about the effects of the lingual arch on these teeth represents a necessity on the orthodontic practice, being an appliance of wide clinical utilization. The purpose of this study was to evaluate the sagittal variation on lower incisors due to utilization of lingual arch on the transition from mixed dentition to permanent.

MATERIAL AND METHODS

The present study comprehended 44 Caucasian patients (26 girls and 18 boys) in need of supervision of the space on the mixed dentition. The transition period from mixed dentition to permanent was monitored in two ways: Control group (CG, n = 14), space monitoring with no orthodontic/orthopedic treatment during the rated period; Experimental group (EG, n = 30), presenting anterior inferior mild crowding and installation of the lingual arch, previously to exfoliation of deciduous second molar, for space maintenance (Fig 1A).

The lingual arch appliance was made with stainless steel wire 0.9 mm (Morelli, Sorocaba/SP) outlining the incisal third of the lower incisors crown. The appliance was attached with glass ionomer cement (3M Unitek, CA/USA) in all patients from the experimental group (Fig 1B).

In the individuals from the control group it were performed lateral radiographs in two-step with a mean age of 9.7 years in T_1 (±1.6) and 11.6 years in T_2 (±1.3). In the patients from the EG, it were also performed two radiographs, in T_1 obtained with mean age of 9.3 years (±1.1) and T_2 with mean age of 11.9 years (±1.1).

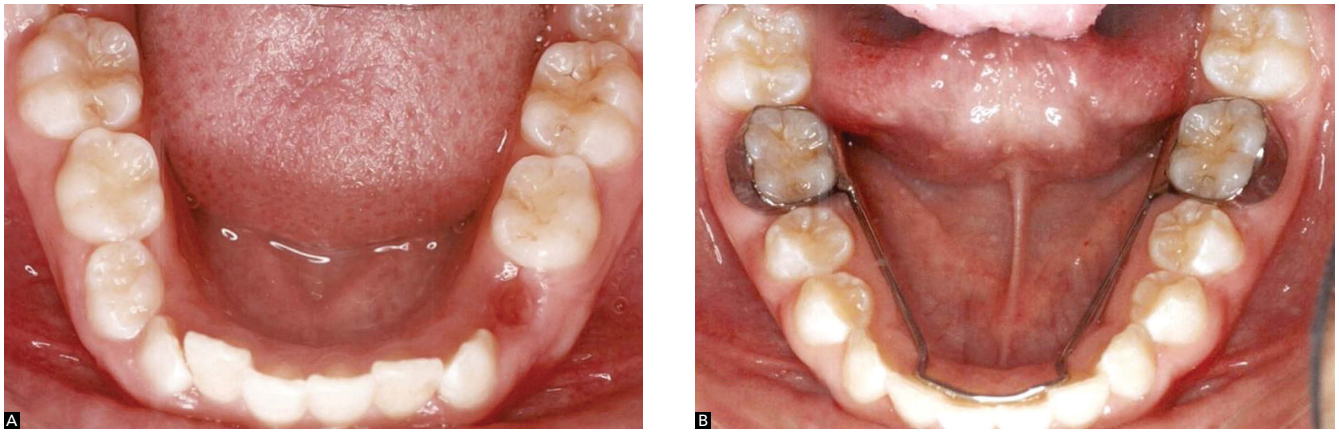


Figure 1 - **A**) T_1: mixed dentition, previously to installation of the lingual arch. **B**) T_2: young permanent dentition with lingual arch installed.

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Computerized cephalometric tracings were obtained from the Ortoview 2.5 software and analyzed at the beginning of the monitoring (T_1) and at the end, after eruption of permanent canines and premolars (T_2), with lingual arch still installed (Figs 2A and 2B). In order to evaluate the sagittal variations of the incisor it was used Tweed[22,23,24] and Steiner[19] measurements:

» IMPA: angle between the long axis of the lower incisor and the base of the mandible (line joining the point "Me" and the "lower portion on the back of the mandible base") – Tweed's analysis;

» 1.NB: angle between the long axis of the lower incisor and the line NB – Steiner's analysis;

» 1-NB: linear distance (mm) between the most prominent portion of the lower incisor crown and line NB – Steiner's analysis.

Initially, it was performed a study of error. The measurements were redone by the same operator and compared through Student's t test for paired samples. There was no significant difference between the values of the 1st and the 2nd measurement for the evaluated measures ($p > 0.05$).

The data were, then, collected and statistically analyzed comparing T_1 to T_2, evaluating the difference between genres and the difference between the two groups. The data were organized in tables and graphics, with mean values and standard deviation for period T_1 and T_2. To compare the two periods it was used the Student's t test for paired data. To evaluate the difference between genres and on comparing the two groups (experimental and control) it was used the Student's t test for independent samples. The results were considered significant in a maximum level of significance of 5%. To verify the normality of the data it was used the Kolmogorov-Smirnov non-parametric test, concluding that they have normal distribution.

RESULTS

The obtained results revealed significant differences between periods T_1 and T_2 in relation to the position of the lower incisors in the experimental group. In this group, it was noticed increasing values in T_2 to the linear measure 1-NB ($p = 0.000$), as to the angular measures 1.NB ($p = 0.007$), IMPA ($p = 0.038$) (Table 1).

The data show the projection on the lower incisors with the utilization of the passive lingual arch. On EG, in T_2, over 40% of the patients presented normal variation to the angular measure IMPA and 85% did not exceeded 100° (Fig 3). In the control group (CG), there was no significant difference between T_1 and T_2 to any of the evaluated measures, according to Table 1. On comparing the differences (T_1-T_2) between the control group and the experimental group, it can be gauged differences significantly superior on experimental group for measure 1.NB($p = 0.002$) and 1-NB($p < 0.000$) (Table 1). There was no significant difference between genres to the evaluated measures (Tables 2 and 3).

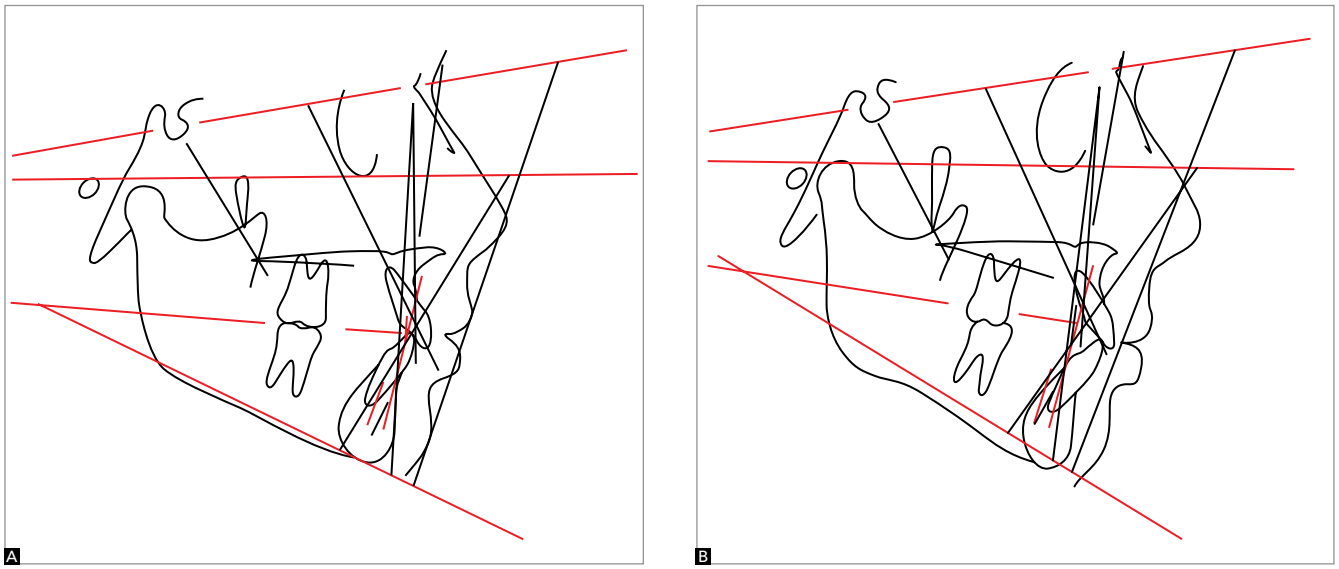


Figure 2 - **A**) Cephalometric tracing at T_1: previously to installation of the lingual arch. **B**) Cephalometric tracing at T_2: young permanent dentition with lingual arch still installed.

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Table 1 - Means, mean differences and t test comparing the groups.

	T_1	T_2	*p	T_2-T_1	**p
IMPA (CG)	94.8	94.2	0.468	-0.6	0.083
IMPA (EG)	92.9	94.8	**0.038**	1.9	
1.NB (CG)	26.7	25.9	0.163	-0.8	**0.002**
1.NB (EG)	27.1	29.8	**0.007**	2.7	
1-NB (CG)	4.9	5.1	0.669	0.2	**0.000**
1-NB (EG)	5.1	6.7	**0.000**	1.6	

*p value: Paired sample; **p value: Independent samples.

Table 2 - EG: Mean differences ± standard deviation and t test comparing genders.

Mean differences T_2-T_1				
	n	1-NB (mm)	1.NB (degrees)	IMPA (degrees)
Feminine	19	1.5 ± 1.1	1.6 ± 4.6	1.1 ± 4.8
Masculine	11	2.0 ± 1.2	4.7 ± 5.6	3.6 ± 5.2
*p		0.258	0.118	0.186

*p value: Independent samples.

Table 3 - CG: Mean differences ± standard deviation and t test comparing genders.

Mean differences T_2-T_1				
	n	1-NB (mm)	1.NB (degrees)	IMPA (degrees)
Feminine	7	-0.1 ± 0.3	-0.4 ± 2.2	-0.1 ± 2.6
Masculine	7	0.2 ± 1.2	-1.2 ± 1.9	-1.1 ± 3.0
*p		0.507	0.455	0.546

*p value: Independent samples.

DISCUSSION

The length of the arch, as well as its perimeter, is reduced on the transition from mixed dentition to permanent, especially on the mandibular arch. This reduction on the arch perimeter is basically due to a mesial migration of the first permanent molar after the loss of the second deciduous molar.[7] The lingual arch shows efficiency on the maintenance of the lower arch perimeter, that is, preventing the molars movement to mesial and the linguoversion of the incisors, fact that can be associated to the reduction of mandibular crowding.[2,25] It allows the lower incisors to take an appropriate position by the perioral musculature and intraoral functional forces. Singer[19] noticed distal inclination of lower molar, tendency (not significant) to projection of incisors and a greater tendency of the incisors and molars to present smaller vertical development in patients treated with lingual arch.

Morphological variations in the symphysis mentalis region, due to growth, result in modifications on the position of lower incisors. The cognition of these variations is of great clinical importance, being fundamental data on orthodontic planning.[8,11] According to Enlow,[5] as regards to lower incisors, there is a physiological remodeling on the alveolar region, causing a lingual inclination. The lower dental arch is referenced as one of the main elements for the diagnosis and for the orthodontic therapy. The dental positions will be established basically by the bone configuration, that is, the teeth should be aligned on the alveolar ridge.[21]

Tweed,[22] through his studies, suggested the inclination of the lower incisors in relation to the mandibular ridge of 90° with a variation of 5° for further or for fewer, creating the IMPA, first angle of what would be the diagnostic facial triangle. Posteriorly, the same author, found the norm of 87° to the angular measure IMPA with variation from 76° to 99°on the studied sample.[23,24] In the experimental group (in T_2), in relation to this angle, over 40% of the patients are within the normal variation and 85% did not exceeded 100° (Fig 3), being these values considered according to acceptable standard of normality and the minimum value found of 82.5°and the maximum of 106°.

Steiner[20] suggested angular and linear mean values to the position of lower incisors in relation to line NB considered as standard, being 25° to 1.NB and 4 mm to 1-NB. In this study, in T_2, to the angular measure 1.NB the minimum value found was 18.8° and the maximum was 36.6°. To the linear measure, 1-NB, the values were 3.6 mm and 11.3 mm, being respectively minimum and maximum. However, values conventionally adopted as representative of normality not always can be used indistinctly, given that variation due to growth and craniofacial development are characteristic of different organisms.[11]

The normal mandibular growth tend to increase the SNB, with greater progress attributed to point B, since the point N does not progresses with the same intensity, altering the geometric relation of the line NB with the long axis of the lower incisor, with artificial reduction of 1.NB and 1-NB. Therefore, the IMPA presents more reliable value for the analysis of the lower incisor position, since it experiences less

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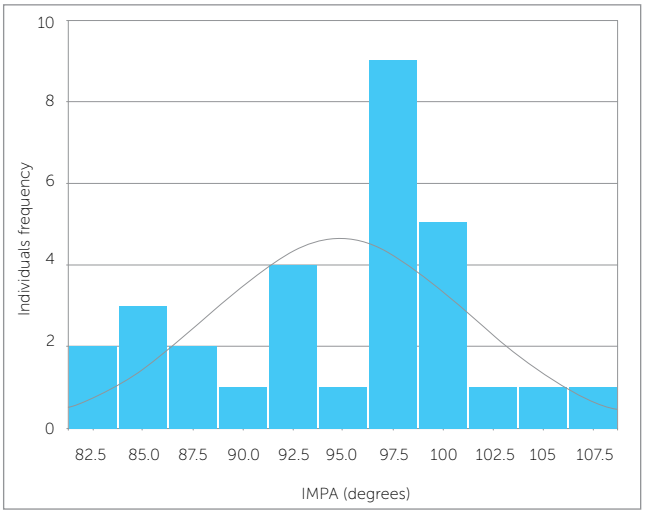


Figure 3 - IMPA (Experimental Group): final value.

influence of the mandibular growth. Aiming to determine accurately the inclination of the lower incisors, the measures 1.NB, 1-NB and IMPA were used with reference in this work.

The variations on point B occur smoothly from 6 to 10 years and well-marked from 10 to 15 years, concomitantly with the lingual inclination of incisors.[8] In agreement to the previous study, Watanabe et al[26] also verified a lingual inclination of mandibular incisors between 8 and 15 years old. During puberty, therefore, the lower incisors tend to move lingual, if nothing prevents this movement. If the lingual inclination does not occur, this can be attributed to crowding in the anterior region.

According to the results found in this study, the use of the lingual arch prevented the tendency of lingual inclination reported on previous studies, being observed some projection of lower incisors. The projection of the lower incisors verified in this study can be considered clinically advantageous, noting that minimizes or even eliminates the necessity of future extractions or stripping during the treatment in cases of small negative discrepancies on the mixed dentition and depending of the cephalometric and facial interpretation, of the complaint of the patient and of what is biologically acceptable in each individual.

This projection can be used, facilitating orthodontic biomechanical with gain of space.[27] The orthodontic intervention on mixed dentition would promote smaller chances of development of future occlusal problems.[9] Besides the maintenance of the Leeway space, using the lingual arch is possible to restore space in up to 2 mm of negative discrepancy, eliminating the crowding on the transition from mixed dentition to permanent when it is presented.[10]

Dugoni et al[4] verified that using the lingual arch on alignment of lower incisors was clinically acceptable in 76% of the cases on the post-restraint period. According to the same authors, the use of the Leeway space to dissolution of crowding may result in better stability in long-term.[4] The methods usually adopted to calculate the discrepancy in the analysis of the mixed dentition can overestimate the values obtained. It is suggested, therefore, the utilization of size prediction methods of permanent teeth that have a coefficient of explanation (R^2) closer to 1. For this, the utilization of oblique teleradiograph of 45° is an option with good degree of accuracy.[12,13]

Rabellato et al[18] reported a slight projection of the lower incisors, finding a mean value of increase on IMPA of 0.73°, having evaluated 14 patients with mean age of 11.5 years, that used only passive lingual arch in this period of the treatment, using the overlay method of cephalometric tracings for comparison pre and post-treatment.

Villalobos[24] reported that the lower incisor presented a discrete retroclination of 0.52°, on average, using the lingual arch through the same overlay method of cephalometric tracings. Despite the methodological difference about the comparison between the initial and the final position of the lower incisors, in the present study it was found a mean projection of 1.9° for the IMPA. The option for using computerized cephalometric tracings with angular and linear measures was based on standardization of the technique, allowing longitudinal evaluations of the same individual with good reliability degree.

CONCLUSION

It was concluded that the lower incisors were projected after using the lingual arch to control the space on the transition from mixed dentition to permanent, however within acceptable standards, not having statistic difference between genres for the evaluated measures.

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Mechanical evaluation of quad-helix appliance made of low-nickel stainless steel wire

Rogério Lacerda dos Santos[1], Matheus Melo Pithon[2]

Objective: The objective of this study was to test the hypothesis that there is no difference between stainless steel and low-nickel stainless steel wires as regards mechanical behavior. Force, resilience, and elastic modulus produced by Quad-helix appliances made of 0.032-inch and 0.036-inch wires were evaluated.

Methods: Sixty Quad-helix appliances were made, thirty for each type of alloy, being fifteen for each wire thickness, 0.032-in and 0.036-in. All the archwires were submitted to mechanical compression test using an EMIC DL-10000 machine simulating activations of 4, 6, 9, and 12 mm. Analysis of variance (ANOVA) with multiple comparisons and Tukey's test were used ($p < 0.05$) to assess force, resilience, and elastic modulus.

Results: Statistically significant difference in the forces generated, resilience and elastic modulus were found between the 0.032 and 0.036 inch thicknesses ($p < 0.05$).

Conclusions: Appliances made of low-nickel stainless steel alloy had force, resilience, and elastic modulus similar to those made of stainless steel alloy.

Keywords: Orthodontic appliances. Hypersensitivity. Nickel.

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INTRODUCTION

In orthodontic practice, a variety of metal alloys, such as stainless steel, cobalt-chrome, nickel-titanium and beta-titanium are used, the majority of which contain nickel.[11] The percentage of nickel in brackets and auxiliary appliances used in orthodontics ranges from 8% (in stainless steel wires) to over 50% (in nickel-titanium wires).[7,17]

Among the austenitic steels most commonly used in Orthodontics, types 302 and 304 are outstanding, according to the American Institute of Steel and Iron, AISI), containing approximately 18% chrome and 8% nickel, which is represented by the 18-8 group of stainless steels.

Nickel is a strong immunologic sensitizer, and may result in hypersensitivity[14] and tissue reactions. These reactions may consist of intraoral diffuse red zones, blisters and ulcerations that may extend to the perioral area. In addition, there may be urticariform and eczematous reactions in the face or in more distant areas of the body.[12]

Therefore, to solve this problem, stainless steel alloys with low nickel content began to be used for fabricating appliances, among them the expanders used for the correction of posterior tooth crossbite. These can be used in primary, mixed and permanent dentition as an alternative for patients who present high allergenic potential.

The appliances commonly used for correcting dental crossbite include the Coffen, "W" arch and Quad-helix arch appliances.[1,3,20]

Graber[9] affirmed that 400 g would be the lowest orthopedic force required to achieve an effect in the maxillary arch. Inversely, the correction of posterior tooth cross bite requires orthodontic forces, and Jarabak and Fizzell[15] recommended ideal levels of force for each group of teeth. They suggested that to move a maxillary molar, a force of 250 g should be used.

Thus, the aim of this study was to test the hypothesis that there would be no difference in the mechanical performance between stainless steel wires and stainless steel wires with a low nickel content when evaluating force, resilience and modulus of elasticity produced by the Quad-helix appliance used for correcting posterior tooth crossbite, and to determine the ideal activation levels for each appliance.

MATERIAL AND METHODS

Sixty Quad-helix appliances were tested, using two wire thicknesses (0.032-in and 0.036-in), two types of metal alloys, the first being stainless steel (stainless steel-CrNi, Morelli, Sorocaba, São Paulo, Brazil) and the second low-nickel stainless steel – nickel content below 0.2 % (Biowire-CrMo, Morelli, Sorocaba, São Paulo, Brazil). Of these, 30 were made of each type of alloy, with 15 being made of 0.032-in and 15 of 0.036-in.

The Quad-helix appliances made had 2 external and internal segments, 40 mm and 35 mm long, respectively, 1 anterior section 10 mm in extension and 4 helical spirals with 1.5 mm in diameter (Fig 1).

The samples were fabricated by the same professional, using patterns of a single model with the same intercanine and intermolar distances. A segment measuring 5 mm long and 0.040 inches in diameter of a telescopic tube was attached to the posterior part of each external extremity of the Quad-helix appliance, to enable the application of force on the maxillary permanent first molars. A 10 mm long stainless steel wire 0.032-in in diameter was silver-welded to the center of the telescopic tube, so that the appliance could be fixed to a universal test machine.[16]

Each sample was initially activated to 12 mm, and after this it was submitted to a series of compression tests in an EMIC DL 10000 machine, using the Mtest program version 1.0, at a speed of 5 mm / min. The Mtest program generated the mean force, resilience

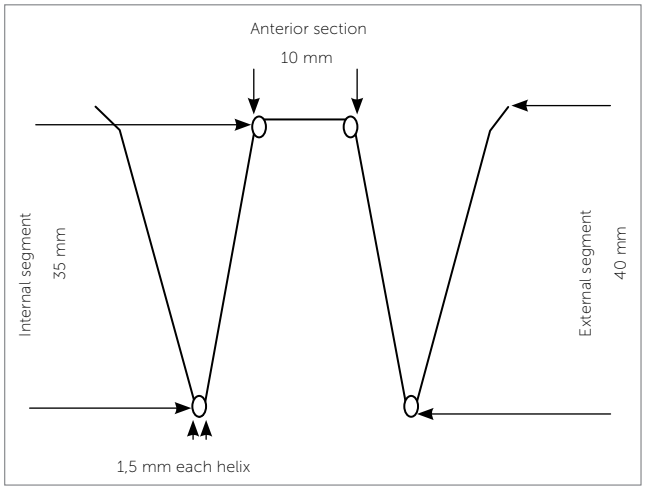


Figure 1 - Diagram used for fabricating the Quad-helix appliance.

Table 1 - Mean force (g) produced by the Quad-helix appliances.

Quad-helix appliance		Activation			
Metal alloy	Wire diameter	4 mm	6 mm	9 mm	12 mm
Stainless steel	0.032-in	108.8 ± 11[a]	136.9 ± 16[a]	189.6 ±15[a]	221.2 ± 12[a]
Stainless steel	0.036-in	123.9 ± 8[b]	172.1 ± 11[b]	245.8 ± 18[b]	291.5 ± 24[b]
Low-nickel stainless steel	0.032-in	110.8 ± 0[a]	139.9 ± 7[a]	193.1 ± 10[a]	224.2 ± 12[a]
Low-nickel stainless steel	0.036-in	126.4 ± 14[b]	175 ± 15[b]	250.3 ± 20[b]	316.1 ± 22[b]

N= 15, for each combination between metal alloy and wire diameter used. Different letters indicate statistically significant difference ($p < 0.05$) between appliances for the same activation.

Table 2 - Resilience and modulus of elasticity produced by the Quad-helix appliances.

Quad-helix appliance			
Metal alloy	Wire diameter	Resilience (g/cm)	Modulus of elasticity (g/cm²)
Stainless steel	0.032-in	146.4 ± 13[a]	84.7 ± 7[a]
	0.036-in	195 ± 15[b]	86 ± 6[b]
Low-nickel stainless steel	0.032-in	149.8 ± 9[a]	86.7 ± 11[a]
	0.036-in	197.4 ± 17[b]	87 ± 12[b]

N= 15, for each combination between metal alloy and wire diameter used. Different letters indicate statistically significant difference ($p < 0.05$).

and modulus of elasticity produced by the activations of 4, 6, 9 and 12 mm, as well as a graph of the mechanical behavior at these activation indices. The results obtained were statistically compared by one-way ANOVA and Tukey's tests.

RESULTS

The low-nickel stainless steel showed greater release of force, resilience and modulus of elasticity compared with conventional stainless steel (Tables 1 and 2).

In both alloys evaluated, the groups using 0.036 inch wire showed statistically higher ($p < 0.05$) levels of force, resilience and modulus of elasticity when compared with appliances made with 0.032-in wire.

For the same wire thickness there was no statistically significant difference between the alloys ($p > 0.05$) (Tables 1 and 2).

DISCUSSION

The mean force values increased proportionally to the activations, which is in agreement with the fact that the appliances operated in the elastic phase, in which deformation is proportional to force. Resilience is the property associated with the capacity of absorbing and releasing energy; therefore, the greater the resistance, the more continuous the force will be.[19]

Studies have reported various forms of palatal arches in the correction of posterior crossbite.[1,5,23] In the present study, the Coffen appliances showed distinct mechanical properties, indicating the need for knowledge about their performance in order to choose them. In addition, it is important to identify the etiology of the malocclusion and determine the ideal force for each treatment[10] to be performed. The movement of a single molar may require 250 g,[15] but orthopedic effects are perceptible in primary and mixed dentition with forces greater than 400 g.[9]

Urbaniak et al[23] in their study observed that the force produced by activation of the Quad-helix appliance is influenced by the size and diameter of the appliance wire. In this study it was verified that the quantity of wire used in fabricating the palatal arch and the force used are inversely proportional, and that the wire diameter is directly proportional to the force.

In other studies on the Quad-helix[3,5,6] the use of a force of approximately 400 g was suggested for an activation of 8 mm.

In view of the results obtained in this study, adequate treatment of cross bite of a single molar, or group of a few teeth is obtained with the Quad-helix appliance made with 0.036 inch wire, with 9 mm of activation, irrespective of the metal alloy.

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The findings showed that the force produced by activations of up to 12 mm with Quad-helix appliances made with 0.036 inch stainless steel alloy or low-nickel stainless steel wire were below 400 g. This force is insufficient for achieving orthopedic effects, whether associated with the use of a fixed appliance, or not. Therefore its use would be invalid for this type of treatment.

Nickel is known for its allergenic potential.[13,18,22] It is estimated that 4.5% to 28.5% of the population is hypersensitive to nickel,[4,14,18,21] with greater prevalence for the female gender. For every 10 women, 1 man presents allergy to nickel.[18] The presence of metal ions such as nickel in orthodontic appliances has been associated with hypersensitivity reactions.[2]

The clinical manifestations of hypersensitivity to nickel are easy to diagnose. When faced with an allergic condition, any intraoral or extraoral appliance that contains nickel must be removed until the signs of adverse effects in the mucosa or skin have completely healed.[7] Previous history of allergy must be considered a predictive factor of clinical manifestations of hypersensitivity to nickel.[8] Therefore, instead of using intra and extraoral appliances that contain nickel, it is suggested that they should be replaced by nickel-free, or low-nickel stainless steel brackets and wires.

Low-nickel stainless steel wire is an option the orthodontist may use in patients with a history of hypersensitivity to nickel, however, the patient should be aware of the activation that will be used in appliances made of this wire. The function of nickel is to stabilize the metal alloy. A reduction in its quantity will alter the physicochemical properties of the alloy. This alteration may generate an increase in rigidity of the orthodontic wire.

The Quad-helix appliance fabricated with low-nickel stainless steel presented greater release of force when compared with the conventional steel alloy, and this may have a significant influence of the proposed treatment, by obtaining greater tooth movement than expected.

CONCLUSION

1) The low-nickel stainless steel showed release of force, resilience and modulus of elasticity similar to conventional stainless steel.
2) Quad-helix appliances produced adequate forces for orthodontic treatment, when their clinical application is correctly planned.

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Transversal changes in dental arches from non-extraction treatment with self ligating brackets

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Objective: The present study aimed at analyzing, with the use of dental casts, the transverse changes of the upper and lower dental arches, after non-extraction orthodontic treatment, with self-ligating brackets.

Methods: The sample comprised 29 patients, all presenting Class I malocclusion with upper and lower crowding of at least 4 mm and treated only with a fixed appliance, without stripping, extraction or distalization. The dental casts were obtained before and after leveling with 0.019 x 0.025-in stainless steel archwires.

Conclusion: The results indicated that the majority of transverse changes occurred at the premolar areas, both the first and the second, as well as on the upper and lower dental arches. The intercanine distance increased 0.75 mm, on average, in the upper arch and 1.96 mm in the lower arch. The molars also demonstrated a tendency towards an increase in their transverse dimension, however, at a lower intensity comparing to premolars. All measurements presented statistically significant differences with the exception of the maxillary second molars.

Keywords: Corrective orthodontics. Dental models. Orthodontic brackets.

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INTRODUCTION

Every orthodontic treatment has its foundation in the moment of diagnosis and planning. A correct diagnosis and a well-designed treatment plan are responsible for the success of the treatment, independent of the selected appliance to achieve the proposed objectives. There are several parameters and tests used to aid in the detection of anomalies and malocclusions affecting patients and guiding the planning, but knowledge of the effects that each appliance provides brings safety to the choice of treatment modality based on the goals set forth. Similarly, knowledge of a successful procedure and how stable it is also brings safety in using a treatment method.

Admittedly, dental malocclusion with dental crowding, can be treated by obtaining space in the arch that can occur in 5 ways: Archwire expansion, protrusion of the anterior teeth, dental extractions, stripping, or even distalization in the upper arch. In Class I malocclusion, the distal procedure presents itself as contraindicated, remaining two alternatives that reduce the arch perimeter and two others that increase the perimeter. To decide on the procedure, the orthodontist must ponder factors like facial convexity, type of mandibular growth, facial pattern, overjet and overbite, among others. Historically, it has been touted in the literature that the extraction procedures would be more stable than the expansion ones, unless through orthopedic expansion at an early age, when is possible to separate the intermaxillary suture with minimal buccal tooth movement.[1,2,3]

There are countless studies in the literature dealing with maxillary expansion caused by rapid maxillary expansion and the skeletal and dental effects resulting from this procedure.[4-9] The purely dental expansion is not accepted by orthodontists because of the alveolar limitation of this procedure, being reduced to only cases with very mild crowding or that permit a buccal tipping effect, especially on the anterior segment.

However, the literature is still not clear on this subject when it comes to stability, since the results of some studies have shown that the dimensions are more altered in the post-treatment period when extraction is performed as opposed to treating without extraction,[10-13] and still others show that post-treatment stability is compromised in both cases with and without extractions.[12,14,15,16] Walter[13] evaluated 50 cases without extractions and 50 with extractions, measuring the intercanine and intermolar widths in the pre and post-treatment periods and 1 year after removal of the retainers. A year after the removal of the retainers, there was a decrease in the intercanine and intermolar widths in cases with or without extractions, demonstrating that the canines and molars rarely remain stable after removal of the appliance, regardless of whether or not the extraction was performed. A similar outcome was found by Heiser et al.[17]

Shapiro[18] sought to identify the alterations that occur in between the intercanine, intermolar widths and the arch length in the pre- and post-treatment phases and 10 years after retention in the lower dental arch in patients orthodontically treated, with or without extractions. Lower dental casts of 80 treated subjects were evaluated, who initially presented Class I or Class II malocclusions, division 1 or 2, measuring the intercanine distance, having the cusp tips of the canines as reference, and intermolar distances, based on the cusp tips of the first molars. The results showed a strong tendency of intercanine width to return to its initial dimension and the length of the dental arch to substantially decrease in all cases during the post-retention period. The intermolar width decreased more in patients treated with extractions, in the period between the phases before treatment and after retention. Several cases where intermolar expansions were obtained during treatment were maintained in the treated group without extractions, although, they tend to return to the initial dimension.

The presence of crowding in the arch, even in mild cases, which were treated without extraction, stripping or expansion, with a fixed appliance demand flaring of the teeth that occurs with greater intensity in the anterior region of the arch, since the occlusal contact of the posterior teeth further restricts the buccal movement and the anterior teeth, besides being smaller and being just juxtaposed, are generally more crowded and therefore more likely to yield to the buccal movement to accommodate all the teeth.

Due to the incisors flaring, instead of the buccal posterior movement to accommodate the crowded teeth, the procedure for correction of crowding would only be suitable for specific cases, such as cases

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of incisors with lingual inclination, absence of narrow arches, or increased overjet.

When they were reintroduced in orthodontics, self-ligating brackets promised tooth movement with a significant reduction of friction. However, Damon[19] raised another possibility that would involve the passive expansion of the arches by means of tooth movement in the buccal direction, due to the freedom of the wires in the slots which would slide in the posterior direction as the crowding is being solved and thus reduce the effect of incisor flaring. In cases with completed facial growth and negative discrepancy, in which the extraction could greatly harm the patient profile, this possibility would present itself as a big advantage for orthodontic treatment. Faced with the controversy that raises this issue, we decided to evaluate in dental casts the transverse changes resulted from a non-extraction treatment with self-ligating brackets.

MATERIAL AND METHODS

Fifty-eight pairs of dental casts were used for this research, 29 pre-treatment and 29 taken at the end of leveling with 0.019 x 0.025-in stainless steel wire. The sample consisted of 29 patients, 12 to 34 years old, all presenting with Class I malocclusion, with a minimum of 4 mm crowding in both upper and lower arch. All patients used Damon 2 brackets bonded with the VA point as a reference point in the center of the clinical crown and undergone a treatment protocol with a sequence of archwires as recommended by Damon,[19] starting with the 0.014-in CuNiti archwire followed by the 0.016 x 0.025-in CuNiti archwire and finishing with the 0.019 x 0.025-in stainless steel archwire. No procedure was performed to obtain space, namely stripping, extraction, distalization or any procedure other than the sequential archwires exchange. To perform the measurements on the dental casts (Fig 1), it was used a Mitutoyo digital caliper with 150 mm capacity and a resolution of 0.01 mm, for it is a very accurate tool.

Dental measurements on cast models

The measurements were performed transversely, from the canines to the second molars in the upper and lower casts. With the caliper positioned parallel to the occlusal plane, it was measured the distance between the cusp tips of the canines, followed by the buccal cusp tips of the first and second premolars and mesiobuccal cusp tips of the first and second molars.

To compare the significance of the transversal changes, it was used the Student t test, with a significance level of 5%. Ten percent of the sample was remeasured with a mean interval of 30 days to evaluate the systematic and random errors. The systematic error was insignificant for all variables except the transverse distance of the first molars that reached a p value of 0.03 and the random error had the higher value of 0.47 mm for the width measurement of the upper first molars

RESULTS

Table 1 shows random and systematic error values of the repetitive measurements evaluated by the Student t test and the Dahlberg's formula.

The initial and final measurements obtained in the dental casts are shown in Tables 2 and 3.

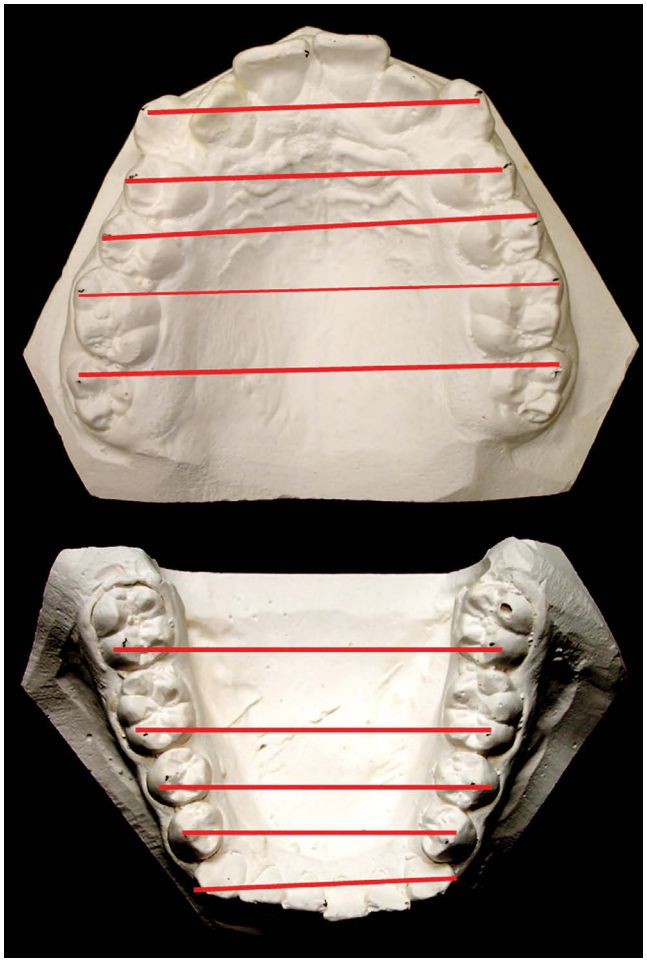


Figure 1 - Transverse measurements performed on the upper and lower casts.

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DISCUSSION

By studying cases that were orthodontically treated successfully, Strang[12] noted that the initial lower intercanine and intermolar distances showed little or no variation in relation to the post-treatment values. He found that the muscle harmony should be preserved and that the forms and positions of the teeth of the upper arch are controlled by the characteristics of the lower arch, which in turn are imposed by the surrounding tissues. Thus, every effort should be made towards preservation of the muscular balance.

Grounded in such a theory as this,[12] Orthodontics understands that cases with crowding, which require space in the arch for correct alignment, should be treated by the extraction of teeth, as it is believed that, proceeding in this manner, the original arch shape is preserved, making the obtained occlusion more stable. The procedure has always been: First obtain the space and then move the displaced teeth, that is out of the arch due to the lack of space.[10,14,15]

With the introduction of nickel titanium wires in the 80s, their property of great flexibility allowed

Table 1 - Systematic and random errors tests, for the upper and lower dental arches variables.

Upper arch	Mean 1 ± SD	Mean 2 ± SD	Dahlberg	t test	p
13 x 23	36.95 ± 3.83	36.92 ± 3.79	0.27	0.23	0.82
14 x 24	42.80 ± 3.79	42.85 ± 3.78	0.32	0.33	0.74
15 x 25	50.50 ± 4.77	50.34 ± 4.74	0.23	1.67	0.12
16 x 26	55.90 ± 1.67	55.82 ± 1.88	0.47	0.24	0.82
17 x 27	52.65 ± 4.36	52.12 ± 4.42	0.35	1.11	0.28
Lower arch	**Mean 1 ± SD**	**Mean 2 ± SD**	**Dahlberg**	**t test**	**p**
33 x 43	26.66 ± 3.14	27.00 ± 3.22	0.41	1.53	0.18
34 x 44	32.70 ± 3.91	32.90 ± 3.96	0.29	1.60	0.14
35 x 45	37.00 ± 3.54	37.06 ± 3.31	0.37	0.38	0.70
36 x 46	42.31 ± 3.91	42.52 ± 3.89	0.24	2.44	0.03*
37 x 47	46.46 ± 3.94	46.44 ± 3.87	0.28	0.18	0.85

*Statistically significant at p<0.05.

Table 2 - Initial and final values, in millimeters, of the transverse measurements of the upper dental arch, standard deviations, mean difference, paired Student t test and p value.

Measurements	Initial average ± SD	Final average ± SD	Mean difference	t test	p
13 x 23	35.99 ± 2.47	36.74 ± 2.20	0.75	2.16	0.03*
14 x 24	41.59 ± 2.96	44.77 ± 2.34	3.18	7.19	0.01*
15 x 25	46.32 ± 3.31	49.66 ± 3.04	3.34	7.53	0.01*
16 x 26	52.13 ± 3.62	54.62 ± 11.24	2.49	7.08	0.01*
17 x 27	58.12 ± 4.02	58.16 ± 3.69	0.04	0.85	0.40

*Statistically significant at p<0.05.

Table 3 - Initial and final values, in millimeters, of the transverse measurements of the lower dental arch, standard deviations, mean difference, paired Student's t test and p value.

Measurements	Initial average ± SD	Final average ± SD	Mean difference	t test	p
33 x 43	26.44 ± 2.40	28.40 ± 2.37	1.96	6.08	0.01*
34 x 44	34.49 ± 2.13	37.44 ± 2.02	2.95	8.41	0.01*
35 x 45	39.43 ± 3.03	42.82 ± 2.39	3.39	11.12	0.01*
36 x 46	44.90 ± 3.73	47.13 ± 2.93	2.23	6.09	0.01*
37 x 47	50.75 ± 3.52	53.12 ± 3.15	2.37	4.09	0.01*

*Statistically significant at p<0.05.

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mal-positioned teeth, even without space, to be connected to the wire. Still, this procedure continued to be contraindicated because the lack of space would require buccal movement of the teeth for aligning. It occurs because the crowding requires an increased archwire length to be ligated on the teeth, and the memory effect of these wires lead to a severe flaring. This effect, under conventional conditions, occurs mainly in the region of the incisors, because they are the teeth usually involved in crowding which have a lower resistance to movement, since there is no occlusal contact, as in the posterior teeth and are also the teeth with a smaller volume of crown and root.

Damon[19] challenged the precepts of orthodontics to indicate that this paradigm to open space before and then proceed to the leveling of mal-positioned teeth can and should be broken, assuming that self-ligating brackets provide a significant reduction in friction, and when a light archwire is used, while alignment occurs, the archwire slides posteriorly, thus avoiding excessive anterior movement of incisor teeth and obtaining spaces mainly through a lateral dentoalveolar expansion, called the "posterior transverse adaption". As the thermal active alloys release light forces, the tipping movement could also be reduced, since the moment created is reduced due to its direct relation to the force magnitude.

As stated by Bagden,[20] the tip of the system is to use light archwire in passive self-ligating brackets, giving great freedom for the wire inside the slot. With the friction and "binding" effect reduced, the teeth align more efficiently and with much less force than required for conventional brackets.

In accordance with this philosophy, the freedom of the wire causes the teeth to suffer the pressure of leveling, but without forcing the movement. Thus, the tooth tends to move towards areas of lesser resistance, i.e., where there is more space and no resistance to tooth movement. Furthermore, since there is no friction and the freedom of the wire is large, it tends to slide in the posterior direction as the teeth are leveled. This sliding allows the wire length — which is greater when inserted, since deflections must occur to fit the mal-positioned teeth — to do not cause excessive expansion of the arches, what leads the teeth to extremely buccal positions, as it easily slides through the adjacent brackets and remains on the distal of the last tooth inserted on leveling, allowing greater control in the tooth movement and less protrusive effect in cases without extractions. The purpose of this study was to evaluate, in patients treated with self-ligating brackets and thermal active nickel titanium alloy wires, if it occurs, in fact, this later expansion by offering space in the arch and therefore reducing the need for protruding incisors, and verify how this treatment interferes with the intercanine distance in the upper and lower arches that could suggest a potentially unstable treatment.

INTERCANINE DISTANCE

Recognizing the canine teeth as corresponding to a stable structure and that any significant change in its position causes post-treatment movement which result in relapse, the less changes in its position, the better is the treatment.[2] Many clinicians and researchers believe that the shape of the mandible represents a state of structural and functional balance that should not be changed with treatment, according to cited by Burke et al.[14] In this study, the upper intercanine distance presented an average expansion of 0.75 mm and the lower, 1.96 mm. This change reached a statistical significant index for both arches, although in the upper arch, on average, the change was smaller than in the lower arch. However, even if statistically significant, it is important to consider if this transverse alteration in the lower canines would be clinically important to cause, in the post-treatment period, a relapse that incurs in failure. To answer this question it is interesting to analyze the literature, and verify the expected alteration in this region with conventional orthodontic treatment. It would be interesting if it could be not modified, but the literature shows that this does not occur. Burke et al,[14] through a meta-analysis, evaluated 26 studies that investigated the longitudinal stability of the intercanine distance. The studies they evaluated had different malocclusions with respect to Angle classification, cases treated with and without extraction and different treatment modalities. This data was checked to verify the relationship in the stability in the inter-canine dimension. The results showed that the intercanine distance tends to increase in the order of 1 to 2 mm, irrespective of malocclusion, treatment modality and treatment with or without extraction, and that this alteration tends to be lost in the post-reten-

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tion period. Johnson,[11] also evaluated the intercanine and intermolar distances in dental casts of cases treated with and without extractions. An average increase of 0.8 mm in the intermolar distance was found, and 0.3 mm for the intercanine distance, while the maximum increase was 1.5 mm in one case without extraction, the intercanine distance did not change. Another interesting work was published by Araújo, Leite and Brito.[10] The authors assessed the alterations in the intercanine distance in the lower arch in patients with Class I malocclusion, treated with and without extraction. The average increase in the intercanine distance observed during treatment was 1.35 mm in cases with extraction and 0.54 mm in cases without extraction. In the post-retention period, there was a reduction of this expansion in the order of 0.5 mm on average in patients treated with extraction and 0.13 mm in cases treated without extraction. In the present study, all patients were treated without extraction, with a minimum of 4 mm crowding in both arches and the changes observed during treatment, were within the parameters indicated in the literature as common in any type of treatment, making the treatment with low friction and thermal nickel titanium wires in cases of crowding, an additional option which tends to have the same degree of stability than any other protocol. Future works evaluating stability regarding the intercanine distance using this modality of treatment may bring greater clarity to the subject, as well as a correlation between the changes after retention and the degree of initial crowding or the amount of alteration observed in the active period of treatment. Once observed that the intercanine width undergoes alterations similar to other therapies, the question arises about where, indeed, there was a greater movement. For this, we also measured the transverse alterations in the premolars and molars region.

INTERPREMOLAR AND INTERMOLAR DISTANCES

In the present study, it was possible to verify that the major average transverse alterations occurred in the region of the premolars, especially in the maxillary arch. In the lower arch, there seemed to have a more uniform distribution of labial movement between the premolars and molars, but with even more intensity for the region of the premolars.

In the upper interpremolar distance, the average alterations surpassed 3 mm, reaching statistically significant values, with a value greater than three times the alteration in the intercanine distance. The molars had a smaller transverse increase, with a mean of 2.49 mm for the first molars, but with a statistical significance and the second molars practically did not alter. In the lower arch, the average alteration in the region of the premolars was 2.95 mm for the first premolars and 3.39 mm for the second premolar, indicating that they were on average 1 mm and 1.43 mm, respectively, larger than the intercanine distance. The difference in expansion between the canine and premolars in the mandibular arch was not as great as in the maxillary arch, however, the lower molars also suffered expansion, far more expressive than in the maxillary arch, especially in the second molar region, where there was an expansion average of 2.37 mm. This difference found between upper and lower second molars seemed to be related to the fact that the upper second molars erupted already, typically, in a more buccal position, being, so, little influenced by the expansion treatment, once they were in a more buccal position than the other teeth of the same arch. But in the lower arch, these teeth erupt with lingual tipping, suffering the influence of the treatment with buccal tipping. All measurements in the lower arch reached a statistical significance.

This difference in expansion, between the maxilla and the mandible, was also observed by Begole, Fox and Sadowsky.[21] Evaluating 76 casts of 38 patients treated with and without extraction of the first premolars, these authors found that, in cases treated without extraction, significant differences were found between the maxillary expansion in relation to the mandible, greater for the maxilla, with the biggest increase in the region of the first and second premolars, except for the canines, which had similar expansions in both arches.

CONCLUSION

This result challenges conventional orthodontics when it proposes that the passive property of the bracket system, allowing all bonded brackets to function as tubes and applying extremely light forces due to the use of light and superelastic wires, allowing for a slow expansion of the dental arches, in many cases eliminating the need for rapid expansion, especially surgically assisted for the maxilla.

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According to the results of this research, it seems clear that occurs, in fact, a lateral expansion, with buccal movement of the premolars, molars and to a lesser extent, of the canines, that provides space for leveling of initially crowded teeth, and most importantly, the alteration in the intercanine dimension was within the literature provides as normal for a conventional treatment, with or without extraction. It seems that the expansion was distributed throughout the dental arch, causing small buccal movement of all teeth, which together reached the space needed for leveling, which also justifies that the alterations are not exaggerated, although they reached statistical significance for most measurements. However, other studies evaluating the movement of the upper and lower incisors in the dental casts, as well in radiographies, can help complete the understanding of how tooth movement occurs with treatment with nickel titanium wire in a low friction system and thereby verify, in relation to the alveolar bone, which are the modifications due to movements of the posterior teeth. These topics, however, will be addressed in future publications.

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Long-term stability of maxillary anterior alignment in non-extraction cases

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Objective: The purpose of this retrospective study was to evaluate long-term stability of maxillary incisors alignment in cases submitted to non-extraction orthodontic treatment.

Methods: The sample comprised 23 patients (13 female; 10 male) at a mean initial age of 13.36 years (SD = 1.81 years), treated with fixed appliances. Dental cast measurements were obtained at three different time points (T_1 – pre-treatment, T_2 – posttreatment and T_3 – long-term posttreatment). Variables assessed in maxillary arch were Little Irregularity Index, intercanine, interpremolar and intermolar widths, arch length and perimeter. The statistical analysis was performed by one-way ANOVA and Tukey tests when necessary. Pearson' correlation coefficients were used to investigate possible associations between the variables evaluated.

Results: There was no significant change in most arch dimension measurements during and after treatment, however, during the long-term posttreatment period, it was observed a significant maxillary incisors crowding relapse.

Conclusion: The maxillary incisors irregularity increased significantly (1.52 mm) during long-term posttreatment. None of the clinical factors studied demonstrated to be predictive of the maxillary crowding relapse.

Keywords: Relapse. Corrective orthodontics. Malocclusion.

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INTRODUCTION

The primary purpose of orthodontic treatments is malocclusion correction; however, treatment stability shows considerable variability during post-retention phase. Despite the literature consensus that some occlusal changes will inevitably occur after orthodontic treatment,[15,19,28] it is noted that long-term stability of the aligned teeth is highly variable and unpredictable.[17]

Greater research emphasis has been placed on relapse of mandibular anterior crowding and little emphasis has been given to investigating the maxillary crowding relapse and parameters that may be helpful in predicting its long-term stability.[2,3,9,12,18,23,25]

Alignment stability of mandibular incisors is less than that of the maxillary anterior teeth.[8,10,22,26,29,30] Factors such as pretreatment crowding severity[25] and gingival fibers traction[5,6,7] are considered risk factors for maxillary incisors crowding relapse. However, there is an association between a prolonged period of retention and greater stability of maxillary teeth alignment.[23] Maxillary incisors tend to rotate in the direction of their initial positions,[25,26] despite buccolingual relapse being unpredictable.[25] Furthermore, palatal contacts between maxillary and mandibular incisors preclude lingual movement of the maxillary teeth and any vestibular movement is probably determined by the lips position and function.[12]

Accordingly to Little,[14] evidence of progressive instability is often first noted by progressive crowding of mandibular incisors following removal of retaining devices. Whatever the multiplicity of causes for relapse, mandibular incisor irregularity is often the precursor of maxillary crowding, deepening of the overbite, and generalized deterioration of orthodontic treated cases.

Kahl-Nieke, Fischbach and Schwarze,[13] evaluated pretreatment, posttreatment, and post-retention models of 226 cases with all types of anomaly. Findings indicated that relapse of incisors crowding occurred in approximately half of the sample and that post-retention crowding increased more frequently in mandible than in the maxilla. Pretreatment variables such as severe crowding and incisors irregularity, arch length deficiency, arch constriction and increased overbite were found to be associated factors in the process of post-retention increase of crowding and incisors irregularity. Premolars extraction treatment exhibited greater maxillary and mandibular crowding relapse than non-extraction protocol.

In a longitudinal study, Moussa, O'Reilly and Close,[18] evaluated 55 non-extraction orthodontic patients that were previously submitted to rapid palatal expansion (RPE). The authors[18] observed that maxillary incisors irregularity increased 0.60 mm during post-retention. They suggested that RPE procedure may be helpful in long-term stability; however, due to the absence of a control group there was no clear evidence about a possible influence of RPE procedure on the crowding relapse. However, Canuto et al,[3] compared the long-term stability of maxillary incisor alignment in patients treated with and without rapid maxillary expansion. They concluded that RME did not influence long-term maxillary anterior alignment stability.

Vaden, Harris and Gardner,[30] concluded that most (96%) of the maxillary incisor irregularity correction was maintained after 15 years of treatment. At the post-retention recall, the maxillary irregularity index increased only 0.30 mm. Surbeck et al[25] evaluated whether pretreatment misalignment of the maxillary anterior teeth are of significance for post-retention relapse of alignment. The results suggested that anatomic contact point displacement of the maxillary anterior teeth and maxillary incisor rotation relative to the dental arch are significant risk factors for post-retention relapse of alignment and that the pattern of rotational displacement relative to the dental arch has a strong tendency to repeat itself.

Taner et al[27] evaluated the effects of fiberotomy in alleviating dental relapse of incisors after orthodontic treatment. The authors described that there was significant increase of irregularity index in the control group, for both maxillary and mandibular anterior segments. Meanwhile, in the group where circumferential supracrestal fiberotomy was performed, no significant increase of the irregularity index was noted. One year later, Huang and Artun,[12] evaluated whether post-retention relapse of maxillary and mandibular incisor alignment were associated. The authors suggested[12] that the occlusal contacts with the mandibular anterior teeth represent lingual boundaries for the maxillary incisor movement, and any labial movement is likely to be determined by the position and function of the lips. In addition, also suggested

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that the post-retention movement of the mandibular incisors may be influenced by the position of the maxillary incisors and vice versa and indicated that an association between the post-retention misalignment of the incisors in the 2 arches might exist.

Ferris et al[9] investigated the long-term post-retention stability of RPE-lip bumper therapy followed by full fixed appliances. The sample comprised 20 patients at the late mixed dentition that were recalled to obtain post-retention records. The subjects were out of retention for an average of 7.9 years. The majority of treatment increases in maxillary and mandibular arch dimensions were maintained during post-retention phase. Post-retention incisor irregularity increased 0.5 mm in the maxillary arch and 1.1 mm in the mandibular arch. The authors[9] concluded that use of RPE–lip bumper therapy in the late mixed dentition followed by full fixed appliances is an effective form of treatment for patients with up to moderate tooth size-arch length discrepancies.

Erdinc, Nanda and Isiksal,[8] evaluated long-term stability of incisor crowding in orthodontic patients treated with and without premolar extractions. Minimal incisor crowding relapse occurred (0.19 mm and 0.12 mm for extraction and non-extraction groups, respectively). Maxillary incisor irregularity relapse was smaller than mandibular incisor relapse for both groups. Intercanine width expanded during treatment. Incisor positions in both groups tended to return to pretreatment values. Clinically acceptable stability was obtained.[8]

Because of insufficient studies on maxillary anterior tooth alignment and parameters that may be helpful in predicting its long-term stability, this study aimed to evaluate the long-term maxillary incisors crowding relapse and possible factors that may influence tooth alignment stability.

MATERIAL AND METHODS

Material

The sample was obtained from the files of Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil, and consisted of Class I and II malocclusion patients treated orthodontically without extractions.

The criteria for sample selection included the presence of all permanent teeth at treatment beginning (at least first permanent molars) and the absence of shape and/or number dental anomalies. All patients had complete orthodontic records, including study models of the initial phase (T_1), end of treatment (T_2) and post-retention (T_3). None of the subjects underwent rapid maxillary expansion.

Sample comprised 69 dental casts of 23 subjects (13 girls and 10 boys; initial mean age: 13.36 years; SD = 1.81 years) who received full maxillary and mandibular fixed edgewise appliances. These patients underwent orthodontic treatment for a mean period of 2.18 years (SD = 0.93) and were satisfactorily finished at a mean age of 15.54 years (SD = 1.86). The post-retention study models were taken after a mean period of 4.92 years (SD = 1.11).

Regarding initial malocclusion, ten patients had Class I, 8 had quarter-cusp Class II, and 5 had half Class II anteroposterior molar relationships. None of the patients exhibited posterior crossbite at T_1.

After active treatment, all patients wore a full time Hawley retainer in the maxillary arch for 12 months. A lingual canine-to-canine mandibular bonded retainer was placed and left for a mean period of 3 years.

Methods

Dental cast measurements

The T_1, T_2 and T_3 maxillary dental casts were used. All dental cast measurements were made with a centesimal precision digital caliper (Mitutoyo America, Aurora, Ill, São Paulo, Brazil).

All were linear measurements, in millimeters, described as follows:

A) Maxillary incisor irregularity[14] (LITTLE) (Fig 1).

B) Intercanine width (A; INTERC): The linear distance between the cusp tips of the maxillary canines. When there was a facet, the cusp tip was estimated (Fig 2).

C) Inter-premolar widths (INTERPB and INTERPB'): The linear distance between left and right central fossae of the maxillary first (B) and second (B') premolars (Fig 2).

D) Intermolar width (C; INTERMOL): The linear distance between the mesiobuccal cusps tips of the maxillary first molars. When there was a facet, the cusp tip was estimated (Fig 2).

E) Arch length (D + E; LENGTH): The linear distance along the midline from the interincisal midline to the mesial contact of the first molars (Fig 2).

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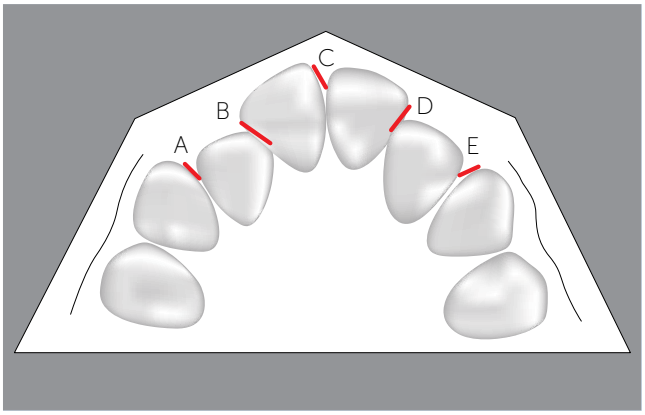


Figure 1 - Little Irregularity Index (modified for the upper arch) = A+B+C+D+E.

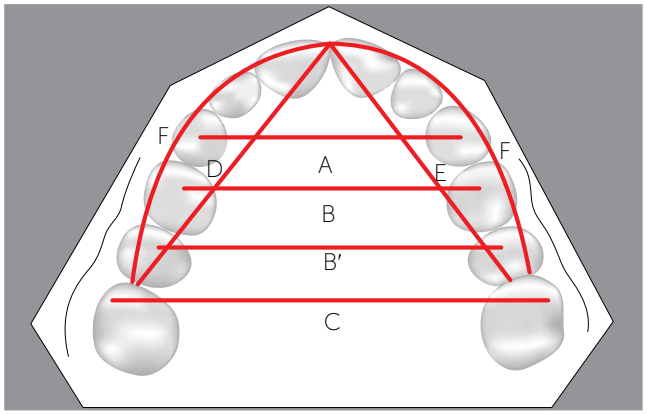


Figure 2 - Variables studied on dental casts: A, intercanine width; B, inter-first-premolar width; B', inter-second-premolar width; C, intermolar width; D + E, arch length; F, arch perimeter.

F) Arch perimeter (F; PERIM): The distance in millimeters from the mesial dental contact of the left first molars to the mesial dental contact of the right first molars to (Fig 2).

Statistical analysis

Method error

Within a month interval from the first measurement, ten dental casts from T_1, T_2 and T_3 phases were randomly selected and remeasured. The casual error was calculated according to Dahlberg's formula ($Se^2 = \Sigma d^2/2n$).[4] The systematic error was calculated with dependent t tests, according to Houston.[11]

Statistical method

One-way dependent ANOVA and Tukey tests were used to evaluate the behavior of the measured variables during the three phases (Initial – T_1; Post-treatment – T_2; Post-retention – T_3).

The Pearson correlation coefficient was calculated by using the whole sample to investigate a significant correlation between maxillary incisors crowding relapse and the pretreatment irregularity or the amount of crowding correction.

Pearson correlation coefficient was also calculated to investigate a association between maxillary incisors crowding relapse and the relapse of intercanine, interpremolar or intermolar widths, arch length and perimeter.

The results were considered statistically significant at $p < 0.05$. All statistical analyses were performed with the software Statistica for Windows, version 6.0, Statsoft, Tulsa, Okla, USA.

RESULTS

Dahlberg's formula and Paired t tests showed no significant casual and systematic errors.

The Table 1 exhibits results of one-way analysis of variance (ANOVA) with the post-hoc Tukey test (different letters means a statistically significant difference between variables) that were used to determine whether there was a significant difference between the measured variables during T_1, T_2 and T_3. The results showed that the incisors irregularity had significant changes not only during treatment but also at posttreatment. Maxillary crowding relapse occurred in most patients with a mean percentage of 30.64% of the treatment correction. However, no significant differences were detected to the dimensional variables evaluated during the 3 phases, except for the inter-first-premolar width (INTERPB), that exhibited a statistically significant increase from pretreatment (T_1) to posttreatment (T_2).

Results of the Pearson correlation tests are in the Tables 2 and 3. There was a significant and negative correlation between maxillary incisors crowding relapse and the relapse of the intercanine and inter-first-premolar widths.

DISCUSSION

Although incisors alignment relapse in maxillary arch is less prevalent than in mandibular arch, the evaluation of possible factors that may influence maxillary tooth alignment stability has validity. Relapse of crowding in this region may also results in esthetic and functional occlusal deficiencies. Mainly due to its

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Table 1 - Results of one-way analysis of variance (ANOVA) with the post-hoc Tukey test (different letters means a statistically significant difference between variables) for the variables measured on dental casts (N = 23), at the three stages studied (T_1, T_2 and T_3).

Variable	Initial (T_1)	Posttreatment (T_2)	Post-retention (T_3)	p
	Mean ± SD	Mean ± SD	Mean ± SD	
LITTLE	6.56 ± 2.83^A	1.59 ± 0.73^B	3.11 ± 1.41^C	0.000*
INTERC	34.07 ± 3.79^A	34.65 ± 1.44^A	34.53 ± 1.87^A	0.653
INTERPB	34.71 ± 1.86^A	36.34 ± 1.81^B	35.76 ± 1.81^B	0.012*
INTERPB'	40.20 ± 2.31^A	41.35 ± 2.15^A	41.09 ± 2.16^A	0.186
INTERMOL	51.13 ± 2.62^A	51.52 ± 2.50^A	51.94 ± 2.51^A	0.560
LENGTH	72.09 ± 4.08^A	73.76 ± 2.49^A	72.07 ± 2.58^A	0.118
PERIM	75.18 ± 3.77^A	76.52 ± 2.66^A	75.32 ± 2.55^A	0.269
LITTLE	6.56 ± 2.83^A	1.59 ± 0.73^B	3.11 ± 1.41^C	0.000*

Table 2 - Results of the Pearson correlation test.

Variable	r	p
LITTLE1 x LITTLE3	0.252	0.071
LITTLE1 x LITTLE3-2	0.241	0.084
LITTLE2-1 x LITTLE3-2	-0.264	0.055

Table 3 - Results of the Pearson correlation test.

Variable	r	p
LITTLE3-2 x INTERC3-2	-0.459	0.000*
LITTLE3-2 x INTERPB3-2	-0.419	0.001*
LITTLE3-2 x INTERPB'3-2	-0.269	0.053
LITTLE3-2 x INTERMOL3-2	-0.064	-0.649
LITTLE3-2 x LENGTH3-2	0.028	0.842
LITTLE3-2 x PERIM3-2	-0.012	0.930

*Statistically significant at $p < 0.05$.

location, maxillary incisors crowding relapse tends to become more visible and therefore promote greater esthetic impacts than mandibular irregularity.

Results for one-way analysis of variance (ANOVA) with the post-hoc Tukey test (Table 1) showed that occurred statistically significant changes in the Little irregularity index during the three phases studied. It was observed a significant maxillary crowding reduction during treatment. However, there was a significant relapse of the incisors irregularity after treatment. Regarding changes in maxillary arch dimensions during treatment, there was only a significant change in the variable INTERPB (Inter-first-premolar width), suggesting that most maxillary arch dimensions were maintained during treatment, and remained stable during post-retention. Sadowsky et al[23] evaluating stability in maxillary and mandibular dental arches of patients treated without extractions and Edgewise mechanics, observed no significant changes in the intercanine and inter-premolars widths, five years post-retention. Erdinc, Nanda and Isiksal,[8] evaluated stability of the orthodontic treatment, with and without extractions. Similarly to the present study, it was observed significant decreases in maxillary incisors irregularity during treatment. Patients treated without extractions exhibited significant increases of the intercanine and inter-premolars widths during treatment. The maxillary arch dimensional measurements showed no significant changes after treatment, however, relapse of maxillary crowding was significant. These studies[8,23] and the present suggests a favorable prognosis regarding maxillary arch long-term dimensional stability of orthodontic cases treated without premolars extractions.

In the present study, mean post-retention crowding relapse was 1.52 mm. Sadowsky et al,[23] assessing stability of subjects treated non-extraction, reported a relatively similar amount of relapse (1.1 mm), 5 years post-retention. However, Moussa, O'Reilly and Close[18] observed more favorable results regarding crowding relapse, 8 to 10 years post-retention, in a sample comprising 18 subjects treated with rapid maxillary expansion and fixed appliances. It was observed a mean maxillary crowding relapse of 0.6 mm (SD = 1.30). Vaden, Harris and Gardner,[30] noted that 96% of the maxillary crowding correction remained

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stable 15 years after treatment. The amount of crowding increased from 1.5 mm at posttreatment to 1.8 mm at post-retention. Ferris et al[9] also evaluated the maxillary crowding relapse in non-extraction cases. It was observed only 0.47 (SD = 1.19) of maxillary irregularity increase during the post-retention (7.9 years). The increased stability observed in these studies may be explained by the prolonged retention protocol after orthodontic treatment.[23] In the Sadowsky et al[23] study, retainers were placed and left for a mean period of 8.4 years. Moussa, O'Reilly and Close,[18] described a mean period of 6.6 years of retention for the mandibular arch and full time Hawley retainer in the maxillary arch for 2 years. The study conducted by Vaden, Harris and Gardner,[30] reports that patients used these retainers in the maxillary and mandibular arches or these retainers in the maxillary arch and a lingual canine-to-canine mandibular bonded retainer. The first posttreatment control was carried out only after six years. The study by Ferris et al[9] described a retention protocol that included the use of Hawley in the maxillary for 3 years (full time during one year) and lingual bonded retainer or Hawley plates in the mandibular arch for a mean period of 3 years. In the present study, all subjects wore a full time Hawley retainer in the maxillary arch for 12 months. A lingual canine-to-canine mandibular bonded retainer was placed and left for a mean period of 3 years.

Erdinc, Nanda and Isiksal[8] described an increase in maxillary incisors irregularity of 0.19 mm and 0.12 mm for patients treated with or without extractions, respectively, 4 years and 11 months after treatment. The extraction group showed 4.4 mm of pretreatment crowding. However, the non-extraction group exhibited only 1.94 mm of initial irregularity. The initial crowding was significantly less severe than that observed in our sample (6.56 mm). Maxillary and mandibular retainers were removed at least two years before the post-retention measurements. The exceptional stability of this study may be related to the amount of initial crowding and due to a short interval between retainer removal and the post-retention evaluation.

Although the results indicate a posttreatment maxillary crowding relapse greater than that reported in previous studies,[8,9,18,23,30] the mean irregularity index at posttreatment (3.12 mm) is considered clinically acceptable according to Little.[14]

Results of the Pearson correlation tests showed no significant correlations to most variables evaluated (Tables 2 and 3). It was observed that the amount of initial crowding had no effect on relapse, as described in previous studies.[1,17] Surbeck et al,[25] in contrast, reported a positive correlation between the amount of maxillary incisors irregularity and the amount of incisors crowding relapse. The authors reported[25] that the tendency to maxillary crowding relapse increases 2.3 times for each 0.2 mm of incisors contact point displacement in relation to the dental arch. Furthermore, each 4° of tooth rotation at pretreatment has increased by 2.7 times the probability of irregularity relapse. The authors[25] also pointed out that partially aligned tooth exhibits significant risk of relapse. They suggested the use of individualized retention protocols and that patients should be aware about the possibility of relapse accordingly to the initial irregularity.[25] However, a positive correlation between the amount maxillary incisors crowding at pretreatment and the crowding relapse after treatment seems unlikely when analyzing our results and previous studies. For example, ours results indicated that the experimental group exhibited 6.56 mm of initial irregularity and had a mean post-retention relapse of 1.52 mm. The mean crowding relapse observed in the present study was higher than that reported by Ferris et al,[9] Sadowsky et al[23] and Vaden, Harris and Gardner,[30] with samples that exhibited more maxillary incisors irregularity at pretreatment (10.45 mm, 8.0 mm and 7.9 mm, respectively). Despite more initial crowding, these studies reported less posttreatment irregularity relapse (0.47 mm, 1.1 mm, 0.3 mm, respectively).

The amount of maxillary crowding relapse (LITTLE3-2) showed a statistically significant and negative correlation ($p < 0.05$) with the post-retention changes in intercanine (INTERC3-2) and inter-first-premolars (INTERPB3 -2) widths (Table 3). These results suggest that the higher the post-retention decreases of intercanine and inter-first-premolars widths the higher the maxillary crowding relapse. However, although these correlations have statistical significance, the coefficients values observed implicate in a weak correlation (*r* values of -0.459 and -0.419, respectively). Therefore, it can be argued that the observed correlation between relapse of the maxillary crowding and the reduction of these dimensional measurements has poor clinical significance.

Moreover, it seems obvious that the reduction of these measurements tends to be consequence of maxillary arch constriction in the anterior region. Therefore, it is expected a space availability decrease and an increase in the amount of tooth crowding.

Despite numerous studies that evaluated a possible relationship between changes in intercanine width and mandibular incisors crowding relapse, the correlation between maxillary crowding relapse and maxillary intercanine width changes were only investigated by Surbeck et al,[25] and Erdinc, Nanda and Isiksal.[8] Surbeck et al[25] found a significant association ($p < 0.001$) between intercanine width decreases and maxillary incisors crowding relapse, however, the correlation test result also revealed a weak association ($r < 0.70$). Erdinc, Nanda and Isiksal,[8] found no correlation between post-retention changes in incisors irregularity and changes in intercanine width.

Clinical implications

Maxillary anterior alignment shows better prognosis regarding stability when compared to the same region in the mandibular arch, this fact may explain the scarce studies in literature about this issue. Despite the greater stability, maxillary crowding relapse can compromise orthodontic results after retention appliances removal. The post-retention relapse observed in this study (1.52 mm), although statistically significant, may be considered clinically acceptable.[14] Otherwise, this minimal amount of crowding relapse can lead to patient dissatisfaction.

Maxillary incisors crowding relapse shows some etiological factors as retention time, initial crowding severity; relapse of teeth in the opposite side, changes in arch dimensions, rotated teeth at pretreatment and lack of complete correction of rotated teeth resulting in absence of adequate interdental contacts. Thus, it becomes clear that more stable results can be obtained with a prolonged retention protocol and an adequate alignment of maxillary incisors during treatment.

CONCLUSION

The maxillary incisors irregularity increased significantly (1.52 mm) five years posttreatment.

None of the clinical factors studied in the dental casts demonstrated to be predictive of the maxillary crowding relapse.

The results suggest that more attention regarding maxillary arch retention protocol should be taken by the clinician. Although alignment stability of mandibular incisors is less than that of the maxillary anterior teeth, maxillary crowding relapse can be significant.

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Influence of surface treatment on shear bond strength of orthodontic brackets

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Introduction: The shear bond strength of orthodontic brackets bonded to micro-hybrid and micro-particulate resins under different surface treatment methods was assessed.

Methods: Two hundred and eighty test samples were divided into 28 groups (n = 10), where 140 specimens were filled with Durafill micro-particulate resin and 140 with Charisma composite. In 140 samples, a coupling agent (silane) was applied. The surface treatment methods were: Phosphoric and hydrofluoric acid etching, sodium bicarbonate and aluminum oxide blasting, stone and burs. A Universal Instron Machine was used to apply an occlusal shear force directly to the resin composite bracket surface at a speed of 0.5 mm/min. The means were compared using analysis of variance and multivariate regression to assess the interaction between composites and surface treatment methods.

Results: Means and standard deviations for the groups were: Sodium bicarbonate jet 11.27±2.78; burs 9.26±3.01; stone 7.95±3.67; aluminum oxide blasting 7.04±3.21; phosphoric acid 5.82±1.90; hydrofluoric acid 4.54±2.87, and without treatment 2.75±1.49. An increase of 1.94 MPa in shear bond strength was seen in Charisma groups. Silane agent application reduced the Charisma shear bond strength by 0.68 Mpa, but increased Durafill means for bicarbonate blasting (0.83), burs (0.98) and stone drilling (0.46).

Conclusion: The sodium bicarbonate blasting, burs and stone drilling methods produced adequate shear bond strength and may be suitable for clinical use. The Charisma micro hybrid resin composite showed higher shear bond means than Durafill micro particle composite.

Keywords: Shear bond strength. Dental materials. Orthodontic brackets. Orthodontics.

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INTRODUCTION

Adult patients undergoing orthodontic treatment often have teeth restored with resin composites commonly used for esthetic purposes and for restorations.[1,2] This type of material is also widely found in the mouths of young patients due to a high incidence of trauma during permanent dentition (30%).[3]

The use of dental composites for bonding orthodontic brackets to enamel is convenient as it allows careful positioning of the orthodontic accessories while promoting bond strength capable of withstanding tooth movement during application of different types of forces. The literature is rich in methods and properties used in the direct bonding of orthodontic metal accessories to ceramic surfaces.[4,5,6] However, few studies have been conducted to evaluate this procedure on composite restorations. Therefore, there is great clinical demand for an effective technique capable of allowing teeth restored with resin composite to be subjected to different types of force application.

In order to develop an efficient method for bonding brackets onto resin composite surfaces it is necessary to learn about the factors that directly influence the success of the procedure, such as type of resin composite (hybrid or micro-particulate) and bond strength. Research carried out by Schwartz, Tyas and West[7] and Lai, Woods and Tyas,[8] demonstrated that metallic brackets bonded to hybrid and micro-particulate restorative composites could withstand 7.8 MPa of shear force, which according to Lopez[9] would be sufficient to ensure a successful bond in clinical practice.

Several methods based on the repairing technique of resin composites have been reported as capable of improving bond strength. These include acid etching,[10,11] air abrasion[12,13] and the use of solvents and silanes.[14,15] However, no consensus has yet been reached regarding the results obtained with different procedures hence, this study. The aim of this study, therefore, was to assess the bond strength resulting from the direct bonding of orthodontic brackets to surfaces composed of micro-particulate and micro-hybrid restorative materials subjected to different chemical and physical surface treatment methods.

MATERIAL AND METHODS

Two hundred and eighty cylinders were fabricated from acrylic (specimens) with 25 mm diameter and 5 mm in height, with an 8 mm diameter and 1.5 mm depth hole, with grooves on the bottom for increased retention of the resin composite. Of these, 240 were used for surface treatment testing and the remaining for the control group. In order to prevent the Transbond XT adhesive (3M/Unitek, Monrovia, CA, USA) from flowing and thereby affecting the yield strength values on shearing, the bonding area was bounded with tape prior to surface preparation.

Two types of resin composites were tested: (a) Durafill resin composite (HeraeusKulzer, Hanau, Germany), and (b) Charisma micro hybrid resin composite (HeraeusKulzer, Hanau, Germany). These materials were all placed in one go to reduce the incorporation of air bubbles, and light cured for 40 seconds, 20 at the top and 20 at the bottom. A glass slide was used for compression and homogenization of the material (Fig 1). Ortholux XT Visible Light Curing Unit (3M Unitek, Monrovia, CA, USA) was used, and had its light intensity measured prior to curing at each stage, in all groups (Optilux Radiometer Model 100, SDS Care, Danbury, CT, USA). The intensity found was 450 ± 10 mW/cm^2. Additionally, the bonding procedures were all performed in the same environment and with a 1kVA voltage stabilizer connected to the curing light. The specimens were stored in plastic containers with distilled water, covered with an opaque lid and kept in an oven at 37 ± 1°C for 7 days for aging.

Sample group composition

The specimens were divided into 28 groups of 10 elements, separated according to the type of surface treatment, type of resin composite and the use / non-use of silane (Table 1). The resinous surfaces were treated by the following agents: 37% phosphoric acid (Dental G Conditioner, Dentsply, Petrópolis, RJ) for



Figure 1 - Light curing of specimens filled with resin composite.

Table 1 - Presentation of groups, types of chemical surface treatment, use or non-use of silane, and type of resin composite used.

Groups	Surface treatments	Silane application	Resin
1	Phosphoric acid no Durafill	No	Durafill
2	Phosphoric acid with Durafill	Yes	Durafill
3	Hydrofluoric acid no Durafill	No	Durafill
4	Hydrofluoric acid with Durafill	Yes	Durafill
5	Aluminum oxide blasting no Durafill	No	Durafill
6	Aluminum oxide blasting with Durafill	Yes	Durafill
7	Sodium bicarbonate no Durafill	No	Durafill
8	Sodium bicarbonate blasting with Durafill	Yes	Durafill
9	Mounted stone no Durafill	No	Durafill
10	Mounted stone with Durafill	Yes	Durafill
11	Diamond bur no Durafill	No	Durafill
12	Diamond bur with Durafill	Yes	Durafill
13	No treatment no Durafill	No	Durafill
14	No treatment with Durafill	Yes	Durafill
15	Phosphoric acid no Charisma	No	Charisma
16	Phosphoric acid with Charisma	Yes	Charisma
17	Phosphoric acid no Charisma	No	Charisma
18	Hydrofluoric acid with Charisma	Yes	Charisma
19	Aluminum oxide blasting no Charisma	No	Charisma
20	Aluminum oxide blasting with Charisma	Yes	Charisma
21	Sodium bicarbonate blasting no Charisma	No	Charisma
22	Sodium bicarbonate blasting with Charisma	Yes	Charisma
23	Mounted stone no Charisma	No	Charisma
24	Mounted stone with Charisma	Yes	Charisma
25	Diamond bur no Charisma	No	Charisma
26	Diamond bur with Charisma	Yes	Charisma
27	No treatment no Charisma	No	Charisma
28	No treatment with Charisma	Yes	Charisma

30 seconds (Fig 2A); 10% hydrofluoric acid (Porcelain Conditioner, Dentsply, Petrópolis, RJ) for 2 minutes (Fig 2B); aluminum oxide blasting (blaster manufactured by Bio Art dental equipment Ltd, São Carlos, São Paulo, Brazil, 50-micron particles) (Fig 2C) and bicarbonate blasting (Profi II Ceramic, Dabi Atlante, Ribeirão Preto, São Paulo, Brazil, 60 pounds) (Fig 2D); mounted cylindrical stone (Jon, São Paulo, SP, Brazil) (Fig 2E) and high speed cylindrical diamond bur (3101, KG Sorensen, Barueri, SP, Brazil) (Fig 2F). In the two latter groups unidirectional grooves were observed by stereomicroscopy. The cleaning and drying procedures were similar in all other groups, and consisted in air/water sprays for 30 seconds followed by drying with air for another 30 seconds.

Thereafter, maxillary central incisor metallic brackets (standard edgewise) (Dental Morelli Ltda., Sorocaba, SP, Brazil) with 3.8 x 3.6 mm base and 0.022 x 0.030-in slot were bonded. The brackets were bonded to the composite restorative system of the specimens using Transbond XT orthodontic adhesive system according to manufacturer's specifications (Fig 3).

In groups where silane (Angelus, Londrina, PR) was applied, a microbrush (KG Sorensen Indústria and Comércio Ltda., Barueri, SP, Brazil) was used, and after a 1 minute interval, was homogenized by air jet for 3 seconds as well as the primer (Transbond XT Primer, 3M Unitek, Monrovia, CA, USA), which was applied with a microbrush and also homogenized by air jet.

Transbond XT adhesive system was applied to the base of the bracket and positioned on the surface of the pretreated resin composite. The brackets were pressed lightly avoiding any movement, with the purpose of causing the adhesive paste to flow and allow for the removal of adhesive flash with

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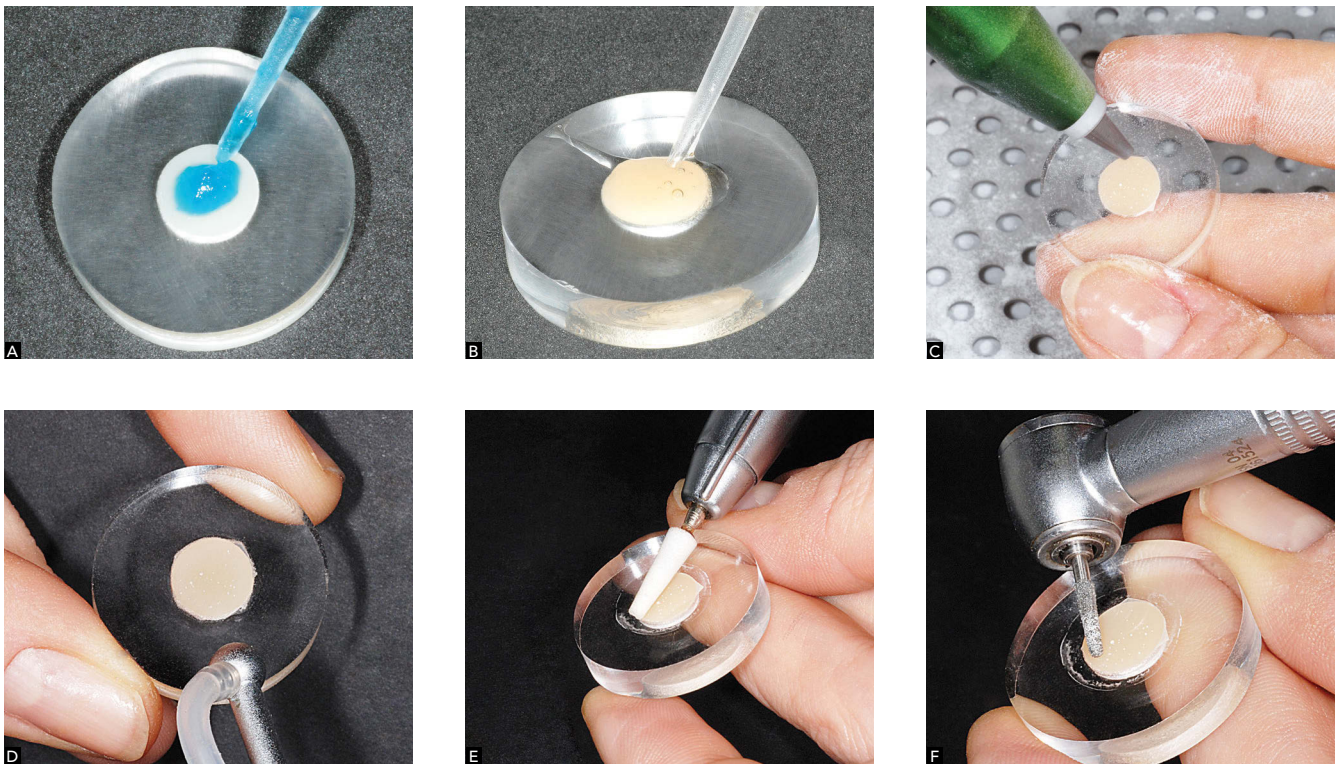


Figure 2 - Surface treatment using: **A**) 37% phosphoric acid, **B**) hydrofluoric acid, **C**) aluminum oxide blasting, **D**) sodium bicarbonate blasting, **E**) mounted stone, and **F**) diamond bur.



Figure 3 - Orthodontic Brackets bonded with Transbond XT light-cured resin onto previously treated surfaces.

an explorer #5 (DUFLEX, Petrópolis, RJ, Brazil). Light curing was performed on the whole set for 20 seconds (10 seconds on the mesial and 10 seconds on the distal surface). After bracket bonding, the same storage protocol described above was performed. The specimens were then once again stored in distilled water at 37° C for 7 days for aging.

Shear test

For the mechanical shear strength test a universal testing machine (EMIC DL 10000 MF cell Trd 21) owned by the Laboratory of Biomaterials at the Military Engineering Institute was used. The specimens are fastened to a device so that the bracket base was kept parallel to the tip of the chisel (Fig 4). Tests were performed with a load cell of 10 kg at a speed of 0.5 mm/min,[16] and data recorded by a computer program (TESC version 3.04, Pinhais, PR, Brazil)

Adhesive remnant index (ARI)

After shearing the specimens, the bases of the brackets and the resin surfaces were examined in a stereomicroscope with 20x magnification. Adhesive remnant index (ARI) was categorized as follows: Score 0 (no adhesive present on the bracket bases); 1 (less than half); 2 (more than half) and 3 (the entire adhesive remained on the bracket base).[17] A descriptive analysis of the data with means, medians and standard deviations was carried out. Comparisons between shear force means were made using analysis of variance (ANOVA) with Scheffe correction for multiple comparisons. Kruskall-Wallis test was used for multiple comparisons between the scores, complemented by Mann-Whitney test.

RESULTS

The mean shear force values ranged between 2.30 MPa and 12.02 MPa, whereas the groups treated with acid etch-

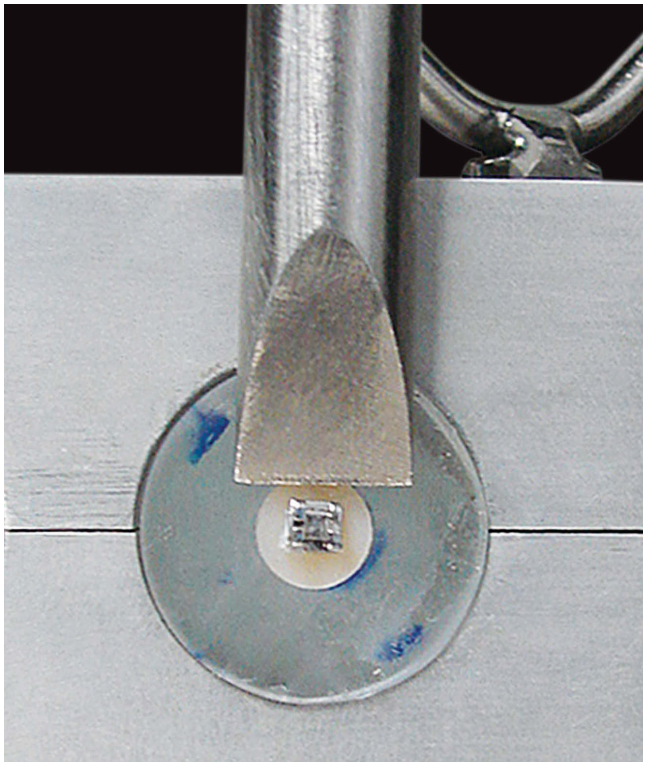


Figure 4 - Bracket shearing in an Emic DL 10000 MF universal testing machine. Note the metallic support for fixation of specimens.

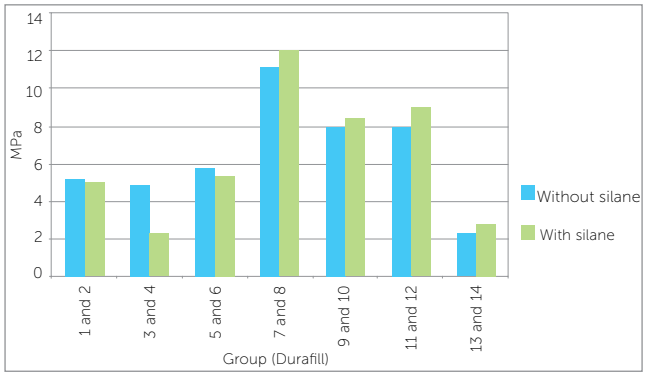


Figure 5 - Diagram showing shearing forces of specimens filled with Durafill resin arranged according to the use or non-use of silane.

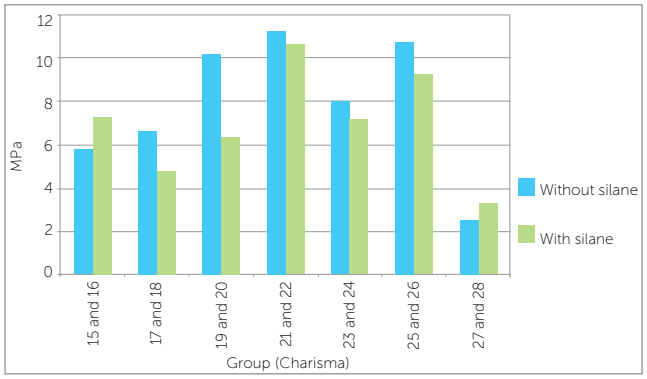


Figure 6 - Diagram showing shearing forces of specimens filled with Charisma resin arranged according to the use or non-use of silane.

ing attained lower values than those observed in the groups treated by blasting and bur/stone. In specimens filled with Durafill resin, silane application improved the means after treatment with bicarbonate blasting, bur and stone, but higher standard deviations were observed (Fig 5). Regarding Charisma, the highest mean was obtained with bicarbonate blasting without silane, although the application of silane worsened the mean yield strength values, with the exception of phosphoric acid etching (Fig 6). The stone without silane group showed the largest standard deviation followed by etching with hydrofluoric acid without silane. The brackets in the control groups of both resin composites had lower shear strength scores (Table 2).

Bivariate analyses showed that there are differences between the means of the groups, i.e., Durafill and Charisma, in terms of surface preparation and silane application. The Charisma group obtained higher means than the Durafill group. The resins tested exhibited their best performance with bicarbonate blasting, and the latter group with diamond burs. The effects produced — regardless of the type of resin composite (Durafill or Charisma) — types of surface preparation and use of silane were assessed by multiple linear regression. Analysis of the model showed significant interaction between type of composite and type of preparation (Table 2).

In trivariate analysis, the Charisma group treated with hydrofluoric acid (Fl) without silane (5.85 MPa) was used as a basis for comparison. Compared to this group, all other surface preparations were significantly different in terms of specimen shear values, except for the use of phosphoric acid ($p = 0.23$). Charisma tests showed that the best surface preparation was bicarbonate blasting (5.42 MPa) followed by the use of burs (4.52 MPa), aluminum oxide (3.01 MPa), and stone (2.23 MPa), compared to hydrofluoric acid. In the control group, the non-use of silane decreased shear strength by 1.94 MPa compared to the use of hydrofluoric acid under the same conditions (Table 2).

In Table 3, the multivariate linear regression model highlights the interaction between the composite type and type of surface preparation variables. Charisma with hydrofluoric acid was used as a basis for comparison, where bonding performed with silane application reduced bracket adhesion, i.e., 0.68 MPa ($p = 0.05$). It was found that the use of Durafill with the same surface preparation, hydrofluoric acid resin without silane, compared to Charisma, caused the shear force to worsen

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Table 2 - Description of mean and standard deviation values of shear forces comprising 4 characteristics. Analysis of Variance (ANOVA) with Scheffe correction.

	Mean ± SD	Size Sample	p value
Composite in restoration			
Charisma	7.45 ± 3.91	130	0.028
Durafill	6.44 ± 3.72	130	
Restoration composite preparation type			
Hydrofluoric acid	$4.54^{a,b,c,d}$ ± 2.87	40	< 0.00
Phosphoric acid	$5.82^{e,f,g}$ ± 1.90	40	
Bur	$9.26^{a,e,h}$ ± 3.01	40	
Bicarbonate blasting	$11.27^{b,d,f,i,j,k}$ ± 2.78	40	
Aluminum oxide	$7.04^{c,i,l}$ ± 3.21	40	
Stone	$7.95^{d,j,m}$ ± 3.67	40	
None	$2.75^{e,g,h,k,l,m}$ ± 1.49	20	
Presence of silane			
No	$7.99^{a,b}$ ± 3.81	120	< 0.00
Yes	$6.70^{b,c}$ ± 3.61	120	
Total	**6.95 ± 3.84**	**260**	**-**

Pairs of means with same letters show statistically significant differences at 5% level after correction using Scheffe's multiple comparisons test.

by up to 1.94 Mpa (Table 3). Although Durafill resulted in smaller magnitudes than Charisma, the combined use of Durafill with bicarbonate blasting resulted in an additional increase in shear force (2.63 MPa) compared with the observed data (means), when the use of bicarbonate blasting and Charisma were combined. The stone group also had a significant increase of 2.37 MPa ($p = 0.05$) relative to the comparison group, Charisma and hydrofluoric acid without silane (Table 3).

Statistical differences between specimen ARI scores in the various groups are depicted in Table 4. Analysis of specimen ARI scores after debracketing revealed a tendency of Charisma group specimens with surfaces treated by hydrofluoric acid, aluminum oxide, mounted stone (with application of silane) and diamond burs (without silane) to exhibit failures at the adhesive/bracket interface. In Durafill groups, the same interface failure was observed in specimens conditioned with hydrofluoric acid and aluminum oxide (without silane application). Charisma groups treated by phosphoric acid, bicarbonate blasting and use of stone (without silane application) and burs (with silane) tended to show failures at the adhesive/specimen interface. The same behavior was observed in the Durafill groups conditioned by phosphoric acid, bicarbonate blasting and after use of stone and diamond burs (Table 4).

The use of silane did not produce ARI differences in many groups, except for 3 specimen groups filled with Charisma, and surfaces treated by hydrofluoric acid, mounted stone and diamond burs.

DISCUSSION

The shear force of both types of resin composites tested were considered different, and were influenced by the vast majority of surface preparations analyzed. According to Swift, Valley and Boyer[10] the shear force of hybrid resin bonding was higher than that of microparticulate resin, although their study did not test adhesion using orthodontic brackets.

Most studies reviewed tested the bond strength of different types of resin in procedures to repair esthetic restorations. In these cases, several authors[18,19,20,21] reported the need to etch the composite in order to enhance its adhesiveness. In this study it was found that the effect of surface preparation on both resin composite types were similar to procedures to repair restorations.

Hydrofluoric acid treatment produced a significant decrease in shear force compared to blasting procedures (aluminum oxide and bicarbonate) or grooved surface (bur and stone) (Tables 2 and 3). This finding corroborates works reported in the literature.[16,22,23]

Swift, Valley and Boyer[10] stated that the effect of hydrofluoric acid is related to its percentage, size and type of inorganic composition. Therefore, depending on the type of resin composite, the effect of hydrofluoric acid may alter the effect of cohesion between

Table 3 - Coefficients of multivariate regression with the shear force interaction terms between composite and preparation.

		Force (MPa)	CI 95%		p-valor	Variable combination description		
			Lower	Upper		Composite	Adhesive	Preparation
Group used for comparison		5.85	4.62	7.08	-	Hydrofluoric acid	Without silane	Charisma
Effect of adhesive	With silane	-0.68	-1.37	0.00	0.05	Hydrofluoric acid	With silane	Charisma
Composite effect	Durafill	-1.94	-3.61	-0.27	0.02	Hydrofluoric acid	Without silane	Durafill
Preparation effect	Phosphoric acid	1.02	-0.65	2.69	0.23	Phosphoric acid	Without silane	Charisma
	Bur	4.51	2.84	6.19	0.00	Bur	Without silane	Charisma
	Bicarbonate blasting	5.42	3.74	7.09	0.00	Bicarbonate blasting	Without silane	Charisma
	Aluminum oxide	3.01	1.34	4.68	0.00	Aluminum oxide	Without silane	Charisma
	Stone	2.23	0.55	3.90	0.01	Stone	Without silane	Charisma
	None	-1.94	-3.84	-0.05	0.05	None	Without silane	Charisma
Interaction Durafill *versus*	Phosphoric acid	0.52	-1.84	2.89	0.67	Phosphoric acid	Without silane	Durafill
	Bur	0.42	-1.94	2.79	0.73	Bur	Without silane	Durafill
	Bicarbonate blasting	2.63	0.26	4.99	0.03	Bicarbonate blasting	Without silane	Durafill
	Aluminum oxide	-1.01	-3.38	1.35	0.40	Aluminum oxide	Without silane	Durafill
	Stone	2.37	0.01	4.74	0.05	Stone	Without silane	Durafill
	None	1.61	-0.76	3.97	0.18	None	Without silane	Durafill

Table 4 - Differences between group scores (ARI).

Group	Differed from groups
1	4, 19, 20, 24, 26
2	4, 19, 20, 24, 26
3	-
4	8, 9, 12, 13, 14, 18, 23, 27, 28
5	8, 9, 12, 13, 14, 23, 27
6	-
7	20
8	19, 20, 24, 26
9	19, 20, 24, 26
10	-
11	20
12	19, 20, 24, 26
13	19, 20, 24, 26
14	19, 20, 24, 26
15	-
16	-
17	18*
18	19, 20
19	23, 27, 28
20	23, 27, 28
21	-
22	-
23	24*, 26
24	27
25	26*
26	27
27	-
28	-

the resins, reducing yield strength. Hydrofluoric acid acts by dissolving glass particles, leading to increased surface porosity, which results in increased retention caused by the mechanical bonding agent. An application of this acid at 9.6% for 2 minutes may be regarded as aggressive since short duration conditioning can dissolve the filling and compromise resin softness. The risks involved in handling hydrofluoric acid and the poor results it yielded may render it less indicated as a surface conditioning agent. This preparation procedure behaved similarly in this study.

Air abrasion showed better results in this study, as well as abrasive grooves. This finding is in agreement with several studies conducted previously.[10,23] Depending on the type of resin composite treated, differences were observed between preparation methods with abrasive blasting. Durafill's shear force performed better with silane application than without it, unlike Charisma, whose higher values were obtained when silane was not applied. These data corroborate the findings of Martin and Lopez[16] but contrast with those of DeSchepper, Tate and Power, who reported improved bond strength with the use of silane after abrasive procedures.[24] Silane application seems to improve the bond strength of the composite after acid etching, blasting and preparation with burs and stones, when it comes to porcelain repairs.[25] Silane application and the use of adhesives seems to slightly increase bond strength compared to using

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adhesive only. The same results were obtained after subjecting both Durafill and Charisma to sodium bicarbonate blasting and grooves with burs and stone, i.e., an increase in shear strength due to silane in areas etched with phosphoric acid (Figs 5 and 6).[26] Although Söderholm and Roberts[27] did not find statistically significant differences in repairing composite surfaces after using silane, this study found an increase in shear strength of surfaces prepared with sodium bicarbonate blasting and grooves with burs and stone in specimens filled with Durafill. Silane may be responsible for the increase in shear forces observed on micro-hybrid resin surfaces.

The action of coupling agents is justified to the extent that it facilitates infiltration of resin composite in microscopic grooves produced in a prior surface preparation.[16] The process of groove creation enables the detachment of inorganic particles, leaving exposed a deeper region in the composite's resin matrix. Given that there is a structural similarity between orthodontic bonding materials and the resin composites evaluated in this study, shear strength values would be expected which allow the clinical longevity of brackets to be bonded. This increase in shear strength after silane application, however, was not observed in Charisma, which might indicate changes in the exposure of deeper portions of the inorganic matrix material when compared to micro-hybrid composites (Fig 6). Additional studies are needed to substantiate this laboratory finding. ARI differences were observed which may be related to the unique features of the two types of composites and the efficiency shown by different types of surface treatments (Table 4). ARI differences were not found between the use or non-use of silane in many groups, a finding that agrees with some studies.[27]

In terms of the mean yield strength values of the brackets relative to the specimens, it should be noted that according to Lopez,[9] such yield strength should withstand at least 7.8 MPa of shear force, an amount sufficient to ensure successful bonding in clinical practice.

In this case, only the specimens filled with Durafill after preparation with bicarbonate blasting, bur and stone, reached means that were above the means suggested by Lopez.[9] As for Charisma, the surface preparation that obtained values greater than 7.8 MPa were the groups that had previously been treated with aluminum oxide blasting, sodium bicarbonate blasting, bur and stone without silane (Table 2). Thus, in Durafill micro-particulate restorations of anterior teeth, orthodontic brackets would be less prone to bond failures if the surfaces were first prepared with bicarbonate blasting, bur or stone, without silane. However, in the case of brackets bonded to esthetic restorations in posterior teeth restored with Charisma micro-hybrid composite, the best surface preparation according to the results would be aluminum oxide and bicarbonate blasting, bur and stone without silane.

There seems to have been operator influence in surface preparation since standard deviation values relative to the mean values were not low, especially in groups prepared with bicarbonate blasting, bur and stone. This suggests that choosing a method for bonding orthodontic brackets onto resin composites can be influenced by the individual orthodontist performing the procedure (Table 2).

CONCLUSIONS

1. Charisma, the micro-hybrid resin composite, displayed higher yield strength during shear testing of the brackets than Durafill, the micro-particulate resin composite.
2. Silane application improved surface preparation of Durafill when performed in conjunction with bicarbonate blasting and grooves with bur and stone.
3. When performed on Charisma, silane application worsened the means obtained for the yield strength of orthodontic brackets in all preparation surfaces, with the exception of phosphoric acid.
4. Surface preparation with bicarbonate blasting, bur and stone experienced greater operator influence than others.
5. Surface treatment with sodium bicarbonate blasting, bur and stone in both types of resin composites tested showed a mean yield strength greater than 7.8 MPa, a value normally recommended and sufficient to ensure successful bonding in clinical practice.

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The evolution of cephalometric diagnosis in Orthodontics

Maurício Barbosa Guerra da Silva[1], Eduardo Franzotti Sant'Anna[2]

Introduction: Although the development of CT have represented a landmark in diagnostic imaging, its use in Dentistry turned out very discretely over the years. With the appearance of programs for analysis of three-dimensional images, specific for Orthodontics and Orthognathic surgery, a new reality is being built.

Objective: The authors of this study aim to inform the orthodontic society of fundamentals about digital cephalometric radiographic image and computed tomography, discussing about: Field of view (FOV), radiation doses, demands for the use in Orthodontics and radiographic simulations.

Keywords: Cone-Beam Computed Tomography. Digital dental radiography. Computer-assisted diagnosis.

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

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INTRODUCTION

In 1931, Orthodontics consecrated the era of cephalometry, from the historical works that presented to the orthodontic community, the cephalostat, device that allows the placement of the patient's head always on the same position.[5,13] With this device, it was possible obtaining the serial radiographs that provided more accurate studies on the human facial growth.[6] This year is considered a landmark for Orthodontics because of the evolution of the specialty as science.

In the late 60s, it began the era of computed cephalometric radiography.[24] The technological evolution in data processing enabled the development of different programs that calculate distances and angles of the cephalometric tracing; reducing the manual work required on studies and consequently accelerating the researches where the cephalometric evaluation is necessary.

With computed tomography, using specific softwares, it began to be considered the possibility of simulating radiographs used in orthodontic diagnosis such as panoramic, lateral and frontal cephalometric; with the advantage of taking only one exam.

The role of extracting two-dimensional images from three-dimensional images becomes extremely important in this transition or change of paradigm from the 2D to the 3D diagnosis, so that the clinician can continue to use the same cephalometric analysis, until it is established consecrated three-dimensional analysis in orthodontic literature and become appealing to the day-by day practice. At first sight, it seems paradoxical the reconstruction of a 3D model and subsequent return to a 2D image, but this can make easier the progressive introduction of CBCT to the practice of the orthodontist[21] and research.

Because of the progressive technological evolution for obtaining auxiliary images on the orthodontic diagnosis, the authors objective is to instruct the orthodontist about the use of the latest techniques for obtaining images.

LITERATURE REVIEW

Digital cephalometric radiography

The digital radiography is a versatile and reliable technology that increases the quality of diagnosis and the possibilities of image sharing in Dentistry.

Digital radiographic images can be produced by different means. Scanners with a transparency adapter, scanners of slides or any digital camera can be used to convert an existent analog radiograph to a digital image. This approach does not need high investment and allows bringing any radiograph to the digital system. The images produced by this technique usually are called indirect digital radiographs.

There are two systems, more advanced, for production of digital images, without a precursor radiograph: The direct and the semidirect. The direct digital images are obtained using a CCD sensor (charge-coupled device) and the semidirects using a system with a phosphor plate, as alternative to radiographic film.[29]

On the direct system, the images are obtained and automatically exported to a computer attached to the X-ray device. On the semidirect, the capture source is a plate that contains crystals of phosphorus photo-stimulated by X-ray and that needs one more step to obtaining the images, which is the readout of the phosphor plate, performed by a scanner specific for this function, that sends the image to an attached computer.

It can be enumerated the advantages that the system of digital radiography offers over the conventional:

1) Allows visualization of the image while patient is still on the chair.
2) Reduces the risk of inappropriate association of the film to another patient's file.
3) Eliminates the possibility of printing mistakes.
4) Allows immediate correction of irregularities on brightness and contrast.
5) Promptly performs calibration of images.
6) Facilitates the overlap of the digital radiograph with the digital image.[8,25,30]
7) Provides images with quality superior than the conventional.[23]

Computed tomography

The computed tomography is a method of diagnostic imaging that uses x-radiation and allows obtaining the reproduction of a section of the human body in any of the three planes of space. It allows the visualization of the structures in slices, especially mineralized tissues, with good definition, allowing the diagnosis of possible alterations, in three dimensions.[9,12]

The traditional computed tomograph (CT) presents three main components: 1) the gantry, which has in its interior an X-ray tube and a ring of radiation detectors, consisted of scintillation crystals; 2) the table, which accommodates the patient lying and that,

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during examination, moves towards inside the gantry and 3) the computer, which reconstructs the tomographic image from the information obtained on the gantry (Fig 1). The CT technician or operator follows the examination through the computer, usually located outside the room that accommodates the gantry and the table, separated by a lead glass wall.

During exam, inside the gantry, the X-rays tube spin inside the stationary ring of receptors (Fig 2). The signals received by the detectors depend on the absorption of the tissues crossed by the radiographic beam and are recorded and processed, mathematically, on the computer.[9]

On the first generation of medical tomographs, the system captured only one slice at each spin of the set inside the gantry. The latest tomographs can obtain up to 64 slices simultaneously, reducing substantially the scanning time, besides improving the quality of the image and reducing substantially the doses of radiation, when compared to their predecessors.[15,26]

When the patient has metallic restorations or uses metallic orthodontic appliance during examination, certain amount of artefacts affects the quality of the obtained image (Fig 3) and that was a remarkable disadvantage for that the fan-beam tomograph was not diffused in the dental area.[14,28]

Aiming to solve the limitations of conventional computed tomography, the department of radiology of the school of Odontology from the University of Nihon (Japan) developed, in 1997, a tomograph specific for Dentistry, using new technology, known as Cone-Beam Computed Tomography.[2]

Contrary to traditional tomographs, which are big and present high cost of acquisition and maintenance, the Cone-Beam tomograph has reduced size and can be installed in small physical spaces besides scanning only the patient's head, meeting the Dentistry needs. This technology allows the reproduction of three-dimensional images of mineralized tissues with minimum distortion, lower cost and lower dose of radiation compared to traditional computed tomography.[22,26]

The conventional tomographs used a narrow source of beam, fan beam, that irradiated an arch-shaped receptor, obtaining one slice at a time. This required the reconstruction of the object slice by slice for obtaining its three-dimensional representation (Fig 4A). On the CBCT, the rays are conically directed on a large flat sensor while both rotate around the patient's head, so that in a single rotation of the set (Fig 4B), which lasts between 20 and 40 seconds, nearly 360 2D slices are performed on the three planes of space. Then, a software reorganizes the slices in a 3D model including all irradiated structures, which can be digitally visualized in different ways. Compared to the conventional CT, the CBCT uses significantly lower radiation, for it performs a single spin around the patient.

The representation of a two-dimensional image is composed of pixels, the short for "picture element". It's the smallest part of a digital image and each one of these parts contains information that determines its characteristics. The pixel is used as unit of measurement to describe the geometric dimension of an image and the larger the amount of pixels per inch, better the quality or resolution of the image. Each pixel brings the information about the level of gray or color that it represents.[20]

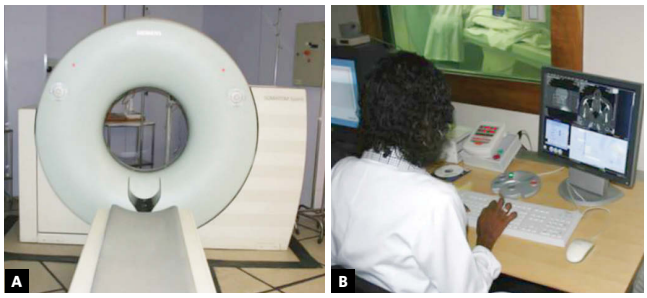


Figure 1 - Traditional computed tomograph: **A**) gantry and table; **B**) tomograph operator and computer.

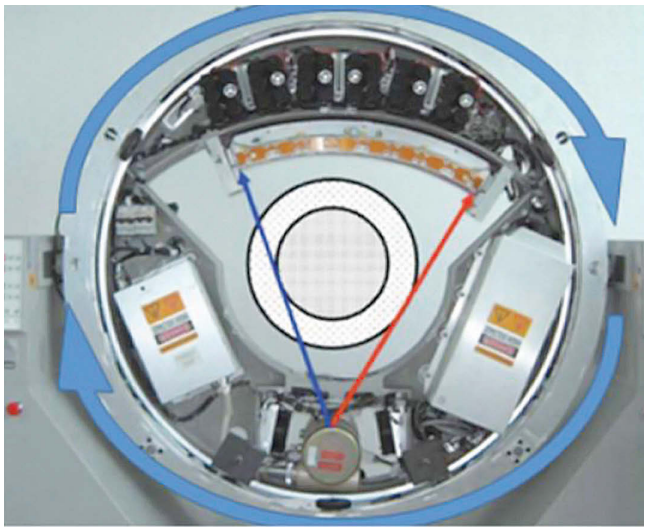


Figure 2 - Inner part of the gantry showing the source of X-rays, the receptor and the direction of spin of the components. (Source: Buzug[33], 2008).

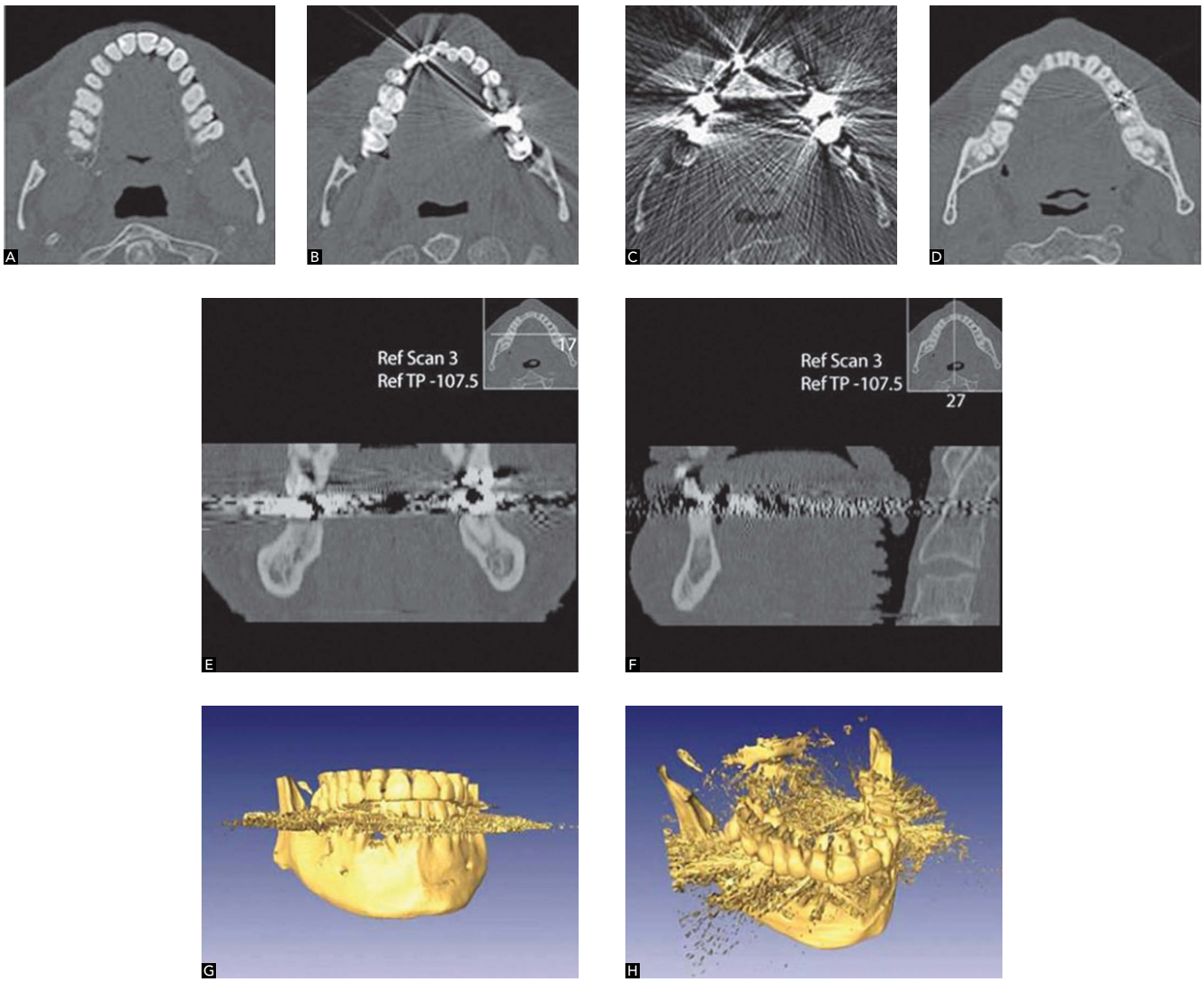


Figure 3 - Artefacts caused by metallic restorations on the images. On image **A**, axial incision without artefact, from **B** to **D**, different levels of artefacts are found depending on the amount of metal present on the section; **E** and **F** show reconstructions of coronal and sagittal slices respectively; figures **G** and **H** show the 3D visualization emphasizing the axial slices that contained metals. Source: Buzug,[33] 2008.

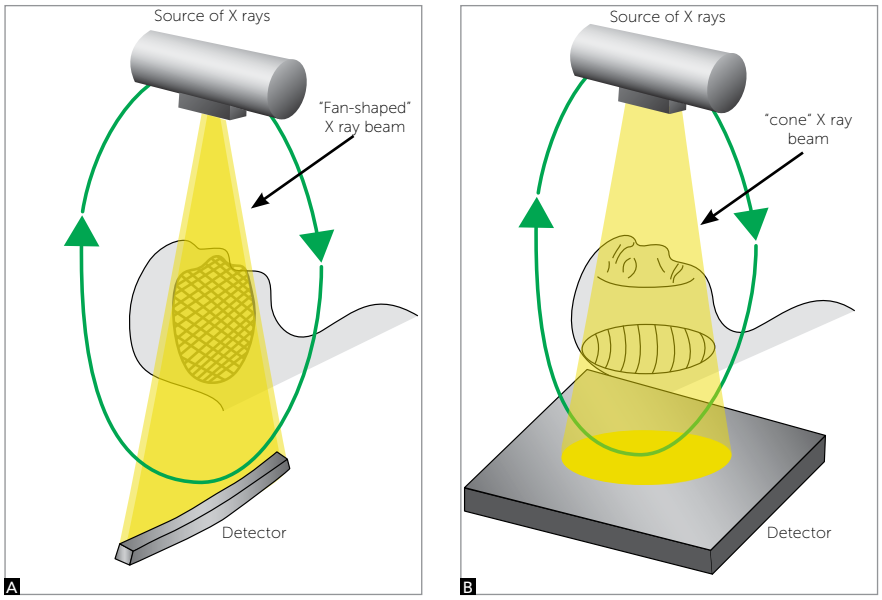


Figure 4 - Draft of projection of X-rays showing the differences on the obtention of image between a simple detector (**A**) and the cone beam (**B**). Source: Sukovic,[27] 2003.

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The volumetric data are formed by voxels, which are the smallest structures makers of the 3D image. It would be a pixel with one more dimension, the depth. Its size determines the resolution of the three-dimensional image (Fig 5). On the CT, the voxels are anisotropic, rectangular cubes where the largest dimension is on the axial plan. Its depth is determined by the thickness of the tomographic section. Contrary to CTs, all CBCT devices generate images with isotropic voxels, i.e., similar in all three dimensions.[3,26] On Figure 6 it can be visualized a plan emphasizing the difference between pixels and voxels.

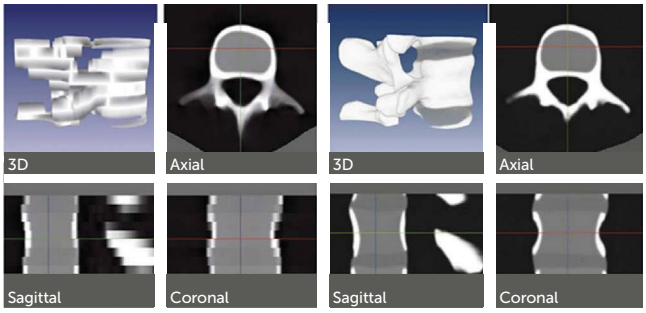


Figure 5 - Images of the same region (vertebra) with different configuration of CT. Images on the left were performed with slices thickness of 6 mm, while on the right with 0,5 mm. Source: Buzug,[33] 2008.

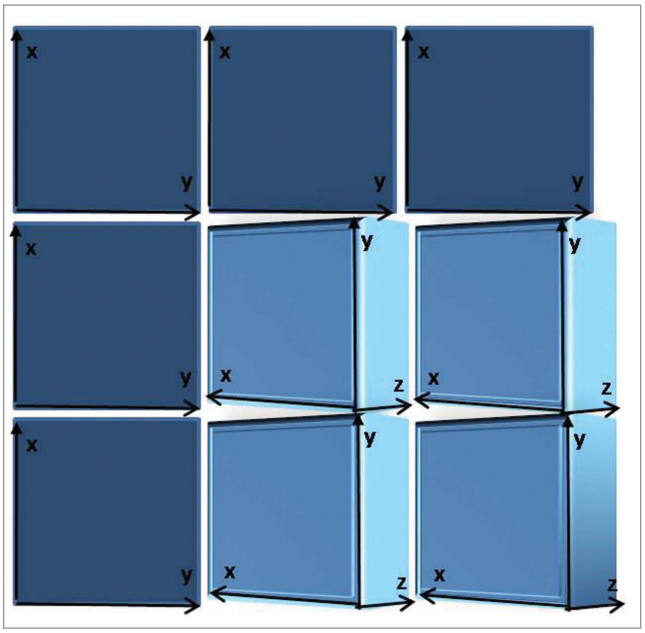


Figure 6 - Scheme showing the pixels in two dimensions (x,y) and the voxels in three dimensions (x,y,z).

Field of view

The field of view or FOV of the cone beam devices, normally work with windows between 6-in and 12-in. The FOV of 6-in is used when you want images restrict to only one of the jaws. On the FOV of 9-in it is possible to visualize both jaws, and depending on the size of the patient, all the craniofacial complex. However, when you want all the craniofacial region inserted in the study, as in cases where you want to cephalometrically analyze the patient, you must select the FOV of 12-in (Fig 7).[3,7,16,18]

The structures and reference points used on the orthodontic analysis comprise the skull base, the facial bones and the dentition, which requires a field of view larger than the used on the analysis for implants. In general, the orthodontist needs to visualize the nasion, on the anterior-superior border of the image, and the mandibular points pogonion, gnathion and mentum on the anterior-inferior border. The posterior field of view must include the sella turcica, the TMJs (condyle point), skull base (basion), and the posterior contour of the mandible (gonion). Besides, the vertebrae until C4, should be visible on the tomography, allowing analysis of the skeletal maturation.[21]

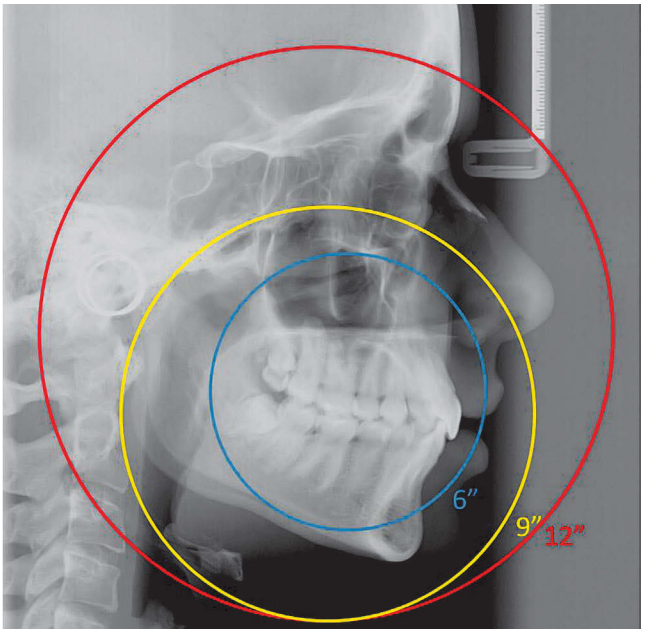


Figure 7 - Image showing the different sizes of FOV (6, 9 and 12 inches).

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Radiation doses

One of the main disadvantages of CT is the fact that it uses x-radiation, which has negative effect on the human body, especially for the capacity to cause mutation, detectable in cells that multiply quickly, as in the case of cells from the buccal mucosa. Although the risk of developing anomalies is low, it is not recommended the performance of CTs on pregnant women, considering very carefully the risks and benefits.[1,17,19]

It is known in radiological literature that a full periapical exam may vary from 33 to 150 microsieverts (μSv), depending on the film and type of collimation used.[4,32] A panoramic review varies from 2,5 to 6,2 μSv (digital) and from 3 to 10 μSv (film), depending on the equipment and the quality of the required image.[10] Effective doses for digital cephalometric radiographs vary from 1,1 to 3,4 μSv, depending on the type of system,[11] while the reported dosage with the use of film is of 2,3 μSv.[31] As parameter, it is known that the mean environmental radiation (cosmic radiation, radiation from the ground, UV rays) is of 3000 μSv/year (around 8 μSv/day), which means that the dosage of a cephalometric and panoramic radiograph is equivalent to half of a day and to one day of environmental radiation, respectively (Table 1).[21]

A research compared the dosimetry of three tomographs, all using the field of view of 12-in, exactly the one of orthodontic interest.[18] Various doses were found, measurements in μSv according to norms by the International Committee of Radiologic Protection (ICRP) of 1990 and 2005, so that the i-CAT presented dosage from 135 to 193 μSv, higher than the NewTom (45 to 59 μSv), while the CB MercuRay showed a dosage significantly higher, from 477 to 558 μSv. That is, the i-CAT and the MercuRay presented doses 3 to 3,3 times and 9,5 to 10,7 times higher than the NewTom, respectively. Besides, the CBCT equipments presented doses from 4 to 42 times higher than a panoramic radiograph (6,3-13,3 μSv). The authors concluded that the dosage ranged substantially depending on the equipment, on the FOV and on specific technical factors (mA and kV). On the i-CAT, the variation of FOV from 12-in to 9-in reduced the dosage from 135-193 μSv to 69-105 μSv. The CB MercuRay, for example, tested on FOV of 12-in with 10 mA/100 kV and 15 mA/120 kV, showed values of 477-558 μSv and 847-1025 μSv, respectively.

Orthodontic demands

Some basic requirements must be considered so that a CBCT equipment is appropriated for orthodontic diagnosis, such as: Have a field of view including all structures of orthodontic interest and allow visibility of soft and hard tissues, with good resolution. It is known that this method is ideal to irradiate teeth and bones, while other methods, as magnetic resonance, would be more recommended for better resolution of soft tissues.

The advantage of relative short period of examination, when compared to fan beam tomograph, may affect the quality of the final image, because it reduces the possibility of artefacts by movimentation of the head. Some equipments bring a head positioner, with support for the mentum and splint for the forehead, but its use must be avoided believing that it may cause distortion on the soft tissues, besides affecting the mandibular positioning.[21]

The cone beam computed tomographs most known on the international market with adequate characteristics for orthodontic use are the NewTom 3G (AFP Imaging, Elmsford, New York, USA), i-CAT (Imaging Sciences International, Hatfield, Pennsylvania, USA) and CB MercuRay (Hitachi Medical Corporation, Tokyo, Japan) (Table 2).

Besides the equipments available today, the trend is that manufacturers develop new systems presenting better x-ray sensors and programs of reconstruction and visualization of the images improved and of easy handling.

Table 1 - Comparison between the dose of radiation of different radiographic and tomographic devices. Source: Motta,[21] 2007.

Reference	Environmental radiation	Cephalometric	Panoramic	Full periapical
Radiation (μSv)	8/day (3000/ano)	1,1 - 3,4	2,5 - 10	33 - 150
Equipment	**NewTom 3G**	**i-CAT**	**CB MercuRay**	**Medical tomograph**
Radiation (μSv)	45 - 59	135 - 193	477 - 558	2100

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Radiographic simulation

Through CBCT technology, all the radiographs possible on the dentomaxillofacial region are obtained in a single exposition, for the technique enables the capture of all the object's volume, in a period inferior to 1 minute. Through this, the orthodontist has diagnostic quality on periapical, panoramic, cephalometric, occlusal, spatial view of temporomandibular

Table 2 - Comparison between characteristics of a medical tomograph and a cone beam one. Source: Adapted from Danforth,[7] 2003.

Parameters	NewTom 3G (Aperio)	i-CAT (Imaging Sciences)	CB MercuRay (Hitachi)	Medical tomograph
Irradiated area	Head	Head	Head	Full body
X-ray beam	Conical	Conical	Conical	Fan
Patient's position	Lying	Sitting	Sitting	Lying
Exam (time)	36s	20 - 40s	11s	Depend on the exam (± 10 min.)
Exposition period	5.4s	3.3s	9.6s	Depend on the exam (> 2 min.)
Detection sensor	Area	Area	Area	Linear
	CCD images intensifier	Amorphous silicon flat panel	CCD images intensifier	Gas or solid state
Voxel (mm^3)	0,07 - 0,20	0,2 - 0,4	0,1 - 0,4	0,317
Obtention	Panoramic	Panoramic	Panoramic	Axial sections
	Single rotation 360°	Single rotation 360°	Single rotation 360°	Multiple rotations 360°

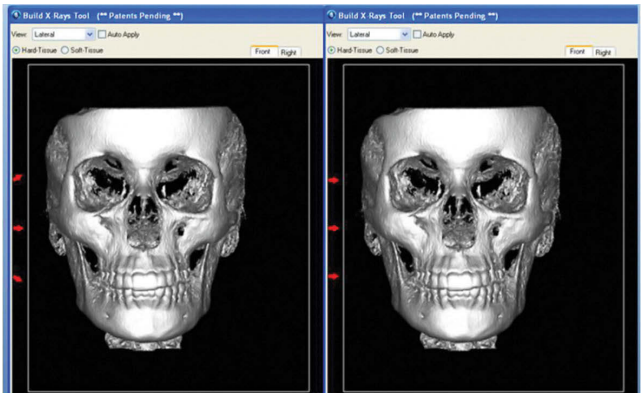


Figure 8 - Illustration of the configuration with divergence or parallelism of X-rays. Note the detail on the left.

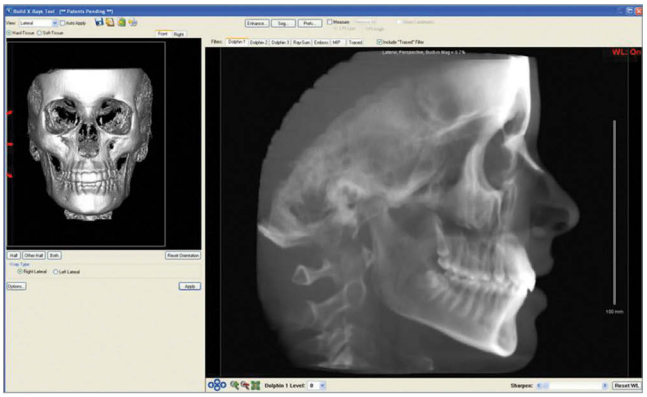


Figure 9 - Prospective cephalometric radiograph including the two sides of the image.

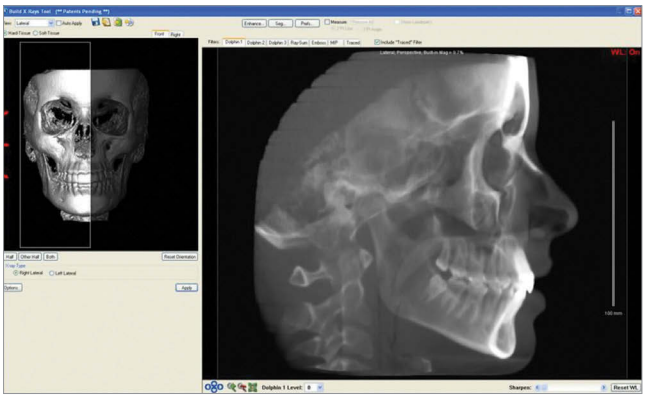


Figure 10 - Prospective cephalometric radiograph including only the right side of the image.

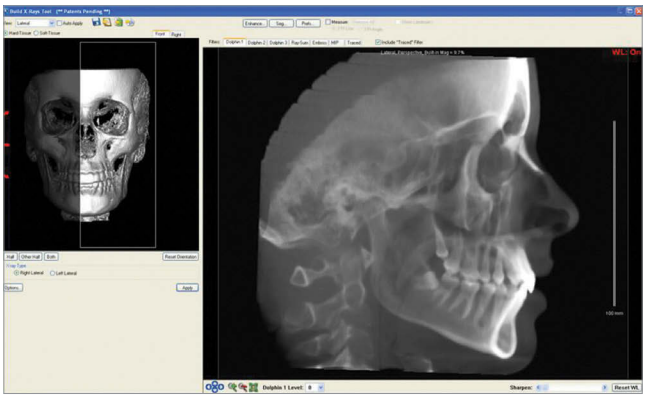


Figure 11 - Prospective cephalometric radiograph including only the left side of the image.

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joint (TMJ), as well as has the possibility to separate the right and left side of the face, on cephalometric analysis, reducing the overlap of bone structures.[27]

The cephalometric radiograph can be simulated from a tomograph with different characteristics, presenting advantageous possibilities. On the simulation of cephalometric radiograph, the volumetric model rebuilt from the tomographic sections is spatially oriented by the operator, as if positioned the patient's head on the cephalostat of conventional teleradiographic equipment, and then it is projected on a two-dimensional image (Fig 9). On the moment of the radiographic simulation, some software as the Dolphin Imaging 3D (Dolphin Imaging & Management Solutions, Chatsworth, California), and the InVivo (Anatomage, San Jose, California, USA) allow adjustments related to divergence or parallelism of rays (Fig 8). It is possible to choose between two configurations: Prospects or Orthogonal. The prospective radiograph is the closest to conventional cephalometrics, for it is simulated with divergence of rays, resulting in a magnification of the image inherent to the technique, causing different extensions between the structures on the left and right side of the face, especially on the lower borders of the mandible. On the orthogonal radiograph, when the projection of rays is parallel, there is a maintenance on the size relation 1:1 for both sides of the face, characteristic of the tomographic take.

When generating the cephalometric, there is the frontal view of the three-dimensional volume and reference lines are provided for a correct positioning of the three-dimensional volume. A window is provided, which works to determine how much of the image must constitute the simulated radiograph. Interesting possibility is the generation of a radiograph for each half of the head, removing the superposition of bilateral structures of the face. It can be simulated at least 3 different images for each configuration (orthogonal or prospects). On Figure 9 there is an image with superpositions, where all the volume was selected; on Figure 10, there is a simulation that includes only the right side of the image, and on Figure 11, there is only the left side structures composing the simulated radiograph.

CONCLUSION

It is extremely important that the orthodontist is always informed about the evolution on techniques of obtaining images, fundamental for diagnosis, so that technology is a strong ally for the success of orthodontic treatments of his patients.

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Transverse maxillary and mandibular growth during and after Bionator therapy: Study with metallic implants

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Introduction: This study evaluated posteroanterior cephalograms before and after treatment and long term follow up of Class II division 1 patients treated with bionator.

Objective: The objective was to demonstrate the transverse growth of maxilla and mandible during and after bionator therapy.

Methods: Measurement of transverse dimensions between posterior maxillary and mandibular implants, as well as the distances between the buccal, gonial and antegonial points were recorded. Measurements were analyzed at three periods: T_1 = before bionator therapy, T_2 = after bionator therapy and T_3 = 5.74 years after T_2.

Results: There was statistically significant transverse increase due to growth and/or treatment for all variables, except for the distance between the anterior maxillary implants.

Conclusions: During the study period only the anterior maxillary area did not show transverse growth.

Keywords: Activator appliances. Angle Class II Malocclusion. Maxillofacial development.

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INTRODUCTION

Few studies evaluating the transverse growth of the face were carried out so far, especially regarding sagittal growth. This is due to problems such as difficulty on identification and consequent reproducibility of cephalometric points,[18,21] standardization of the head positioning,[20,11] radiographic magnification[9,11,15,27] and standardization of the sample.[19] In the last years, some studies assessed the facial skeletal growth without interference of functional orthopedic appliances.[9,10,13,16,17,25] Several studies showed the potential of increase on transverse growth of the jaws by the use of functional appliances[1,8,12,14,23,26] and three of them[12,14,26] followed longitudinally the patients after treatment, but without radiographic evaluation. The longitudinal examination using metallic implants carried out so far refers to Class I patients with or without treatment[4,5,10,17] or to mixed samples.[16]

The cephalometric studies in teleradiographs with metallic implants proved to be the most efficient method to longitudinally assess the craniofacial growth[3,5] due to the difficulty of identification of cephalometric points and remodeling that occurs on the surface of the jaws. The objective of the present study is to evaluate the maxillary transverse growth and its relation to the treatment, through posteroanterior radiographs, during 6 years after the use of Balters' bionator in patients with metallic implants.

MATERIAL AND METHODS

The sample consisted of 25 patients that used bionator (15 boys and 10 girls), participants on a prior study[1] and treated in the Department of Orthodontics at the School of Dentistry of Araraquara – Unesp. Each one of them presented skeletal Class II with mandibular retrusion, upper and lower incisors erupted or in eruption, overbite, no dental loss, absence of crowding and/or posterior cross bite. The subjects of the sample had metallic implants inserted in the maxilla (four implants) and mandible (three implants), according to proposed by Björk.[6,7] From the original sample of 25 patients (mean age of 9.2 years), it was possible to obtain long term radiographs of 13 patients (9 boys and 4 girls) with mean age of 16.95 years. The other patients could not be contacted. On the final sample, one patient did not present the posterior implants on the maxilla in T_3 and on the mandible in T_1, other patient did not present one anterior implant in T_3 and another patient did not present one of the posterior implants on the mandible. Table 1 shows age and gender of the sample and Table 2 characterizes the sample.

Lateral and posteroanterior teleradiographs were obtained in three time periods: T_1 at the beginning of treatment with bionator, T_2 at the end of the bionator therapy and (T_3) 5.74 years, on average, after T_2. The teleradiographs were manually traced and the cephalometric points were digitized twice on Dentofacial Planner Plus (DFP Plus, version 2.0, Toronto, Ontario, Ca) by a single examiner and the digitalization mean was used for cephalometric measurements. The cephalometric points used on the posteroanterior teleradiographs are described on Table 3 and Figure 1.

The transverse growth was calculated by the transverse linear distance between the cephalometric points on the right and on the left. Corrections for magnification on transverse linear measurements were necessary before classifying the growth data, because although the posteroanterior teleradiographs had been taken with cephalostat, the radiographic magnification of the region of the metallic implants is different from the region of the acoustic meatus center plane because it is closer to the radiographic film, especially compared to the anterior implants on the maxilla. Another reason for correction is that, with the facial growth, maxilla move forward carrying together the metallic implants making them closer to the radiographic film. These variations on radiographic magnification were mathematically corrected by a combination of information of lateral and posteroanterior teleradiograph using correction method recommended by Hsiao et al.[15] A reference system, comprised by Frankfurt's horizontal plane and a vertical line perpendicular from the Porion, built in each lateral teleradiograph allowed the calculation of distance from the position of the implants mean to the acoustic meatus center plane (Fig 2).

With these measures it was possible to calculate the radiographic magnification on the region of metallic implants for each patient based on the formula described by Hsiao et al:[15] Inter-implants real distance = inter-implants radiographic distance x focus-ear rods distance + ear rods-implant distance / distance focus-film (Fig 3).

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Table 1 - Characteristics of the studied sample.

Individuals	n	T_1 Mean (years) ± SD	T_2 Mean (years) ± SD	T_3 Mean (years) ± SD
Male	9	9.25 ± 1.39	11.08 ± 1.28	16.99 ± 1.62
Female	4	9.55 ± 1.01	11.52 ± 1.7	16.86 ± 2.17
Total	13	9.34 ± 1.25	11.21 ± 1.36	16.95 ± 1.71

T_1 - (beginning of treatment).
T_2 - (end of treatment with bionator).
T_3 - (final evaluation).

Table 2 - Sagittal and vertical angular cephalometric measures.

MEASURES	T_1 Mean (years) ± SD	T_2 Mean (years) ± SD	T_3 Mean (years) ± SD
SNA	82.92 ± 4.0°	81.53 ± 3.9°	81.26 ± 4.4°
SNB	76.75 ± 3.5°	77.56 ± 3.9°	78.20 ± 4.3°
ANB	6.17 ± 1.9°	3.96 ± 2.3°	3.05 ± 2.6°
SN.GoMe	32.91 ± 5.3°	33.57 ± 5.9°	31.73 ± 6.4°
FMA	23.49 ± 3.8°	23.86 ± 4.4°	22.33 ± 5.4°
SN-ANS-PNS	5.98 ± 2.7°	6.78 ± 4.2°	6.43 ± 3.5°

Table 3 - Cephalometric points digitized on the posteroanterior teleradiograph.

CEPHALOMETRIC POINTS	DESCRIPTION
1) R PIMX	Right posterior implant of the maxilla
2) L PIMX	Left posterior implant of the maxilla
3) R AIMX	Right anterior implant of the maxilla
4) L AIMX	Left anterior implant of the maxilla
5) RJ	Intersection of the right maxillary tuber with the zygomatic wall
6) LJ	Intersection of the left maxillary tuber with the zygomatic wall
7) R PIMD	Right posterior implant of the mandible
8) L PIMD	Left posterior implant of the mandible
9) R Go (Right Gonion)	Most posterior and inferior point of the right gonial angle
10) L Go (Left Gonion)	Most posterior and inferior point of the left gonial angle
11) R Ag (Right Antegonion)	Deeper point of the right antegonial notch
12) L Ag (Left Antegonion)	Deeper point of the left antegonial notch

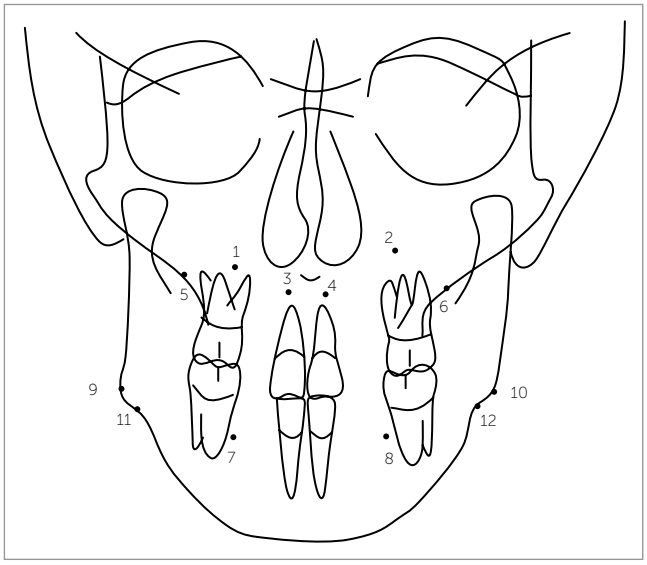


Figure 1 - Cephalometric points digitized on the posteroanterior teleradiograph. Table 3 identifies each cephalometric point.

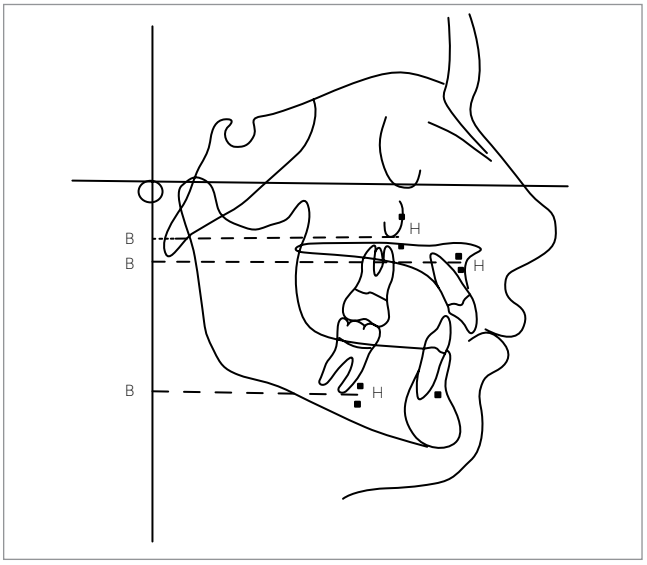


Figure 2 - Traced line shows the calculation of distance from the position of implants (mean point between implants) to the acoustic meatus center plane.

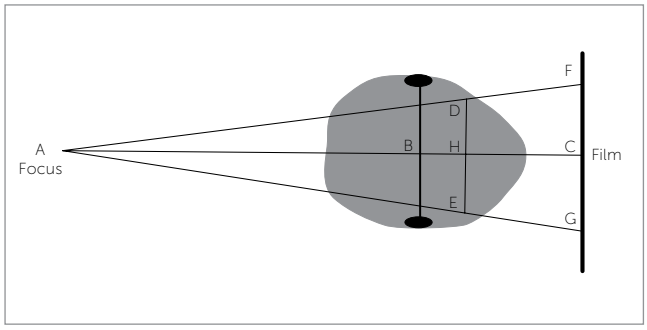


Figure 3 - AB: Distance focus-olive; BH: ear rods-implant distance; AC: focus-film distance; DE: inter-implants real distance (posterior inter-implants of the maxilla, anterior inter-implants of the maxilla and posterior inter-implants of the mandible); FG: inter-implants. radiographic distance (Source: Hsiao et al.[15]).

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The following transverse measurements were performed:

- R PIMX - L PIMX: Distance inter-posterior implants of the maxilla.
- R AIMX - L AIMX: Distance inter-anterior implants of the maxilla.
- RJ - LJ: Distance inter-jugal, in relation to the maxilla width.
- R PIMD - L PIMD: Distance inter-posterior implants of the mandible.
- R Go - L Go: Distance inter-gonial, in relation to mandibular width on point Go.
- R Ag - L Ag: Distance inter-antegonial, in relation to mandibular width on point Ag.

Statistical analysis

The mean and standard deviation were calculated for each variable. The different variables presented normal distribution and the Student's *t* test was used to evaluate the significance of the changes during evaluation periods (T_2–T_1, T_3–T_2, and T_3–T_1). The level of significance used was $p \leq 0.05$. All calculations were performed with SPSS for Windows (version 10.0, SPSS Inc., Chicago, Ill).

Method error

To evaluate the error on the localization of cephalometric points and digitalization procedures all tracings were digitalized again after two weeks by the same examiner. The random error was evaluated using Dahlberg's formula and the systematic errors were evaluated using paired *t* test. The method random error (Dahlberg's formula) did not exceed 0,33 mm. The paired *t* test did not show statistically significant systematic error.

RESULTS

Table 4 shows the transverse dimension of the maxilla and mandible on the three periods of evaluation. Table 5 shows that there was statistically significant increase of the maxillary transverse distances on the region of anatomic cephalometric points (Go, Ag and J) and of implants in all evaluated periods, except for the region of anterior implants of the maxilla that did not show statistically significant growth at no time. The lowest gains obtained were on the distance between mandibular implants and the highest were found on the inter-gonial distance.

DISCUSSION

The size of the sample cannot be considered representative of the population in a statistical sense, on the other side, due to the use of metallic implants, a detailed analysis can provide information on the facial growth.[16] Studies with posteroanterior radiographs present some limitations such as variability on the magnification of the projected transverse dimension,[9,16,22] problem of standardization of the head positioning on the cephalostat[16,22,25] due to slight up and down movements of the head and difficulty on identification of points.[16,18,22]

Table 4 - Means and standard deviation of the maxillary and mandibular dimension by period of evaluation.

Variable	T_1 Mean ± SD	T_2 Mean ± SD	T_3 Mean ± SD
R Go – L Go	82.37 ± 4.8	84.71 ± 5.1	91.04 ± 5.5
R Ag – L Ag	75.56 ± 5.5	77.63 ± 5.8	81.05 ± 5.6
R J – L J	57.46 ± 2.0	59.32 ± 2.4	63.01 ± 2.8

Table 5 - Transverse alterations of the distances between implants and of the maxilla and mandible widths.

Variable	$T_2 - T_1$		$T_3 - T_2$		$T_3 - T_1$	
	Mean ± SD	p	Mean ± SD	p	Mean ± SD	p
R PIMX – L PIMX	1.27 ± 0.5	0.000 *	2.52 ± 1.5	0.000*	3.77 ± 1.6	0.000*
R AIMX – L AIMX	0.12 ± 0.4	0.356	-0.53 ± 1.3	0.209	-0.35 ± 1.4	0.414
R PIMD – L PIMD	0.66 ± 0.8	0.027*	0.83 ± 1.2	0.049*	1.49 ± 1.6	0.015 *
R Go – L Go	2.33 ± 1.1	0.000 *	6.33 ± 2.6	0.000*	8.66 ± 2.2	0.000*
R Ag – L Ag	2.06 ± 1.6	0.001 *	3.42 ± 2.1	0.000*	5.48 ± 2.0	0.000*
R J – L J	1.85 ± 1.3	0.000 *	2.68 ± 2.2	0.000*	5.54 ± 1.8	0.000*

* = statistically significant values $p \leq 0.05$.

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The problem on identification of points is corrected when metallic implants are used, the variability of magnification was individually corrected for the distances between implants in each period of evaluation, but the problems of standardization of the head positioning are impossible to solve because slight movements of the head are inevitable,[14] however, some studies[11,20] did not find statistically significant differences among measures taken with up to 10° of difference.

The study confirmed the increase of bone bases and evidenced that the maxillary growth was greater than the mandibular.[1,10,17] The distance between posterior implants of the maxilla increased more than the distance between the anterior implants confirming the findings of other studies[4,5,10,17] and showing that the maxillary growth on the posterior region was greater than the anterior besides confirming the existence of transverse growth until the studied age. The mean increase of the distance between posterior implants of the maxilla during all evaluated period, T_1-T_3, was of 3.77 mm. Björk and Skieller[5] found 3 mm increase from 10-11 years to 21 years and in a previous study[4] they found 2.8 mm from 11 to 19 years of age. The result in this work was a little higher, but considering the standard deviation the values are similar because they also observed great variability.[5] The amount of maxillary transverse growth between the implants when compared to the increase related to Jugal point agrees with the present literature[4,5] confirming the median palatine suture as the main site for the maxillary transverse growth and, less expressive, the bone apposition in other areas completing the transverse growth (Table 5).

The differential maxillary transverse increase regarding the anterior and posterior region implies in a transverse rotation between the sides.[4,5,10,17] Our findings agree with other study[10] about the posterior move of the maxillary transverse rotation center with aging in function of the immutability of the anterior maxillary transverse distance.

Table 6 shows that the annual growth of the posterior region of the maxilla was the greatest among the studies that used metallic implants. This result may be associated to the influence of the facial pattern since the patients with horizontal growth pattern present larger transverse facial dimensions when compared to other patterns,[27] may be due to the fact that the sample is composed mostly by male that presents facial widths larger than female[9,17,24,25,28] and/or stimulation of transverse growth by the use of bionator.[1,8] During the treatment with bionator there was an increase of 1.85 mm on the distance RJ - LJ. A previous study[19] showed 1.72 mm increase during the same period in Class II division 1 patients and 2.03 mm in Class I patients. This difference may be related to the therapy used because when comparing Class II our results were higher and when compared Class I they were lower, but it must be emphasized that Class II patients present the maxillary transverse dimension smaller than Class I patients.[19] Besides, the remodeling of the Jugal point during this period was also greater than the presented by other works.[2,9,13] The annual transverse increase between the maxillary implants calculated on the same period was 0.73 mm. In one year of treatment with Frankel's appliance, a study[8] showed 0.57 mm of increase in patients with age and gender distribution similar to the present study. It was concluded that the treatment was capable to increase the basal transverse distances of the maxilla. As the values of annual growth in the present study, were higher it is believed that the bionator also has the capacity to increase the maxillary bone base,[1] although it is not clinically significant.

Table 6 - Annual changes (mm/year) and standard deviation in transverse growth with metallic implants according to the location.

Authors	Anterior of the maxilla	Posterior of the maxilla	Posterior of the mandible	n	Age (years)
Björk, Skieller[4,5]	0.12 ± 0.06	0.42 ± 0.12	Did not report	9	10 to 20
Korn, Baumrind[17]	0.15 ± 0.11	0.43 ± 0.18	0.28 ± 0.15	31	8.5 to 15.5
Gandini, Buschang[10]	-0.10 ± 0.18	0.27 ± 0.13	0.19 ± 0.20	13	13.9 to 16.7
Iseri, Solow[16]	Did not report	Did not report	0.13 ± 0.06	10	6 a 18
Marotta Araujo et al.[1]	-0.14 ± 0.53	0.40 ± 0.17	0.03 ± 0.25	14	8.9 to 9.9
Present study	-0.04 ± 0.18	0.49 ± 0.22	0.18 ± 0.18	13	9.34 to 16.95

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During the bionator therapy, the presented mandibular basal transverse growth was 0.66 mm. Another study,[16] on the same period of evaluation, found 0,46 mm and despite not presenting similar sample to the present study, it could be assumed that the bionator has the ability of increasing the mandibular bone base, when used appropriately. This information was already reported by another study[1] that did not find statistically significant mandibular transverse increase during one year of treatment with bionator, but observed higher value on the treated group. Evaluating the annual changes of growth on the two periods it is observed that on the stage of treatment with bionator the maxillary and mandibular basal transverse growth was 0.73 mm/year and 0.37 mm/year, respectively. After therapy, the normal growth showed 0.43 mm/year and 0.14 mm/year for maxilla and mandible showing the stimulation of growth with bionator (Figs 4 to 8). The mandibular basal transverse increase is a supposition, but at a dental and dentoalveolar matter it was already identified in studies with functional appliances.[12,14,23,26] The width of the mandibular implants increased 0.18 mm/year, value similar to the one found previously[10] in older Class I patients. This result may represent that Class II patients have lower potential of mandibular basal transverse growth even if treated at a young age, however some authors[19] did not identify difference on the mandible between Class I and II patients.

After therapy with bionator, the remodeling on the Jugal point found by the present study was greater than the ones shown by several articles with similar period of observation.[2,9,13,19,27] Differently from the maxilla, the contribution of the basal growth on the mandibular transverse increase is lower than the remodeling[10] (Table 5). Regarding the mandibular remodeling, after therapy with bionator, our results were lower than the ones presented by other works,[2,9,19,27] and observing the increase of the distance R Ag-L Ag during therapy with bionator, the amount of remodeling was identical to one found in the same period (2 mm),[9] but inferior to other works.[2,19,27] However the values of annual growth obtained during the treatment were systematically higher (Fig 4).

The mandibular transverse distance, both on the region of Gonion and Antegonion, evaluated in T_3, is lower than the presented by Lux et al[19] evaluating 15 years old

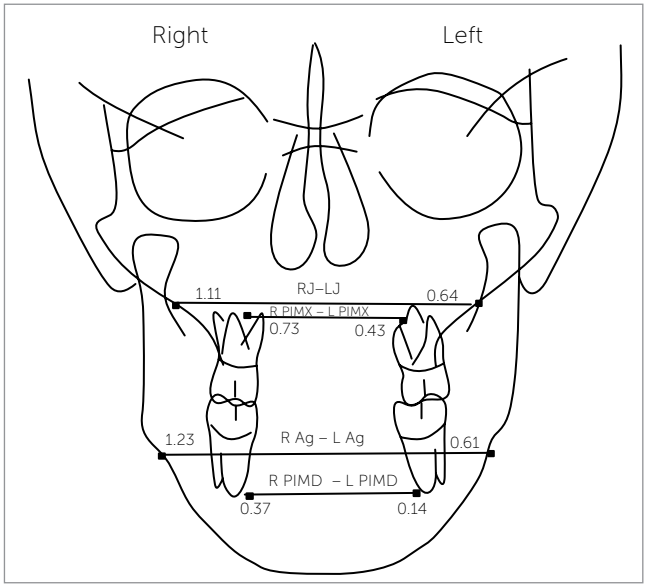


Figure 4 - Annual changes in transverse growth during bionator therapy (values on the right) and after bionator therapy (values on the left).

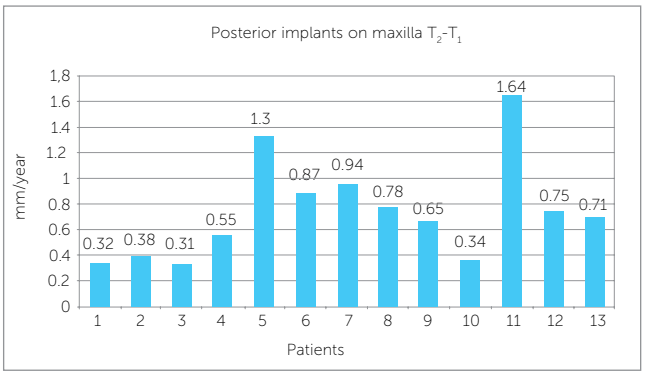


Figure 5 - Individual annual changes in transverse growth on the region of posterior implants of the maxilla during bionator therapy.

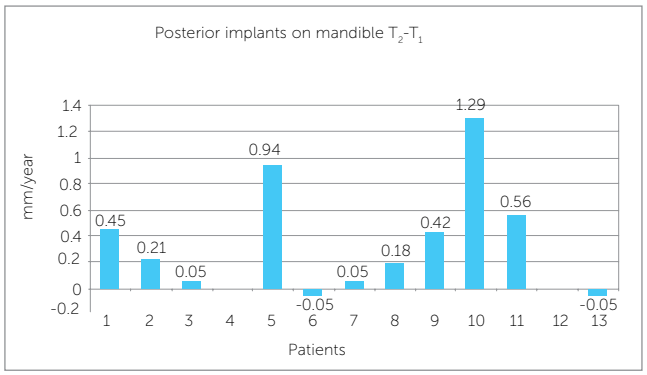


Figure 6 - Individual annual changes in transverse growth on the region of posterior implants of the mandible during bionator therapy.

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Class I or II patients. It was also lower than presented in other studies.[2,13,27] Thus, our results suggest that the Class II patients, present mandibular transverse growth and dimensions lower that Class I patients, not confirming the result by Lux et al,[19] although the found differences of size probably have little clinical meaning once they were not greater than 4 mm. Besides, the gonial region showed wide remodeling during growth and it is the transverse dimension of the lower third of the face that presents greater growth and possibility of morphological variation. On Table 7 it can be noticed the influence of gender and malocclusion on the mandibular transverse growth since the lowest annual growths are related to studies evaluating female patients and/or with Class II malocclusion. Another aspect is that the comparison of normative values between the studies is not appropriated due to radiographic magnification. Some articles do not mention the correction and other do not describe appropriately the used methodology. Due to these problems some studies[9,27] suggest the use of proportion (JJ/AgAg) instead of normative values to minimize the problem although not solving it because some centers take posteroanterior radiographs with Frankfurt's plane parallel to the ground and others with Frankfurt plane inclined 35° down.

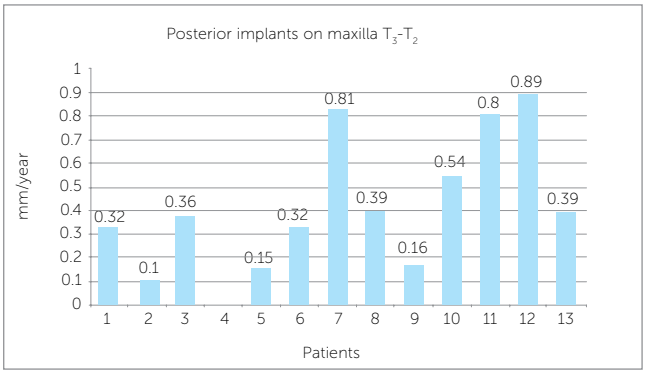


Figure 7 - Individual annual changes in transverse growth on the region of posterior implants of the maxilla after bionator therapy.

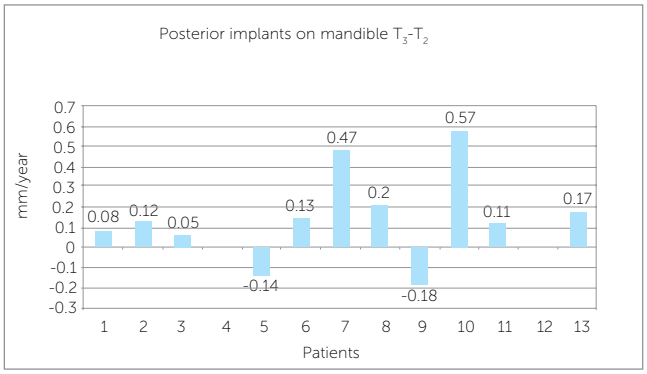


Figure 8 - Individual annual changes in transverse growth on the region of posterior implants of the mandible after bionator therapy.

Table 7 - Annual changes (mm/year) in transverse growth of anatomic points according to the location.

Author	R J– L J	R Go – L Go	R Ag – L Ag	Age (years)	Corrected magnification	Type of malocclusion
Cortella et al[9]	0.58	Not informed	1.03	5 to 18	Yes	I
Snodell et al[25]	0.73	1.53	Not informed	6 to 18	Not informed	I
Hesby et al[13]	0.76	1.42	1.24	7.6 to 16.5	Yes	I
Yavuz et al[28]	1.05	Not informed	1.98	10 to 14	Not informed	I
Lux et al[19] (boys)	0.98	1.68	1.40	7.64 to 15.61	Yes	I
Lux et al[19] (girls)	0.66	1.37	1.21	7.6 to 15.66	Yes	I
Lux et al[19] (boys)	0.65	1.54	1.15	7.49 to 15.6	Yes	II
Lux et al[19] (girls)	0.61	1.36	1.13	7.52 to 15.59	Yes	II
Athanasiou et al[2]	0.70	Not informed	1.41	6 to 15	No	Several
Wagner and Chung[27] (girls)	0.56	Not informed	1.16	6 to 18	Yes	I and II
Present study	0.73	1.14	0.72	9.34 to 16.95	Yes	II

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The findings in this study are limited by the size of the sample, bias of the treatment potential and lack of control group. Although the size of the sample is small, the highly significant probabilities obtained ($p < 0.001$) suggest that the changes observed in growth are real. Besides, additional studies with larger samples are necessary to provide better estimates of variation on transverse increase by growth. There is also the possibility of influence of the treatment subsequent to the bionator on the transverse increase although it is hardly likely that conventional fixed appliances have some potential of orthopedic effect.

CONCLUSIONS

1) The maxillary and mandibular bone bases seem to be affected by bionator therapy, during treatment, returning to a normal pattern on the post-treatment.
2) The maxillary and mandible remodeling pattern followed the same tendency of transverse growth of metallic implants.
3) With aging, the center of transverse rotation of the maxilla is displaced posteriorly.

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The influence of patient's motivation on reported pain during orthodontic treatment

Marcio José da Silva Campos[1], Robert Willer Farinazzo Vitral[2]

Introduction: Patients usually experience pain during orthodontic treatment. This fact can affect cooperation and the development of treatment. Reporting pain during treatment seems to be influenced by emotional aspects such as the patient's motivation.

Objective: To assess the relationship between patient's motivation and the intensity of reported pain during two stages of treatment.

Methods: Twenty males (11-37 years old) answered a questionnaire divided into five categories regarding their motivation towards treatment. The subjects were studied for 14 days (7 days with bonded brackets and 7 days with the initial arch inserted) and the intensity of pain was evaluated on a daily basis. All the issues, including the intensity of pain, were measured through the visual analog scale (VAS).

Results: The VAS-associated questionnaire proved to have good temporal reliability and reasonable internal consistency, being that the "perceived severity" domain had the greatest, although not significant ($p = 0.196$) correlation with pain intensity. Only the question asking the patients if they thought that their teeth were too uneven showed a positive correlation with pain intensity ($p = 0.048$).

Conclusion: The results seem to indicate that the five categories related to treatment motivation cannot be used to predict discomfort during treatment. In addition, patients who think their teeth are too uneven may experience more severe pain due to greater strength when inserting the initial arch.

Keywords: Pain. Orthodontics. Motivation.

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INTRODUCTION

Success of orthodontic treatment is often dependent on the use of devices and techniques to minimize patient's discomfort, once pain and discomfort hamper cooperation, leading to poor adherence to follow-up and treatment interruption.[22] Pain is commonly assessed through the Visual Analogue Scale (VAS),[2,7,8,9,15,17,21,24,25,27,29] which records the subjective experience of pain.

Pain during orthodontic treatment is reported by up to 95% of the patients,[20,25] being associated with trauma to the buccal mucosa[2,20,21] and application of force to the teeth.[2,3,7,8,13,15,21,22,25] Yet, because pain is strongly related to emotional, cognitive and cultural factors,[2,12] the intensity is modulated by the individual's personality.[15,16]

Subjective factors, such as self-perception of dental status and esthetic, greatly influence the individual's willingness to undergo orthodontic treatment.[1,16,21] These factors, along with the patient's information on the orthodontic treatment, make up treatment motivation. The degree of motivation may influence pain perception during treatment, with patients who are willing to undergo treatment or find their malocclusion severe enough reporting lower pain levels.[26]

This study aimed to assess the correlation between patient's motivation and pain intensity, reported during the initial phases of orthodontic treatment.

MATERIAL AND METHODS

Twenty male individuals, aged from 11 to 37 years (mean age 18.5 ±6.2 years), who sought orthodontic treatment, were selected after the following criteria were satisfied: Absence of deciduous teeth; no previous orthodontic treatment; good general health; and no periodontal disease.

Because pain experience is influenced by emotional, cognitive and motivational characteristics, and also by family behavior patterns,[2,18] the following subjects were excluded from the study: Dentists; dental students; close relatives or partners of Dentists or individuals who had used a fixed appliance in the preceding 12 months; individuals who feared dental treatment; and those on psychotropic drugs (antipsychotics, benzodiazepines, anticonvulsants or antidepressants), anti-inflammatory drugs and analgesics.

This study was approved by the Research Ethics Committee of the Federal University of Juiz de Fora. All participants were volunteers and signed their informed consent after a thorough explanation of the procedures to be undertaken.

In the initial consultation, patient's motivation to undergo orthodontic treatment was assessed through a 27-question questionnaire, divided into 5 domains: Perceived Severity, Dental Esthetic, Willingness-to-Treat, Treatment Perception and Occlusion Importance. The questions were answered through a 100 mm VAS,[11] (Fig 1) which varied according to Table 1. Only one examiner applied the questionnaire, informing the participants about the way to fill it in, but without providing further information on the questions. The VAS value was calculated as the distance in millimeters from the left end of the horizontal line to the center of the mark made by the patient, the value for each domain consisting of the arithmetic mean of the corresponding answers.

In order to assess the reliability of the 27 questions, and determine their temporal stability, a pre-questionnaire was applied twice, to 20 individuals, with a mean interval of 42.7 days between applications.

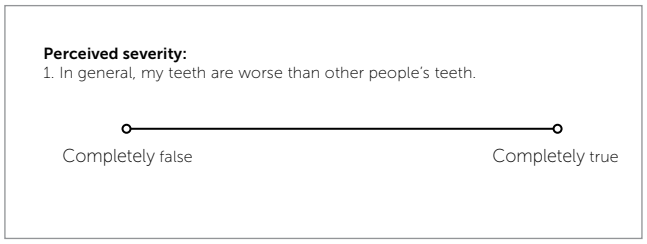


Figure 1 - Question 1 of the 100 mm Visual Analogue Scale.

Table 1 - Questionnaire domains and VAS variations.

Domains	Questions	VAS variation
Perceived severity	1 to 7	Completely true / Completely false
Dental esthetic	8 to 10	Completely true / Completely false
Willingness-to-treat	11 to 14	Completely true / Completely false
	15 - 16	Totally disagree / totally agree
	17 - 18	Definitely not / definitely yes
Treatment perception	19 to 25	Totally disagree / totally agree
Occlusion importance	26 - 27	Without importance / very important

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Patient assessment lasted 14 days and was divided into 2 phases: Bonding (days 1-7) and initial arch (days 8-14). On the morning of the day preceding assessment onset, brackets and tubes (Mini Standard Edgewise, American Orthodontics, Wisconsin, USA) were bonded to the vestibular surfaces of the maxillary incisors, canines, premolars and first molars. On the morning of day 7, a 0.014-in pre-formed archwire (Titanium Memory Wire, American Orthodontics, Wisconsin, USA) was totally inserted in the slots of all brackets and tubes, being then fixed with a 0,010-in steel ligature wire.

Pain intensity was recorded daily during the 14 study days, at wake-up time. Two 100 mm VAS were used, one for tooth pain and the other for buccal mucosa pain, with a range from "without pain" to "worst pain ever", measurements being taken similarly to the procedure used in the questionnaire. Pain intensity was the arithmetic mean of the VAS for tooth pain and buccal mucosa pain.

STATISTICAL ANALYSIS

The test-retest reliability of the questions from each domain of the pre-questionnaire was assessed by the Interclass Correlation Coefficient (ICC), based on variance analysis. The internal consistency of each domain was assessed through Cronbach's alpha coefficient. Pearson's Correlation Coefficient assessed the relationship between the questionnaire domains and pain intensity means, and between each question and pain intensity means. The *Statistical Package for the Social Sciences* (SPSS 11.0.0) program was used for the analyses.

RESULTS

Analysis of the pre-questionnaire, which determined the ICC, showed excellent reliability (ICC > 0.75) for the Dental Esthetic, Treatment Perception and Occlusion Importance domains, and good reliability (0.4 < ICC < 0.75) for the Perceived Severity and Willingness-to-Treat domains (Table 2).

Based on the applied questionnaire, Cronbach's alpha coefficient was calculated for the estimation of the internal consistency of each domain (Table 2). The Occlusion Importance domain had very good internal consistency (α > 0.9), the Perceived Severity and Treatment Perception domains had good consistency (α between 0.8 and 0.9), the Willingness-to-Treat domain had regular consistency (α between 0.7 and 0.8), and the Dental Esthetic domain had weak consistency (α between 0.6 and 0.7).[23]

The pain intensity means reported by the patients every day of the study period are shown in Figure 2. The correlations between each domain of the questionnaire of assessment of treatment motivation and the pain intensity means are shown in Table 3. No significant correlation was found for any domain. Tables 4 to 8 show the correlation between each question and pain intensity. Only question 2 showed a significant positive correlation.

Table 2 - Test-retest reliability and internal consistency of each questionnaire domain.

Domains	ICC*	α**
Perceived severity	0.71 (0.60 – 0.80)	0.83
Dental esthetic	0.79 (0.65 – 0.88)	0.62
Willingness-to-treat	0.71 (0.60 – 0.79)	0.70
Treatment perception	0.81 (0.73 – 0.86)	0.83
Occlusion importance	0.83 (0.67 – 0.91)	0.98

* Interclass correlation coefficient with 95% confidence interval;
** Cronbach's alpha coefficient.

Table 3 - Correlation between the questionnaire domains and pain intensity.

Domains	Value (VAS)		Coefficient of correlation with pain intensity	Significance (p value)
	Mean	Variation		
Perceived severity	58.0	0 - 93	0.302	0.196
Dental esthetic	75.1	33 - 100	0.096	0.687
Willingness-to- treat	69.6	25 - 100	0.134	0.574
Treatment perception	65.7	0 - 100	0.101	0.673
Occlusion importance	91.5	58 - 100	-0.006	0.981

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Table 4 - Correlation between the questions of the Perceived Severity domain and pain intensity.

Questions	Correlation coefficient	Significance (p value)
1. In general, my teeth are worse than the teeth of other people	-0.124	0.602
2. My teeth are too crooked	0.447	0.048*
3. My teeth really need correcting	0.261	0.267
4. I am not happy with the appearance of my teeth when I bite	0.013	0.955
5. I am worried about the appearance of my teeth when I bite	0.308	0.187
6. My crooked teeth bother me	0.266	0.258
7. My teeth don't look nice the way they are	0.289	0.216

* $p < 0.05$ according to Pearson's test

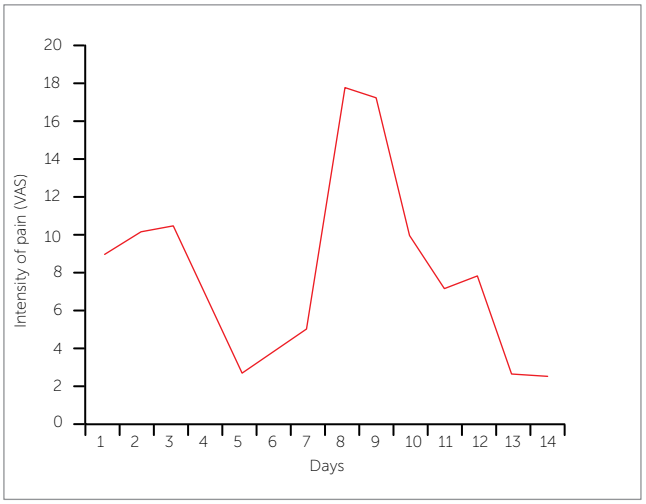


Figure 2 - Intensity of patients' reported pain during the bonding (days 1 to 7) and initial arch (days 8 to 14) phases.

Table 5 - Correlation between the Dental Esthetic domain questions and pain intensity.

Questions	Correlation coefficient	Significance (p value)
8. A beautiful smile is important	-0.005	0.982
9. The teeth are the most important contributor to the beauty of people's faces	0.372	0.106
10. When I see people's faces, the first point I'm generally drawn to are the teeth	-0.069	0.773

Table 6 - Correlation between the Willingness-to-treat domain questions and pain intensity.

Questions	Correlation coefficient	Significance (p value)
11. I think about using a tooth appliance	0.186	0.433
12. I would be happy to treat my teeth with an orthodontic appliance	0.174	0.462
13. I wish I could afford to have my teeth aligned	0.298	0.203
14. I want to have my teeth aligned	0.107	0.653
15. People who use a fixed appliance are luckier than I am	0.119	0.617
16. Even if it is costly, it pays to have my teeth aligned	-0.118	0.621
17. I'm willing to use a fixed appliance for a long time	-0.088	0.713
18. I'm willing to tolerate bouts of pain during the orthodontic treatment	0.020	0.934

Table 7 - Correlation between the Treatment Perception domain questions and pain intensity.

Questions	Correlation coefficient	Significance (p value)
19. People who use fixed appliances don't look silly	0.212	0.370
20. A fixed appliance doesn't make the teeth look ugly	-0.067	0.780
21. I can see myself using a fixed appliance	0.238	0.311
22. Using a fixed appliance is not worse than wearing glasses	-0.210	0.374
23. Using a fixed appliance would not bother me at all	0.275	0.241
24. People who use a fixed appliance seem not to perceive them	0.099	0.678
25. The fixed appliance is not going to bother me	0.023	0.924

Table 8 - Correlation between the Occlusion Importance domain questions and pain intensity.

Questions	Correlation coefficient	Significance (p value)
26. In your opinion, what is the importance of having aligned teeth that articulate correctly?	-0.046	0.847
27. In your opinion, for a person whose teeth are crooked and do not articulate correctly, what is the importance of having aligned teeth?	0.038	0.873

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DISCUSSION

The high prevalence rates of pain reported by patients during orthodontic treatment[2,3,7,8,13,15,19-22,25] may lead to treatment failure due to lack of adherence[5,22] and treatment drop-out.[22] Thus, it is important to search for factors that may influence the prevalence and intensity of the pain experienced by these patients.

Authors[3,15] suggested that psychological factors might somehow influence the reports of pain and discomfort. Among such factors, patient's motivation to undergo orthodontic treatment seems to be the most relevant.[1,16,26]

Patient's motivation has been studied through self-assessment of the dental condition,[10,28] esthetic perception[1,10,16,21] and knowledge about the orthodontic treatment.[10] In this study, patient's motivation was assessed through a questionnaire based on the works of Clemmer and Hayes[4] and Fox et al.[10] The 27 questions addressed: 1) perception of the severity of the dental problem; 2) importance of dental esthetic; 3) willingness to undergo orthodontic correction; 4) impressions about the orthodontic treatment; and 5) importance of good occlusion.

The questions were answered according to a VAS, a widely used scale to assess pain intensity,[2,7,8,9,15,17,21,24,25,27,29] and which has been used in some questionnaires.[2,6,30] The reliability test showed a good to excellent precision for all questionnaire domains, pointing to the good assessment stability of VAS-associated questions at different times.

Although the patients were motivated to undergo the treatment, with domain values ranging from 58 to 91 (VAS), there was no significant correlation between the degree of motivation and the reported pain intensity. This happened when the questions were analyzed by domains or individually, except for question 2. These results agree with other studies, which failed to find a correlation between pain intensity and dentofacial esthetic, or with the self-perceived treatment need.[1,8]

Although no domain was significantly correlated with pain intensity, Perceived Severity had the lowest p value (0.196), with a positive correlation. Contrary to this trend, Sergl et al[26] found a negative correlation, indicating that patients who perceived their malocclusion to be more severe reported less intense pain.

The significance of the Perceived Severity domain was influenced by question 2, the only one that showed a significant positive correlation with pain intensity. Because this question assessed whether the patient considers their teeth to be "very crooked", the result highlights the hypothesis that the intensity of force application to the teeth, regardless of the degree of tooth crowding, has a relationship with pain reported during the alignment and leveling phase,[2] although other studies have not confirmed this relationship.[14,15]

The existence of a relationship between the degree of dental crowding and pain intensity is a reminder of the importance of educating patients on the possibility of more intense pain, proportional to the severity of dental crowding, chiefly after insertion of the initial arch during the alignment and leveling phase.

CONCLUSION

The results indicate that the intensity of reported pain during orthodontic treatment is not related to treatment motivation, evidencing no rationale to use the degree of a patient's motivation to predict discomfort experienced after installation and activation of the orthodontic appliance.

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Comparative evaluation of cephalometric and occlusal characteristics between the Long Face pattern and Pattern I

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Objective: To compare the cephalometric and intraoral characteristics between Long Face pattern and Pattern I patients, besides evaluating associations between subjective facial patterns, cephalometric facial patterns and the intraoral characteristics.

Methods: Through evaluation of frontal and right side extraoral photographs, three previously calibrated and experienced examiners selected 30 Long Face patients (Group 1) and 30 Pattern I patients (Group 2), aged between 9 and 19 years, of both genders. The cephalometric characteristics were assessed by the following variables: SN.GoGn, NS.Gn, AIFH, SNA, SNB, ANB, $\underline{1}.\overline{1}$, 1.NA,1-NA, 1.NB, 1-NB, NA.Po, nasolabial angle and H-Nose. Clinical evaluations were also performed to determine the presence of posterior crossbite, anterior open bite and type of Angle's malocclusion. The cephalometric data were compared by independent t test. The chi-square test was used to evaluate the association between qualitative variables.

Results: Significant differences were observed between groups regarding the variables SN.GoGn, NS.Gn, AIFH, ANB, NA.Pog, 1-NA, 1.NB and 1-NB, with an increase of these measures in Group 1. There were also significant differences between groups on variable $\underline{1}.\overline{1}$, being lower in Group 1 than in Group 2.

Conclusions: The Long Face was associated to Angle Class II malocclusion, to the presence of posterior crossbite and to anterior open bite. The Long Face subjective facial pattern was associated to dolichofacial cephalometric pattern.

Keywords: Cephalometry. Orthodontics. Diagnosis.

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

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INTRODUCTION

The long face is a deformity with skeletal implication and with unfavorable esthetics,[8,10] that can be observed in the three sagittal dental relations, being however, more associated to Class II sagittal discrepancies.[7,10]

The children, teenagers and adults that present this excessive vertical facial growth, have a peculiar characteristic, described in literature as "Long Face syndrome",[4,30] hyperdivergent facial type[16,24] and, recently, as Long Face pattern.[7-11]

The diagnosis of Long Face pattern is based in evaluations of the face morphology and cephalometry. The facial analysis allows to verify several characteristics common to these individuals such as: Absence of passive lip seal and contraction of mentalis muscles during labial closure,[1] besides a great exposure of upper incisors when lips are resting and great gingival exposure during smile,[1,4,30] the nose is generally long, with narrowing of the alar bases and the lower third of the face is increased, resulting in retrognathia appearance of the mandible.[1,26,30]

The cephalometry constitutes a necessary instrument to define, locate and quantify the skeletal disharmony present in patients with Long Face pattern, which can be associated to a horizontal growth of the condyle[6,26] and/or to an excessive posterior growth of the maxilla.[15,30]

Regarding the cephalometric characteristics, it is observed an increase on the total anterior height of the face and on the anterior and inferior facial height.[15,17] The anterior and superior facial height is generally normal,[1,4,30] but the proportion between medium and lower third is reduced.[3] The angle of the mandibular plane is increased,[4,8,11,15,28,29] as well as the gonial angle.[8,11] It is observed a mandibular retropositioning in relation to the skull base.[1,11] The maxilla, however, is well positioned in relation to the skull base.[1,15]

Lately, it is observed in literature[13,21] that the cephalometric means, used in several cephalometric tracings, cannot be generically applied for diagnosis and treatment. Several researchers[5,20,23] concluded that most cephalometric standards varies significantly, when compared to several facial patterns. Before this, a more individualized interpretation of the cephalometry must become a rule, or rather, an association between the cephalometric analysis and the facial analysis must be standard for diagnosis, planning of treatment and orthodontic treatment. Therefore, the final decision of a planning must be taken based in cephalometric and facial findings. This way, this work had as objective to perform a comparative study of cephalometric and intraoral characteristics between Long Face patients and Pattern I, diagnosed by the subjective facial analysis, besides evaluating the associations between subjective facial patterns and cephalometric facial patterns.

MATERIAL AND METHODS

Material

The sample was selected according to the following criteria of inclusion:

- Caucasians;
- Long Face pattern or Pattern I;
- Full orthodontic records;
- Ages between 9 and 19 years;
- No previous orthodontic treatment.

Methods

Orthodontic records

Extraoral, frontal and right side photographs from the orthodontic records belonging to patients registered for orthodontic treatment on the Specialization Course in Orthodontics, of the Odontology Academy of Ceará were used. The sample was selected by three experienced and previously calibrated examinators, in distinct moments and each one individually, to avoid that the evaluation of one examinator interfered on the others. Only the patients who had diagnostic concordance were selected.

All photographs were performed by the same radiology center (Prof. Perboyre Castelo), presenting a pattern. The patients during the photographs were in natural position of the head (NPH):[22] standing,with the feet 10 cm apart from each other, lips at rest, looking to an oval mirror located 1 meter before the patient and instructed to observe their own eyes reflection, keeping the pupils on the eye center.

The patients classified with Long Face pattern,[7-11] were on the frontal and right side photograph with excessive exposure of the resting teeth and gingiva when smiling, lower third of the face increased in relation to the medium third, difficulty of lip seal, resting upper lip with short appearance, everted lower lip, retruded mandible and short chin-neck line (Figs 1 and 2).

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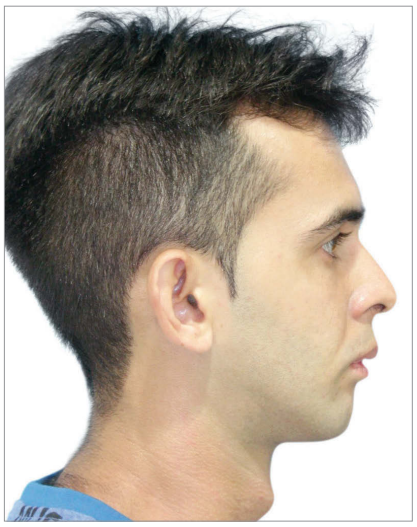




Figure 1 and 2 - Frontal and right side photograph of long face pattern patient.

The Pattern I patients[7-11,13] were identified by the facial normality and characterized by balanced vertical and skeletal sagittal relations on the front and profile evaluations. In frontal photograph they had apparent symmetry, proportion between the facial thirds, proportional volume of the lips vermilion and passive lip seal (Fig 3). On the evaluation of the right side photograph, Pattern I patients had mild facial convexity, expressive chin-neck line and parallel to Camper plane, and esthetically pleasant mentolabial sulcus, built with equal participation of the mentum and lower lip (Fig 4).

The patient's full name, gender and date of birth were obtained also from the orthodontic records. The date of birth allowed the accurate calculus of initial ages of the patients.

All patients that agreed to participate in the research filled out a form with their data, as well as signed a free informed term of consent (FITC), approved by the ethics committee in research (CER) of the University Center of Maranhão (UNICEUMA), protocol number 00469/08, according to standards of the resolution CNS 196/96.

Cephalometry

After evaluation of the photographs from orthodontic records for selection of the sample, the facial pattern was evaluated through cephalometry with variables that determined the facial growth pattern: SN.GoGn, NS.Gn (Axis Y) and AIFH (anterior inferior facial height). Besides these variables, other measurements were performed of the skeletal components (SNA, SNB and ANB), dentoalveolar components ($\underline{1}.\overline{1}$, 1.NA, 1-NA, 1.NB, 1-NB) and bone and tissue profiles (NAPog, nasolabial angle, H-Nose).

The radiographs were performed by the digital panoramic x-ray device (Orthopantomograph OP100-D, Instrumentarium, Palodex group, Tuusula, Finland, 2006). This digital device used a sensor that sent the images captured in the radiographic take to the computer screen. These images were saved in CD and printed in films by laser printer model Dryview 8150. The digital radiographic images were inserted on the program Cef X (CDT Software, Dourados, Mato Grosso, Brazil, version 2.1.24, 1995) and the reference points, lines and planes were demarcated.

The cephalometric facial pattern was determined when the patient showed at least two measures alterated. It was considered: Dolichofacial the patient that showed SN.GoGn with values higher than 34 degrees,[19] NS.Gn (Axis Y) with values higher than 69.9 degrees[19] and AIFH with values higher than 71 mm;[27] mesofacial the patient that showed SN.GoGn with values within 30 and 34 degrees,[19] NS.Gn with values within 63.5 and 69.5 degrees[19] and AIFH with values within 63 and 71 mm[27] and brachyfacial the patient that showed SN.GoGn with values lower than 30 degrees,[19] NS.Gn with values lower than 63.5 degrees,[19] and AIFH with values lower than 63 mm.[27]

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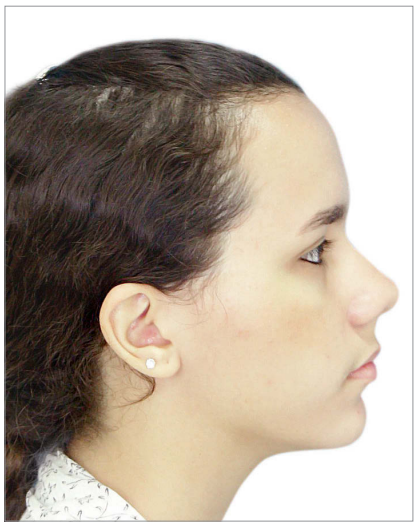




Figure 3 and 4 - Right side and frontal photograph of Pattern I patient.

Clinical assessment

It was filled out a clinical form for each patient containing data obtained from orthodontic records and observations such as: Initial age, presence of open bite and/or crossbite and classification of Angle's malocclusion.

The patients classified with presence of posterior crossbite, were those with abnormal buccolingual relation between superior and inferior teeth, of at least three teeth, when the dental arches were in centric relation, being uni or bilateral[25] and with presence of anterior open bite when showed a negative overbite between the edges of anterior, superior and inferior teeth, with measurement larger than 1 mm, obtained in millimetric ruler.[25]

On the investigation of the dental relation, it was observed a sagittal relation between the upper and lower permanent first molars.[2] The patients were classified as Class I, when presented a molar relation with the upper permanent first molar's mesiobuccal cusp occluding the lower permanent first molar's mesiobuccal sulcus,[2] as Class II when presented the lower permanent first molar positioned distally in relation to the upper permanent first molar and as Class III when presented the lower permanent first molars situated mesially to the upper permanent first molars.[2]

Statistical analysis

Method error

To determine the reliability of the obtained cephalometric results, after 15 days, it was randomly selected a group of 20% of the radiographs, that were digitalized again and had their points demarcated by the same researcher. It was applied the dependent Student's t test in order to assess the systematic error.[18] For evaluation of the random error it was used the Dahlberg's formula.[12]

Statistical test

It was used the descriptive statistics (mean and standard deviation) for initial age and all cephalometric measures used.

The independent t test was applied to verify the compatibility between the initial ages of studied groups and to compare the cephalometric variables between groups.

It was applied the Chi-square test to evaluate the compatibility of groups regarding the proportion between genders, to verify the association between subjective facial pattern and cephalometric facial pattern and to evaluate the association of Long Face pattern and intraoral characteristics (posterior crossbite, anterior open bite and Angle's malocclusion).

Besides these tests, it was determined the prevalences of cephalometric facial patterns, posterior crossbite, anterior open bite and the type of Angle's malocclusion in relation to subjective facial pattern. Results with $p < 0,05$ were considered statistically significant. Tests were applied through BioEstat 5.0 (AYRES, Sociedade Civil Mamirauá, MCT-CNPq, Belém, PA, Brazil, 2005).

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RESULTS

The sample consisted of photographs and teleradiographs of 60 patients, divided in two groups according to facial pattern (Table 1).

Regarding the method error, for the cephalometric variables it was not detected any random error and only one systematic error. For the variable NS.Gn, it was found, on the first measurement, a mean value of 72.62 degrees, and for the second measurement a mean value of 73.97 degrees. Considering that it occurred only one systematic error (7.15%) with variation of 1.35 degrees between the measurements, and none random error, the obtained results can be considered reliable.

The groups were compatible in relation to age and distribution of genders (Tables 2 and 3).

Regarding cephalometric variables, the studied groups presented statistically significant differences in: NS.GoGn, NS.Gn, AIFH, ANB, 1.1, 1-NA, 1.NB, 1-NB, NA.Pog (Table 2).

The Long Face pattern was associated to dolichofacial cephalometric facial pattern, and the Pattern I was associated to mesofacial cephalometric facial pattern (Table 3).

The Long Face pattern patients were associated to posterior crossbite, anterior open bite and Angle Class II malocclusion (Table 3).

Among the Long Face pattern patients 93.3% were dolichofacial patients, 43.3% with presence of posterior crossbite, 16.6% with presence of anterior open bite and 60% with Angle Class II malocclusion (Table 4).

Now, on the group of Pattern I patients 83.3% were mesofacial patients, 13.3% with presence of posterior

Table 1 - Classification of the sample according to age and gender.

Variables	GROUP 1 (n = 30) LONG FACE	GROUP 2 (n= 30) PATTERN I
Age		
Mean ± SD	13.43 ± 2.95	12.83 ± 3.02
Maximum age	9	9
Minimum age	18	19
Gender		
Male	13	13
Female	17	17

Table 2 - Comparative analysis of cephalometric variables and age between groups, according to independent t test.

Variables	GROUP 1 (n = 30) LONG FACE Mean ± SD	GROUP 2 (n= 30) PATTERN I Mean ± SD	p
Skeletal components			
SNA (degrees)	82.86 ± 4.29	82.59 ± 4.00	0.802
SNB (degrees)	78.00 ± 4.49	79.06 ± 3.92	0.333
ANB (degrees)	4.85 ± 2.22	3.57 ± 2.01	0.022*
Growth pattern			
SN.GoGn (degrees)	41.80 ± 6.78	34.37 ± 6.77	0.000*
NS.Gn (degrees)	70.90 ± 4.64	67.76 ± 4.03	0.006*
AIFH (mm)	77.49 ± 8.88	68.64 ± 6.23	0.000*
Dentoalveolar components			
1.1 (degrees)	117.11 ± 14.56	124.79 ± 10.58	0.022*
1.NA (degrees)	26.27 ± 10.24	23.02 ± 7.26	0.161
1-NA (mm)	6.27 ± 3.91	4.45 ± 2.33	0.033*
1.NB (degrees)	31.80 ± 7.39	27.80 ± 6.13	0.026*
1-NB (mm)	8.32 ± 2.87	5.78 ± 2.42	0.000*
Osseous profile x tissue profile			
NA.Pog (degrees)	9.14 ± 4.91	6.07 ± 4.69	0.016*
ANL (degrees)	98.84 ± 13.54	101.24 ± 9.88	0.435
H-Nose (mm)	2.18 ± 4.62	2.99 ± 3.19	0.434
Compatibility between ages			
Age	13.43 ± 2.95	12.83 ± 3.02	0.444

*Statistically significant ($p < 0.05$).

Table 3 - Analysis of the compatibility of genders, facial pattern, cephalometric facial pattern, posterior crossbite, anterior open bite and classification of the Angle's malocclusions between the groups, according to Chi-square test.

Variables	GROUP 1 (n = 30) LONG FACE	GROUP 2 (n=30) PATTERN I	Total	χ^2	P
Gender					
Female	17	17	34	0.00	1.00
Male	13	13	26		
Cephalometric facial pattern					
Brachyfacial	0	3	3	45.126	
Dolichofacial	28	2	30		0.000*
Mesofacial	2	25	27		
Posterior crossbite					
Absence	17	26	43	6.65	0.010*
Presence	13	4	17		
Anterior open bite					
Absence	25	30	55	5.45	0.020*
Presence	5	0	5		
Angle classification					
Class I	11	21	32	7.125	
Class II	18	9	27		0.028*
Class III	1	0	1		

*Statistically significant ($p < 0.05$).

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Table 4 - Prevalence of cephalometric facial patterns, posterior crossbite, anterior open bite and type of Angle's malocclusion on the different groups.

Variables	GROUP 1 (n=30) LONG FACE	GROUP 2 (n=30) PATTERN I
Cephalometric facial pattern		
Brachyfacial	0%	10%
Dolichofacial	93.3%	6.6%
Mesofacial	6.6%	83.3%
Posterior crossbite		
Absence	56.6%	86.6%
Presence	43.3%	13.3%
Anterior open bite		
Absence	83.3%	100%
Presence	16.6%	0%
Angle classification		
Class I	36.6%	70%
Class II	60%	30%
Class III	3.3%	0%

crossbite, 70% with Angle Class I maloccusion and 30% with Angle Class II malocclusion. However, no Pattern I patient presented anterior open bite (Table 4).

DISCUSSION

The subjective facial analysis represents an important tool of orthodontic diagnosis,[13] that can be easily used for identification of Long Face pattern patients. These patients generally present several occlusal problems that may be associated to this facial growth pattern as: posterior crossbite, anterior open bite and Class II malocclusion. Many times, when the problem of vertical growth is identified through the face, the problem is also cephalometrically confirmed, however, when the problem is diagnosed cephalometrically first, it is not necessarily confirmed on the face, ie, the facial analysis allows a more accurate diagnosis of the Long Face pattern.

On the cephalometric assessment, the groups presented significative differences in relation to the following variables: SN.GoGn, NS.Gn, AIFH, ANB, 1.1, 1-NA, 1.NB, 1-NB and NA.Pog. The Long Face pattern patients presented increase on the angles: SN.GoGn (41.80±6.78), NS.Gn (70.90±4.64), indicating vertical growth pattern; NA.Pog (9.14±4.91), showing increase of convexity of the bone profile; ANB (4.85±2.22), evidencing the increase on degree of sagittal discrepancy between maxilla and mandible and 1.NB (31.80±7.39) indicating vestibularization of lower incisors in relation to bone base. The linear measures 1-NA (26.27±10.24), 1-NB (8.32±2.87) and AIFH (77.49±8.88) were increased; indicating protrusion of upper and lower incisors and increase of the lower third of the face. The measure 1.1, that also presented significative difference between groups, showed decreased value for Long Face pattern patients, factor indicative of maxillomandibular retrusion.

Cardoso et al[11] also found significative differences in relation to the variables ANB, AIFH, SN.GoGn and NA.Pog when compared the cephalometric characteristics of Long Face pattern and of Pattern I.[11] They observed that Long Face pattern individuals presented increase of the cephalometric measures located below the palatal plane.[11]

Capelozza Filho et al[8] evaluating the cephalometric characteristics of Long Face pattern, did not observe significative differences in relation to sexual dimorphism and showed that male Long Face pattern patients, when compared to Pattern I patients, presented disparities in relation to magnitudes related to facial height, to growth pattern and to sagittal relation.

The assessment of maxillomandibular relation, based on value of angle ANB, was greater also in Long Face pattern individuals evaluated by Cardoso et al[9] and Capelozza Filho et al,[8] showing the tendency to Class II malocclusion that the carriers of this deformity present. The values for anterior and inferior facial height were higher for the Long Face pattern group with statistical significance, also observed in studies performed by Cardoso et al[9] and Capelozza Filho et al.[8] This result was also expected, since the increase on anterior inferior facial height constitutes the essence of the studied disease, being frequently found in literature.

Regarding the mandibular plane (SNGoGn), the mean values of this angle for Long Face pattern individuals were close to the maximum values of Pattern I individuals. This implies on the necessity of association of several cephalometric characteristics for definition of the Long Face pattern. Values above 37 degrees for the angle of the mandibular plane were reported in litera-

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ture[4,14,15,16,20,28,29] as parameter to define Long Face pattern individuals. Although the values found in the studies performed by Capelozza Filho et al[8] and Cardoso et al[9] overcome this value, they cannot be used separately. In fact, the disease consists in an imbalance between the vertical components, and, therefore, a single parameter must not be used; therefore in this study it was associated to the mandibular plane (SN.GoGn), the measurement of the Y axis of growth (Ns.Gn) and the measurement of the anterior and inferior facial height for determination of cephalometric facial pattern.

The mandibular retrusion was emphasized with the assessment of NAP angle which was significantly different between Long Face pattern and Pattern I groups also in the study by Cardoso et al,[10] showing greater mandibular retrognathia and convexity of bone profile in Long Face pattern patients.

As for the cephalometric growth pattern, it was obtained 93,3% of dolichofacial patients on Group 1 (Long Face pattern) and 83.3% of mesofacial patients on Group 2 (Pattern I). The Chi-square test showed presence of association between the subjective facial pattern and the cephalometric facial pattern, which allows to conclude that the studied facial patterns, classified by the subjective analysis, are associated to cephalometric classification of the facial pattern, enabling the methodology used for identification of patients by subjective facial analysis, besides allowing the comparison between results from this study and other results from works in literature.

The patients on Group 1 presented a prevalence of 43.3% of posterior crossbite and the patients on Group 2 presented 13.3% of posterior crossbite. In relation to the Chi-square test it was observed an association between facial pattern and posterior crossbite. The prevalence of posterior crossbite in Long Face pattern patients is according to the observed in a study by Cardoso et al[10] in which the authors showed a prevalence of 34.2% of this malocclusion.

Regarding the presence of anterior open bite, the patients on Group 1 presented a prevalence of 16.6%, while on Group 2, no patients showed anterior open bite. In relation to the Chi-square test, it was observed an association between the Long Face pattern and the presence of anterior open bite.

About Angle's classification, the patients on Group 1 presented: 36.6% Class I, 60% Class II and 3.33% Class III; now the patients on Group 2 presented: 70% Class I and 30% Class II. As result of the Chi-square test, it was found an association between the facial pattern and Angle's classification. Patients on Group 1 were associated to Class II malocclusion and patients on Group 2 were associated to Class I malocclusion. This result agrees with the study performed by Cardoso et al[10] who found in Long Face pattern patients the following prevalences in relation to Angle malocclusions: 13.2% Class I, 71% Class II and 15.8% Class III. Probably, the Long Face pattern is associated to Class II malocclusion for these patients present a clockwise mandibular rotation, which facilitate a Class II sagittal relation.

CONCLUSIONS

The Long Face pattern was associated to Angle Class II malocclusion, to presence of posterior crossbite and to anterior open bite. The subjective Long Face pattern was associated to dolichofacial cephalometric facial pattern.

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Surgical-orthodontic treatment of Class III malocclusion with agenesis of lateral incisor and unerupted canine

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Introduction: Orthodontic-surgical treatment was performed in patient with skeletal Class III malocclusion due to exceeding mandibular growth. Patient also presented upper and lower dental protrusion, overjet of -3.0 mm, overbite of -1.0 mm, congenital absence of tooth #22, teeth #13 and supernumerary impaction, tooth #12 with conoid shape and partly erupted in supraversion, prolonged retention of tooth #53, tendency to vertical growth of the face and facial asymmetry. The discrepancy on the upper arch was -2.0 mm and -5.0 mm on the lower arch.

Methods: The pre-surgical orthodontic treatment was performed with extractions of the teeth #35 and #45. On the upper arch, teeth #53, #12 and supernumerary were extracted to accomplish the traction of the impacted canine. The spaces of the lower extractions were closed with mesialization of posterior segment. After aligning and leveling the teeth, extractions spaces closure and correct positioning of teeth on the bone bases, the correct intercuspation of the dental arch, with molars and canines in Angle's Class I, coincident midline, normal overjet and overbite and ideal torques, were evaluated through study models. The patient was submitted to orthognathic surgery and then the post-surgical orthodontic treatment was finished.

Results: The Class III malocclusion was treated establishing occlusal and facial normal standards.

Keywords: Orthodontics. Angle Class III malocclusion. Oral surgery.

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

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INTRODUCTION

The Class III malocclusions are characterized by more anterior positioning of the mandible in relation to the maxilla, considering that the discrepancy can be caused by the maxilla growth deficit, excessive mandibular prognathism or the combination of both.[5,8,9,16,17] In general, the facial aspect is very compromised, motivating the patient to seek treatment.[4,13,19] Regarding etiology, factors such as heredity and the environmental action are considered relevant. The treatment of the Class III malocclusion in adults is limited, requiring a multidisciplinary planning that provides functional and esthetic benefits for the maxillomandibular complex. The options may be a compensatory treatment or combined treatment, consisted of orthodontic-surgical treatment that may require advancement of the maxilla, retraction of the mandible or a combination of both.[20] The main objectives of the orthognathic surgery are to obtain normal occlusion and improve the facial esthetic, resulting on the balance of the soft tissues of the face, besides the obtainment of functional improvement on mastication, phonation, breathing and occlusion,[15,20] the reported case, also presents dental impaction, prolonged retention of deciduous tooth and presence of supernumerary tooth, that are common characteristics of orthodontic patients.[2,10,12,14] For the success of dental traction, achieving an ideal positioning of the crown and root, previous procedures as the extraction of supernumerary teeth may be necessary.[1,6,11,24,25]

CASE REPORT

Female Caucasian patient, 14 years and 8 months old, presenting Angle Class III malocclusion, skeletal Class III pattern due to mandibular excessive growth, superior and inferior dental protrusion, overjet of -3 mm, overbite of -1 mm, congenital absence of tooth #22, teeth #13 and supernumerary impacted, tooth #12 with conoid shape and partly erupted in supraversion, prolonged retention of tooth #53, tendency to vertical growth of the face and facial asymmetry. Patient main complaint was the malposition of the teeth.

FACIAL AND FUNCTIONAL ANALYSIS

Analysis showed facial asymmetry, with concave profile, normal nasolabial angle, deficiency on the paranasal region, increased lower facial third, normal lip thickness with mentum prominence. On the functional analysis it was found: Nasal breathing, normal phonation, atypical



Figure 1 - Extraoral and intraoral initial photographs.

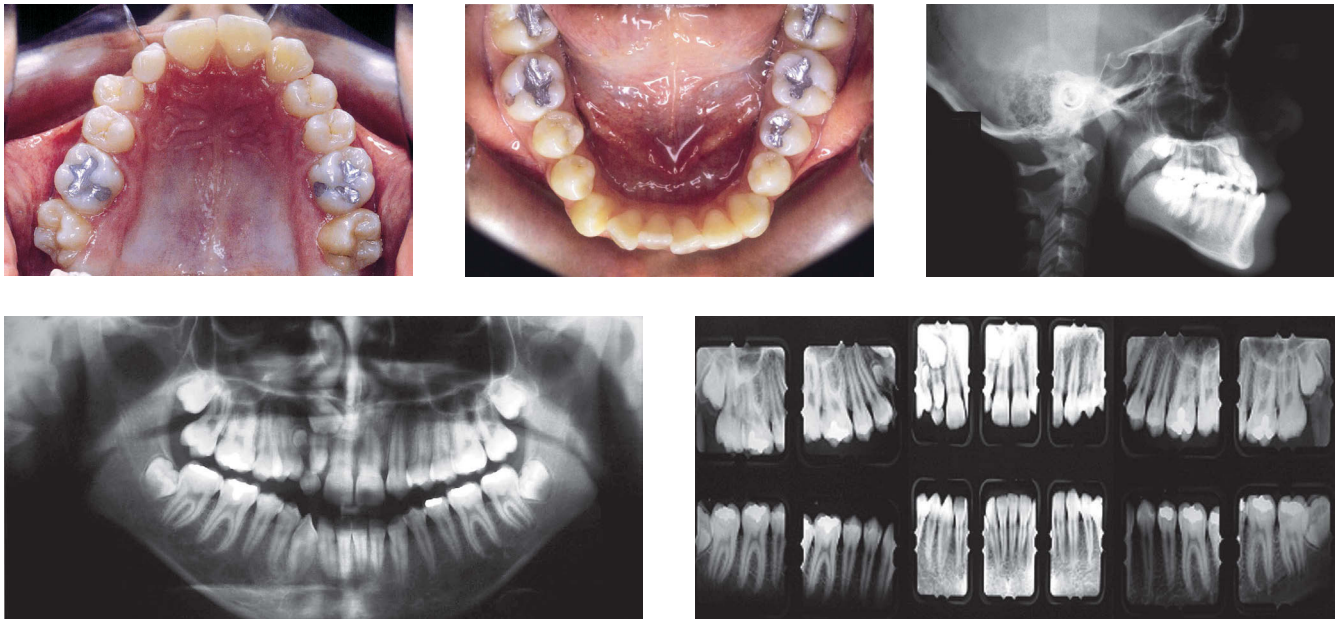


Figure 2 - Occlusal photographs and initial radiographs.

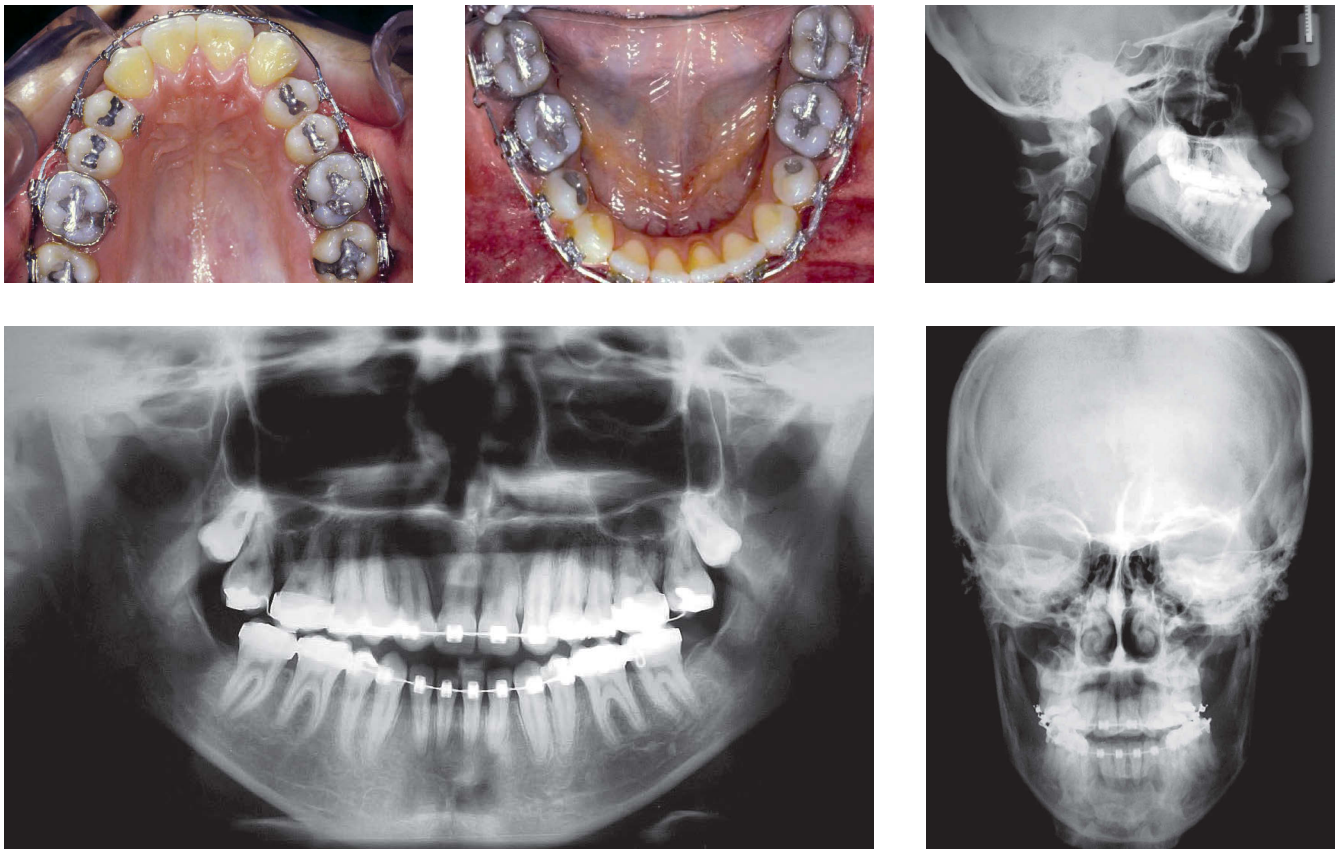


Figure 3 - Occlusal photographs and pre-surgical radiographs.

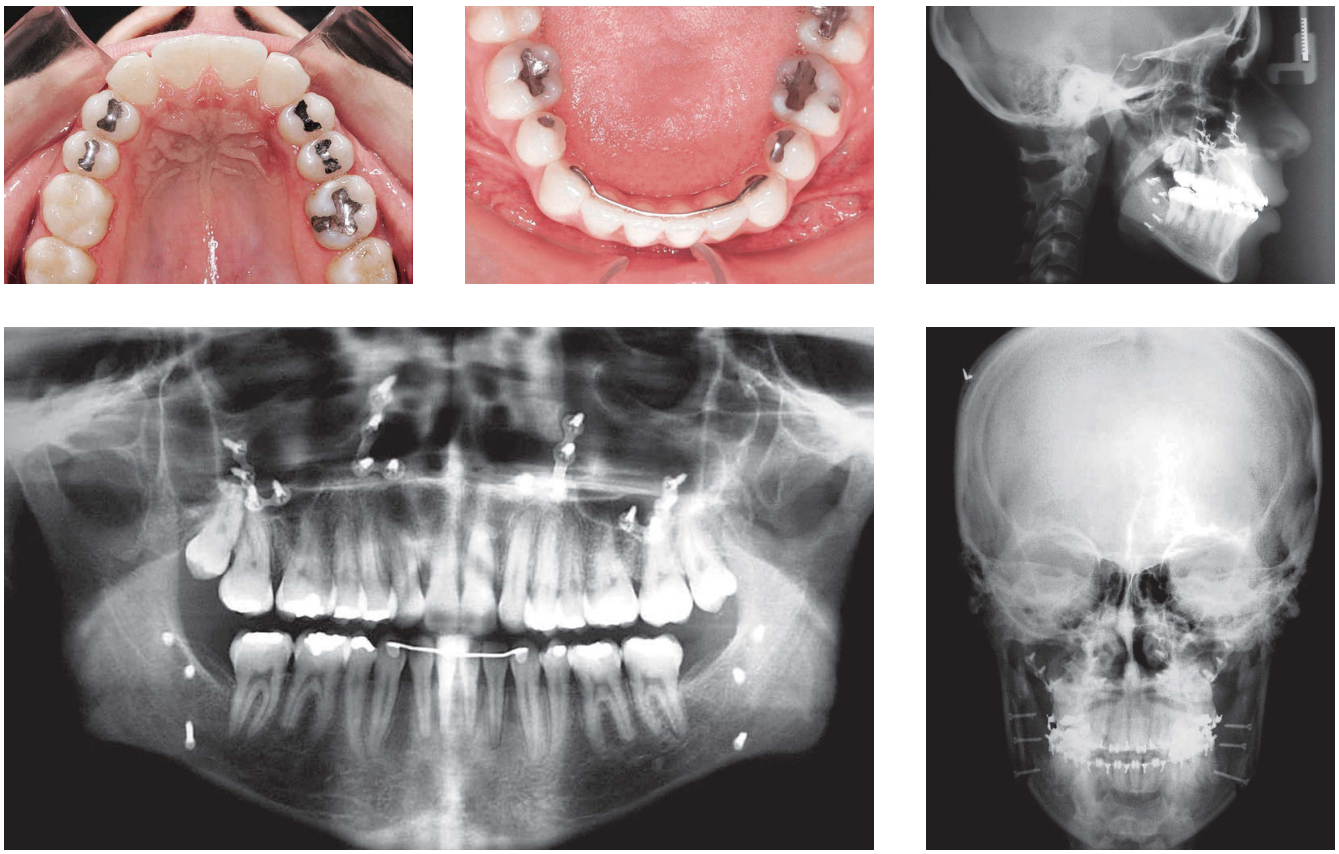


Figure 4 - Occlusal photographs and final radiographs.

swallowing, normal pharyngeal and palatine tonsils, with upper and lower lips in normal function, mandibular closing pattern with deviation to the right and ATM without any anomalies, however, presenting painful symptomatology during intense mastication.

INTRAORAL CLINICAL EXAMINATION

The patient presented good oral hygiene, periodontium with aspect of normality, absence of carious lesions, dental anomaly of number, shape and size, labial and lingual frenum with normal insertions and Class III relation of molars. According to Angle's classification, the patient presented a Class III malocclusion, with superior and inferior midline deviation to the right.

INTERPRETATION OF CEPHALOMETRIC MEASURES AND ANALYSIS OF MODELS

On the analysis of the skeletal pattern it was observed maxillary retrusion, mandibular protrusion, skeletal Class III malocclusion (ANB = -2°), tendency to vertical growth of the face (NSGn = 69°, SN.GoGn = 37°) with dolichofacial morphological pattern, according to Steiner's measures.[23,24] The measures of the dental pattern showed protrusion and increase of axial inclinations of upper incisors (1-NA = 6 mm and 1.NA = 25°) and protruded lower incisors with normal axial inclinations (1-NB = 7 mm and 1.NB = 25°). The occlusal plane was inclined in relation to cranial base. On the model analysis,[5,20] it was verified that the discrepancy on the upper arch was of -2 mm and -5.0 mm for the lower arch, upper arch contracted in relation to the lower and deep ogival palate. The upper midline, evaluated on study models, was 1.5 mm deviated to the right and the lower 3.5 mm to the right side, confirming the facial assessment.

PRE-SURGICAL ORTHODONTIC TREATMENT

The orthodontic treatment was initiated with the installation of the standard edgewise appliance (0.022 x 0.028-in), consisted of bracket bonding on

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Figure 5 - Final extraoral and intraoral photographs.



Figure 6 - Observe the canines esthetics.

upper and lower teeth, cemented rings on first molars of both arches and second lower molars.

It was initiated the alignment and levelling of the upper arch with stainless steel 0.014-in, 0.016-in, 0.018-in and 0.020-in archwires.

It was performed extraction of the teeth #53 (deciduous upper right canine), supernumerary and tooth #12 (lateral upper right incisor). On the same surgical act, it was performed button bonding to the tooth #13 in order to perform traction.

It was also indicated extraction of teeth #38 and #48, with a minimum of six months before the orthognathic surgery so that there was enough time for bone formation on the location where it would be performed the mandibular osteotomy.

The traction was done through a chain elastic and rubber type action line (GAC), connected to the tying wire installed during the act of dental extractions.

After traction, the right upper canine, was aligned and leveled through new stainless steel 0.014-in, 0.016 -in, 0.018-in and 0.020-in archwire.

For the lower arch, extraction of the second premolars was required. Alignment and levelling stainless steel 0.014-in, 0.016 -in, 0.018-in and 0.020-in archwires were made and installed, with anchorage type C planned on both sides.

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Table 1 - Table with initial and final values of the Steiner analysis.

Measures	Normal values	Age	
		14 years	22 years
SNA	82,0°	80,0°	84,0°
SNB	80,0°	82,0°	82,0°
ANB	2,0°	-2,0°	2,0°
SND	78,0°	78,0°	77,0°
1-NA	4,0 mm	6,0 mm	6,0 mm
1.NA	22,0°	25,0°	25,0°
1-NB	4,0 mm	7,0 mm	6,0 mm
1.NB	25,0°	25,0°	25,0°
Pg-NB		1,0 mm	1,0 mm
Pg-NB / (1-NB)		6,0 mm	5,0 mm
1.1	131,0°	133,0°	127,0°
SN.PlO	14,0°	21,0°	14,0°
SN.GoGn	32,0°	37,0°	32,0°
NSGn	67,0°	69,0°	69,0°
Line S-Ls 0	0 mm	-1 mm	0 mm
Line S-Li 0	0 mm	5 mm	3 mm

On the lower arch 0.020-in, the partial distalization of the first molars and canines, was performed to obtain the alignment of the incisors. After finishing the alignment and leveling, the spaces were closed with loss of anchorage and mesialization of the first and second molars.

With the complete closure of the spaces ideal lower rectangular archwire 0.019 x 0.025-in, coordinated with the opposite and with necessary torques was set.

After alignment and levelling of both arches, closing of spaces from extractions, correct positioning of teeth on the bone base with ideal torques for each tooth, it was obtained study models to evaluate, on the pre-surgical phase, the correct intercuspation (Class I of molars and canines with coincident midlines).

Interdental hooks were welded on the upper and lower arch 0.019 x 0.025-in, for metallic individual tying wire. In this stage the patient was referred to combined orthognathic surgery of maxilla and mandible.

POST-SURGICAL ORTHODONTIC TREATMENT

The post-surgical orthodontic treatment consisted in finishing the intercuspation and the occlusal functions, through the adjustment of torque, characterization of upper canines in lateral incisors and use of intermaxillary elastics.

Functional adjustments of teeth #14 and #24 that substituted the upper canines were performed to obtain guides of disocclusion, Extractions of teeth #18 and #28 were also performed.

The upper and lower fixed appliances were removed and the retainers were installed, being in the upper arch a modified Hawley plate and, in the lower arch, lingual bar bonded to teeth #33 and #43 (Figs 5 and 6).

The patient was orientated to use upper retainer 24 hours a day, during a period of 12 months and after that the period of use should be overnight. The lower retainer should be kept for undetermined period. It was also recommended a speech treatment for adaptation to new muscle functions.

FINAL CONSIDERATIONS

The objectives of the treatment were achieved with the association of the orthodontic-surgical treatment. Molar Class I relation and normal overjet and overbite were obtained. It was performed the traction of tooth #13, which, along with teeth #23, replaced lateral upper incisors. The Class III malocclusion was well corrected, establishing a normal occlusal, facial and functional patterns.

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Evaluation of metallic brackets adhesion after the use of bleaching gels with and without amorphous calcium phosphate (ACP): *In vitro* study

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Objective: To evaluate *in vitro* the effects of tooth whitening using gel with Amorphous Calcium Phosphate (ACP) on the bond strength of metal brackets.

Methods: Thirty-six bovine incisors were sectioned at the crown-root interface, and the crowns were then placed in PVC cylinders. The specimens were divided into 3 groups (n = 12) according to whitening treatment and type of gel used, as follows: G1 (control) = no whitening; G2 = whitening with gel not containing ACP (Whiteness Perfect - FGM), G3 = whitening with gel containing ACP (Nite White ACP - Discus Dental). Groups G2 and G3 were subjected to 14 cycles of whitening followed by an interval of 15 days before the bonding of metal brackets. Shear bond strength testing was performed on a Kratos universal test machine at a speed of 0.5 mm/min. After the mechanical test, the specimens were assessed to determine the adhesive remnant index (ARI). The results were subjected to ANOVA, Tukey's test and Kruskal-Wallis test (5%).

Results: Significant differences were noted between the groups. Control group (G1 = 11.10 MPa) showed a statistically higher shear bond strength than the groups that underwent whitening (G2 = 5.40 Mpa, G3 = 3.73 MPa), which did not differ from each other. There were no significant differences between the groups in terms of ARI.

Conclusion: Tooth whitening reduces the bond strength of metal brackets, whereas the presence of ACP in the whitening gel has no bearing on the results.

Keywords: Tooth whitening. Dental bonding. Shear bond strength. Orthodontics. Tooth enamel.

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INTRODUCTION

Human beings' motivation towards body esthetics and beauty has been increasingly extended to the smile.[29] Dental esthetics is now a primary factor in seeking dental treatment, thus rendering teeth whitening a very sought procedure. Therefore, today this procedure is usually performed prior to different treatments in dentistry, such as tooth alignment with orthodontic appliances.

To be successful, orthodontic treatment with fixed appliances depends, among other factors, on proper bonding of brackets and a lasting retention of these attachments to the teeth. The need to rebond orthodontic attachments can severely hinder treatment progress, thereby increasing biological and financial costs.[22] These attachments are placed on the tooth enamel and are subject to a wide range of intraoral forces, which is often entirely delivered to the bonding adhesive layer and the adhesive/enamel interface.[6] Thus, any treatment of the tooth surface using chemicals – such as whitening agents – could potentially affect bond strength.[22]

Nowadays, teeth whitening is a widespread cosmetic procedure in society, with a number of whitening products available in the market. Among the existing techniques, at-home whitening, which involves low concentrations, has evolved into a very popular technique given its effectiveness and convenience.[7] However, even with the use of low concentrations, several studies report changes in tooth structure in the whitened areas.[18,31] There are differences in the degree of adverse effects caused by whitening vital teeth.[30]

Although it has been found that whitening teeth with carbamide peroxide at 10% does not interfere with bond strength to the enamel when performed prior to the bonding of brackets,[2] there have been reports[18] of interferences with the mechanical bonding of orthodontic appliances to enamel previously subjected to the whitening procedure. Remnants from the whitening material possibly interfere with the composite by changing or preventing the formation of tags, thus impairing mechanical bond strength.

Some of the noteworthy changes occur in the mineral content of the whitened teeth, which can generate: Increased porosity and permeability of the enamel, which reduces its microhardness, undermines bond strength after whitening, and an increase in dentin hypersensitivity during and after treatment.[5] In an attempt to avoid or minimize the undesirable effects that may occur in the whitened tooth structure dental products have been launched on the market with some changes in their composition.

Recently, whitening gels and amorphous calcium phosphate (ACP), or just calcium, have been added to the composition. Manufacturers claim that these substances can supply minerals to the whitened tooth structure and thereby prevent the emergence of porosities and erosions. Additionally, they contribute to reducing trans- and postoperative sensitivity by decreasing enamel permeability, inhibiting neural activation and/or obliterating exposed and open dentinal tubules.[11] However, few studies have been published on the behavior of these whitening gels as well as how their use can influence the bond strength of orthodontic appliances. The present study therefore aimed to use these new products as a means to investigate the potential effects of employing them prior to bracket bonding.

OBJECTIVE

To evaluate, *in vitro,* the bond strength of orthodontic brackets after tooth whitening with and without ACP through mechanical shear bond tests. The adhesive remnant index (ARI) of orthodontic brackets after the use of different dental whitening agents was also examined.

MATERIAL AND METHODS

This study was approved by the Ethics Committee for Animal Research (CEPAN) of the Pará State University (UEPA) under file nº 067-2009.

The study included 36 recently extracted bovine teeth, all permanent mandibular incisors, supplied by a slaughterhouse in the city of Belem, Pará State (PA). The selection criteria required that each tooth enamel be intact, with no cracks and no prior use of chemical agents. Teeth with anatomical irregularities in their labial surfaces were also excluded from the study. The specimens were stored in aqueous solution, and the water was changed every 5 days at room temperature.

After the extractions, followed by removal of periodontal tissues and rinsing, the teeth were stored in distilled water. Thereafter, the root portion was removed with a stainless steel disc (Starret - Germany)

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at low speed, the pulp was removed with endodontic curettes (Ice - SP). Subsequently the crowns were attached to 25 x 20 mm PVC cylinders with self-curing acrylic resin (JET, São Paulo, SP), so that the most prominent portion and central labial surface of the teeth was exposed perpendicularly to the cylinder. This position was obtained with the aid of a square by determining a 90° angle between the labial surface of the crown and the cylinder base.

Prophylaxis was performed on the labial surface of the teeth with a rubber cup and pumice (fine-grained and without fluoride - JET-São Paulo/SP) for 10s and then each specimen was rinsed with water/air sprays for an equal time length.

Groups

The specimens were randomly divided into three groups (n = 12) according to whether or not they had been whitened, and the type of whitening gel (Table 1). The gels were applied as recommended by the manufacturers on the labial surface of the enamel in a layer about 0.5 mm thick, which corresponded to one cycle. Upon completion of each gel application cycle the specimens were washed with air/water jets for 30 seconds, and thereafter immersed in distilled water renewed weekly and stored at 34° C room temperature on average. Fourteen cycles were carried out spanning a 15-day time interval since the end of the whitening treatment. Only then were the brackets bonded to the teeth.

Standard Edgewise metal brackets with slots 0.022 x 0.028-in (Abzil, 3M/Unitek, São José do Rio Preto/SP, Brazil) were bonded to the maxillary central incisors. The size of the bracket base, as informed by the manufacturer, was 14.35 mm.[2] The base featured metal mesh type mechanical retention. Transbond XT adhesive system (3M Unitek, Monrovia, CA, USA) was used for bonding the brackets. The brackets were bonded to the tooth surface with the slot parallel to the base of the cylinder, following the manufacturer's protocol.

To perform the shear bond strength test of the specimens a Kratos TRCV59DUSB universal mechanical testing machine (Jundiaí, SP, Brazil) was utilized at a speed of 0.5 mm/min (ISO 11405:2003)[14] with a chisel tip. Shear bond strength results were obtained in kgf, converted to N, and divided by the bracket base area (14.35 mm^2), yielding the results in MPa.

After conducting the test, the labial surface of each specimen was evaluated by stereomicroscopy (Opton, Germany) with 8x magnification to measure Adhesive Remnant Index (ARI), as recommended by Årtun and Bergland,[1] where 0 = no composite remnant adhered to the enamel, 1 = less than half of composite adhered to the enamel, 2 = more than half of composite adhered to enamel, 3 = all composite adhered to the enamel.

Statistical analysis

All data were analyzed for normality by the Shapiro-Wilk test was used for normality analysis of all data. Data were considered normal after excluding an outlier (Group 2). If this specimen had been included the data would have been considered abnormal.

Shear bond strength test results were subjected to analysis of variance (ANOVA) at 5% significance level, and subsequently Tukey's test to compare the control group with the other treatments, and also between the experimental groups (G2 and G3). Kruskal-Wallis test at 5% was used in evaluating ARI scores.

Table 1 - Experimental groups, product/manufacturer and basic composition of whitening gels.

EXPERIMENTAL GROUPS	PRODUCT/MANUFACTURER	BASIC COMPOSITION
GROUP 1		
G1 (n = 12): Standardized bracket bonding, and shear bond test without prior whitening - control group.	_____	_____
GROUP 2		
G2 (n = 12): 14 cycles of at-home whitening without ACP – 15-day time interval immersed in distilled water. Bracket bonding and shear bond test.	Whiteness Perfect / FGM Lot 181209	Carbamide peroxide at 16% + Potassium Nitrate + Fluoride
GROUP 3		
G3 (n = 12): 14 cycles of at-home whitening with ACP – 15-day interval immersed in distilled water. Bracket bonding and shear bond test.	NiteWhite ACP / Discus Dental Lot 08315151	Carbamide peroxide 16% + Potassium nitrate + Calcium + Phosphate

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RESULTS

ANOVA analysis of variance results with p values are depicted in Table 2.

Differences in bond strength between groups are displayed in Figure 1, which shows a significant difference between Group 1 – control (not whitened), and the groups after whitening (Group 2 – conventional whitening product, and Group 3 – whitening product containing ACP). No significant differences were found between the whitened groups.

The value of the Kruskal-Wallis statistical test for ARI was p = 0.0509, indicating a statistically insignificant difference. Figure 2 shows ARI in both groups.

DISCUSSION

A number of studies have evaluated the bond strength of orthodontic brackets bonded to different surfaces.[3,20,27] In this context, preference has been given to central incisor brackets as they feature a flatter base surface, which adapts more easily to the surfaces being tested. These surfaces are normally flat since specimens are seldom fabricated with crown contours, which explains the brackets used in this experiment.

Table 2 - P values of the statistical test between experimental groups.

Groups	p value
Groups 1 and 2	< 0.05
Groups 1 and 3	< 0.01
Groups 2 and 3	n.s.

Nevertheless, it is noteworthy that *in vitro* tests exhibit numerous differences compared with *in vivo* tests. The key difference lies in the fact that the forces which occur during mastication are compressive in nature and pose a greater risk of damage to enamel than forces applied to the bracket/adhesive during shear bond tests.[13] These peculiarities of laboratory tests should be emphasized as they improve variable control. Conversely, clinical studies do not allow these variables to be controlled, which warrants further studies on this topic.

In actuality there is no such thing as a pure shear force *in vivo*, given that the different components combine to influence the bond. Moreover, *in vitro* results undergo significant effects, as shown by Swift Jr., Perdigão;[29] Bishara and Sulieman.[4] Despite the above, this investigation followed the methodology adopted by the ISO/TS11405 standard.

As regards the type of substrate used, bovine teeth have long been considered a good alternative since not only are they more readily available but their enamel structure is similar to that of human teeth. Assessments made by comparative studies involving different substrates show that the bond strength of bovine enamel is quite acceptable, although their bond strength may be lower compared to human teeth.[9,21]

Another noteworthy aspect concerns the storage medium adopted in the present study (distilled water). In bond strength tests of whitened substrates the storage medium used for the specimens plays a role as relevant as it is controversial. Artificial saliva, which

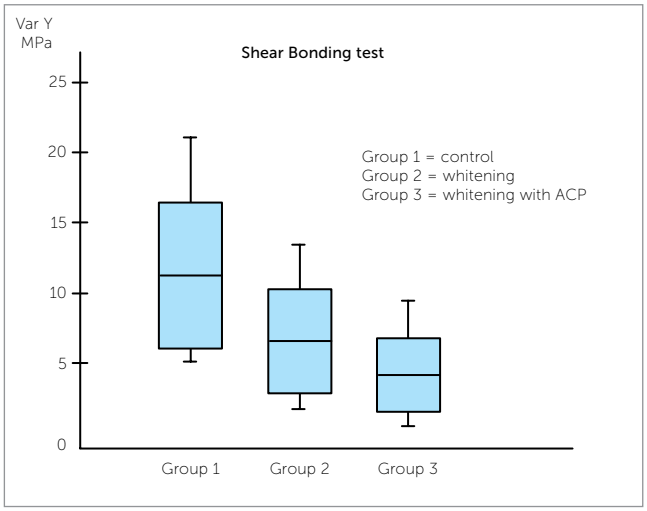


Figure 1 - Shear bond strength values, means and standard deviations of groups 1, 2 and 3.

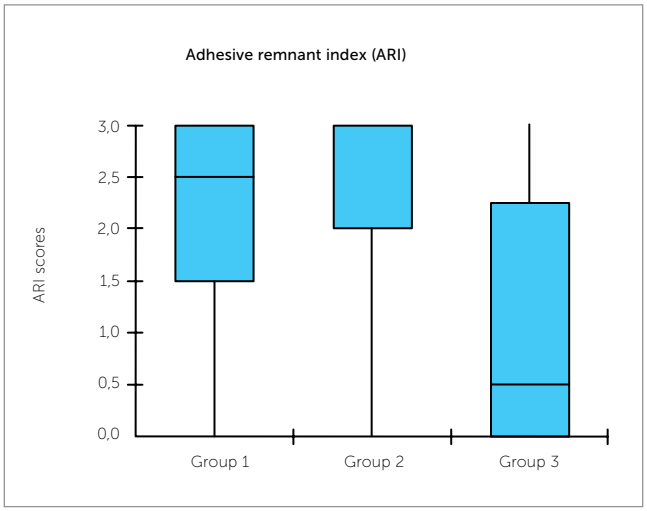


Figure 2 - Adhesive remnant index (ARI), median and quartile in groups 1, 2 and 3.

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has been employed in different studies,[8,10,16,17,28] is primarily aimed at making laboratory tests resemble as closely as possible the clinical conditions actually experienced in routine practice.

As to the mechanical test, it is a known fact that orthodontic brackets require a bond strength capable of withstanding masticatory forces and activation of the mechanics utilized.[21] The minimum acceptable bond strength for routine orthodontic procedures ranges from 6 to 8 Mpa.[21] The results showed unacceptable mean bond strength values for whitened teeth.

Thus, artificial saliva has often been blamed for the lack of differences in bond strength after whitening, according to published studies.[15,19] This finding could be attributed to the remineralizing effect of saliva cited by Souza,[28] who argued that enamel samples treated with 10% carbamide peroxide and stored in artificial saliva display smaller spaces in between the hydroxyapatite crystals. However, other studies[29,30] claim that this potential remineralizing effect of saliva has not yet been properly explained.

Therefore, in order to avert a possible potentiating (remineralizing), or deleterious effect by artificial saliva, which could interfere with the analysis of the results, a storage medium. i.e., distilled water, was chosen as it exerts little or no effect on bond strength.

Residues derived from the degradation of peroxide or oxygen leads to a lower amount of shorter resinous tags compared to teeth not subjected to whitening,[7,18] resulting in lower bond strength as hydrogen peroxide negatively affects the curing of adhesive systems.[12,14,16,23,30]

Therefore, teeth whitening can change the mineral structure of tooth enamel and, hence, affect the bond between this substrate and adhesive systems.[24,25] It is thus necessary to wait for a post-whitening period long enough for the enamel's mineral structure to be restored, and for the residual oxygen of the whitening agent to be completely removed. Although the literature shows significant variation in the length of the post-whitening period recommended before bonding brackets (24h to 4 weeks), Cavalli[8] showed that a minimum of two weeks would be required for the structure to recover its adhesive properties. The results led the authors to believe that 15 days were not sufficient to restore the enamel, suggesting therefore that a longer time interval should be allowed to elapse prior to bonding any orthodontic appliances.

Furthermore, removal of the remaining resin from the tooth surface does not pose a challenge since removal of adhesive remnants from tooth surfaces after removal of the fixed orthodontic appliance is a routine procedure. Thus, the choice of bonding materials depends on a careful assessment of their clinical properties. This finding concerning the adhesive remnant index (ARI) is of great interest to the orthodontist, who can thus choose materials that respond clinically by presenting a greater amount of adhesive remnants on the tooth surface after removal of the brackets. This should ensure greater safety, preventing enamel fractures and preserving tooth integrity.

Although the use of hydrogen peroxide at 35% significantly reduces the amount of resin on the tooth surface after debonding,[31] this study did not reveal any differences in terms of ARI in both whitened and non-whitened teeth, with and without ACP.

Proper orthodontic treatment requires scientific knowledge and special technical skills. It is also paramount that orthodontists be instructed about the wide array of materials of different types and manufacturers currently available for clinical use. There are various products of different origins, both domestic and imported, manufactured specifically for direct bonding of orthodontic attachments to enamel. It is therefore extremely important that these results be applied in clinical practice in order to optimize professional orthodontic treatment, thus avoiding frequent bond failures due to poor bond strength between brackets and tooth enamel.

CONCLUSION

Significant differences were found in the bond strength of metal brackets between whitened and non-whitened teeth. There was a considerable reduction in bond strength in the groups that were subjected to tooth surface whitening. Both whitened groups (2 and 3) failed to achieve a clinically efficient bond strength, especially group 3 (whitened with ACP), underscoring the need to restore the tooth surface and remove all chemical whitening agents prior to bonding the brackets. As regards ARI, there was no statistically significant difference between the 3 groups tested.

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Superficial morphology and mechanical properties of *in vivo* aged orthodontic ligatures

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Introduction: The degradation of elastic ligatures in the oral environment results in the need of periodic replacement to maintain the optimal force during the orthodontic treatment. The purpose of this work was to realize a clinical prospective randomized study of the degradation of orthodontic elastomeric ligatures in the oral environment by scanning electron microscopy (SEM) and tensile strength test.

Method: Two hundred elastic ligatures were randomly selected and placed around the brackets of 5 volunteers and removed in groups of 10, at different times (1, 2, 3, and 4 weeks). The control group was performed by another fifty ligatures which were not submitted to the oral degradation. The analyses were done by scanning electron microscopy (SEM) and mechanical strength test.

Results: The tensile strength test results showed reduction in the ultimate strength values after four weeks ageing in the oral environment and no statistical difference in the yield strength values ($p < 0.05$). The orthodontic elastomeric ligatures surface was significantly degraded in the oral cavity after four weeks. The elastomeric degradation began in the first week when the increase in the roughness could be detected just in some areas. Afterwards, the surface became gradually rougher and, after 4 weeks, it was totally rough with some crack areas.

Conclusions: The aged elastic ligatures in the oral environment showed higher superficial degradation and lower loss of mechanical properties after the maximum experimental period.

Keywords: Elastomers. Elastic ligature. Degradation.

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INTRODUCTION

Polymeric materials have been used in Orthodontics since 1893[14,15] and the elastomers are the main polymers used in it. Orthodontic tooth movement is achieved by low force application for long periods, and the elastomers are the most used method to supply orthodontic force in the tooth movement.[21] Its use is related to the transformation of elastic potential energy in mechanical energy, resulting in tooth movement.[3,12]

Natural rubber (NR) was commercially produced in the beginning of the last century through cultivation and puncture of the rubber tree (*Haevea brasiliensis*), in Amazon, Brazil. The natural polymer synthesized from Haevea species has a high molecular weight average of nearly a million. It is composed of 3 trans-isoprene units at the end of the molecule and of several thousands of cis-isoprene units in the main chain.

Synthetic isoprene rubber (SR) is a polymer with cis-isoprene units combined by 1,4-linkages.[4] The SR has better properties than NR to orthodontic use.[16] Synthetic rubbers are the most used orthodontic polymer because they produce optimal force, are comfortable, are easy to clean and have low cost.[19] Nevertheless, these materials have quick degradation in the oral cavity and, consequently, short lifetime, which is a notable disadvantage. The main causes of the quick degradation are the variation on pH and temperature, the humidity of the environment, the stress, and the bacterial action.[7]

The complex conditions present in the oral cavity cause degradation in elastomers. Some factors of this environment as humidity and temperature can be simulated *in vitro*, but others such as the presence of complex flora and its products can not be. These *in vivo* factors are able to induce substantial alterations in the structure and surface of elastomers.[10]

Thus, the purpose of the present work was to investigate the degradation of orthodontic elastomeric ligatures in the oral environment by scanning electron microscopy (SEM) and tensile strength test.

MATERIAL AND METHODS

Two hundred and fifty elastomeric ligatures obtained from manufacturer (TP Orthodontics, Indiana, USA) were randomly distributed in 5 equal groups composed by fifty test specimens each. Five volunteers who had not had any complicating medicine and had not used antibiotics in the last 2 months were selected from patients about to start their orthodontic treatment with fixed appliances in orthodontic department of Rio de Janeiro Federal University. The patients were invited to participate in the study during 6 weeks. After approval, written consent was given by patient in the moment of placement of appliances. Forty elastomers were kept in the oral cavity of each patient for 1, 2, 3 or 4 weeks and the control group were not placed in the oral environment.

At the first visit, 20 orthodontic elastomeric ligatures were randomly selected and placed around the brackets in the oral cavity from the second premolar on one side to the second premolar on the opposite side, in both arches.

At the second appointment, after one week, 10 ligatures were pulled out (week-1 group). Five of them were evaluated by scanning electron microscopy to analyze the changes in the superficial morphology caused by oral degradation. The other five were submitted to tensile strength test to analyze the changes in the mechanical properties. At the same appointment, 10 new elastomeric ligatures were placed around the brackets which had the ligatures pulled out.

At the third visit, 10 ligatures which have been in the oral cavity for 2 weeks were pulled out (week-2 group) and analyzed in the same way of the first group. At this moment, 10 new ligatures were placed around the brackets.

After 2 weeks, in the fourth appointment, 10 ligatures which have been in the oral cavity for 3 weeks were pulled out (week-3 group) and analyzed as the other groups.

In the last appointment, after 2 weeks more, the ligatures that have been in the oral cavity for 4 weeks were removed (week-4 group) and analyzed by scanning electron microscopy and tensile strength test.

The tensile test was performed in ambient temperature, in a universal test machine (Emic DL 10000, Brazil) with cross-head speed of 2 mm/min and load cell of 50 N. A pair of hooks was done with stainless steel (0.032-in diameter) and adapted in the test machine[11] (Fig 1). The yield strength and the ultimate strength were used as parameters of the tensile test.[21] Tensile strength data were statistically analyzed using one-way ANOVA and compare means with Tukey post hoc test,[5] based on significance level of 0.05%.

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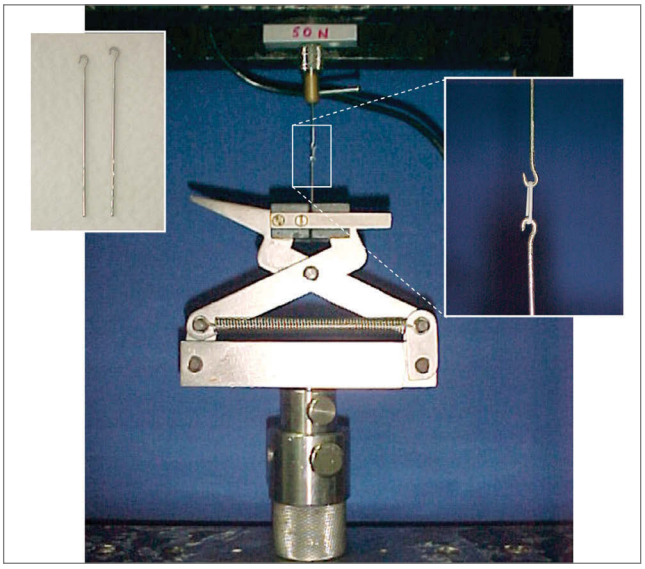


Figure 1 - Tensile strength test adapted with two stainless steel hooks (0.032 inch).

For surface degradation analysis, the test specimens were coated with gold for 3 minutes at a current of 20 mÅ and vacuum of 200 mTorr. The images were obtained by secondary electrons detector using a scanning electron microscope (JSM 5800, Jeol, Tokyo, Japan).[23]

RESULTS

The analysis gave evidences of higher superficial degradation than mechanical properties loss. The tensile strength test results showed few mechanical properties changes in both parameters. The ultimate strength values demonstrated no statistical difference among control, week-1, week-2, and week-3 groups. Although, the week-4 group had been significantly lower than the other groups. The values of yield strength did not show any statistical difference among all groups (Fig 2).

The surface analysis showed gradual degradation indicated by the increase of superficial roughness. Effects of viscoelastic fluency were detectable after the first week and became more intense with increase of the oral permanency time. The superficial roughness raised in specific points in the week-1 group. The week-2 and week-3 groups demonstrated higher area of roughness. In the week-4 group, cracks were visible in elastomeric surfaces and the entire elastomeric surface was rough (Fig 3).

DISCUSSION

The surface morphology of the elastic ligatures has been significantly changed after the normal use in the oral environment during progressive intervals.

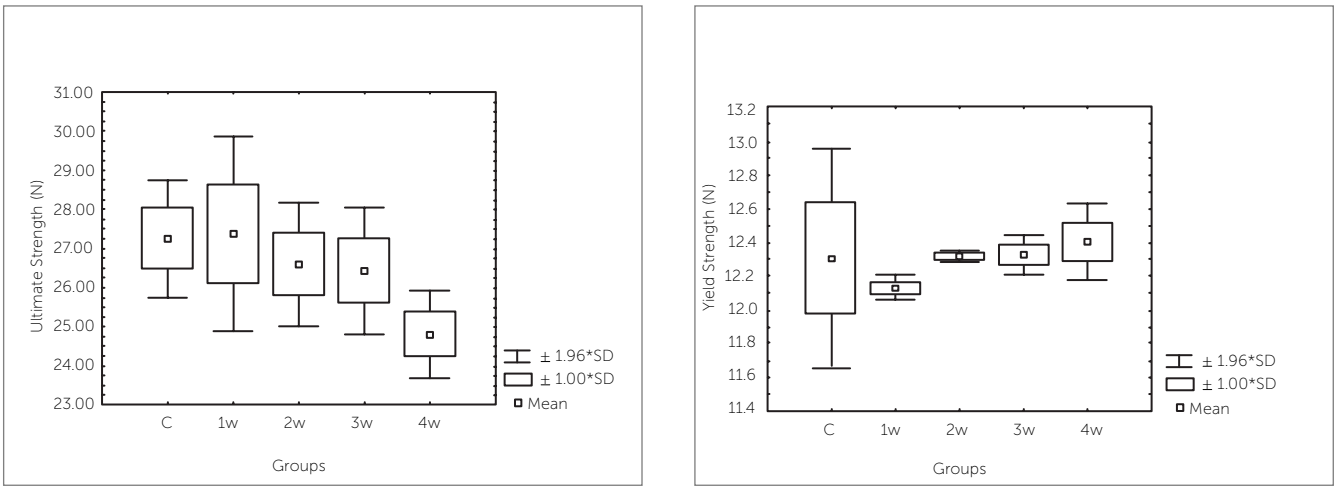


Figure 2 - Box plot graph: difference in ultimate strength and yield strength among groups.

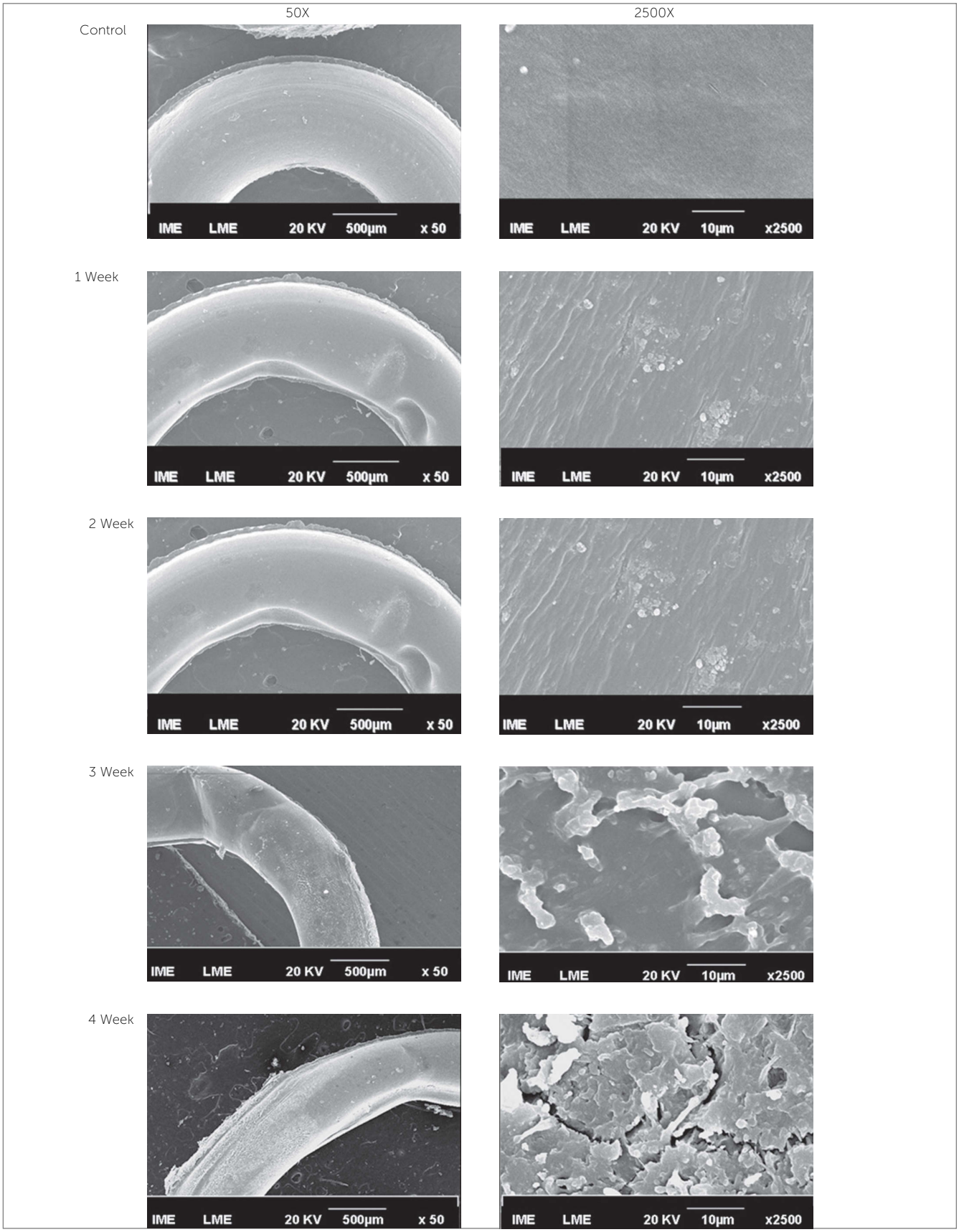


Figure 3 - SEM surface morphology photomicrographs (electron secondary image). Control group: The superficial smoothness of the elastomer; Week-1 group: The effects of viscoelastic fluency are apparent in some specific points; Week-2 group: The increase of deformation points and the presence of biofilm above the elastomer are visible; Week-3 group: The superficial roughness is significantly higher and the thickness of the elastomer is decreased; Week-4 group: The degradation of the elastomer is clearly identified for cracks and roughness in the total area.

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This in-use biomaterial changes were caused by a process known as aging. In the present study the elastic ligatures aging was characterized by the gradual increase in the surface roughness and by few changes in the mechanical properties of the material. Comparing the results of the tensile test and of the SEM analysis, one may suggest that elastomers have higher superficial degradation than loss of mechanical properties.

The orthodontic elastomers are biodegraded in the oral environment mainly by hydrolyses. Their secondary links are broken and the result is the relaxation,[2,13] which is the main characteristic of degradation in orthodontics elastomers. This phenomenon is responsible for the constant replacements of the elastomeric ligatures. The relaxation consequence is the decrease on mechanical energy transmitted to the tooth and finally, the reduction of effectiveness of the tooth movement.[2,11,13,14] After relaxation, the elastomers commonly suffer the effects of viscoelastic fluency. This phenomenon consists in plastic deformation when the elastomer is submitted to forces below the plastic limit.[6,17] Clinically, this effect could be observed in SEM figures. Permanent deformities are visible in all ligatures submitted to the oral environment, although none of them was stressed above their plastic limit (Fig 3).

Hwang and Cha,[14] in an *in vitro* study, observed quick relaxation in elastic chains. The author described reduction of 50% on the initial force in the first 24 hours. Andreasen and Bishara,[1] in an *in vivo* study, described reduction of 74% on initial force after the same degradation time. Some important degradation mechanisms are present just in the oral ambient. In example, the accumulation of plaque on the elastomers and the prolonged contact with enzymes cause significant degradation in these biomaterials.[11] In the present study, a gradual increase of superficial roughness occurred between 1 and 4 weeks. Eliades et al[10] described that elastomeric surfaces were modified by irreversible adsorption of proteinaceous matter forming a biofilm after 24 hours in oral cavity. After 3 weeks, this biofilm on elastomeric surface exhibited excessive mineralization increasing the surface roughness.[10] In agreement, the SEM figures of week-1, 2, 3 and 4 groups exhibited increase of roughness and it could be caused by formation of the mineralized biofilm.

Some factors present in the oral environment as the intermittent stress of the elastomers, the pH, the oxygen content and the temperature variation are related to the relaxation. Although, the increase on the temperature is the most significant point of the degradation mechanism.[16,18,22] De Genova et al,[8] related that the temperature in the oral cavity could vary from 0 to 64 °C. In this manner, one important aspect of oral degradation is the variation of the oral environment temperature and it depends on each individual.[11] In spite of the patients have different eating habits, in the present work, it was observed similar viscoelastic fluency effects in the elastomeric ligatures of all patients. The increase in the internal diameter and reduction in the thickness of ligatures were clearly detected after the first week in the oral cavity. This degradation increased gradually, with the increase of permanency time in the oral environment (Fig 3).

Other important polymeric degradation mechanism occurs in the immersion in water solution as the saliva. This mechanism is pointed out by swelling and dissolution. The liquid is absorbed by the polymer, penetrating among the macromolecules. This produces an internal force that separates the chains and expands the polymer by breaking the secondary links resulting on relaxation.[4]

The degradation of orthodontic elastomers can also occur by oxidation resulting in superficial cracks. The oxidation consists in the interaction among the elastomeric macromolecules with ozone and oxygen. The mechanism responsible for the chemical degradation is the scission of macromolecules chains, in the couple bond between carbon atoms, preferentially attacked by ozone.[4] In this study, it was observed cracks on the surface of orthodontic elastomeric ligatures of week-4 group. These elastomeric ligatures were not totally immersed in oral fluids during its use. Thus, they have partial contact with air and consequently with ozone and oxygen, that are factors of degradation.

The presence of bacterial flora is another important factor of degradation. Bode et al[4] isolated a lot of bacterium able to degraded natural and synthetic rubber. Most of them are present in the oral environment, accelerating the biodegradation process.

The complex oral environment results in degradation with many variables like temperature, bac-

terium, enzymes, pH, stress, chemical contents and others. More researches are necessary to produce new types of elastomers able to resist in this environment.

CONCLUSIONS

The elastic ligatures aged in the oral environment showed higher superficial degradation and lower loss of mechanical properties after the maximum experimental period.

The clinically significant result is that after the first week in the oral cavity, the elastomeric ligatures already presented significant superficial degradation and this process gradually increases resulting in significant superficial roughness, supporting plaque accumulation.

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Time of guard of orthodontic records versus legal time for their prescription

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Introduction: After promulgation and wider dissemination of the Code of Consumer Protection, there was an increase in the number of legal conflicts between patients and dentists, leading these health professionals to increasingly guard themselves from possible lawsuits. As such, it becomes critical the preparation of an adequate and complete clinical record, even though the keeping time remains uncertain.

Objective: To review the literature and discuss the keeping time of orthodontic records versus the legal time for their prescription, as well as to propose a model of a Term upon Completion of Dental Treatment.

Conclusion: It is advised to return part of the clinical records to their rightful owners by means of an itemized receipt. The Term upon Completion reflects the patient's awareness and could be considered by the CCP as the initial term of the prescription time, because it implicates that the patient recognizes the quality of service provided and satisfactory results achieved.

Keywords: Documentation. Orthodontics. Forensic dentistry. Legislation.

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INTRODUCTION

The increased dissemination of the Code of Consumer Protection[1] (CCP) and the absence of a specific legislation for the provision of dental services have broadened the number of legal conflicts between patients and dental surgeons (DS). As a way for professionals to ensure themselves from possible lawsuits, the preparation of an adequate clinical record becomes indispensable, even though its keeping time remains doubtful for dental professionals, service providers and intermediating providers of dental services.

The Brazilian Code of Civil Procedure states in the Chapter VI (Of Evidence), in which is inferred that the record is a document of probative force to defend the dental surgeon (DS), as disposed in the article 332, that: "All legal as well as morally legitimate means, though not specified in this Code, are able to prove the truth of the facts on which are based the claim or defense".[2] In addition to this legal issue, the development and updated maintenance of dental records in a separate file are ethical professional duties according to the Dental Code of Ethics,[3] and the elements contained therein may be requested for purposes of human identification.[4,5,6]

The scientific literature has no consensus on the need and keeping time of dental records, and there are even those who say that this period should be unlimited.[7] The Statute of Children and Adolescents[8] (SCA) clearly requires hospitals and other health care facilities supporting pregnant women (either public or private) to keep records (individual forms) of activities for eighteen years — until reaching the age of majority.

Keeping clinical documentation (or also called the clinical record, e.g. clinical and anamnesis forms, treatment plan, informed consent, contract of service delivery, imaging tests — X-rays, CT scans, photographs etc, dental certificate, referrals, plaster casts, and all types of documents produced as a result of the care given to the patient) has been being questioned and discussed in the field of forensic dentistry. It was suggested that the best thing to do is to deliver part of this documentation to its rightful owner,[9] or even give it 5 years after the end of the orthodontic treatment,[5] in both cases by means of an itemized receipt of all documents provided.

It is pointed out the advantage in keeping only the receipt paper, which would take much less space; and regarding the burden of proof, the DS should only present the receipt that the responsibility for putting such documents under court, if necessary, would turn to the patient. Also, it is worth noting that the patients, in bad faith, may hide such records from the court. They will do so when records contain evidence unfavorable to their legal claim. One can argue, for example, that had the documents lost or misplaced. In this case, the absence of such documents, by itself, will not cause the patient major consequences. However, the patient must prove his/her allegations by other evidences. With regard to the professional, the instrument of defense or proof of his/her reasons will remain to be the clinical record in the form of a descriptive report.

Therefore, the clinical record composed by anamnesis, dental chart, clinical treatment outcomes — report of the diverse occurrences, procedures, measures and recommendations given to the patient etc — may be filed both in binder and computerized system, since it has digital signature of the patient or caregiver to give validity to the data.[10] For legal purposes, it is important for the professional to keep the clinical record at hand, i.e., the report of occurrences that happened during the treatment. In this case, the fuller is the report, the more ensured will be the professional in proving his/her conduct and how clinical condition evolved in the course of treatment.

In other words, the literature showed that many of the procedures performed in the dental practice can present with faults barely identifiable (hidden defect), implying the maintenance of the patient's records in full indefinitely.[11]

The awareness of the prescription of an action represents the end of the proceedings with judgment on merits, in the terms of the article 269, Paragraph IV of the Code of Civil Procedure,[2] which states: "*Article 269. There will be resolution of the merits: IV - when the judge declares decline or prescription*". This means that the action was *stillborn*. That is, after a given time any legal action with indemnity purposes has no legal support. Nevertheless, it is worth noting that such circumstance by itself does not exempt the professional from the obligation of replying the proceedings with the help

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of a counselor. This happens because although the prescription is matter of public law that can be recognized *ex officio* by the judge, the counselor is required to contest the lawsuit, pointing out not only the prescription, but also the merits, i.e., besides claiming the prescription, the counselor should develop a complete defense relevant to the case. Why must this be so? Because in the case the judge does not admit the prescription, the absence of contestation as to the merits may lead the defendant the consequences of default, which is the presumption of truth regarding the facts alleged by the author. In this respect, the article 319 of the Code of Civil Procedure[2] states: "*If the defendant does not contest the action, the facts stated by the author will be deemed true*".

The recognition of the prescription time for civil lawsuits may depend on the use of evidences and the object of the contractual relationship, noting that the article 206, § 3rd, incise V of the current Brazilian Civil Code (Law no. 10.406/2002),[12] in force since 01/11/2003, reduced the prescription time to three years.

However, with the previous approval of the Code of Consumer Protection[1] (Law 8.078/1990), the relationship patient-health professional was considered as a consumption relationship, due to the contained in the article 2nd, which defines as a consumer "any person or entity that acquires or uses products or services as final receiver". It is understood, therefore, by this law, that any person or entity engaged in economic activity, even atypical or occasional, characterizes a consumption relationship. As such, the medical professional or dentist is the service provider and the patient is the consumer. Generally, the service may be the medical or dental act such as the consultation, intervention or other procedure.

Moreover, the CCP[1] is the law that preserves the public order targeting the social interest. Therefore, since it is in force, it has been applicable to all issues dealing with consumption relationship. So the prescription of the action claiming damage repair due to medical or dental misconduct shall be governed by the article 27 of this law, which states: "*Article 27. It is prescribed in five years the pretension to the repair of damages related to the product or service provided, according to the Section II of this chapter, counting the time from the awareness of the damage and its authorship".*

In this sense, it is appropriate to refer to a recent decision of the Superior Court of Justice issued on Motion for Clarification of Special Appeal, which thus established: *"The jurisprudential orientation of this Superior Court is that the Code of Consumer Protection is applied to medical services, including those related to the five-year limitation period advocated in the article 27 of the CCP".*[13]

DISCUSSION

Many doubts may be raised as regards the prescriptional time. So, it is questioned if the consumption relationship should be ruled by the Civil Code[12] (article 206, § 3rd, incise V) that establishes three years, or by the Code of Consume Protection (article 27) that determines five years. The solution deemed as legally feasible lies on the fact that the entry into force of the new Civil Code[12] did not change the estimation set out in the Code of Consumer Protection. This is because the latter is a specific law that must prevail over the law that has general character. This prescription time also prevails when the responsible for the damage is a public entity such as a hospital or clinics held by the government.

Since when does the counting to the prescription time start? The counting starts from the moment that the damage is identified, i.e., when the patient or his/her legal guardian becomes aware of the fact. Obviously, in the case of dental services, the legal relationship between the service provider and the consumer becomes unstable and insecure, because this *time* has become somewhat subjective, and is always dependent on a future and uncertain issue. In other words, when will the patients come to know the fact that caused them harms? This is not known, nor predictable. Nonetheless, one should remember that the majority of jurisprudence states that the time of prescription is five years. Here, it is recommended whenever possible to have the patient's written consent, including his/her signature on the sidelines of the dental chart, for example, or on another document.

In view of this legal uncertainty, it is difficult to know how long health professionals should keep the care records under their custody.

Hence, one should follow here the unwritten rule of common sense, which recommends that each one should endeavor in order to be the safest possible. It is better to keep the records for a longer time. "Man forewarned is forearmed".

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This caution is justified still by the fact that it is not enough for the professionals to be assured they did everything right or think that the patient seems well-intentioned. One cannot ignore that there are indemnity actions proposed in bad faith, in expectation of easy money, a kind of lottery game. This occurs especially when the author has legal aid – does not pay costs or honorariums and is not subjected to the burden of defeat. So, there would be nothing to lose. It could still be inferred that the author, in such cases, should be condemned as a litigator in bad faith, based on the article 16 of the Code of Civil Procedure,[2] which says: "*Responds for damages and losses that individual who claims in bad faith as an author, defendant or intervener*". Nonetheless, this condemnation will have little effect if the author has no proven financial conditions to reimburse the damages.

Finally, there is another ethical and moral issue in keeping patient's records longer: The occasional need for identification in case of accident or criminal event – that requires the help of human identification tools. Thus, it is concluded that guard of orthodontic records must be taken seriously by the dentist and, again, decided reasonably according to the real needs of each case.

PROPOSAL FOR A TERM UPON COMPLETION OF DENTAL TREATMENT

The possibility of delivering the clinical record by means of a receipt to the patient or caregiver is legal and feasible, since the dentist keeps the patient's dental records either in signed paper or digital media, including anamnesis, initial and final dental chart, clinical evolution, considerations and drug prescriptions, copies of certificates, prescriptions and referrals, as well as duplicate of the contract for dental services and informed consent term. Documents and exams requested by the patient, such as radiographs (with tracing), photographs and plaster casts (due to the volume these occupy), can be delivered to the interested legitimate person — by signing the receipt — and not to a third party.

The provision of services between the DS and the patient leads a business or legal pact. In order to guarantee the management of this relationship, it is absolutely recommended that the DS be ensured by a contract of service delivery so doubts or difficulties will not come to foster future discussion. This same caution can be adopted with the signing of a term upon completion of treatment, according to a model proposed herein (Fig 1). This term reflects the awareness of the fact by the patient and could be considered as the initial term of the prescription time by the CCP, because it implies that the patient recognizes the quality of service provided and satisfactory results achieved.

TERM UPON COMPLETION OF DENTAL TREATMENT

Professional's: .....
Patient's: .....
Patient's Legal Guardian: .....

By this term upon completion of services, the parties are in agreement that:

a) The services proposed in the contract as of __/__/__ were accomplished.
b) There were improvements both in esthetical and functional features, with specific recovery of the following aspects: .....

c) The patient declares to be in agreement and satisfied with the final result achieved in the treatment, recognizing expressly that it met his/her expectations.

d) The professional affirms that received the amount of money foreseen in the contract. Or: It is established that the balance due shall be paid as follows: .....

e) The patient declares receiving, in this act, the following materials and documents, which will be kept under his/her custody and exclusive responsibility: .....
.....
.....
.....

In view of the aforementioned facts, accepted by the parties as an expression of truth, sign this document for legal purposes.

City, ___/___/_____.

_____
Professional's signature: .....

_____ _____
Patient's Name: ..... Legal guardian's signature Name: .....

Figure 1 - Term upon completion of treatment to be used at the end of the orthodontic treatment. Note the presence of receipt of records on the part of the patient or legal guardian.

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Short-term efficacy of mandibular advancement splint in treatment of obstructive sleep apnea-hypopnea syndrome

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Objective: The aim of the present study was to determine the short-term efficacy of treatment for snoring and obstructive sleep apnea-hypopnea syndrome (OSAHS) using a mandibular advancement splint.

Methods: The sample comprised 20 patients (13 men and 7 women; mean age = 48 years; mean body mass index = 27.07) with OSAHS. Polysomnograms were performed before and 60 days after mandibular advancement splint therapy.

Results: There was a significant reduction in the apnea-hypopnea index (AHI) following treatment (mean pretreatment AHI = 20.89 ± 17.9 *versus* mean posttreatment AHI = 4.43 ± 3.09) ($p < 0.05$). The snoring reduced and the sleep efficiency improved, as registered by polysomnograms ($p<0.05$).

Conclusions: The sleep quality improved in patients using mandibular advancement splint. Further studies evaluating long-term effects are needed.

Keywords: Sleep apnea syndrome. Snoring. Polysomnography.

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

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INTRODUCTION

Snoring and sleep apnea stand out among the 84-catalogued diseases related to sleep disorders, affecting 10% of the population worldwide. More than 15 million Brazilians snore. With regard to sex, the proportion of men to women is 10:1, as men are more prone to the buildup of fat in neck and abdominal region[16].

Sleep is essential to the homeostasis and restoration of the organism, including the central nervous system. Sleep is a dynamic physiological process involving the loss of consciousness and inactivation of the voluntary musculature, and is reversible through the effect of stimuli (tactile, auditory, somatosensory).[9]

Obstructive sleep apnea is a chronic, progressive respiration disorder involving the periodic interruption of breathing during sleep.[28] This condition is characterized by the apposition of the tongue and soft palate on the lateral and posterior walls of the oropharynx, causing the collapse of these structures. The reduction in or complete absence of airflow varies with the severity of the obstruction, normally occurring from 5 to 10 seconds as well as 5 to 10 times during sleep. Once the individual becomes hypoxemic, he/she awakens and the airways become unblocked. The individual then falls asleep again and the event is repeated. The repetitive effort to maintain air passing through the airways causes a 30% increase in volume and flaccidity of these structures.[27]

Snoring is defined as an inspiratory noise caused by friction of the soft tissues of the oropharynx due to partial obstruction of the upper airways. It is estimated that 35% of habitual snorers can develop obstructive sleep apnea-hypopnea syndrome (OSAHS).[10] The main etiological factors of OSAHS are muscle hypotonicity (due to alcohol, drugs, muscle relaxants, sedentary lifestyle, ageing and mouth breathing), obesity (increase in adipose tissue in the upper torso and cervical region), increased volume of respiratory secretion, hypertension, hypertrophy of the tonsils and uvula, dorsal decubitus position during sleep, retrognathia and macroglossia.[7,9,10,11,27]

OSAHS is considered a public health problem due to the related cardiovascular problems and the risk of work-related and traffic accidents stemming from daytime sleepiness and consequent mistakes when making decisions. OSAHS is also related to a poor quality of life, with the deterioration of neurocognitive aspects and subsequent negative repercussions on family/social relations and intellectual/professional production.[9]

Depending on the severity of the condition, treatment can range from behavior modification to surgical procedures.[7,23] Behavior modification includes sleep posture, weight loss, the suspension of alcohol and sedatives, and sleep hygiene.[7,9,22] Patients who sleep in a dorsal decubitus position snore more loudly and experience a worsening in apnea events. This is due to the posterior movement of the dorsum of the tongue, soft palate and palatine uvula, thereby causing obstruction. It is therefore recommended that patients sleep in the lateral decubitus position.[9,16,22] Sleep hygiene consists of healthy attitudes and practices aimed at promoting continuous, efficient sleep, leading to a reduction in daytime sleepiness. Such practices include regular times for going to sleep and waking up, regular physical exercise (but not close to bedtime), light eating with a minimal interval of two hours prior to sleep, avoiding substances with caffeine and/or nicotine at least four hours prior to sleep, limiting the use of alcohol to the minimum and adapting the environment to favor restful sleep by avoiding incompatible activities, such as watching television, snacking and using the telephone.[9,27]

Intraoral mandibular advancement appliances to treat primary snoring problems and mild OSAHS are derived from functional orthopedic appliances, which are used in the treatment of retrognathia in patients in growth phase.[7-11,23,24,25] These appliances have been employed as a treatment alternative for patients with moderate to severe sleep apnea who are intolerant to the use of continuous positive airway pressure (CPAP).[1,2,7-13,21,23,24,25]

This study focused in short-term efficacy and acceptance of a mandibular advancement splint (intraoral appliance) as an aid in the treatment of snoring and obstructive sleep apnea-hypopnea syndrome.

METHODS

The present study received approval from the Ethics Committee of the State University of Maringá (UEM/Brazil) and all subjects signed terms of informed consent agreeing to participate in the study. The sample was selected from 30 patients

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who sought treatment of snoring and sleep apnea between June 2006 and June 2007 at Dental Press Educational Center (Maringá/PR, Brazil). Seven were excluded due to excessive tooth loss leading to difficulty in adapting the splint, active periodontal disease, craniofacial disorders, upper airways obstruction or systemic disease. Three patients abandoned treatment one day after the installation of the appliance, reporting considerable discomfort. Thus, the sample consisted of 20 patients between 32 and 60 years of age (mean = 48 years), 13 of whom were male (65%) and 7 were female (35%). Either the participants themselves or their spouses (which was more frequently the case) reported snoring or interrupted breathing during sleep.

All patients underwent polysomnography prior and 60 days after installation of the mandibular advancement splint (nighttime use). All exams were obtained from Neuromap 40i equipment (Neurotec, Itajubá-MG, Brazil) over an average of seven hours. Polysomnograms recorded AHI, snoring events, sleep efficiency, minimal oxygen saturation and heart arrhythmia.

Body mass index (BMI) was also recorded before and after polysomnograms.

The mandibular advancement splint used included an advancement tube-pin system (modified removable MPA, Coelho Filho, 1995).[6,23] The tube-pin connects the upper and lower plates to promote the forward movement of the mandible. Intermaxillary elastic bands (1/8-in) were placed on the hooks of the acrylic plates for better fixation of the mandible in a more forward position (Figs 1, 2 and 3).

The acrylic plates were limited to an average of 3 mm of functional free space to avoid neuromuscular discomfort.[9,11] The appliances were constructed with the greatest possible mandibular advancement of each patient without discomfort.

The Wilcoxon test was used to compare pre and posttreatment findings, at 5% significance level.

RESULTS

Table 1 shows comparison between AHI results at pre and post-advancement splint therapy exams. Table 2 demonstrates snoring recorded at pre and post-therapy evaluations. Table 3 presents BMI, minimum O_2 saturation and sleep efficiency at the two experimental times. Table 4 shows arrhythmia records before and after splint therapy.

DISCUSSION

As reported in the literature,[5,8,12,13,17,18,19,21,25,26,28,29] the mean apnea-hypopnea index (AHI) reduced significantly among the patients in the present study, that underwent intraoral splint therapy (mandibular advancement device). Mean AHI reduced from 20.89 ± 17.9/hour to 4.43 ± 3.09/hour.

Efficacy of mandibular advancement splint therapy has been related to AHI reduction. In mild to moderate OSAHS the treatment success using intraoral devices could range from 80 to 90%. However, in severe cases this kind of therapy successfully treats 50 to 60%, with partial efficacy.[7] The present study corroborates those data. After treatment, 15 patients had no apnea or less than 5/hour, four had mild apnea (5 to 15/hour) and one had moderate apnea (15 > AHI < 30/ hour) ($p < 0.05$). Among those patients who presented severe OSAHS in pretreatment phase (n = 5), two went to mild after treatment, one went to moderate, and two were considered successfully treated (AHI < 5).



Figure 1 - Mandibular advancement splint used.



Figure 2 - Frontal intraoral view of mandibular advancement splint.



Figure 3 - Lateral intraoral view of mandibular advancement splint.

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Table 1 - Pretreatment and posttreatment mean apnea-hypopnea index (AHI), and level of severity distribution.

AHI	pretreatment	posttreatment	significance
$\bar{X} \pm SD$	20.89 ± 17.46	4.43 ± 3.09	*
Absent (AHI < 5) (n)	0	15	*
Mild (5 > AHI < 15) (n)	9	4	*
Moderate (15 > AHI < 30) (n)	6	1	*
Severe (AHI > 30) (n)	5	0	*

* $p < 0.05$.

Table 2 - Pretreatment and posttreatment snoring severity.

Snoring	pretreatment	posttreatment	significance
Absent (n)	0	6	*
Mild (n)	4	13	*
Moderate (n)	9	1	*
Severe (n)	7	0	*
Total (n)	20	20	

* $p < 0.05$.

Table 3 - Mean and standard deviation of pretreatment and posttreatment BMI, minimum SO_2 and sleep efficiency.

	pretreatment	posttreatment	
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	p
BMI	27.07 ± 4.49	27.65 ± 4.33	0.109 (ns)
SO_2	84.3 ± 9.33	92.75 ± 2.4	0.009 (ns)
Sleep efficiency (%)	83.58 ± 7.58	88.13 ± 4.45	0.033*

* $p < 0.05$.

Table 4 - Presence of pretreatment and posttreatment heart arrhythmia.

Arrhythmia	pretreatment	posttreatment	significance
Yes (n)	3	0	n.s.
No (n)	17	20	n.s.
Total (n)	20	20	

Among those patients who presented moderate OSAHS before treatment (n = 6), two presented mild and four presented AHI less than five after treatment. All patients presenting mild OSAHS before treatment (n = 9) were considered treated after the use of mandibular advancement splint.

In the present study the severity of the snoring reduced significantly, as documented by the polysomnograms, which revealed the absence of snoring in 6 patients (30%), while 13 exhibited mild snoring (65%) and only 1 patient exhibited moderate snoring (5%) ($p < 0.05$). Snoring could remain at some level although AHI reduces.[7,13]

Saturated O_2 went from 84.3±9.33 to 92.75±2.4, however with no statistical significance ($p > 0.05$). The quantitative sleep efficiency improved from 83.58 ± 7.58 to 88.03 ± 4.45 ($p < 0.05$). There were no significant changes in BMI. Three patients exhibited pretreatment heart arrhythmia, whereas no patients exhibited heart arrhythmia during the post-treatment polysomnogram, although this data were not statistically significant. In general, those data confirm the benefits of related AHI reduction by using intraoral appliance.

It was reported that mandibular advancement appliance prevent the collapse of the upper airways during sleep by maintaining the mandible in a protrusive position, exerting extrusive forces and lingual movement on the upper anterior teeth, and mesial and vestibular movement on the lower anterior teeth, with significant long-term occlusal changes.[14,15,20] It was also reported that the use of a mandibular advancement appliance alters the configuration of the upper airways, with a decrease in the length of the palate and an increase in the area of the pharynx, likely due to a loss of edema caused by snoring and repetitive apnea events.[3,4]

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Although some dental alterations and other side effects may be undesirable in certain patients, the effective treatment of a life-threatening condition, such as OSAHS, is believed to supersede the maintenance of referential occlusion. Even in the presence of large dental movements, interruption of the treatment with an oral appliance should only occur when the patient accepts another treatment modality, such as continuous positive airway pressure equipment for the upper airways.[7,8,14,15]

Patients who require treatment for OSAHS are generally over 40 years of age, which is when periodontal disease begins to become aggravated. Thus, prospective studies involving a detailed periodontal evaluation are needed to determine a possible predicting factor of dental movement.[14]

As an oral appliance for the treatment of OSAHS is a life-long approach and the consequences of its use beyond six years are unknown, periodic clinical and radiographic exams are required to monitor the effects, which are at times beneficial and other times harmful, depending on facial pattern and pretreatment occlusion.

It is suggested that clinicians should be cautious in dental practice when treating patients with apnea using oral appliances if they have an ample anteroposterior airway and alteration in weight during treatment.[17]

Despite the positive results found in the present study, follow-up of these patients is necessary for determining long-term results regarding the snore and sleep apnea and side effects stemming from treatment.

CONCLUSIONS

Sleep quality improved in patients using mandibular advancement splint, but further studies evaluating long-term effects are needed.

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In vitro analysis of shear bond strength and adhesive remnant index comparing light curing and self-curing composites

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Objective: Evaluate, *in vitro*, the shear bond strength of self-curing (Concise™ – 3M and Alpha Plast – DFL) and light-curing composites (Transbond™ XT – 3M and Natural Ortho – DFL) used in orthodontics bonding, associated to Morelli metal brackets, with further analysis of adhesive remnant index (ARI) and enamel condition in scanning electron microscopy (SEM).

Methods: Forty human premolars, just extracted and stored in physiologic solution 0.9 % were used. Randomly, these samples were divided in four groups: G1 group, the brackets were bonded with Concise™ – 3M composite; in G2 group, Alpha Plast – DFL composite was used; in G3 group, Transbond™ XT – 3M was used; in G4 group, Natural Ortho – DFL composite was used. These groups were submitted to shear strength tests in universal testing machine, at 0.5 mm per minute speed.

Results: Statistical difference between G3 and G4 groups was recorded, as G4 showing higher strength resistance than G3. In the other hand, there were no statistical differences between G1, G2 and G3 and G1, G2 and G4 groups. ARI analysis showed that there was no statistical difference between the groups, and low scores were recorded among then. The scanning electron microscopy (SEM) analysis revealed the debonding spots and the enamel surface integrity.

Conclusions: Shear bond strength was satisfactory and similar between the composites, however Natural Ortho – DFL revealed best comparing to Transbond™ XT – 3M.

Keywords: Composite resins. Shear strength. Microscopy Electron Scanning.

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INTRODUCTION

Orthodontics showed great strides with regard to the materials used for bonding orthodontic accessories to tooth from the 70's.[19] Several bonding materials have been used, including composites which have good resistance, toughness and dimensional stability.[8]

Advantages to use light-curing resin in orthodontic procedures include reduced risk of contamination and increased accuracy in positioning the bracket, compared to the use of self-curing resin. However, this optimizes the clinical time by not requiring light cure action.[21]

It is not easy to quantify the ideal adhesive strength for bonding orthodontic accessories. It is known that there must not be extremely low or too high, so that the debonding does not cause fractures in the enamel surface.[5] According to Bishara et al,[2] to obtain a good result in orthodontic treatment, it is important after the removal of orthodontic brackets the enamel integrity is preserved. For Grandhi et al,[9] the ideal would be to minimize the loss of enamel in the bonding, debonding and removal of residual composite stages, remaining tooth surface with the original roughness degree of the tooth.

The evaluation of the enamel surface after debonding of orthodontic accessories may be accomplished by means of the adhesive remnant index (ARI), recommended by Årtun and Bergland.[1] However in order to ratify the enamel damage caused by the resistance strength of the bracket, the Scanning Electron Microscopy (SEM) analysis can be used.[3,22]

MATERIAL AND METHODS

For this experiment it was used 40 human upper premolars, free from cracks and fractures and freshly extracted for orthodontic reasons. After the extractions, teeth were washed, immersed and kept in plastic containers containing 50 ml of 0.9 % saline solution at room temperature. The use of teeth followed the guidelines of the Ministry of Health according to resolution 196/96 of National Health Council of 10/10/96 approved by the Ethics Committee of the Federal University of Pará – Approval No. 030/2008. For the preparation of the specimens, the teeth roots were embedded in P.V.C. tubes (Tigre) with 25 mm of diameter / 25 mm of height, filled with special plaster stone (Durone - Dentsply).[16] In the moment of the teeth insertion, the buccal surfaces were positioned perpendicular to the ground, using as an aid a juxtaposed square to the bonding surface and the excesses were removed with a spatula LeCron (Duflex). The specimens were stored again at 0.9 % saline solution.[18]

The objective of this research was to evaluate the shear strength of the union of the bracket to the tooth, in the post fixation of 24 hours, comparatively using four resins: Two launched in the national market, Alpha Plast – DFL (self-curing) and Natural Ortho – DFL (light-curing), and two resins traditionally accepted as efficient, Concise™ Orthodontic – 3M (self-curing) and Transbond™ XT – 3M (self-curing); using the bracket marketed in Brazil (Morelli). After debonding of the bracket, the adhesive remnant index (ARI) will be evaluated and the enamel surface analysis will be performed in scanning electron microscopy (SEM).

The specimens were randomly divided into four groups of ten specimens. In the first group (G1) Morelli bracket was used with the Concise™ Orthodontic composite (self-curing); the second group (G2) Morelli bracket was associated with the Alpha Plast composite (self-curing); the third group (G3) Morelli bracket was associated with the Transbond™ XT composite (light-curing); and the fourth group (G4) Morelli bracket was used with the Natural Ortho composite (light-curing).

In the buccal surface of the teeth was performed prophylaxis with pumice stone, rubber cup and water for 10 seconds; washing with air/water spray for 15 seconds and drying for 10 seconds.[14] Then the etching was done with 37% phosphoric acid for 20 seconds, washing with air/water spray and drying for 20 seconds each.[15] After, brackets were bonded following the manufacturer's instructions for each composite. Positioning of the bracket was done manually with forceps, and to standardize the application of force procedure was performed by a single operator.

The groups of specimens were subjected to shear bond strength test in universal testing machine (Kratos). The tests were conducted at 24 hours after bonding with of 0.5 mm per minute. The final results were obtained in Megapascal (MPa) by the relationship of forces in Newton (N) by the area of the brackets base used.

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After the shear bond strength test, the enamel surfaces of each specimen were classified according to the scores of the adhesive remnant index (ARI) proposed by Årtun and Bergland,[1] being: Score 0 = no amount of adhesive material adhered to the tooth; score 1 = less than half of the adhesive material adhered to the tooth; score 2 = more than half of the adhesive material adhered to the tooth; and score 3 = all adhesive material adhered to the tooth, including bracket mesh impression.[6]

Representative samples of each type of ARI score were selected among the four groups, and suffered the gold metallization process. Then these samples were taken for SEM analysis. The teeth were displayed in their buccal surfaces in regions where the brackets were before the shear bond strength test. With illustrative purposes, the limits of fracture of composite and enamel surface were highlighted with 50 and 100x increases for each sample.

Analysis of variance (ANOVA) was used to compare differences between the groups in terms of mean of shear strength because the data is parametric and submit normality and equality of variances (homoscedasticity). To compare the rate of adhesive remnant index between the groups, varying the type of composite, the Kruskal-Wallis test was used. In all statistical tests the significance level of $\alpha = 5\ \%$ was applied.

RESULTS

Table 1 presents the descriptive statistics data regarding the tension in Megapascal (MPa) (Table 1).

According to Analysis of Variance (ANOVA) for the shear bond strength test, we observed a statistically significant difference between groups ($p = 0.0355$).

After performing the Tukey's multiple comparison tests, it was observed that the difference was between groups G3 and G4, and the group G4 showed statistically more resistant to shear than the G3. Other groups did not differ with respect to shear bond strength. All mean values of the tested groups represent bond strength greater than the consistent value with clinical needs in Orthodontics, ranging from 5.9 to 7.8 MPa (Fig 1).

For the adhesive remnant index (ARI), after application of the Kruskal-Wallis test to compare the groups in relation to the amount of scores presented, it was realized that there is no statistically significant difference between groups ($p = 0.9318$) (Tables 2 and 3).

The results of photomicrographs of selected samples are presented in the following Figure 2. The images show the limits of fracture of correlate composites, sequentially to the four possible adhesive remnant index outcomes.

DISCUSSION

In orthodontic treatment using direct fixation composite must suit clinical needs, promoting sufficient bonding strength to carry out the procedures. Reynolds[17] suggested a minimum bonding strength between 6 and 8 MPa. Values below this average are

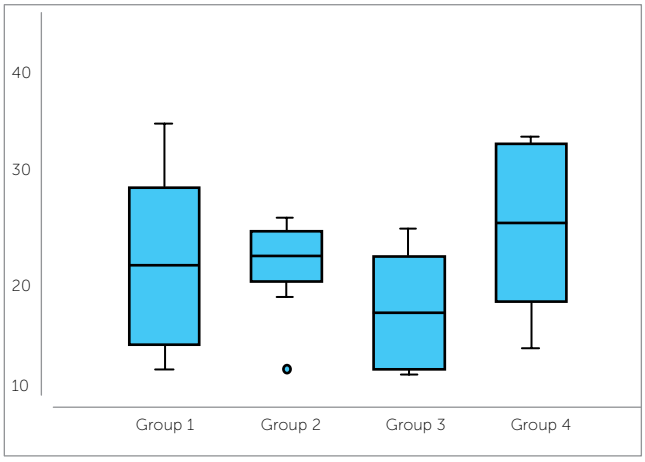


Figure 1 - Box-Plot representing the mean and standard deviation of the groups in relation to the tension applied in Megapascal (Mpa).

Table 1 - Descriptive Statistics regarding tension in Megapascal (Mpa).

Sample Size	G1: Concise™ Orthodontic (n = 10)	G2: Alpha Plast (n = 10)	G3: Transbond™ (n = 10)	G4 – Natural Ortho (n = 10)
Minimum	11.5360	11.5360	10.9690	13.4930
Maximum	36.4610	26.9340	25.8010	35.0880
Mean	21.9662	21.7309	17.0855	26.3417
Standard Deviation	7.9854	4.3439	5.8128	8.0216

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Table 2 - Descriptive statistics regarding the adhesive remnant index (scores).

	G1: Concise™ 3M	G2: Alpha Plast DFL	G3: Transbond™ XT 3M	G4: Natural Ortho DFL
Minimum	0.0000	0.0000	0.0000	0.0000
Maximum	2.0000	1.0000	2.0000	3.0000
Mean	0.7000	0.7000	0.6000	0.7000
Standard Deviation	0.8233	0.4830	0.8433	0.9487

Table 3 - Scores for adhesive remnant index from different groups.

	G1: Concise™ Orthodontic	G2: Alpha Plast	G3: Transbond™ XT	G4: Natural Ortho
Specimen 1	2	1	1	0
Specimen 2	0	1	1	0
Specimen 3	0	1	0	0
Specimen 4	0	1	0	1
Specimen 5	1	1	2	3
Specimen 6	1	0	0	1
Specimen 7	2	0	2	0
Specimen 8	0	1	0	1
Specimen 9	0	1	0	0
Specimen 10	1	0	0	1

synonymous with failure. As in other studies, all tests in the present study were higher than the average proposed.[13,20,23]

When comparing the resins, the statistical difference result between groups stands out. The analysis reveals that the G4 appeared more resistant to shear than G3. However, when comparing the groups G1, G2 and G3, and G1, G2 and G4 no statistically significant differences were found between them (Fig 1).

These findings are similar to Mondelli and Feitas[11] and Valletta et al,[24] but confront with the results obtained from Giannini and Francisconi[7] research, wherein the Concise™ orthodontic composite appeared stronger than Transbond™ XT composite.

For the Alpha Plast and Natural Ortho composites, no evident research was found in the literature. Both materials are newly available and inexpensive when compared to Concise™ orthodontic and Transbond™ XT composites, universally accepted by science as materials of excellence for clinical use. However, these new composite proved as highly resistant to shear.

This research also analyzed the adhesive remnant index (ARI), proposed by Årtun and Bergland.[1]

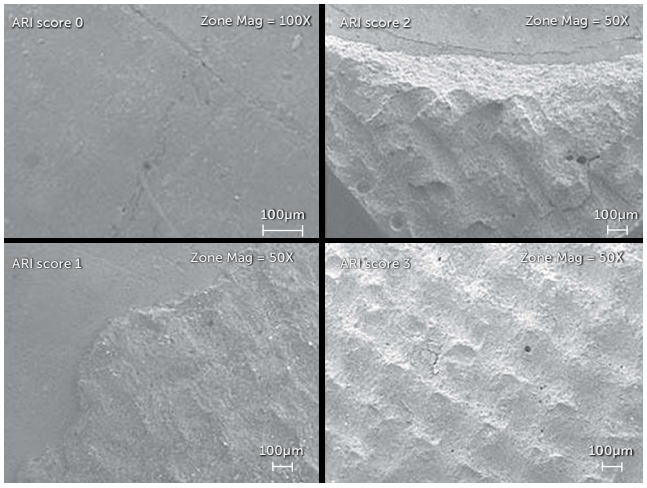


Figure 2 - Representative specimens for ARI, subjected to SEM increase.

The classification of the composite amount adhered to the tooth, after removing the bracket suggests degrees of susceptibility to enamel fracture. To maintain the integrity of the enamel, the ideal is to achieve high scores on the ARI, i.e. greater amount of material adhered to the tooth. This avoids a situation where there is disruption of hydroxyapatite crystals in enamel. Moreover, these composite may be easily removed with finishing burs, without any damage to enamel.

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The results of this research revealed predominantly low scores for all groups, and the comparison between showed no statistically significant difference (Tables 2 and 3).

For ARI to the Concise™ orthodontic (G1) and Transbond™ XT (G3) resins, the results reinforce the research of Derech et al,[5] Montasser et al,[12] and Penido et al[4] who also obtained low scores. On the other hand, our results confront studies which reported the majority of disruptions in the interface composite/bracket.[4,15,16,19,24]

After shear bond strength test and during the ARI evaluation enamel fractures were observed in four specimens distributed among the four groups. This relative frequency of fractures among groups, supported by the study by Liu et al,[10] may be associated with high strength supported by the samples.

These findings are conflicting when compared to those obtained by Mondelli and Feitas,[11] who claim that the weakest link in the orthodontic bonding is in the interface composite/bracket, reiterating that the adhesive interface is critical in terms of resistance.

Despite the lack of comparison parameters in literature, it must ratify the results for Alpha Plast and Natural Ortho composites behaved similar to Concise™ orthodontic and Transbond™ XT composites, for ARI.

SEM photomicrographs allowed most accurate view of the enamel surface and the of composite fracture areas. These same features enabled Stratmann et al[22] estimate risk of enamel fracture between 23 % and 63 % of specimens associated with Concise™ orthodontic composite. In the study by Chen et al[3] in which metallic brackets are fixed with the composite Transbond™ XT, it was observed enamel fractures in 40 % of samples.

Impartiality business is one of the requirements of this study, so our purpose is to highlight, through testing, specific characteristics of these composites. It is noteworthy that all tested products are fully suitable for clinical use, with the primary objective of maintaining the integrity of the enamel.

CONCLUSION

It was concluded that all composites, both self-curing and light-curing, used in this study exhibited good strength and similar results. Natural Ortho composite presented higher strength in comparison to Transbond™ XT composite.

Regarding the adhesive remnant index (ARI), there was a predominance of low scores between the groups, showing little or no amount of resin bonded to enamel.

With the illustrative results of the enamel surface by scanning electron microscopy (SEM), it was ratified the amount of material adhered to the tooth of selected samples, besides the need to display the limits of composite fracture.

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Comparison of mesiodistal tooth widths in Caucasian, African and Japanese individuals with Brazilian ancestry and normal occlusion

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Objective: To observe the presence of sexual dimorphism and compare the mesiodistal width of the teeth in Caucasian, African and Japanese individuals with Brazilian ancestry not orthodontically treated and with normal occlusion.

Methods: One hundred pairs of dental casts were used. It was measured, from first molar to first molar in both arches, the teeth's mesiodistal widths, using a digital caliper. For the statistical analysis of results it was used Kolmogorov-Smirnov, *t* test, ANOVA and Tukey's test ($p < 0.05$).

Results: Sexual dimorphism occurred on the three evaluated groups, and the highest mesiodistal widths were found in males. There was statistically significant difference between racial groups in all evaluated teeth in males. However, in females, this same difference was found only on upper lateral incisor and first molar; and lower lateral incisor, canine, first premolar and first molar.

Conclusion: Most of mesiodistal measures present particular characteristics in relation to gender, with higher values for males, and to race, with a tendency for African to present greater mesiodistal distance of the teeth, followed by Japanese and Caucasians, respectively, important for the correct diagnosis and orthodontic planning.

Keywords: Orthodontics. Balanced dental occlusion. Tooth.

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INTRODUCTION

The dental arch models, part of the orthodontic records, are indispensable for diagnosis and orthodontic planning, being also used for evaluation of treatment and case control. The mesiodistal and vertical widths of the dental crowns and the shape of upper and lower arches enable the correlation of them with the face, besides allow identifying possible alterations of shape.[31] The measurement of upper and lower mesiodistal dental sizes is an important factor to establish an accurate diagnosis, determine the right treatment plan, and obtain greater stability.[6,21] The tooth contouring and reshaping, when well indicated and functionally adjusted, can provide satisfactory results.[11,26,30]

The dental size can vary according to gender and race[1,16,21] becoming necessary new studies that quantify these measures,[2] for these differences can complicate the orthodontic treatment.

The professionals must be prepared to attend individuals from different ethnicities and be capable to anticipate these differences of size and shape of the dental arch, establishing a more personalized treatment.[7] Thus, due to the theme's relevance, it was concluded the necessity for a comparison of mesiodistal measures for the different racial groups, constituting appropriated patterns for Caucasian, African and Japanese.

MATERIAL AND METHODS

Sample composition and criteria for selection

The sample comprised 100 pairs of dental casts of untreated individuals (50 of each gender) with normal occlusion, harmonious face and mean age of 15.16 years old. The sample was from the division of Orthodontics of the Bauru School of Dentistry and approved by this institution's Ethics Committee. The total was 30 Caucasian individuals (15 of each gender) with mean age of 20.22 years old, 40 African individuals (20 of each gender) with mean age of 13.26 years old and 30 Japanese individuals (15 of each gender) with mean age of 15.71 years old.

The Caucasian group was constituted of Mediterranean descendents; the African, mainly descendents from the African coast; and the Japanese, by individuals Japanese ancestry, and these three samples did not present mixed-race individuals.

The criteria for selection of the sample were: (1) upper and lower permanent teeth in occlusion, being facultative the presence of second and third molars; (2) good occlusion (Angle Class I relationship, with no crowding, no open bite or overbite); (3) absence of previous subjection to orthodontic treatment; (4) absence of teeth with morphology or number anomalies; (5) without extractions; (6) absence of large restorations that could affect the teeth's mesiodistal diameter; (7) models in good conditions and (8) ethnicity verified by photographs and patient's history obtained in surveys filled out by themselves or by their guardians.

Data collection

After calibration of the examiner, the process of data collection was initiated. The measurements were done directly on the models with the aid of the digital caliper (Mitutoyo, Illinois, USA), enabling to obtain values with accuracy of up to 0.01 mm, measuring the largest mesiodistal measure of incisors, canines, premolars and molars in both sides, in this sequence. The caliper was positioned parallel to the occlusal surface, by the buccal face, perpendicular to the long axis of the crown, measuring the tooth's largest mesiodistal distance.

Statistical analysis

The data was analyzed through tables and graphics with mean values and standard deviations. The Kolmogorov-Smirnov test proved the normal distribution for all studied variables allowing the use of parametric tests. Thus, for the comparative statistical analysis of the data it were used the following tests: The *t* test for comparison between genders and ANOVA, for comparison of groups (Caucasian, African, and Japanese) considering a significance level of 5%. The tests were performed on Statistica for Windows 6.0 (Statistica for Windows 6.0 Copyright StatSoft, Inc. Tulsa, Okla, USA).

RESULTS

The random errors, obtained through the Dalhberg formula, were considered acceptable and the teeth's mesiodistal distances ranged from 0.09 to 0.33 mm. The molars presented the higher error and the canines the lower. The systematic errors, observed through dependent *t* test, were considered low and from the 24 evaluated variables only 4 presented statistically significant difference (upper first premolar and molar and lower canine and first premolar).

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The results are presented in tables and figures. Dimorphism between genders occurred in all evaluated groups and the teeth that presented this statistically significant difference can be visualized on Tables 1, 2 and 3 which compare the mesiodistal measures through *t* test on African, Caucasians and Japanese, respectively. The racial differences were statistically significant between all variables for the male gender

Table 1 - Comparison of studied variables between genders on the African sample with *t* test.

African			
	Male (n = 20) Mean ± S.D.	Female (n = 20) Mean ± S.D.	p
Upper teeth			
CI	9.05 ± 0.56	8.63 ± 0.57	0.024*
LI	7.37 ± 0.53	7.03 ± 0.68	0.085
C	8.26 ± 0.50	7.73 ± 0.54	0.003*
1Pm	7.63 ± 0.59	7.31 ± 0.64	0.107
2Pm	7.10 ± 0.67	6.84 ± 0.52	0.170
1M	10.96 ± 0.62	10.22 ± 0.48	0.000*
Lower teeth			
CI	5.61 ± 0.40	5.25 ± 0.40	0.009*
LI	6.33 ± 0.45	5.97 ± 0.42	0.012*
C	7.44 ± 0.57	6.86 ± 0.49	0.001*
1Pm	7.70 ± 0.46	7.30 ± 0.54	0.016*
2Pm	7.63 ± 0.57	7.11 ± 0.60	0.008*
1M	11.66 ± 0.49	11.09 ± 0.58	0.002*

* Statistically significant for p < 0.05

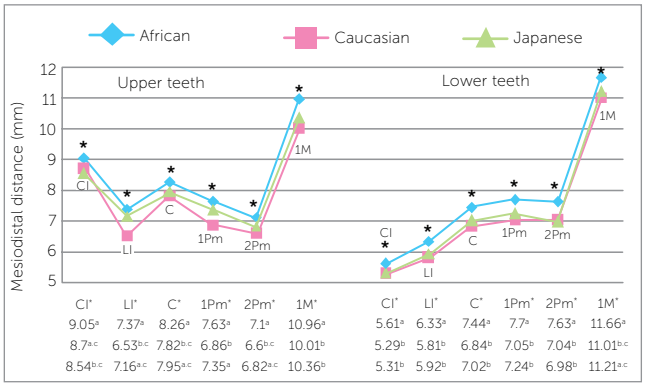


Figure 1 - Comparison of individual values of the studied dental groups (upper and lower teeth) for male gender between the different samples by ANOVA test.
* Statistically significant for p < 0.05.
Different letters on the vertical direction indicate significant difference between groups (Tukey).

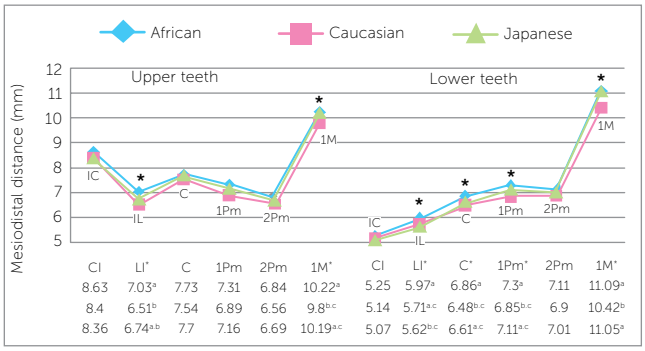


Figure 2 - Comparison of individual values of the studied dental groups (upper and lower teeth) for female gender between the different samples by ANOVA test.
* Statistically significant for p < 0,05.
Different letters on the vertical direction indicate significant difference between groups (Tukey).

Table 2 - Comparison of studied variables between genders on the Caucasian sample by *t* test.

Caucasian			
	Male (n = 15) MEan ± S.D.	Female (n = 15) Mean ± S.D.	p
Upper teeth			
CI	8.70 ± 0.55	8.40 ± 0.36	0.088
LI	6.53 ± 0.48	6.51 ± 0.50	0.938
C	7.82 ± 0.45	7.54 ± 0.46	0.110
1Pm	6.86 ± 0.47	6.89 ± 0.42	0.842
2Pm	6.60 ± 0.34	6.56 ± 0.31	0.739
1M	10.01 ± 0.39	9.80 ± 0.55	0.235
Lower teeth			
CI	5.29 ± 0.29	5.14 ± 0.21	0.117
LI	5.81 ± 0.31	5.71 ± 0.30	0.381
C	6.84 ± 0.33	6.48 ± 0.33	0.005*
1Pm	7.05 ± 0.43	6.85 ± 0.43	0.219
2Pm	7.04 ± 0.38	6.90 ± 0.42	0.356
1M	11.01 ± 0.77	10.42 ± 0.57	0.024*

* Statistically significant for p < 0.05

Table 3 - Comparison of studied variables between genders on the Japanese sample by *t* test.

Japanese			
	Male (n = 15) Mean ± S.D.	Female (n = 15) Mean ± S.D.	p
Upper teeth			
CI	8.54 ± 0.40	8.36 ± 0.39	0.219
LI	7.16 ± 0.36	6.74 ± 0.56	0.021*
C	7.95 ± 0.44	7.70 ± 0.50	0.166
1Pm	7.35 ± 0.52	7.16 ± 0.39	0.274
2Pm	6.82 ± 0.40	6.69 ± 0.37	0.376
1M	10.36 ± 0.57	10.19 ± 0.41	0.348
Lower teeth			
CI	5.31 ± 0.35	5.07 ± 0.22	0.034*
LI	5.92 ± 0.36	5.62 ± 0.32	0.019*
C	7.02 ± 0.42	6.61 ± 0.48	0.020*
1Pm	7.24 ± 0.43	7.11 ± 0.47	0.433
2Pm	6.98 ± 0.48	7.01 ± 0.33	0.815
1M	11.21 ± 0.41	11.05 ± 0.51	0.340

* Statistically significant for p < 0.05

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(Fig 1) and for 6 variables, upper lateral incisor and first molar; and lower lateral incisor, canine, first premolar and first molar, for the female gender (Fig 2) when compared the three groups.

DISCUSSION

Measurement collection

The orthodontic diagnosis is an essential factor for the elaboration of an adequate treatment plan. Thus, this research had as main objective to determine the dental mesiodistal distances in dental casts, in order to contribute with reasonable information to the orthodontic diagnosis on the different studied races.

In this study, the measurements were performed directly on the casts with digital caliper, because it was already proved that measurements done in study models are more reliable than measurements done directly in the mouth of the patient [13] and that the caliper is the best way to perform the analysis of dental size for it has more reliability when compared to the EKG caliper.[13,24,25] Thus, the method used for the measurement of mesiodistal distance of each tooth was obtained by the largest distance between the teeth's mesial and distal faces, through a digital caliper, positioned as parallel as possible to the occlusal surface, by the tooth's buccal face.[14,17,22,31]

Sexual dimorphism

Several studies have reported the existence of significant differences between men and women's tooth size, with a tendency for men to present larger teeth on mesiodistal direction.[2,5,9,15,21,28] Therefore, the first caution of this research was to verify the presence of sexual dimorphism within the different racial types. This procedure aimed to determine if it was possible to group the genders in each specific racial group or if there would be the necessity for an individual evaluation, to avoid any gender interferences. Once proven the occurrence of sexual dimorphism between mesiodistal distance in the three analyzed samples (Tables 1, 2 and 3), the two genders were not grouped and it was possible to compare the racial differences, without interference from this factor.

Although in Brazil it occurs a large racial miscegenation of the population, which complicates the accurate establishment of the ethnic origin of the individuals, in this study it was sought to work only with individuals without miscegenation (African, Caucasians and Japanese). In the African group, the male gender presented mesiodistal distances of all teeth larger than the females gender, with nine statistically significant variables (upper central incisors, canines and first molars and all lower teeth) confirming the study by Burris and Harris[7] which also found larger teeth for males than for females in African-American individuals.

However, for the other two ethnic groups this difference was not as evident. In Caucasians, only two variables (lower canines and first molars) present statistically significant difference, showing little occurrence of sexual dimorphism (Table 2). But, all dental groups even though not statistically significant presented higher values for men, except for upper first premolar, with mean of 6.86 mm for males and 6.89 mm for females.

For Japanese, it occurred sexual dimorphism in four variables (upper lateral incisors; lower central and lateral incisors and canines) as it can be observed on Table 3. Only the lower second premolars were larger in women than in men, despite not statistically significant, with values of 7.01 and 6.98 mm, respectively. It can be said, in general, that the male gender presented larger mesiodistal distances than the female gender, corroborating several authors.[4,12,22,27]

On the three studied racial groups it was possible to notice that there was sexual dimorphism on the lower canine, confirming the studies that indicate the lower canine as the tooth that most presents difference between the male and female genders.[20] This difference can be used as instrument on the differentiation of genders in Forensic Dentistry.[20]

Ethnic origin

Many reports in literature emphasize the racial differences,[5,10,15,21,28] both in the teeth's dimensions and proportions. Therefore, the authors Nie and Lin[19] and Ta et al[29] suggest to minimize any racial influence, to evaluate individually the different groups, as done in this work. All results obtained on the means of mesiodistal diameters of the groups of teeth in the male gender, when compared the three ethnic groups, presented statistically significant differences (Fig 1). For the female gender, half of the variables presented statistically significant difference (upper lateral incisors and first molars; lower lateral incisors, canines first premolars and first molars), as it can be verified on Figure 2.

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The individual distances of the teeth in the male gender has a tendency to be larger in most dental groups of the African sample, followed by the Japanese and the lowest values found are related to Caucasians, both in the upper and lower teeth (Fig 1). However, this difference was not so clear in the female gender, which repeated the descending order of mesiodistal distances in African, Japanese and Caucasians, but with comparative results not always significant for each group of teeth (Fig 2).

It is known that Negroids present maxilla and mandible more protruded,[8] lower and upper incisors more tipped to buccal and more protruded and upper and lower lips more protruded than individuals from different ethnic origins.[3,8,18] It can be concluded that this double protrusion of teeth can be associated to the larger mesiodistal distance of African as it was found in this study, since the sample was constituted of patients that presented normal occlusion. In the same line of reasoning, it can be concluded that the smaller mesiodistal distances found in Caucasians can be related to the lower tipping normally found in Caucasians.[23]

In the clinical routine, the orthodontist can have trouble when find problems in the dental shape and size.[31] From the collected data and its analysis, it can be concluded that most mesiodistal measurements present particular characteristics in relation to gender and race, confirming the conclusions by Smith et al[28] who observed that the relation between the teeth's size depends on the population, gender and arch length.

Besides, it can be mentioned that the evaluation of the dental size in the clinical behavior can become indispensable on the choice for a tooth to be extracted and on the possible amount of dental stripping, for it can directly affect the treatment planning and prognosis. Thus, confirming the importance of evaluation of dental mesiodistal measurements for the correct diagnosis, orthodontic planning and cases individualization.

CONCLUSION

The results obtained in this research allowed to conclude that:

1) There is sexual dimorphism on the teeth's mesiodistal distances of male individuals, being greater than in females in:
   - » *African*: Lower teeth and upper central incisors, canines and first molars.
   - » *Caucasian*: Lower canines and first molars.
   - » *Japanese*: Upper lateral incisors and lower central and lateral incisors and canines.
2) There was a tendency for negroids to present greater mesiodistal distance, followed by Japanese and Caucasians, respectively.
3) Most mesiodistal distances presented particular characteristics in relation to gender and race.

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Deformation of elastomeric chains related to the amount and time of stretching

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Objective: Investigate a potential relationship between degree of stretching and resulting permanent deformation of elastomeric chains (ECs) as well as whether or not stretching time has any bearing on the degree of permanent deformation.

Methods: Five-module segments of closed elastomeric chains manufactured by 3M Unitek were stretched to 10-100% of their original length in devices especially designed for this purpose, remaining submerged in artificial saliva at 37 ± 1° C and were removed sequentially after 1, 2, 3 and 4 weeks. Upon removal, each segment was measured and once recorded the values were analyzed statistically with the purpose of assessing the degree of permanent deformation.

Conclusions: It was concluded that permanent deformation is directly proportional to the degree of stretching of the ECs assessed. The mean percentages found were 8.4% to 10% of stretching, and exceeding 20% (21.3%) when stretched by 40%, and reaching 56.6% permanent deformation when stretched 100% of their original length. Finally, the highest percentage of permanent deformation occurred during the first week and was not statistically significant after this period.

Keywords: Elastomers. Tensile strength. Permanent deformation.

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INTRODUCTION AND LITERATURE REVIEW

Among the various force-producing mechanisms used in orthodontics to move teeth as physiologically as possible through the alveolar bone, elastomeric chains (ECs) are undoubtedly the most widely employed in daily practice.[14,15]

EC insertion and removal requires little chair time and is not dependent on patient compliance. Furthermore, ECs are inexpensive and compatible with soft tissues.[8] When stretched, ECs generate elastic potential energy that can be transformed into mechanical energy, which in turn produces tooth movement. Given that they are made from amorphous polyurethane-based polymers, ECs exhibit characteristics of both rubber and plastic, which accounts for their elasticity.[5] The polymers are composed of primary and secondary links with weak molecular attraction that initially display a spiral pattern. When this pattern is subjected to the application of forces it undergoes deformation, causing ECs to be arranged linearly through crosslinking. The weak secondary links allow the spiral pattern to be transformed into a linear pattern while recovery of the initial structure becomes possible by means of crosslinking.[16] Permanent deformation occurs when the polymer is stretched beyond its elastic limit, causing disruption of crosslinks. However, certain factors influence EC performance, such as rapid force decay after stretching, i.e., inability to develop constant forces for an extended period of time, thereby impairing their effectiveness.[1,3,7,13,14,16] Additionally, ECs are influenced by temperature variations, salivary pH and the degree of stretching to which they are subjected.[14] In the oral environment, ECs absorb water, saliva and pigments, eventually undergoing chemical degradation, which results in the weakening of intermolecular forces, thereby decomposing their internal links. This leads to the onset of force decay processes, lack of dimensional stability and permanent deformation, making it difficult to determine the actual force magnitude being delivered to a given tooth.[3] Therefore, this *in vitro* study aimed to investigate the potential relationship between degree of stretching and resulting permanent deformation of elastomeric chains (ECs), as well as determine whether or not stretching time has any bearing on the degree of permanent deformation of ECs.

MATERIAL AND METHODS

For this research, closed gray ECs (CK Chain Spool - 3M Unitek), were carefully sectioned into segments of five modules each, with an initial length of 10 mm, ignoring the two ends of the segments, whose function was only to facilitate EC stretching. Four acrylic plates were fabricated and perforated for the insertion of 20 stainless steel pins with 0.2 cm diameter and 1.5 cm length arranged in parallel in 10 pairs with increasing distance between them in 1.0 mm increments, starting from 1.1 cm and ending with 2.0 cm. Ten EC segments were fitted to each pair of pins with the aid of a Mathieu needle holder, and were thus stretched to 10-100% of their original length. To prevent the pins from approaching each other due to the tension produced in stretching the ECs, a pin of equal length was fitted between all pairs of pins as shown in Figure 1. The plates were immersed in a stainless steel case containing artificial saliva with the following composition: Calcium 1.5 mmol L-1, Phosphate 0.9 mmol L-1, KCL 150 mmol L-1 in cacodylate buffer, 0.1 mol L-1 pH 7.0, Fluorine 0.05 mg/mL (1.1 mL solution/mm^2). This case was kept closed and in water bath at 37 ± 1° C in a soaking tub (Fig 2). These plates were first identified with a black OHP marker pen, according to the duration of the experiment. It is noteworthy that the water level was kept below the stainless steel lid, thus preventing contamination of the artificial saliva. Subsequently, the plates were removed sequentially after 1, 2, 3 and 4 weeks. Once retrieved from the saliva and blotted dry, each elastomeric segment was fitted to a measuring device especially made for this purpose consisting of a pin fixed to a wooden base, covered with graph paper (Fig 2). One end of the EC was seated in the pin and its final length recorded on graph paper. Thereafter, the length of each EC was measured and recorded with a caliper. Each week, the artificial saliva was replaced. It was first pre-heated in a container up to a temperature of 37 ± 1 °C, thereby averting changes in temperature.

Data were statistically analyzed by analysis of covariance (ANCOVA) with the purpose of checking whether there was a statistically significant difference between time and degree of stretching. Level of significance was set at 5% ($p = 0.0556$), to identify possible differences between groups.

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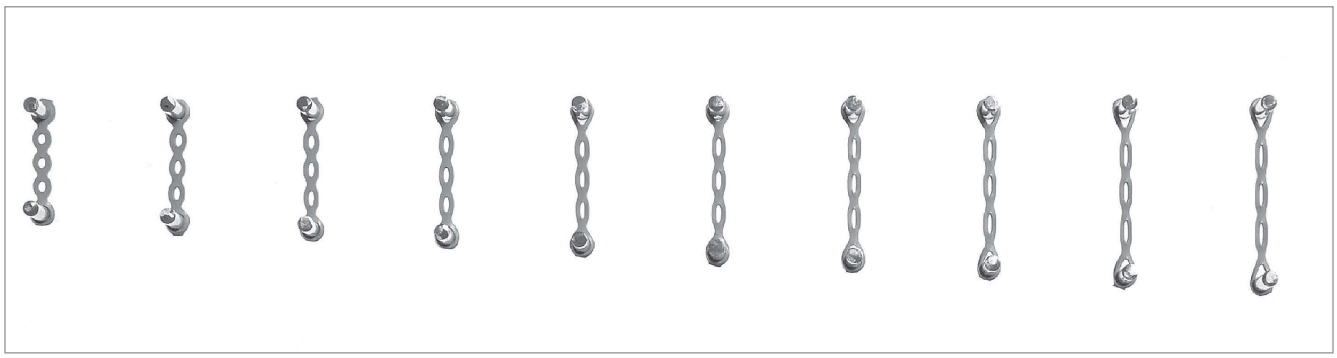


Figure 1 - Acrylic plate with stretched elastomeric chains.

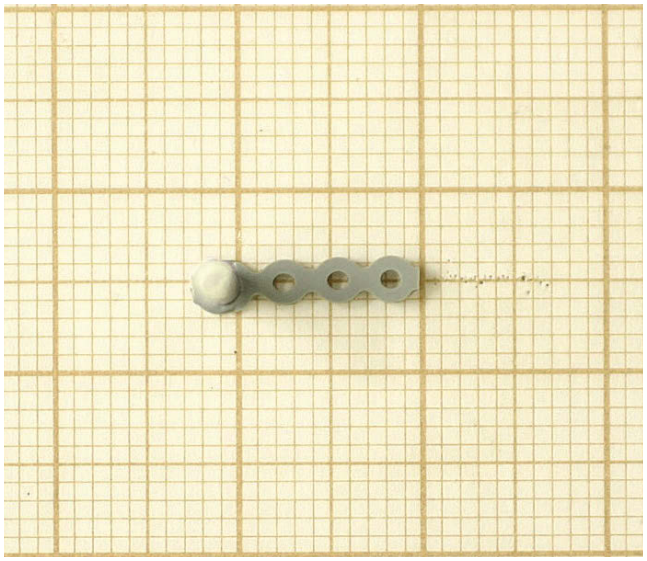


Figure 2 - Soaking tub used in the experiment.

RESULTS

Overall, it was found that permanent deformation of ECs was proportional to increases in stretching (Table 5). However, it was found that the mean deformation observed in the second, third and fourth weeks differed significantly from the mean stretching observed in the first week. No statistically significant differences were found in comparing the second to the third, the second to the fourth as well as the third to the fourth weeks (Table 7).

The results found in each week, according to time and degree of stretching, are presented in Tables 1, 2, 3 and 4; mean and standard deviation values reflecting the behavior of the variable *deformation* according to week and degree of stretching are shown in Table 5.

In order to assess to what extent the mean deformation was similar in all weeks, the test of equality of inclination coefficient was applied with a 5% level of significance ($p = 0.0556$). This was necessary because the hypothesis which assumed that the mean deformation in at least one week was influenced by the percentage separation between the pins was rejected. The magnitude of these differences can be seen in Table 6, in the inclination coefficient column. Table 6 also shows the mean stretching throughout the levels of separation for each week. The term *intercept* refers to the estimated mean deformation in millimeters in each week, irrespective of distance. The expression *inclination coefficient* refers to the mean change in one distance unit (10%). In the first week, regardless of distance, a mean deformation of 0.0479 mm per 10% stretching was found, i.e., in order to reach a mean deformation of 10% to 50% stretching, or 20% to 60%, one can simply multiply 0.0479 mm by 5, and a deformation of 0.23 mm is obtained. In the second week, the deformation was 0.0564 mm, in the third was 0.0530, and in the fourth, 0.0544 mm.

Based on the analysis of covariance (ANCOVA), it was found initially that, for all weeks, the mean deformation depends linearly (Fig 3) on the percentage of pin stretching ($p < 0.001$), i.e., in at least one of the weeks the mean deformation was influenced by the percentage of pin stretching (independent variable).

Since the hypothesis of lack of parallelism is not rejected yet, the mean elongations were compared between weeks (distances between the adjusted straight lines). These results can be seen in Figure 4.

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Table 1 - Results, in mm, obtained after stretching for one week.

1st week	STRETCHING (mm) Initial length = 10 mm									
Trial	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	10.7	11.2	11.5	11.9	12.5	13.0	13.2	13.8	14.5	15.0
2	10.7	11.1	11.3	12.0	12.1	13.0	13.3	13.7	14.6	15.1
3	10.8	11.0	11.5	12.0	12.5	13.0	13.2	13.9	14.5	15.0
4	10.7	11.1	11.5	12.0	12.3	13.0	13.2	13.9	14.6	15.0
5	10.7	11.1	11.5	12.0	12.4	13.0	13.2	13.8	14.6	15.0
6	10.7	11.0	11.5	12.0	12.5	13.0	13.3	13.7	14.6	15.1
7	10.7	11.1	11.5	12.0	12.5	13.0	13.3	13.7	14.5	15.1
8	10.7	11.2	11.5	12.0	12.5	13.0	13.2	13.8	14.5	15.0
9	10.7	11.1	11.4	12.0	12.5	13.0	13.2	13.8	14.6	15.0
10	10.7	11.1	11.5	12.0	12.5	13.0	13.2	13.9	14.5	15.1

Table 2 - Results, in mm, after stretching for two weeks.

2nd week	STRETCHING (mm) Initial length = 10 mm									
Trial	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	10.9	11.0	11.9	12.0	12.9	13.0	13.7	14.4	15.4	16.4
2	10.8	11.0	11.9	12.0	12.8	13.0	13.9	14.4	15.0	15.9
3	10.9	11.3	11.6	12.5	12.8	13.0	13.9	14.4	15.0	15.9
4	10.8	11.0	11.6	12.0	12.8	13.0	13.9	14.4	15.2	15.9
5	10.9	11.1	11.7	12.0	12.8	13.0	13.9	14.4	15.2	15.9
6	10.9	11.2	11.9	12.0	12.9	13.0	13.8	14.4	15.4	16.1
7	10.8	11.3	11.9	12.0	12.9	13.0	13.9	14.4	15.0	16.3
8	10.9	11.1	11.9	12.0	12.8	13.0	13.8	14.4	15.0	15.9
9	10.8	11.0	11.9	12.0	12.8	13.0	13.8	14.4	15.0	16.0
10	10.9	11.0	11.9	12.0	12.8	13.0	13.9	14.4	15.0	15.9

Table 3 - Results, in mm, after stretching for three weeks.

3rd week	STRETCHING (mm) Initial length = 10 mm									
Trial	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	10.9	11.1	11.9	12.0	12.8	13.0	13.9	14.1	15.0	15.7
2	10.9	11.1	11.9	12.0	12.5	12.9	13.9	14.1	15.0	15.7
3	10.9	11.1	11.9	12.0	12.8	13.0	13.8	14.1	15.0	15.7
4	10.9	11.1	11.9	12.0	12.6	13.0	13.9	14.1	15.0	15.7
5	10.9	11.1	11.9	12.0	12.8	13.0	13.8	14.1	15.0	15.7
6	10.9	11.1	11.9	12.0	12.7	12.9	13.9	14.1	15.0	15.7
7	10.9	11.1	11.9	12.0	12.8	13.0	13.9	14.1	15.0	15.7
8	10.9	11.1	11.9	12.0	12.8	13.0	13.8	14.1	15.0	15.7
9	10.9	11.1	11.9	12.0	12.5	13.0	13.9	14.1	15.0	15.7
10	10.9	11.1	11.9	12.0	12.8	13.0	13.9	14.1	15.0	15.7

Table 4 - Results, in mm, after stretching for four weeks.

4th week	STRETCHING (mm) Initial length = 10 mm									
Trial	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	10.9	11.5	12.0	12.1	12.9	13.3	14.0	14.5	15.1	15.8
2	10.9	11.4	12.0	12.2	12.9	13.3	14.0	14.8	15.0	16.0
3	10.9	11.4	11.9	12.2	12.9	13.0	14.0	14.7	15.5	15.9
4	10.9	11.4	11.9	12.2	12.9	13.1	14.0	14.7	15.3	15.9
5	10.9	11.4	12.0	12.2	12.9	13.2	14.0	14.8	15.0	15.9
6	10.9	11.5	12.0	12.2	12.9	13.2	14.0	14.6	15.5	16.0
7	10.9	11.4	12.0	12.9	12.9	13.0	14.0	14.5	15.1	15.9
8	10.9	11.4	12.0	12.9	12.9	13.3	14.0	14.7	15.3	15.8
9	10.9	11.4	12.0	12.9	12.9	13.3	14.0	14.8	15.0	15.9
10	10.9	11.5	12.0	12.9	12.9	13.0	14.0	14.8	15.2	15.9

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Table 5 - Mean and standard deviation values, in mm, for each degree of stretching vs. week combination.

Stretching	1st week	2nd week	3rd week	4th week	Mean ± SD
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
10%	10.71 ± 0.03	10.86 ± 0.05	10.90 ± 0.00	10.90 ± 0.00	10.84 ± 0.08
20%	11.10 ± 0.07	11.10 ± 0.12	11.10 ± 0.00	11.43 ± 0.05	11.18 ± 0.16
30%	11.47 ±0.07	11.82 ± 0.13	11.90 ± 0.00	11.98 ± 0.04	11.79 ± 0.21
40%	11.99 ±0.03	12.05 ± 0.16	12.00 ± 0.00	12.47 ± 0.37	12.13 ± 0.28
50%	12.43 ±0.13	12.83 ± 0.05	12.71 ± 0.13	12.90 ± 0.00	12.72 ± 0.20
60%	13.00 ± 0.00	13.00 ± 0.00	12.98 ± 0.04	13.17 ± 0.13	13.04 ± 0.10
70%	13.23 ± 0.05	13.85 ± 0.07	13.87 ± 0.05	14.00 ± 0.00	13.74 ± 0.31
80%	13.80 ± 0.08	14.40 ± 0.00	14.10 ± 0.00	14.69 ± 0.12	14.25 ± 0.34
90%	14.55 ± 0.05	15.12 ± 0.17	15.00 ± 0.00	15.20 ± 0.19	14.97 ± 0.28
100%	15.04 ± 0.05	16.02 ± 0.19	15.70 ± 0.00	15.90 ± 0.07	15.66 ± 0.40
Mean	12.732	13.105	13.026	13.264	13.03
SD	1.39	1.65	1.54	1.58	1.55

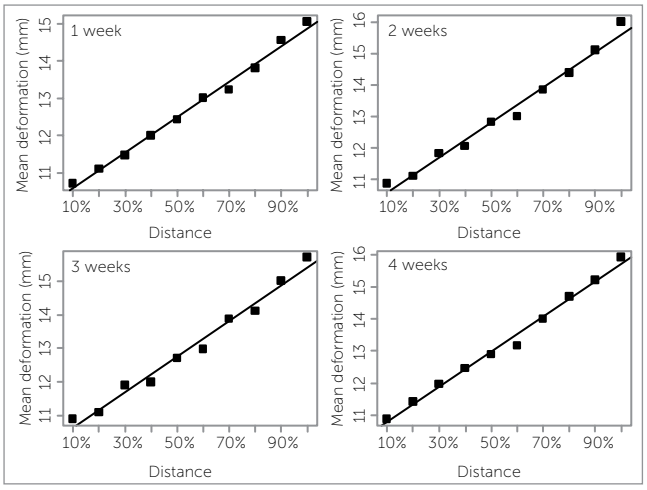


Figure 3 - Dispersion of mean deformation vs. distance. The straight line shows adjustment by least squares.

Table 6 - Estimates of parameters for adjusted models.

Week	Intercept	Inclination coefficient	R^2
1st Week	12.732	0.0479	0.9919
	(0.004)*	(0.0014) *	
2nd Week	13.105	0.0564	0.9805
	(0.076) *	(0.0027) *	
3rd Week	13.026	0.0530	0.9796
	(0.073) *	(0.0025) *	
4th Week	13.264	0.0544	0.9905
	(0.051) *	(0.0018) *	

R^2 = Adjusted determination coefficient; * standard deviation.

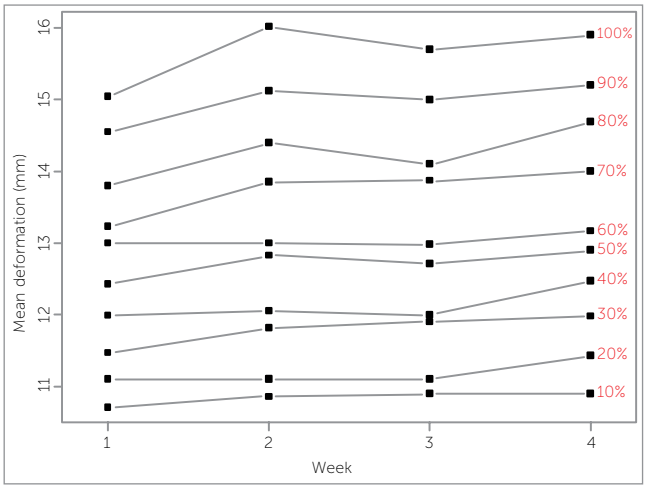


Figure 4 - Mean deformation, over the weeks, for each of the distances.

Table 7 - Comparison between mean deformations.

	1st week	2nd week	3rd week	4th week
1st Week		0.0004*	0.0037*	< 0.0001*
2nd Week	0.0004*		0.4086	0.1012
3rd Week	0.0037*	0.4086		0.0165*
4th Week	< 0.0001*	0.1012	0.0165*	

* = Statistically significant difference.

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In comparing the mean deformations, statistically significant differences were detected only in the first week, compared to the others. Table 7 demonstrates a comparison between mean deformations in all weeks.

In this study it was found that the percentage of force decay rises as immersion time increases. However, a reversal – though not statistically significant – was observed between the means of the second and third weeks (Table 5 and Fig 4).

DISCUSSION

To be effective in their function, ECs should produce an appropriate magnitude of force for a certain period of time.[10] However, it is known that ECs cannot generate constant forces for a long period of time since their elastic properties are altered over time, causing permanent deformation and, consequently, loss of tension. The inability of elastic materials to return to their original size after undergoing substantial deformation and releasing the tensile forces applied to them, is defined as plastic, or permanent, deformation.[4] The effects of this plastic deformation are manifested by the decrease of these materials' ability to deliver forces.[15]

In the present study, EC behavior was evaluated weekly over a period of 4 weeks — the interval between patient visits,[4,8,9,12,17] as this time period coincides with the average period when orthodontists usually replace the patient's elastics.[2] The time factor is of paramount importance for ECs, since it is known that one of their main properties, i.e., the dissipation of forces with constant magnitude during their clinical application, is directly influenced by the time period during which they are employed, given a loss of tension and consequent force decay.[18] In the present study, a statistically significant difference was noted between the mean deformation of the first week and the others (Table 7), which suggests - without considering the biology of tooth movement – that it is convenient to change ECs weekly, since comparisons between the second and third weeks, between the third and fourth weeks, and between the second and fourth weeks, showed no significant differences. However, it is recommended that ECs be replaced every 3 weeks.[6,13] Furthermore, ECs should not be used for longer than 4 weeks, not only due to force decay but also due to difficulties in oral cleaning, with the resulting accumulation of food debris.[13] Additionally, EC use should not exceed a period of 6 weeks as ECs eventually lose, on average, 30% of their initial force. Besides, there is an increase in the accumulation of plaque and chemical interaction with food and oral fluids.[11]

Regarding immersion time in artificial saliva, the rate of force decay increases with time,[1,9,24] as concluded in this study. Although not significant statistically, a reversal was also observed between the means of the second and third weeks (Table 5 and Fig 5).

As regards the degree of elongation undergone by ECs, force decay is proportional to the degree of stretching to which the ECs are subjected,[1] in agreement with the findings of this study (Table 5 and Fig 4). For example, it became evident that, as shown in Table 1, 10% stretching yielded a mean deformation of approximately 8.4%, whereas 100% stretching caused the deformation to increase to 56.6%. Thus, from a clinical standpoint, an issue could be raised: How much stretching is recommended to (a) achieve a low rate of permanent deformation, and (b) apply forces that are as constant as possible? Based on the results of this study, it would be reasonable to suggest 30% stretching, which would provide a mean deformation of about 17.9%. However, it should be emphasized that this argument is only applicable to 3M Unitek ECs which were analyzed here, since ECs can vary in thickness, elastic property, manufacturing process, adding pigments or fluorine and distance between modules. These factors, acting alone or in conjunction, will certainly influence both the forces delivered and the degree of permanent deformation undergone by these materials. Therefore, professionals who use ECs should be aware of the various issues and types of materials addressed in this study, and act accordingly.

The use of a tension gauge is advised to measure the initial force since certain closed chains — when stretched to 100% of their original length — can produce excessive forces, approaching 450 grams. It is therefore recommended to stretch these ECs between 50% and 75% of their original length. However, there are ECs which, when stretched to 100% of their original length, produce acceptable magnitudes of force (approximately 300 grams).[3] Based on this, professionals are advised to stock in their offices

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ECs with at least three different distances between modules, provided they have the same thickness and are manufactured by the same company. This would allow the application of the desired force magnitude, taking into consideration the degree of stretching recommended by this study (30%).

Furthermore, a permanent deformation of 50% to 60% was observed when the ECs were stretched to 100% of their original length. These percentages resemble those found for American Orthodontics (54%) ECs.[15] However, the percentages found for 3M Unitek (76%) ECs[15] differ from those found in this study.

While a simulation was made of the oral environment, it should be stressed that in an *in vivo* study, a wide range of factors such as the patient's diet, the composition of their saliva, presence of bacterial enzymes, masticatory forces, tooth movement, distance of force application, presence of fluoride and temperature changes could affect the mechanical performance of ECs, thereby altering the results obtained in this study.

CONCLUSION

Based on the results it can be conclude that:

1) A direct relationship was found between degree of stretching and permanent deformation of the ECs evaluated.

2) The mean stretching percentages found were 8.4% to 10%, exceeding 20% (21.3%) when stretched by 40%, and reaching 56.6% permanent deformation when stretched to 100% of their original length.

3) The highest percentage of permanent deformation occurred during the first week, and was not statistically significant after this period.

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Cephalometric analysis for the diagnosis of sleep apnea: A comparative study between reference values and measurements obtained for Brazilian subjects

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Objective: To verify if the reference values of Sleep Apnea cephalometric analysis of North American individuals are similar to the ones of Brazilian individuals presenting no craniofacial anomalies. The study also aimed to identify craniofacial alterations in Obstructive Sleep Apnea-Hypopnea Syndrome (OSAHS) patients in relation to individuals without clinical characteristics of the disease through this cephalometric analysis.

Method: It were used 55 lateral cephalograms consisted of 29 for the control group of adult individuals without clinical characteristics of OSAHS and 26 apneic adults. All radiographs were submitted to Sleep Apnea cephalometric analysis through Radiocef Studio 2.0. The standard values of this analysis were compared, by means of z test, to the ones obtained from the control group and these were compared to values from apneic group through Student's *t* test.

Results: There were no significant differences between values obtained from control group and standard values. On the group of OSAHS patients it was observed a decrease on the dimensions of upper airways and an increase on the soft palate length.

Conclusions: The standard values of Sleep Apnea analysis can be used as reference in Brazilian individuals. Besides, through lateral cephalograms it was possible to identify craniofacial alterations in OSAHS patients.

Keywords: Obstructive sleep apnea. Comparative study. Cephalometry

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

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INTRODUCTION

The radiographic cephalometry is an important element for investigation of alterations that occur during craniofacial growth and development. This technique transcended the boundaries of odontology and, today, presents significative importance in other areas, such as Otorhinolaryngology, as an important tool for the evaluation of upper airways (UA) and diagnosis of the obstructive sleep apnea-hypopnea syndrome (OSAHS).[25]

The OSAHS consists in repeated apneic events, resultant from total or partial collapse of the pharynx during sleep. It was identified, predisposing factors such as obesity, alterations on the neuromuscular pattern and skeletal or soft tissue anatomical alterations.[24] Many authors[1,4,7,9,21] discussed and validated the lateral cephalometric radiograph for evaluation of the UA. Although it consists in method of diagnosis through two-dimensional image, the lateral cephalometric radiograph provides linear and angular measurements that are essential to locate the spots of obstruction of the pharynx.[17,18]

Simões[24] evaluated through lateral cephalometric radiographs, the pharyngeal space in north American individuals with normal occlusions belonging to Ann Arbor's sample. This work generated a table with standard values that is widely used as reference in Brazilian radiological and orthodontic clinics. However, studies that validated this analysis were not found for the use in the Brazilian population.

In this context, the objective of this study was to verify if reference values of Sleep Apnea cephalometric analysis relative to North American individuals are similar to the ones of Brazilian individuals with no craniofacial anomalies. The study also aimed to identify craniofacial alterations in OSAHS patients in relation to individuals without clinical characteristics of the disease.

MATERIAL AND METHODS

The present study was approved by the Ethics Committee in Research of the State University of São Paulo, São José dos Campos, School of Dentistry, under the protocol number 103/2007/2006-PH/CEP.

Sample selection

In the present study, 55 lateral cephalometric radiographs were used. Twenty-six from individuals with diagnosis of OSAHS confirmed by polysomnographic exam, consisted of 18 males ranging from 20 to 70 years of age, and 8 females from 30 to 57 years of age. The radiographs were obtained at the same center of dental radiology. Polysomnographic exams were also performed in a single clinic specialized in sleep disorders.

Twenty nine radiographs of individuals presenting no symptoms relative to OSAHS were also used, comprising 11 males from 18 to 29 years of age and 18 females from 19 to 35 years of age.

The criteria for inclusion of the cephalometric radiographs of OSAHS patients were: Polysomnographic examination report that corroborated the diagnosis of OSAHS available and performed in specialized clinic according to protocol recommended by the Brazilian Society of Sleep on the I Consensus in Snore and Sleep Apnea,[27] including the AHI values, body mass index (BMI), total period of sleep and period of sleep in each stage, average heart rate and baseline oxyhemoglobin saturation (SO_2).

Regarding the control group, the criteria were: Existence of medical report with full information about the systemic conditions of the individuals: Not syndromic, did not snore, did not use medicines to induce sleep (hypnotic or neuroleptic), had not been subjected to orthognathic surgical treatment, upper airways treatment or previous orthodontic treatment, did not have respiratory or neurological problems, were not obese and with harmonious facial profile and Class I skeletal pattern.

It were excluded the radiographs that presented the image of the soft palate in format of inverted V, which, according to McNamara Jr.,[19] indicates that the individual swallowed at the moment of obtaining the image, which can interfere on measurements related to this structure.

Cephalometric analysis

The cephalometric radiographs were digitized with resolution of 300 dpi through flatbed scanner EPSON Perfection 4990 (Epson America Inc., Long Beach, California,USA) with transparency reader attached and its respective software SilverFast® SE 6. The images were saved in TIFF format (Tagged Image File Format) without compression. The cephalometric analysis were performed by a single evaluator and digitized through the software Radiocef Studio 2.0 (Radiomemory, Belo Horizonte/MG).

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In the present study, for the classification of individuals on the control group regarding the sagittal skeletal pattern, it was used the ANB angle. Only individuals with ANB between 0° and 4° were selected.

For evaluation of the UA and related structures, it was used the Sleep Apnea analysis which is in the list of analysis of the software and is based on works by Simões[24] and Pinto.[21] This cephalometric analysis is constituted of 28 points forming 14 factors (linear measures), shown in Figure 1.

Statistical analysis

For evaluation of method error, the measures were obtained twice with 30 days interval. The results of both readings were compared through simple Linear Regression Analysis and Student's *t* test with level of significance at 5% ($\alpha = 0.05$).

The mean for every factor obtained on the control group was compared to the standard value of the Sleep Apnea analysis through the test. Posteriorly, to verify differences between the group of OSAHS patients and the control group, it was used the Student's *t* test with $\alpha = 0.05$.

RESULTS

The mean between the first and the second reading of each measure was used to calculate the analyzed factors. The results of z test, used for comparison of means of the control group and of standard values of Sleep Apnea analysis,[24] are represented on Table 1 and Figure 2 for females and on Table 2 and Figure 3 for males.

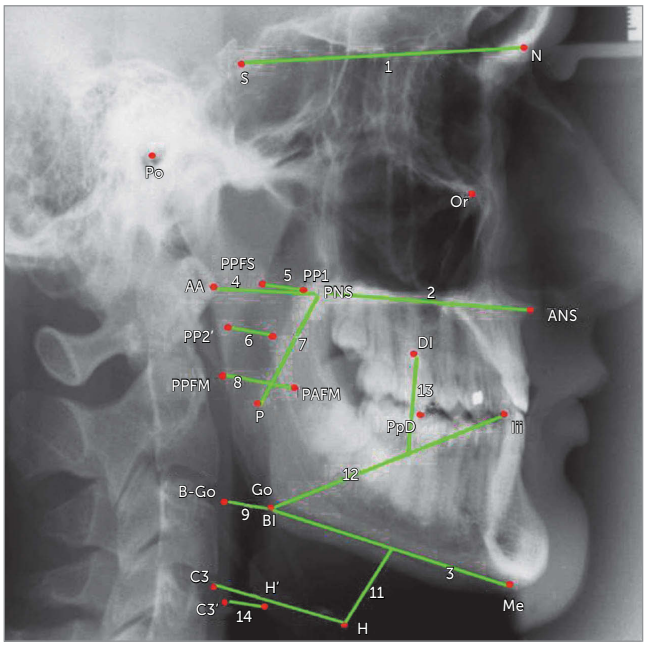


Figure 1 - Representation of points and factors evaluated on Sleep Apnea cephalometric analysis.

Table 1 - Mean, standard deviation (SD) and p value of the 14 linear measures (mm) on control group and standard for females, after application of z test.

Factor	Group control Mean ± SD	Standard Value Mean ± SD	p value
1) S-N	69.70 ± 3.11	73 ± 3.0	0.2858
2) ANS-PNS	53.20 ± 2.82	54 ± 3.0	0.7964
3) Goc-Me	73.92 ± 6.37	74 ± 5.0	0.9883
4) AA-PNS	39.88 ± 5.42	36 ± 3.0	0.2335
5) PPFS-PP1	20.09 ± 3.50	24 ± 3.5	0.2780
6) PP2-PP2'	13.90 ± 2.48	14 ± 2.0	0.9618
7) PNS-P	33.02 ± 4.83	35 ± 4.5	0.6703
8) PPFM-PAFM	17.77 ± 3.36	21 ± 3.5	0.3683
9) B-Go/BI	11.87 ± 2.93	13 ± 2.5	0.6643
10) C3-H	34.27 ± 3.70	36 ± 3.0	0.5808
11) PM-H	20.51 ± 15.32	15 ± 3.0	0.2398
12) BI-PI	69.87 ± 6.14	72.5 ± 3.0	0.4308
13) DI-PI/BI	22.38 ± 3.76	24 ± 3.0	0.6049
14) C3'-H'	11.74 ± 2.85	13.5 ± 2.0	0.4049

* Significant level: 5%.

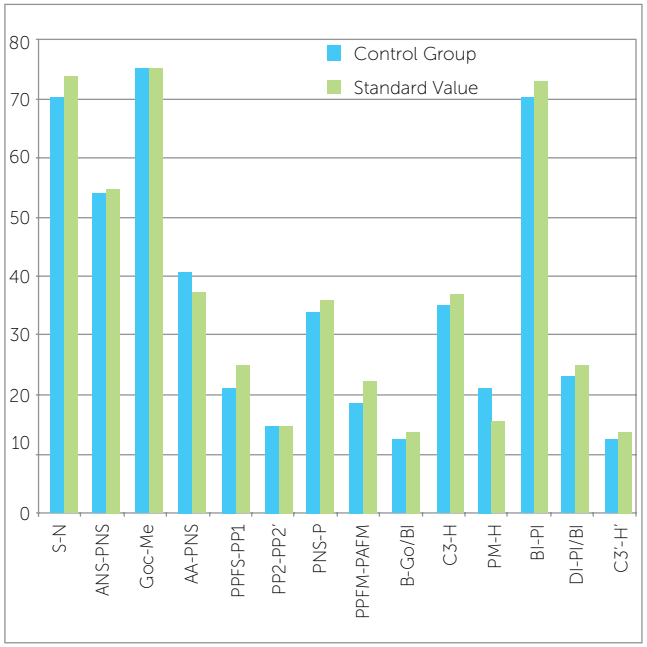


Figure 2 - Graphic of comparison between the factors values, in millimeters, of the control group and standard values in female individuals.

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Table 2 - Mean, standard deviation and p value of the 14 linear measures (mm) on the control group and standard values for male individuals after application of z test.

Factor	Control Group Mean ± S.D.	Standard values Mean ± S.D.	p value
1) S-N	76.10 ± 4.34	80 ± 2.00	0.1031
2) ANS-PNS	60.02 ± 4.97	62.5 ± 4.00	0.5625
3) Goc-Me	79.26 ± 4.12	84.5 ± 5.00	0.3099
4) AA-PNS	40.83 ± 2.32	36 ± 3.50	0.1758
5) PPFS-PP1	19.91 ± 2.84	26 ± 4.00	0.1367
6) PP2-PP2'	14.11 ± 2.04	12 ± 3.00	0.4894
7) PNS-P	34.68 ± 3.75	34 ± 5.00	0.8944
8) PPFM-PAFM	19.45 ± 2.41	22 ± 4.50	0.5761
9) B-Go/Bl	14.45 ± 3.57	15.5 ± 3.50	0.7749
10) C3-H	40.81 ± 4.29	41 ± 3.50	0.9614
11) PM-H	19.79 ± 4.80	19 ± 6.00	0.8969
12) Bl-Pl	73.39 ± 4.88	79 ± 5.00	0.2819
13) Dl-Pl/Bl	24.38 ± 3.56	29.5 ± 3.00	0.1084
14) C3'-H'	16.77 ± 5.37	17.5 ± 4.00	0.8617

* Significance level: 5%.

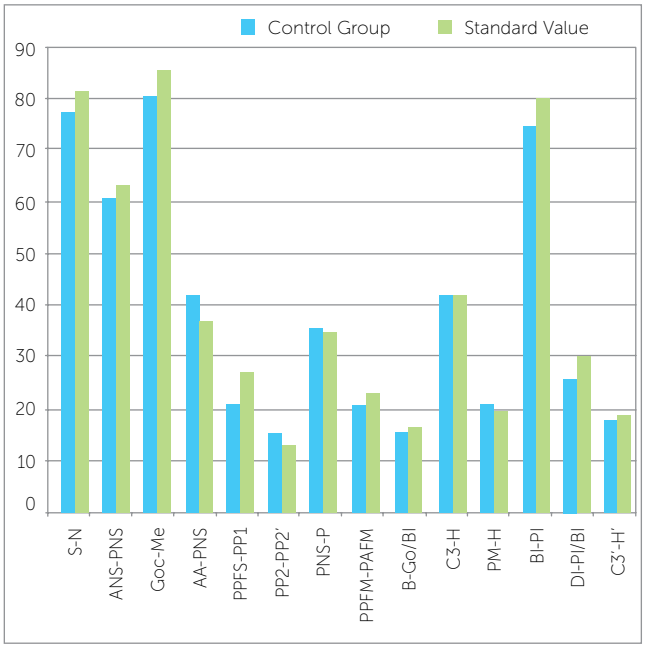


Figure 3 - Graphic of comparison between the factors values, in millimeters, of the control group and standard values in male individuals.

Table 3 - Mean, standard deviation and p value of linear measures in males on the control group and on the OSAHS group after application of Student's *t* test.

Factor	OSAHS (n = 18) Mean ± S.D.	Control (n = 11) Mean ± S.D.	p value
1) S-N	74.8 ± 3.3	76.1 ± 4.3	0.3734
2) ANS-PNS	56.9 ± 5.1	60 ± 5	0.3734
3) Goc-Me	71.1 ± 3.2	79.3 ± 4.1	0.3734
4) AA-PNS	37.3 ± 4.1	40.8 ± 2.3	0.0431
5) PPFS-PP1	14.4 ± 3.5	19.9 ± 2.9	0.0000*
6) PP2-PP2'	7.5 ± 2.5	14.1 ± 2.1	0.0000*
7) PNS-P	43.3 ± 4.5	34.7 ± 3.8	0.0000*
8) PPFM-PAFM	15.1 ± 2.8	19.5 ± 2.4	0.0000*
9) B-Go/Bl	12.1 ± 3.2	14.5 ± 3.6	0.0796
10) C3-H	43.4 ± 5.1	40.8 ± 4.3	0.1545
11) PM-H	26 ± 6.5	19.8 ± 4.8	0.0223
12) Bl-Pl	73.9 ± 4.9	73.4 ± 4.9	0.8921
13) Dl-Pl/Bl	24 ± 2.7	24.4 ± 4.2	0.9500
14) C3'-H'	6.1 ± 2	16.8 ± 5.4	0.0000*

* Significance level: 5%.

Table 4 - Graphic of comparison between the factors values, in millimeters, of the control group and of the standard values in female individuals.

Factor	OSAHS (n = 8) Mean ± S.D.	Control (n = 18) Mean ± S.D.	p value
1) S-N	68.4 ± 3.93	69.7 ± 3.12	0.0021*
2) ANS-PNS	48.8 ± 4.64	53.21 ± 2.83	0.0021*
3) Goc-Me	68.68 ± 6.96	73.92 ± 6.38	0.1869
4) AA-PNS	37.25 ± 6.9	39.89 ± 4.41	0.5570
5) PPFS-PP1	16.75 ± 3.78	20.1 ± 3.51	0.1222
6) PP2-PP2'	6.67 ± 2.51	13.9 ± 2.48	0.0000*
7) PNS-P	41.14 ± 3.14	33.02 ± 4.84	0.0003*
8) PPFM-PAFM	12.01 ± 2.74	17.77 ± 3.36	0.0005*
9) B-Go/Bl	7.12 ± 1.57	11.87 ± 2.94	0.0003*
10) C3-H	41.68 ± 7.09	34.27 ± 3.71	0.0005*
11) PM-H	23.88 ± 7.26	20.52 ± 15.32	0.6133
12) Bl-Pl	67.76 ± 6.21	69.88 ± 6.15	0.5514
13) Dl-Pl/Bl	19.98 ± 3.03	22.38 ± 3.76	0.0000*
14) C3'-H'	6.08 ± 2.35	11.74 ± 2.86	0.0000*

* Significance level: 5%.

The p values of comparisons and results of Student's *t* test for studied groups are represented on Tables 3 and 4.

DISCUSSION

Through the results of the present study it was observed that, despite the evident physical differences between Brazilian and north American individuals, there was no significative difference on the cephalometric dimensions relative to UA among the individuals of these two nationalities, indicating that there is possibility of using the table of standard values for OSAHS on the evaluation of Brazilian individuals.

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Today, the diagnosis and treatment of OSAHS depend on a multidisciplinary team of health professionals. The dentist, specially the orthodontist, maxillary functional orthopedist and oral and maxillofacial surgeon have fundamental role on the diagnosis of obstruction of UA through radiographs that are part of their work routine. Besides, they participate actively on the treatment of apneic individuals through intraoral appliances[11,12,22] or orthognathic surgeries.

Several methods of diagnosis by image can be used in order to evaluate the dimensions of UA, however in this study, it was chosen the lateral cephalometric radiograph because this exam is considered the most accessible and widely requested method according to other authors.[1,4,17,18]

The choice for the cephalometric analysis used in this study was due to its large use in radiological and orthodontic clinics and for it embraces measures in all regions susceptible to obstruction.

It was considered important to verify if reference values for the craniofacial measures based in studies with American individuals can be used for Brazilian individuals since in a study comparing OSAHS patients from two distinct ethnicities, Cakirer et al[6] found significant differences on the craniofacial characteristics associated to UA between these groups.

The narrowing of the nasopharynx observed in OSAHS male patients (Table 3) was a finding similar to presented by other authors.[1,4,17,21,23] According to some studies,[5,19,21] the upper pharyngeal space is one of the regions most susceptible to collapse due to frequent hypertrophy of the pharyngeal tonsils. In the present study, the tonsils were not separately evaluated, however, it was considered the dimensions of the soft tissue on the nasopharynx by marking the posterior point where there was greater obstruction of the airway according to McNamara Jr.[19]

King[15] mentioned that the forward and downward growth of the face is affected by the anterior growth of the cranial base and posterior growth of the occipital bone or by the association of both, and this growth will contribute to the increase of the pharynx's diameter. In female OSAHS patients was observed a reduction on the cranial base and on the dimensions in all regions of the pharynx. Some authors[3,2,8,26] mentioned the decrease of the cranial base as one of the cephalometric findings characteristics of OSAHS.

The hyoid bone was more anteriorly positioned in females on the group of OSAHS subjects and did not present significant difference in males on the present research, similar to the findings by Tsai et al,[26] who found that this factor is associated to greater severity of OSAHS in females.

It is known that the hyoid bone has no bone articulation and is suspended by a grid of muscles and ligaments. Therefore, its position is largely dependent of muscle ligaments, such as tongue, and it is also influenced by the individual's posture.[8] This fact explains the importance of evaluating this structure in apneic individuals.

Battagel and L'Estrange[4] asserted that the greater alterations on dimensions of UA in OSAHS patients occur in the oropharynx, agreeing with Lowe et al,[16] and were related to the reduction of the median posterior palatal space that, in the present work, was also reduced on the group of OSAHS subjects. This space has close relation to the dimensions of the soft palate which increased length was related to presence of OSAHS in several researches[3,4,10,20,25,26] and the present study.

The lower airspace is significantly reduced on the group of OSAHS patients agreeing with Lyberg et al.[17] This obstruction of the hypopharynx is related to the epiglottic region that corresponds to the area of great interest for orthognathic surgeries.[13]

On Figure 4, it can be compared lateral cephalometric radiographs correspondent to group of OSAHS subjects and the control group, in which is observed the most common alterations of UA and related structures found on the group of OSAHS patients in relation to the control group.

The hypothesis that anatomic factors, are involved on the etiology of OSAHS has great support in literature. Therefore, it is important to know the anatomic alterations predominant in apneic individuals so that professionals that work directly with lateral cephalometric radiograph can identify risk factors and refer the patient to specialists and specific exams such as polysomnography, considered the gold standard exam for diagnosis of OSAHS. This will contribute to the early diagnosis of the disease, avoiding the severe sequelae related to it.

CONCLUSIONS

» Craniofacial measures used as reference on the diagnosis of OSAHS, can be applied to Brazilian individuals.

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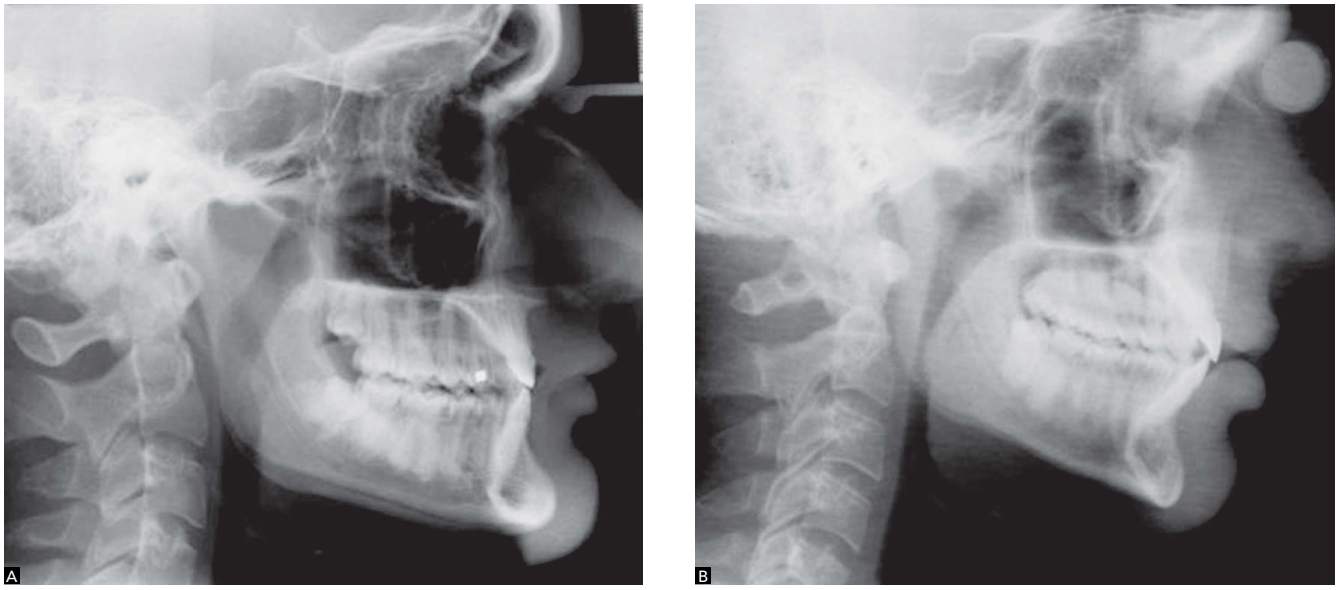


Figure 4 - **A**) Example of radiographs of control group's individual **B**) example of radiographs of OSAHS individuals.

» There were significative craniofacial alterations in OSAHS patients when compared to individuals without clinical characteristics of this disease.
» In male apneics it were observed reductions of the upper, mean, inferior and retropalatal air spaces and increase of the soft palate length.
» In female apneics, reduction of the dimensions in all evaluated pharyngeal regions, of anterior cranial base and maxilla length.

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Angle Class I malocclusion treated with lower incisor extraction

Vanessa Leal Tavares Barbosa[1]

In planning orthodontic cases that include extractions as an alternative to solve the problem of negative space discrepancy, the critical decision is to determine which teeth will be extracted. Several aspects must be considered, such as periodontal health, orthodontic mechanics, functional and esthetic alterations, and treatment stability. Despite controversies, extraction of teeth to solve dental crowding is a therapy that has been used for decades. Premolar extractions are the most common, but there are situations in which atypical extractions facilitate mechanics, preserve periodontal health and favor maintenance of the facial profile, which tends to unfavorably change due to facial changes with age. The extraction of a lower incisor, in selected cases, is an effective approach, and literature describes greater post-treatment stability when compared with premolar extractions. This article reports the clinical case of a patient with Angle Class I malocclusion and upper and lower anterior crowding, a balanced face and harmonious facial profile. The presence of gingival and bone recession limited large orthodontic movements. The molars and premolars were well occluded, and the discrepancy was mainly concentrated in the anterior region of the lower dental arch. The extraction of a lower incisor in the most ectopic position and with compromised periodontium, associated with interproximal stripping in the upper and lower arches, was the alternative of choice for this treatment, which restored function, providing improved periodontal health, maintained facial esthetics and allowed finishing with a stable and balanced occlusion. This case was presented to the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO), as part of the requirements for obtaining the BBO Diplomate title.

Keywords: Crowding. Lower incisor extraction. Gingival recession.

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* Clinical case, category 2, accepted by the Brazilian Board of Orthodontics and Dentofacial Orthopedics, BBO.

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

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HISTORY AND ETIOLOGY

Female patient, Caucasian, searched for orthodontic treatment at age 44, in good general health with no significant medical history. The main complaint was related to crowding in the upper arch, and especially in the lower arch, as well as the gingival recessions, which were increasing over the years (Fig 1). There was a history of caries and unsatisfactory restorations in several teeth. No esthetic complaints were reported. In functional occlusion analysis, it was found that the right and left lateral guides were performed by the first upper and lower premolars. The gingival recession of tooth #14 was, possibly, due to occlusal overload. Despite no functional guides were present, there were no signs or symptoms of temporomandibular disorders. No orthodontic intervention had been performed before.

DIAGNOSIS

Regarding facial characteristics the following features were present: A mesocephalic pattern, symmetrical face, normal nasolabial angle, with a straight profile. The lower lip was slightly ahead of the Steiner's line and the patient had difficulty to obtain a passive lip seal. In the intraoral evaluation, it was observed a high number of caries, nasal breathing, Angle Class I malocclusion, with severe lower anterior crowding (7 mm negative discrepancy in dental arch analysis) and slight crowding in the upper arch. A reduced overbite was present, with less than 1/3 overlap of the lower incisors, and an almost edge to edge anterior occlusion — except in the region of tooth #11, which had 3 mm overjet, due to its protrusion and rotation. The upper midline was inclined. In the transverse direction, there was a constriction of the upper



Figure 1 - Initial facial and intraoral photographs.

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arch in the premolars and molars region, with a tendency to crossbite. The lower midline was shifted 1 mm to the left side, and the upper and lower incisors and lower right canine were projected in relation to their apical bases. Tooth #43 was labially positioned with the long axis mesially displaced, and presented marked gingival recession (Figs 1 and 2). The panoramic radiograph reported the presence of third molars, with the lower ones mesially tipped. Periapical radiographs revealed a regular alveolar bone loss in the maxilla and mandible, and suggested external root resorption in the apical third of the teeth #31 and #41. Interproximal radiographs demonstrated excess of restorative material in several teeth. The cephalometric diagnosis confirmed the labial protrusion of the upper incisors (1-NA = 32° and 7.5 mm) as well as the lower ones (1-NB = 25° and 7 mm) (Figs 3, 4 and 5).

TREATMENT OBJECTIVES

Orthodontic treatment aimed to eliminate the anterior dental discrepancy, correcting the crowding of upper and lower incisors, aligning and leveling the teeth without jeopardizing the facial profile; establishing esthetically favorable and functionally effective overjet and overbite, properly positioning the teeth on their apical bases and contributing to improve periodontal health. The extraction of premolars could result in flattening of the facial profile, aggravated by facial changes due to age; however, the treatment without extractions would increase the lack of lip seal, and contribute to the worsening of gingival recession and a greater tendency to relapse.[8] Through the diagnostic setup the possibility of a lower incisor extraction was evaluated, because it is one of the most valuable orthodontic records to determine if a lower incisor should be extracted.[1,3,11,22,24] Prior to orthodontics, the patient would be referred to the periodontist for free gingival graft in the teeth with accentuated gingival recession, preventing its intensification and creating a thicker marginal gingiva.[25] The shape of the upper arch should be improved by expanding the molar and premolar regions, which tended to cross, favoring a greater filling of the buccal corridor and broadening the smile. The occlusion key of the right and left molars and left canine would be kept, while the Class I relationship in the right canine should be achieved. Inadequate restorations would be replaced at the end of orthodontic treatment, aiming periodontal health and occlusal stability.

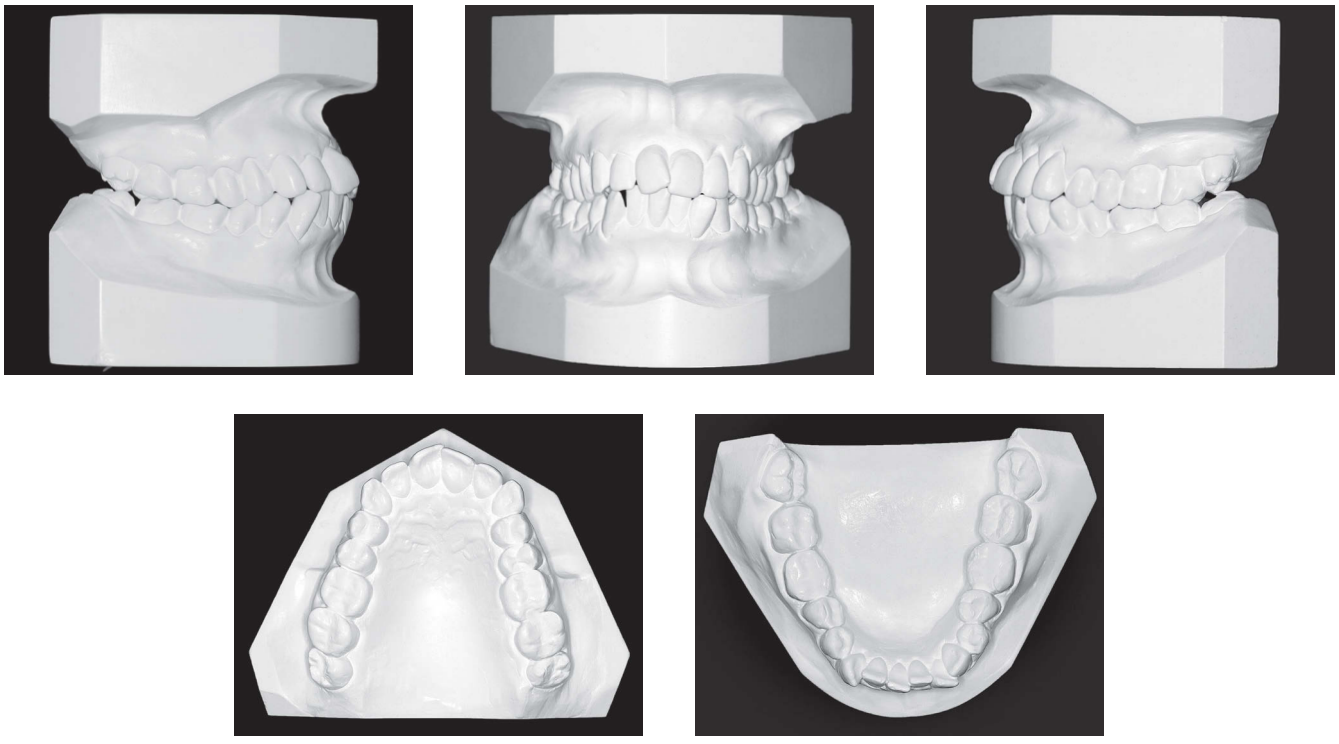


Figure 2 - Initial casts.

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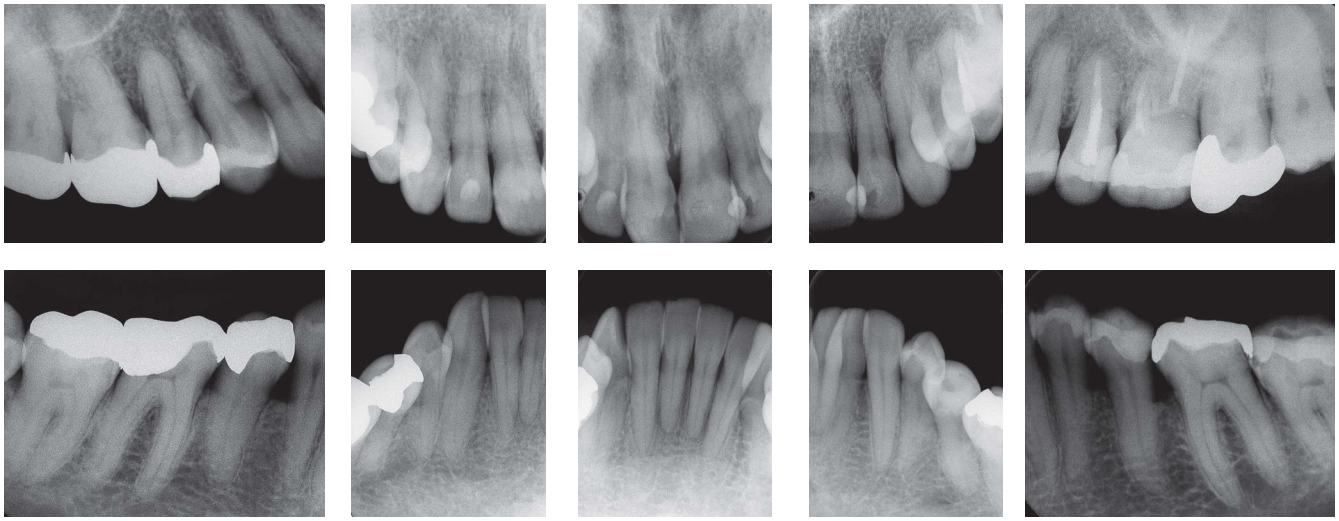


Figure 3 - Initial periapical radiographs.

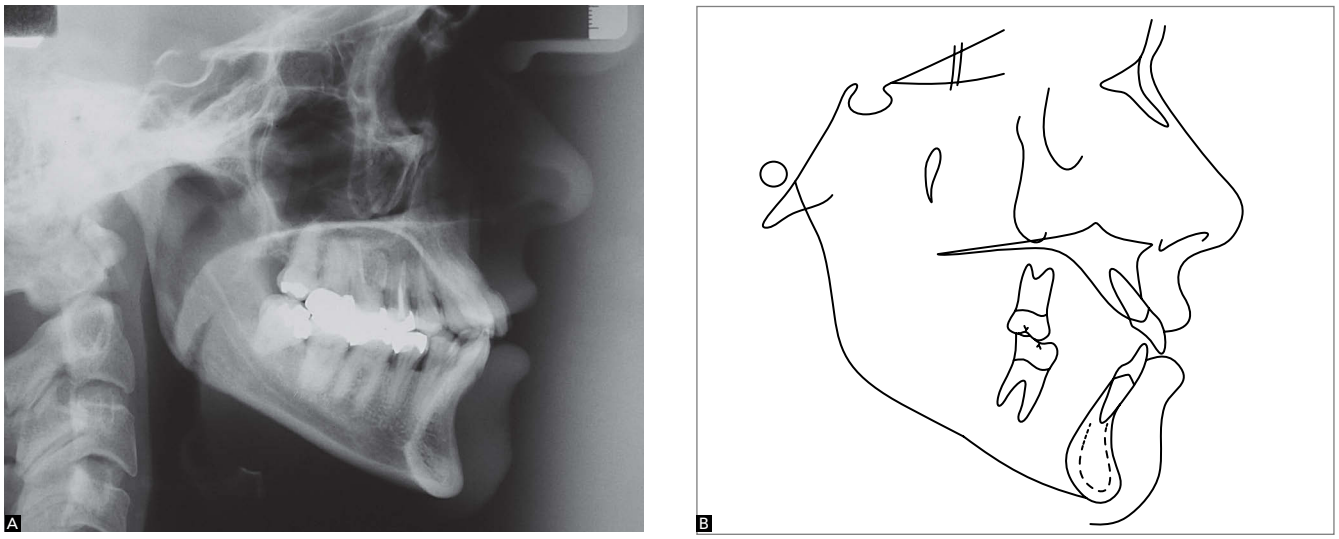


Figure 4 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).



Figure 5 - Initial panoramic radiograph.

TREATMENT PLAN

Performing the diagnostic setup was essential for the decision of the lower incisor extraction, besides helping to visualize treatment outcome and determine the amount of interproximal stripping that would be performed on the upper incisors for proper intercuspation.[17,24] To indicate the treatment with incisor extraction, some requirements that applied to this case were also considered: Class I molar relationship, mandibular crowding greater than 4.5 mm (in this case, it was 7 mm), slight or nonexistent maxillary crowding (in this case, it was 3 mm), balanced soft tissue profile, minimal or moderate overbite and overjet[1,7,22,24] (Figs 1 and 2). However, before the beginning of orthodontic treat-

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ment, the patient would be referred to the periodontist to control periodontal health conditions and to plan the free graft surgery in teeth with more advanced gingival recession (#23 and #43). Only after 60 days these teeth could be moved. For the maxillofacial surgeon, extraction of third molars would be required, because these teeth were in unfavorable positions. After the initial procedures with the multidisciplinary team, orthodontic treatment would start with bonding the brackets on upper and lower dental arches, Straight-Wire system, Roth prescription, slot 0.022 x 0.028-in — except in the #43 tooth, which would not receive a bracket until the space for its alignment in the arch was obtained. Interproximal stripping in the #45 and #44 teeth, which presented excess of restorative material, were scheduled in order to optimize the space for the tooth #43. The finalization would be accomplished through coordinated rectangular arches with ideal torques and shapes, and the use of intermaxillary elastics for final intercuspation. If necessary, it would be requested an occlusal adjustment with the general dentist for occlusion refinement and replacement of initially inadequate restorations.

TREATMENT PROGRESS

As planned, prior to orthodontics, the patient was referred to the periodontist for the control of periodontal health and conditions and free graft in the region of teeth #23 and #43 — to increase the thickness of the marginal gingiva because orthodontic movement could favor the increase of gingival recession and bone fenestrations.[9,21,25] After 60 days, orthodontic movement in these teeth was permitted. Third molar extraction, which were in unfavorable positions, was also performed at this stage.

Then, brackets were bonded on the upper teeth, Straight-Wire system, Roth prescription, slot 0.022 x 0.028-in, on teeth #17 to #27. Then, stripping was performed on the upper incisors, with manual abrasive strips, to facilitate alignment, avoid black spaces between these teeth and achieve excellent incisal relationship, by controlling the overbite and reducing overjet — considering that the new occlusal situation would promote articulation of six upper teeth with five lower ones.[7,20,24] Alignment and leveling nickel-titanium 0.012-in and 0.014-in archewires were used followed by stainless steel round and 0.014-in, 0.016-in, 0.018-in and 0.020-in archewires. Finishing occurred with 0.019 x 0.025-in stainless steel rectangular archwires with ideal shape and torque.

In the mandibular arch a Straight-Wire fixed orthodontic appliance, Roth prescription, slot 0.022 x 0.028-in was placed, except in the tooth #43, which received bracket bonding after opening of space for its alignment and correction of the long axis, which was markedly mesial. Stripping was performed for removal of restorative material excess in teeth #45 (mesial) and #44 (distal), and to facilitate the alignment of the tooth #43. The extraction of the lower left lateral incisor (#32) was required for being the incisor in the most ectopic position and with the most unfavorable periodontal conditions.[6,14] The closure of the extraction space was conducted using a passive stainless steel 0.018-in round archwire and through distal movement of tooth #31 and mesial movement of the teeth #41 and #42 with elastomeric chain and nickel-titanium open spring installed between the teeth #44 and #42. Posterior anchorage in the right and left sides was obtained by tying together the molars and premolars with metal ligatures. After obtaining space for tooth #43, bracket bonding was proceeded, a lower 0.018 x 0.025-in stainless steel base archwire with a bypass was made for this tooth and, for its alignment and leveling, a superimposed 0.012-in nickel-titanium sectioned archwire was initially used, followed by a 0.014-in archwire, evolving into continuous arches, for completion of this phase. The finishing was done with 0.018 x 0.025-in stainless steel rectangular archwire with ideal form and torques, coordinated with the upper arch. Light triangular 1/4-in intermaxillary elastics were used in the canines and premolars region. Throughout the treatment, the patient was accompanied by the periodontist, with appointments every three months. After verifying the achievement of the goals predefined in the initial planning, the fixed orthodontic appliance was removed, initiating the retention phase. A removable upper wraparound retainer was used as well as a bonded lingual retainer, made with 0.038-in braided stainless steel wire. The use of the upper retainer plate was recommended for 24 hours a day in the first six months; 18 hours a day, in the following six months; 12 hours a day, for more six months; and then daily use at night.

TREATMENT EVALUATION

The main treatment goals were achieved. The molar and premolar occlusion, which was very favorable, was maintained and the lower anterior dental crowding, patient's main complaint, was corrected. The correction

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Figure 6 - Final intraoral and facial photographs.

of the axial inclination of the incisors resulted in significant improvement in dental esthetics and reflected in the facial profile, with retraction of the lower lip, from a position 1 mm forward the S line (Steiner) to 0 mm, favoring passive lip sealing (Table 1). In the frontal photograph, the final smile was more harmonious. The upper midline, which was angled, was corrected and became coincident with the middle of the lower central incisor, without esthetic commitment[10,24] (Fig 6).

The periodontal health was markedly improved and the increase of overbite and overjet, which had its measures reduced, allowed the establishment of a functionally balanced occlusion (Fig 7).

The left and right molars and left canine keys of occlusion were maintained and the occlusion key on the right canine was achieved, resulting in right and left laterality with disocclusion in the canines and without contacts in balance. The protrusive excursion resulted in adequate posterior disocclusion.

Total superimposition of cephalometric tracings illustrates the profile improvement with the change in the lower lip position, which made it more pleasant (Fig 10A). The partial superimpositions of the maxilla and mandible confirm the significant reduction in labial axial inclination of the upper incisors and discrete uprighting of lower ones, with slight anchorage loss (Fig 10B).

The decision on the extraction of the lateral incisor instead of a central incisor was beneficial because it avoided the presence of an undesirable black triangle between the middle third of the tooth and gingiva, for the distal surface of a central incisor contacts better to mesial surface of a canine.[16]

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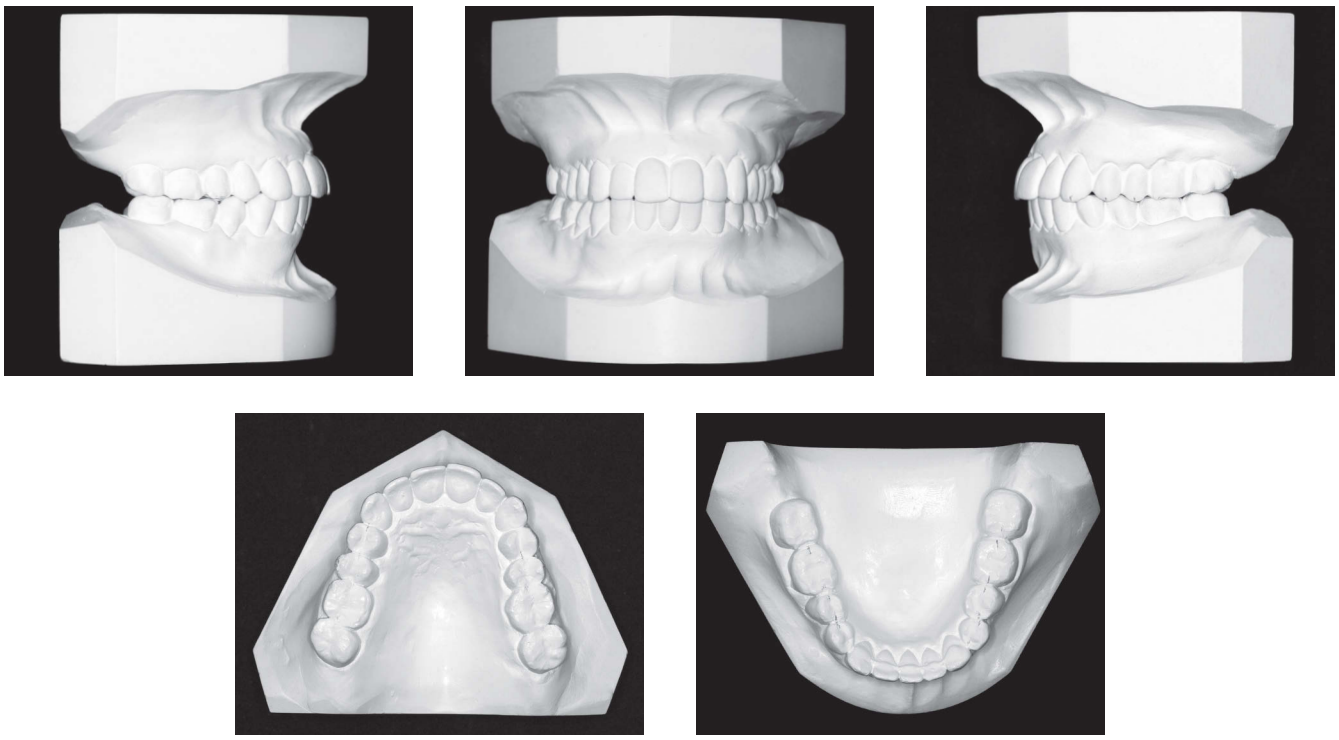


Figure 7 - Final casts.

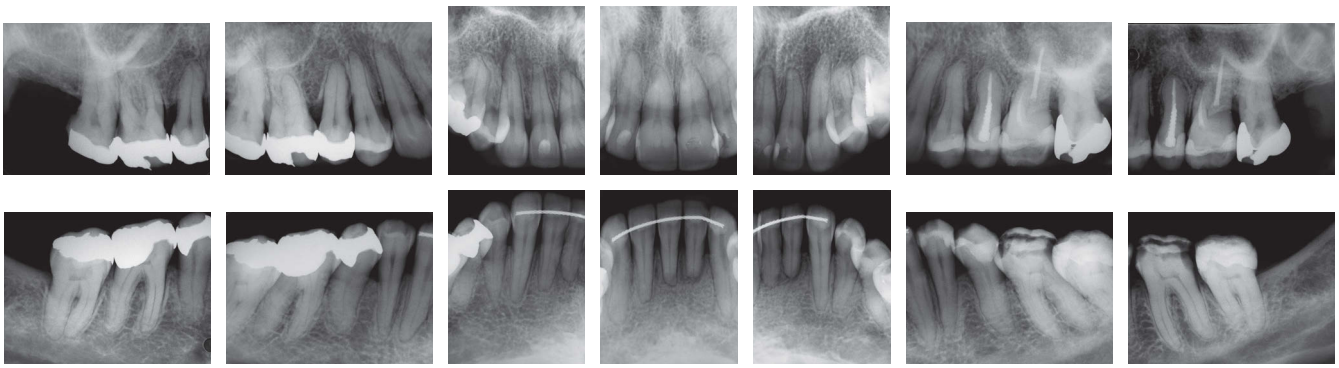


Figure 8 - Final periapical radiographs.

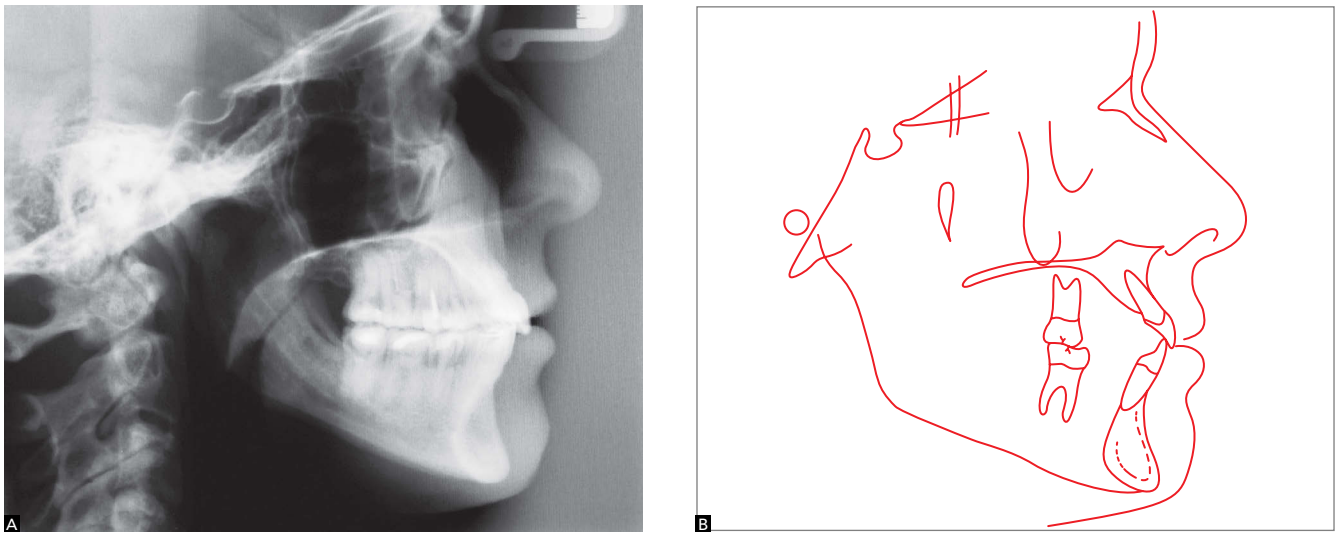


Figure 9 - Final lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

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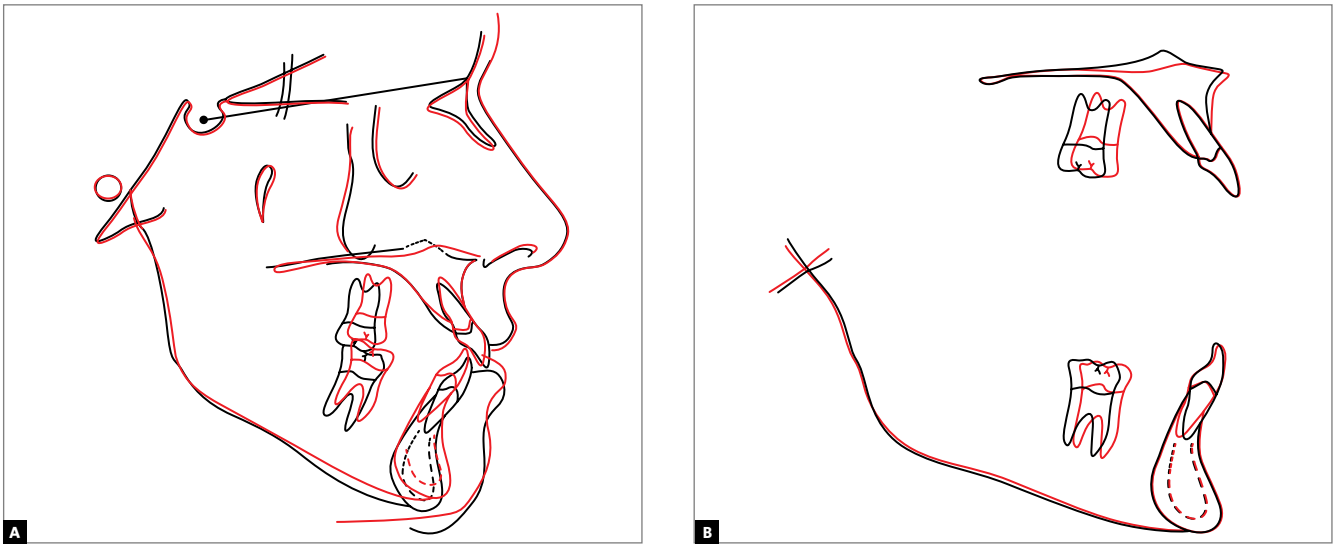


Figure 10 - Total (**A**) and partial (**B**) superimpositions of initial (black) and final (red) tracings.

Table 1 - Summary of cephalometric measures.

	MEASURES		Normal	A	B	A/B diff.
Skeletal pattern	SNA	(Steiner)	82°	80°	80°	0
	SNB	(Steiner)	80°	77°	77°	0
	ANB	(Steiner)	2°	3°	3°	0
	Convexity angle	(Downs)	0°	4°	3°	1
	Y axis	(Downs)	59°	59°	58°	1
	Facial angle	(Downs)	87°	86°	87°	1
	SN-GoGn	(Steiner)	32°	35°	33°	2
	FMA	(Tweed)	25°	28°	24°	4
Dental pattern	IMPA	(Tweed)	90°	93°	98°	5
	$\underline{1}$.NA (degrees)	(Steiner)	22°	32°	27°	5
	$\underline{1}$-NA (mm)	(Steiner)	4 mm	7,5 mm	6 mm	1.5
	$\bar{1}$.NB (degrees)	(Steiner)	25°	25°	27°	2
	$\bar{1}$-NB (mm)	(Steiner)	4 mm	7 mm	6 mm	1
	$\frac{1}{1}$ -Interincisal angle	(Downs)	130°	120°	120°	0
	$\bar{1}$-APo (mm)	(Ricketts)	1 mm	5 mm	4 mm	1
Profile	Upper lip – S line	(Steiner)	0 mm	-2 mm	-2 mm	0
	Lower lip – S line	(Steiner)	0 mm	0 mm	-1 mm	1

Assessing the intercanine distance, it was found that there was a 1-mm reduction, and it can be said that the maintenance or reduction of this distance during mechanical extraction of incisors is advantageous[10] compared to premolars, because there is a strong relationship between long-term stability of crowding correction and intercanine distance. It is believed that the treatment with extraction of an incisor and maintenance of that distance or even decreasing it, in anticipation of a further natural decrease, provides better stability for the final outcome.[24] However, other authors[6,18] suggest that the simple maintenance or reduction of intercanine distance during treatment does not guarantee total stability in the long-term, despite contributing to a lower degree of relapse compared to patients treated with premolar extractions. The gingival recession of #14 tooth was improved, probably due to the removal of occlusal trauma, since prior to the orthodontic treatment, the right side laterality was accomplished by this tooth and the tooth #44.

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In the evaluation of final periapical radiographs it was observed the absence of the upper and lower third molars, which were removed; and increasing of root apex rounding on the lower incisors (#41 and #31), which had already been observed in the initial radiographs (Fig 8). The improvement in axial inclination of #43 tooth, severely tipped mesially and out of position before treatment, draws attention to its repositioning in the arch and excellent periodontal recovery. The replacement of inadequate restorations was requested at the end of treatment, but had not been completed yet.

FINAL CONCLUSIONS

The diagnosis and careful planning, with the help of the diagnostic setup,[4] was essential for the decision of treatment with extraction of a lower incisor. Referring the patient to the periodontist to perform gingival graft before orthodontic treatment enabled orthodontic movement more safely and without injury to teeth already compromised by periodontal recessions.[21,25]

Despite the difficulties or limitations that planning of cases with incisor extraction may result during orthodontic treatment, provided properly conducted and evaluated — considering the particularities of each case —, it can be stated that the lower incisor extraction contributes effectively in the treatment of certain malocclusions, seeking excellence in orthodontic treatment outcomes (maximum function, esthetics and stability).[13] The patient's satisfaction by having her main complaint resolved reflected also in increased self-esteem and gain of quality of life — benefits provided by orthodontics in the aspect of overall health.

Based on data from the literature and exemplified by the clinical report of this case, it can be concluded that the extraction of a lower incisor is a very effective therapeutic approach in carefully selected situations.[15]

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Brachycephalic, dolichocephalic and mesocephalic: Is it appropriate to describe the face using skull patterns?

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The use of a standardized terminology in the medical sciences is essential for both clinical practice and scientific research. In addition to facilitating communication between professionals, it enhances the reliability of comparisons made between studies from different areas, thereby contributing to a higher level of scientific evidence. Examples of attempts made to standardize the terminology in other areas dedicated to the study of craniofacial morphology can be found in the literature. On the other hand, one can find in the orthodontic literature a variety of terms that render the consensus and communication between orthodontists and other researchers even more problematic. As an example, one could cite the use of the terms brachyfacial, mesofacial and dolichofacial, which form part of a cranial index terminology used to describe facial types. Thus, a reflection on the origin and differences of the terms used to describe the human facial phenotype may pave the way toward a consensus regarding the meaning that best represents the craniofacial patterns.

Keywords: Face. Terminology. Classification.

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INTRODUCTION

Facial type assessment is in many aspects crucial for the planning and prognosis of orthodontic treatment. Facial morphology is related to factors such as volume and shape of pharyngeal airspace,[1] anatomy of masticatory muscles,[2,3] dentoalveolar anatomy[4] and occlusion type.[5,6] Moreover, the facial pattern indicates the direction of growth of the craniofacial complex[7,8] and must be taken into consideration when selecting the orthodontic biomechanics.[9]

The terminology used to describe the craniofacial complex stemmed from classical anthropometry, which employs measurements taken in living individuals and human skulls as well as indices that represent facial proportions.[10,12] The most common among these is the cranial index (which classifies skull types as brachycephalic, mesocephalic and dolichocephalic), and the facial index (which classifies the face as euryprosopic, mesoprosopic and leptoprosopic).[11,13] Despite the need to standardize the terminology, in orthodontics one still notes a wide range of terms to describe the various facial types.[14] The standardization of these terms in different fields of knowledge is essential to facilitate communication between researchers and allow reliable comparisons between different studies.[15] In view of these issues, this article aimed to clarify the concept, origin and differences between the terms that describe the human facial phenotype.

CEPHALIC AND FACIAL INDICES

The first classification based on cranial morphology is attributed to the professor of anatomy Anders Retzius (1840). Retzius described as *gentes dolichocephalae* those individuals who had an elongated skull shape, and *gentes brachycephalae* those whose skulls were short. However, he assigned no numerical values to set the boundaries between individual types in both groups and neither did he use the intermediate term *mesocephalae*, which was introduced at a later time.[14] The measures used by Retzius — when applied to living individuals — are known as cephalic index, and when referring to dry skulls, cranial index.[12,13] These indices are calculated by determining the ratio between maximum width and maximum length of the head (Fig 1).[12,13] The concept was subsequently enhanced with the definition of intermediate values,[14] which provide a classification system and reflect more accurately the diversity found in human facial morphology (Table 1).[16] Both the cephalic and cranial indices are therefore measures related to the shape of the skull. The index used in anthropometry to describe the face proportions is the facial index, a product of morphological facial height, measured from the Nasion (N) to Gnathion (Gn) anatomical landmarks, divided by the bizygomatic width, measured from the right to the left Zygion (Zyr-Zyl) (Fig 2).[11,13] Semantically, the terms used in the facial index are derived from Greek, where the word for face is *prosopon*.[14] According to this classification system, numerical values are assigned which establish the euryprosopic, mesoprosopic and leptoprosopic categories (Table 2).[11,13]

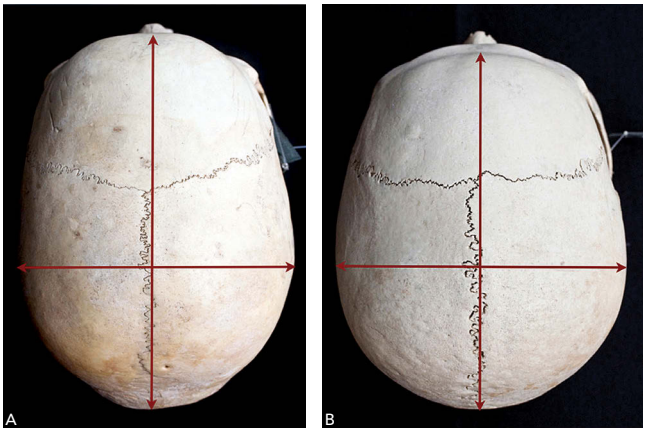


Figure 1 - Cranial index: Calculated using the ratio between the maximum width and length of the head. In **A**, dolichocephalic skull and in **B**, brachycephalic skull.

Table 1 - Head classification according to the cephalic index.

Ultradolichocephalic	x - 64.9
Hyperdolichocephalic	65.0 - 69.9
Dolichocephalic	70.0 - 74.9
Mesocephalic	75.0 - 79.9
Brachycephalic	80.0 - 84.9
Hyperbrachycephalic	85.0 - 89.9
Ultrabrachycephalic	90.0 - x
Cranial index	Maximum skull width x 100 / Maximum skull length

Table 2 - Face classification according to the facial index.

Hypereuryprosopic	x - 79.9
Euryprosopic	80.0 - 84.9
Mesoprosopic	85.0 - 89.9
Leptoprosopic	90.0 - 94.9
Hyperleptoprosopic	95.0 - x
Facial index	Morphological facial height (N-Gn) x 100 / Bizygomatic width (Zyr – Zyl)

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FACIAL MORPHOLOGY IN PHYSICAL ANTHROPOLOGY

The description of the human body has been a major concern since ancient times. In ancient Greece, canons based on ratio rules were used to describe the ideal human figure. These canons were once again employed by Renaissance artists such as Leonardo da Vinci and Albrecht Dürer.[17,18] Many of these neoclassical principles are used today in the arts and medicine.[17,18,19] The physical anthropology, or anthropometry, provide a scientific foundation to these concepts with a view to evaluating the dimensions and proportions of the human body.[17]

It was only when anthropometric methods were adopted in clinical practice to quantify changes in the craniofacial structure that a wide diversity of human phenotypes and specific features that differentiate individuals and ethnic groups emerged.[16,20] In different areas of clinical care, standardized anthropometric data have become indispensable for an accurate assessment of the degree of deviation from normality.[15,16] Examples can be found in plastic surgery, during the treatment of congenital or post-traumatic deformities[16,17,21], or in legal or forensic medicine when identifying individuals,[22] or in medical genetics for the diagnosis of dysmorphisms or craniofacial abnormalities.[15]

Attempts to build a comprehensive database covering different populations have been made by the international scientific community. One could cite an international group of scientists led by Leslie Farkas,[16] who compiled measurements of the face of 1,470 healthy subjects aged between 18 and 30 years, covering the European, Asian and African continents as well as the Middle East. Farkas himself, a plastic surgeon living in Canada,[23] has devoted much of his career to gleaning

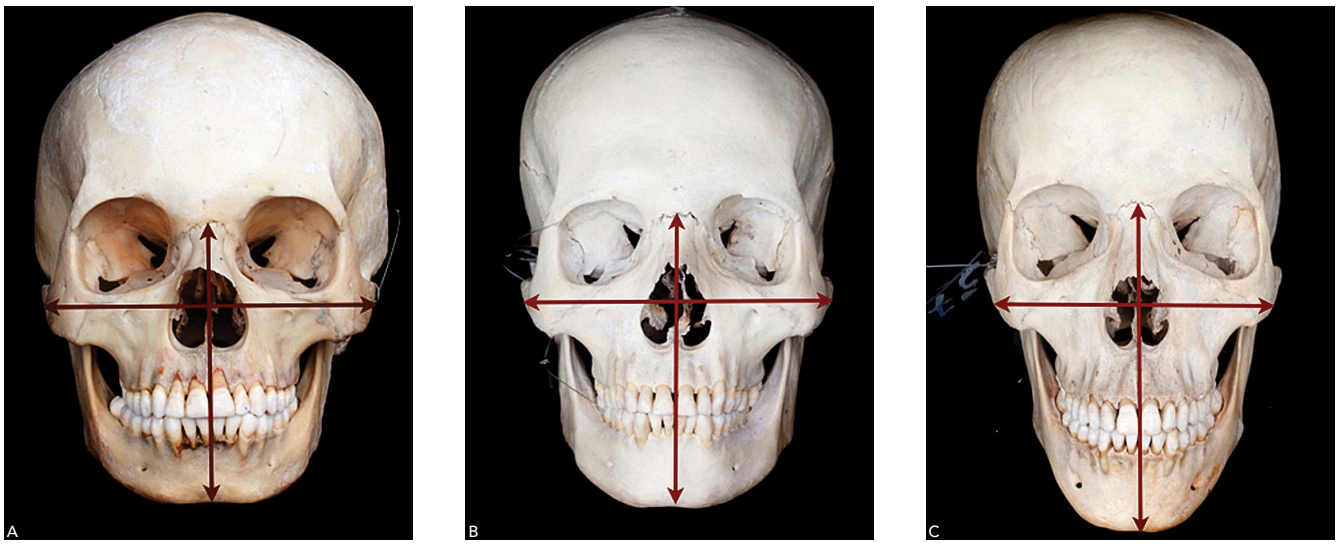


Figure 2 - Facial index: Calculated as the ratio between the morphological face height (N-Gn) and bizygomatic width (Zyr-Zyl). In **A**, euryprosopic face; in **B**, mesoprosopic face, and in **C**, leptoprosopic face.

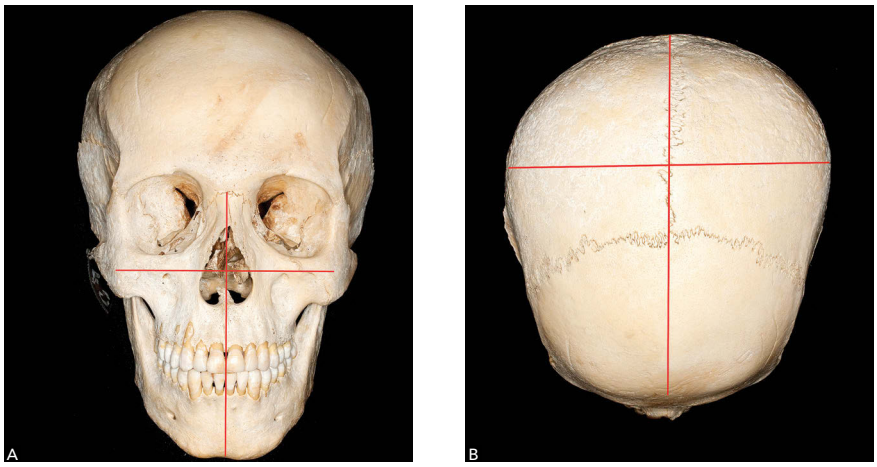


Figure 3 - Skull classified as hyperleptoprosopic (facial index = 96.2%) in relation to its predominantly vertical facial morphology (**A**), and hyperbrachycephalic (cranial index = 87.3%) in terms of shape (**B**).

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facial anthropometric data to set the standards for U.S. Caucasian individuals.[16,23] It should be emphasized that today the advent of globalization and the emergence of multicultural societies have strengthened the importance of differentiating ethnic characteristics in the selection of samples in scientific studies.[17] Yet another noteworthy concern, especially in medical genetics, regards the standardization of the terminology used to describe craniofacial dysmorphisms or anomalies. In this sense, the objectives are to standardize the terminology and establish consensus regarding definitions and deviations from a standard of normality.[15]

In the medical field, most studies make use of a nomenclature to describe facial patterns in accordance with anthropometry.[15,17] The term brachycephaly, for example, describes individuals with a cephalic index greater than 81% and the skull shortened in its anteroposterior dimension. Dolichocephaly, on the other hand, consists of anomalies with a cephalic index below 71% and an elongated cranial vault.[15]

FACIAL MORPHOLOGY IN ORTHODONTICS

In orthodontics, the assessment of facial morphology differs from other medical areas, especially by taking as reference the facial profile or side view, rather than the front view of the face. Therefore, the face width is not considered in most classification systems.[14] This trend can be understood in light of the importance of radiographic cephalometry in modern orthodontics, with the prevalence of analyses based on lateral cephalometric radiographies.[7] Some of the terminology used to describe the facial pattern are: Dolichofacial, mesofacial or brachyfacial;[24] hyperdivergent, neutral or hypodivergent;[6] long, medium or short;[7] and skeletal open bite or skeletal deep bite.[20] It should be noted that the terms brachyfacial, dolichofacial and mesofacial, which are commonly used by orthodontists, were introduced in the orthodontic literature in an article by Ricketts in 1960.[14,24] Some orthodontics textbooks describe the face by resorting to terms such as brachycephalic, dolichocephalic and mesocephalic, and associate specific types of facial morphology with specific dental arch forms. This association should be avoided, since a direct relationship between the shape of the face, skull shape and arch form does not occur in all individuals (Fig 3).[25,26] The terms euryprosopic, mesoprosopic and leptoprosopic appear in European orthodontic literature and are consistent with other areas that also address facial morphology, such as anthropology, plastic surgery and genetics.[14] An important issue to consider is that in studies evaluating craniofacial dysmorphisms the terms brachycephaly and dolichocephaly are used to describe deformations of the cranial vault.[15]

THE EFFECTS OF GROWTH

Any reflection on the meaning and validity of the different systems of facial morphology classification must take into account changes that occur in facial growth.[14] One particularly significant factor regards evaluating the influence exerted by the head shape on the shape of the face, since the base of the skull is considered a primarily stable structure, from which the face develops in an inferior and anterior direction.[8]

Some studies conducted by Enlow et al,[8,27,28] are based on the premise that face morphology can be determined by the cranial base, which acts as a mold or "template." According to these studies, individuals with a dolichocephalic head shape have a brain that is long in the anteroposterior direction and narrow in the transverse direction, which results in a longer, flatter skull base, i.e., the angle formed by the floor of the skull is wider. As a result, the entire nasomaxillary complex assumes a lower, more protrusive position, inducing an inferior and posterior rotation of the mandible. Thus, a dolichocephalic head would favor the development of a predominantly long morphology of the face, with a tendency toward a retrognathic mandible and a Class II molar relationship compatible with a leptoprosopic facial type. The same reasoning may be applied to patients with a brachycephalic head shape. Their brains would be wider and more rounded, with a shorter, more angular cranial base, causing a relative retrusion of the nasomaxillary complex and anterior rotation of the mandible. Therefore, these individuals would exhibit features that are closer to a euryprosopic facial pattern.[8]

The influence of cranial morphology on facial type is still not fully understood and few studies directly assess the impact of these variables. Bhat and Enlow[27] investigated the relationship between facial types and head shape in individuals with Class I and Class II malocclusions that had not been treated orthodontically. They noted that the leptoprosopic facial type and a tendency toward developing a Class II are characteristic of mesocephalic and dolichocephalic skulls; whereas the tendency to develop a protruded mandible is related to brachycephalic skulls. Results from

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other investigations[28,29] also give grounds to infer a positive relationship between skull morphology and face morphology. However, there is no consensus concerning this association, given that studies[25,26] using different methodologies have failed to reach the same conclusions. In a study to investigate the craniofacial morphology of bruxist and non-bruxist individuals, Menapace et al[26] found no relationship between head shape and craniofacial morphology. In this sample, a frequent association was found between dolichocephalic head shape and euryprosopic facial type.

FINAL CONSIDERATIONS

The growing presence of orthodontics in the context of scientific research makes it necessary to adopt a language consistent with other biological fields.

Terminology standardization is essential to facilitate communication among professionals, enabling comparisons to be made between different studies and affording increasingly evidence-based outcomes.

Nevertheless, it is a fact that currently a non-homogeneous nomenclature is still employed in orthodontics to describe facial patterns, a terminology that often differs from that used in other medical fields. This is due in large measure to a strong influence exerted by cephalometrics as a method to study craniofacial growth, notably based on studies that emphasize the role of skull morphology in determining the shape of the face. Investigating the influence of skull shape on face shape can provide a benchmark to validate the nomenclature used in orthodontics. If the assertion that skull type determines face type is true then it would not be wrong to use terms derived from the cephalic index, such as "brachyfacial", "mesofacial" and "dolichofacial," to describe the face. On the other hand, in the event that it is not possible to determine this correlation, the use of this nomenclature, as well as hindering communication with other medical specialties, would not be justified — and the terms "euryprosopic", "mesoprosopic" and "leptoprosopic" should be incorporated into orthodontic terminology. These issues point to the need for further research on this topic.

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1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (http://www.who.int/ictrp/network/en/index.html), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
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- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

3. Dental Press Journal of Orthodontics - Statement and Notice

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Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

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