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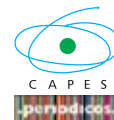
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and T2 in the test and control groups.					
Index	Score	Test N=1050		Control N=1296	
		T1	T2	T1	T2
Gingival bleeding (%)	**.	98.8	94.2	98.9	97.2
	***.	1.2	5.8	1.1	2.8
	Total	100	100	100	100
	P	*0.000		*0.001	
		*0.000			

TABLE 1 - Evaluation of intra-examiner error in Subjective Facial Profile Analysis

Measure	Descriptive measures					P
	Minimum	Maximum	Mean	SD		
First	1.0	9.0	4.9	1.6	0.357/n.s.	P = S
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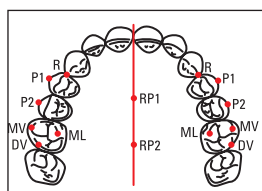
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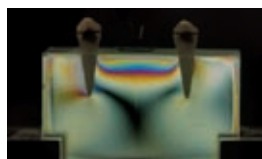
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The orthodontic treatment will be offered free of charge in all Specialized Dental Clinics in Brazil, and it will benefit millions of Brazilians over the years

Last December I gave a class in Taiwan. On a tour around the island, I was impressed with the image that Brazil currently topples in Asia. All the comments I heard did not refer to our football, but to both, the economic growth and the position the country is in the geopolitical pitch. Hearing the opinions of the international scouts called my attention to a reality in our area: wherever we are in Brazil, we can see people being submitted to an orthodontic treatment.

This fact shows the relevance people give to this type of correction, either for esthetic or functional reasons. It was the rise in consumption of Classes C and D that enabled a larger number of people to have access to Orthodontics. And the part of the population who will benefit from orthodontic treatment will further increase.

From 2011 on, orthodontic treatment will be an integral part of the services offered by public centers known as CEOs—Dental Specialized Clinics, which are part of a program called *Brasil Sorridente* (Smiling Brazil)—the Federal Government Program for oral health. Such an advance has already been published in the Brazilian newspaper called *Diário Oficial da União*, and will mark a new way of access to orthodontic treatment.

Evidently, this new way of access will not come true easily and spontaneously. It will require a great involvement of the Ministry of Health—as well as of the Brazilian orthodontic

community, through the Brazilian Association of Orthodontics and Dentofacial Orthopedics (ABOR)—so that we can have protocols based on evidence that support the treatment decisions that will be made for our population. In addition, it is important mentioning that these two parties have already been working hard with this purpose, and that the partnership between government and society is essential for us to build the country we want in the future.

In 2010 Dr. Gilberto Pucca, the National Coordinator of Oral Health, told me something interesting during an informal dinner in Brasília. We were talking about his periodic meetings with President Lula, the progress of the implementation of the CEOs, and the relevance that the President himself used to give to oral health when he told me: ‘Faber, every time I meet the President, he asks me: ‘Hey, Pucca, have children already been placing braces?’

In my opinion perhaps that was the dream of the former President himself as a child, and it is very gratifying to know that such a dream will come true for many of our children.

Have a good reading.

Jorge Faber
Editor-in-chief (faber@dentalpress.com.br)

ABOR



8th BRAZILIAN ORTHODONTIC ASSOCIATION
INTERNATIONAL CONGRESS

BRAZIL BELO HORIZONTE | MG OCTOBER 12 to 15

2011

The organizing committee of the 8th ABOR (Brazilian Orthodontic Association) INTERNATIONAL CONGRESS, October 2011 in Belo Horizonte, is working to offer a scientific program with national and international outstanding speakers on orthodontics and dentofacial orthopedics who will discuss relevant contemporary research and clinical topics.

In addition, a special program has been prepared for graduate students.

Among the international speakers we have confirmed Dr. James McNamara (USA), Dr. Rolf Behrents (USA), Dr. Juan Martim Palomo (USA), Dr. Marco Rosa (ITALY), Dr. Stephen Yen (USA), Dr. Albino Triaca (SWITZERLAND) and Dr. Giuseppe Scuzzo (ITALY).

Save the date on your calendar to participate of this wonderful opportunity and also enjoy Minas Gerais and its unique life style through an exciting social programming. Come and experiment the Brazilian hospitality.

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The São Paulo Symposium

March 18-19, 2011

The largest city in Brazil is the setting for this one-and-a-half day course. Five respected speakers from two continents will present timely perspectives on a variety of subjects. With a city motto which translates to, "I am not led, I lead," the São Paulo Symposium inspires leadership in clinical excellence.



Professora Birte Melsen one of the true icons of orthodontics today, Birte's life-long passion commitment to the service of her profession gained her an international reputation and respect from her peers. She is known as a consummate and meticulous researcher and her peer-reviewed publications cover a broad range of topics pertinent to both basic biology and clinical treatment.



Dr. Mauro Cozzani has published more than 50 papers in specialized Italian and foreign journals and has given over 100 speeches, communications and courses in Italy and abroad. His research activity focuses on molecular biology and bone regeneration while his clinical interest is focused on early treatment, arch form, non-compliance appliances, temporary anchorage devices, self-ligating brackets, and distraction osteogenesis.



Dr. Claudio R. Azenha is a specialist in orthodontics from PUC – Campinas and Master of Science in Orthodontics from SLM. Finishing In Orthodontics and Contemporary Orthodontics.



Dr. Maria Laura Irurzun is Professor and Chairwoman of Orthodontics II and Professor of the Postgraduate Specialization Course at the University of Salvador School of Dentistry. Orthodontics Today.



Dr. Dauro Oliveira has earned his Master of Science in Orthodontics from Marquette University. He is currently the Coordinator of the Master in Orthodontics of the PUC Minas, Belo Horizonte University.

When and How can Alveolar Corticotomies Improve Orthodontic Treatment?

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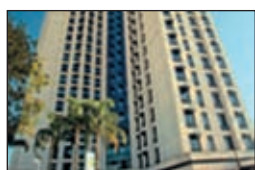


6º Congresso Internacional - Ortodontia: Ciência com consciência social

Date: March 24 to 26, 2011

Location: Centro de Convenções de Goiânia - Goiânia / GO

Information: www.aborgoias.com.br



Mega Curso de Ortodontia em Adultos em São Paulo

Date: March 30 to April 2, 2011

Location: Hotel Quality Suítes - Congonhas / SP

Information: www.megacurso.tumblr.com

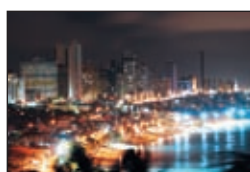


Curso de Capacitação Biomecânica Interativa Auto Ligante

Date: April 1 and 2, 2011

Location: São José dos Campos / SP

Information: (12) 3923-2626
celestino@nyu.edu



Linha de Pensamento - Sistemas Ertty Ortodontia | DTM | Oclusão

Date: April 1 and 2, 2011

Location: Natal / RN

Information: www.ertty.com.br



Curso Mini-implantes 2011 - Hands on - Dr. Carlo Marassi

Date: April 8 and 9, 2011

Location: Rio de Janeiro - Flamengo

Information: (21) 3325-5621
www.marassiortodontia.com.br



Sistemas Ertty

Date: May 5 to 7, 2011

Location: Quality Suítes Congonhas - Campo Belo - São Paulo / SP

Information: (61) 3248-0859
www.ertty.com.br



Encontro do Centro de Ortodontia de Ribeirão Preto

Date: May 12 and 13, 2011

Location: Edifício Office Tower - Ribeirão Preto / SP

Information: (16) 3620-5635
www.ortogotardo.com.br



V Congresso Sul Brasileiro de Ortodontia

Date: August 25 to 27, 2011

Location: OralEsthetic Instituto - Rua Frei Rogério, 237 - Lages / SC

Information: www.oraesthetic.com

Why orthodontists should be aware of the quality of life of their patients

Daniela Feu*

Given the elective nature of orthodontic treatment the decision to start treatment hinges on the opinions of patients and their parents, which means that patients' motivation is often derived from the negative impact of their malocclusion, be it aesthetic, functional or social. Therefore, this patient autonomy plays an important role in predicting the final results since theoretically satisfaction is related to a reduction or utter elimination of the factors that led them to seek treatment in the first place. So how can orthodontists perform treatments capable of benefitting patients psychosocially and be successful in this endeavor without gaining insight into the impact caused by malocclusion?

Faced with this new paradigm, Evidence-Based Dentistry has posed a major challenge to orthodontic practice, namely: To be aware of how orthodontic treatment impacts on patients' daily lives. The reason for this lies in the fact that, to be considered viable, any treatment, including orthodontic treatment, should be capable of bringing significant benefits above and beyond the biological and financial costs to each individual patient.^{3,20,26}

Evidence has been produced to the effect that patients with malocclusions have a poorer quality of life in terms of oral health than do patients with balanced occlusions.^{7,13,23,24,26} No scientific evidence has been found, however, to prove that untreated malocclusions can increase

the risk of developing dental caries,¹ gingivitis and periodontal changes,^{24,25} or even that orthodontic treatment can prevent the development of joint disorders^{16,22} or improve patients' masticatory function.^{10,18} Therefore, the main benefits of orthodontic treatment would be related to improved aesthetics and masticatory function, which would, in turn, result in improvements in the patient's social and psychological well-being, reflected in a better "quality of life."^{3,6,7,8,13,24,25}

The beneficial impact of conventional fixed orthodontic treatment on quality of life, particularly in its psychosocial dimensions, was confirmed recently by a case-control³ study and two longitudinal prospective evaluations.^{6,8} "Oral Health-Related Quality of Life" (OHRQoL) is a multidimensional concept that includes the subjective perception of physical, psychological and social well-being, and an overall sense of subjective well-being. Its essence, according to some authors, reflects an individual's experiences, which would influence their satisfaction with life in all different aspects.^{4,12,13}

To assess patients quality of life, questionnaires, known as "sociodental indicators", are administered. These indicators seek to reveal the perceived impact of oral health problems on quality of life. The patient's report will reveal to a greater extent the consequences arising from oral diseases such as functional and aesthetic changes, since these are ultimately individual experiences.^{4,12,14}

* Specialist and M.Sc. in Orthodontics, Rio de Janeiro State University (UERJ). PhD Student, Department of Orthodontics, Rio de Janeiro State University (UERJ).

The need to evaluate orthodontic patients' quality of life reflects the importance of dental and facial aesthetics in people's lives, and the extent to which they evaluate their own aesthetics. Within a social context of the cult of beauty, a significant presence in Brazil, this type of analysis can not be apart of the diagnosis. This evaluation will seek to primarily evaluate the impact and/or disadvantages that malocclusion and consequential aesthetic, functional and social amendments will generate, since, for the same malocclusion, there will be different psychosocial impacts. This means that the same malocclusion may be perceived differently by people, and that individual perception is probably the key to search for orthodontic treatment, relating to whether or not the severity of malocclusion.¹⁹ Similarly, for these different perceptions, expectations of different results emerge which are not always commensurate with the dimension of the malocclusion, but rather with the extent of the impact it has generated for that particular patient. Consequently, these outcome expectations will vary from individual to individual for the same malocclusion.⁴

In general, questionnaires are divided into "dimensions of impact." That is to say, groups of questions that identify whether a specific dimension, e.g., the patient's masticatory function or social life, is being affected by the problem presented by the patient.¹⁴

Locker¹⁴ was one of the first authors to argue that these indicators should be used in dental offices and clinics to assist professionals in their understanding of the individual needs of each patient, which are usually unknown. Besides providing greater knowledge of each individual patient, the use of these questionnaires in the initial consultation will reflect the type of demand that is generated. The dimensions of impact that are most negatively affected by patients may disclose how society and the professional colleagues, who referred these patients in

the first place, view the treatment performed on these patients. The question is: Which dimension of negative impact has led the patient to seek treatment? Aesthetic? Functional? Psychosocial? This knowledge can help professionals to identify their faults and weaknesses, improve marketing and visibility from other areas of impact and break new ground in clinics and offices.

However, scientific research also produces very interesting data that can greatly help professionals in their day-to-day activities. A study that described the OHRQoL in 250 Chinese adolescents undergoing orthodontic treatment in periods of one week, one month, three months, six months, and after treatment showed that fixed orthodontic treatment improved the subjects' quality of life after treatment completion.⁶ This study also concluded that orthodontic treatment exerts a negative effect on the patients' OHRQoL, as has been observed in other studies.^{8,15,19} In these studies, pain due to treatment was the main causative factor in maintaining the negative impact on quality of life experienced by patients while undergoing treatment. In fact, the "physical pain" dimension was predominant and increased significantly during orthodontic treatment.^{6,8} Chen et al⁶ noted an even more negative impact in the first week of treatment.

According to these authors, the negative impact of the first week is significantly worse than what prompted the patient to seek orthodontic treatment in the first place, and it only goes back to normal three months into treatment.⁶ During this period, the patient should be clearly focused on the likely effects of the first treatment phase in order to avert a breach of trust. In fact, Pringle et al²¹ reported that in their sample, 91% of the orthodontic patients experienced episodes of pain. Pain was described as the worst aspect of treatment and as the key reason to want to discontinue orthodontic treatment.^{17,21} In the patients' view,

the major relationship problem was a lack of feedback from the orthodontist during the first phase of treatment and in episodes of acute pain caused directly by the appliance. It should be borne in mind that during periods of pain patients' quality of life is significantly undermined and, therefore, clinicians are expected to provide immediate assistance.

After setting up the orthodontic appliance, some authors recommend that a phone call be scheduled for the following day, and report that thanks to this call significant results were achieved in reducing the patients' pain perception.^{2,17} Bartlett et al² also observed that the contents of the phone call made no difference in the positive impact it generated on these patients. These studies did not address the quality of life of treated individuals, but rather their perception of pain and, considering the negative results observed in the first week of treatment, actions that can improve patients' quality of life should be employed.

As regards patient compliance with the treatment, assessment of quality of life can also help professionals better understand the patient before proposing and initiating any treatment modality. Chew and Aw⁵ observed that, in adolescents, the impact of a poor aesthetic condition is significantly worse for the parents. Often, it is precisely this impact on the parents that leads them to seek treatment for their children. Professionals should try to identify whether or not the children, who are ultimately the patients, are also negatively affected by their malocclusion.

To this end, it is recommended that sociodental questionnaires be administered separately to parents and adolescents so as to correctly identify their complaints. A negative impact on quality of life of adolescents does not necessarily mean that they will be more cooperative during treatment.¹⁵ However, being aware of their perception and whether in fact there are negative impacts can certainly assist professionals to properly individualize and adapt their treatment plan.

Knowledge of the impact of teenagers' oral conditions on their quality of life has several positive implications,^{7,15} as it reveals their perceptions about their own oral health and appearance, thereby providing better communication between patient, parents and orthodontist.^{9,11} As orthodontists gain insight into the consequences and importance of the adolescents' oral conditions in their daily life as well as in the lives of their parents, quality individualized treatment can be rendered to patients and their family alike.¹¹

Therefore, assessing quality of life as it relates to patients' oral health before and after treatment makes it possible to significantly improve the dentist-patient relationship and, especially, to achieve more successful treatment results. Obviously, searching for a patient's "chief complaint" demonstrates concern for the negative impact generated by their malocclusion, and this has been accomplished by orthodontists and other dental specialists for years. But nowadays, in light of the new tools designed specifically to measure these impacts, is that enough?

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Multiple or severe root resorptions are not associated with systemic factors, individual susceptibility, family tendency or individual predisposition

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Multiple or severe root resorptions, still often assigned to systemic changes, particularly endocrinopathies, are seen when the severity of alveolar bone loss is great, especially during orthodontic movements.^{18,19,20}

In bone turnover, matrix deposition alternates continuously with bone resorption at different sites and times. This dynamic process enables the bone to adapt to the functional demands of each skeletal area and to actively participate in the maintenance of the mineral homeostasis to control serum calcium and phosphorus concentrations.^{2,3,6,15} The skeleton renews completely at variable time intervals according to the patient's age.²²

Teeth, particularly root structures, do not have bone turnover,^{1,8,12,17} a consequence of the activity of osteoblasts, osteocytes, macrophages and osteoclasts. These cells organize in basic multicellular units (BMUs), or bone remodeling cells, and receive stimuli from systemic and local mediators found in membrane surface receptors of several cell types, particularly osteoblasts and macrophages.^{2,7,22}

Cementoblasts, the cells that populate the root surface, do not have receptors in sufficient number and significance to become bone turnover mediators.^{6,21} Cementoblasts are "deaf" to the messages sent by the bone turnover mediators, even when found in large concentrations in periodontal tissues, as is the case in hyperparathyroidism. In periodontal inflammation, the local levels of mediators that induce bone resorption are also high, but cementoblasts do not respond to them and, therefore, teeth are protected from bone turnover (Figs 1 and 2).

The "absence" of cementoblast surface receptors for bone turnover mediators complicates any attempt to assign a systemic origin, such as endocrinopathies, to root resorptions.²¹ In other words, cementoblasts are not affected by systemic mediators or hormones. Cementoblasts remain on the root surfaces no matter whether the concentration of systemic mediators is high or low.

The causes of root resorption should be associated with the loss of cementoblasts from the root surface, which may have its origin in trauma

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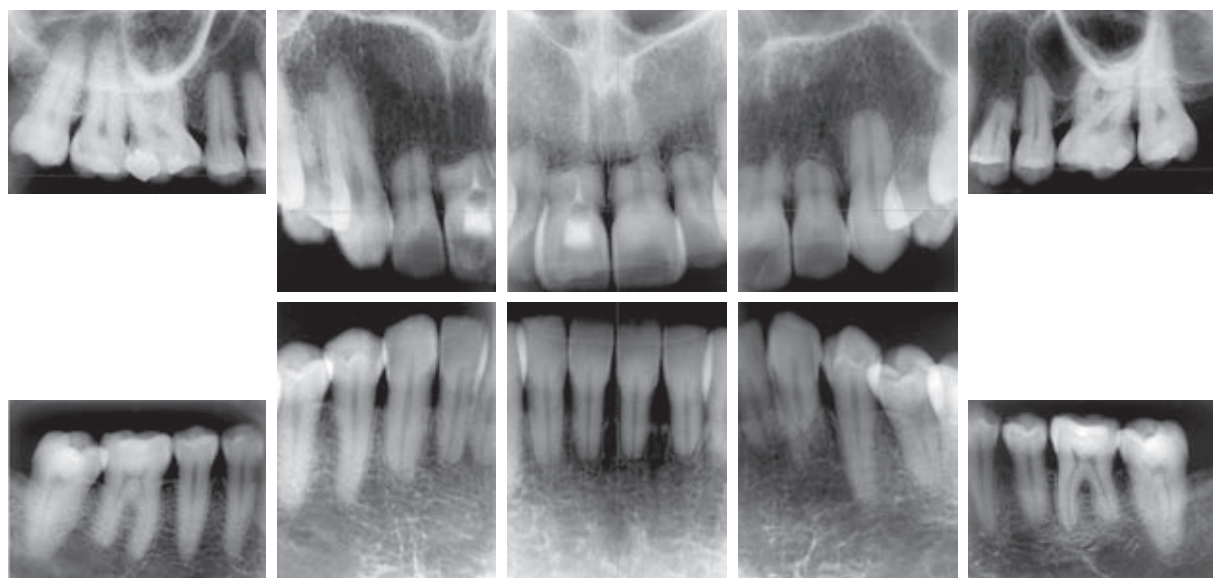


FIGURE 1 - Female patient with anterior open bite underwent orthodontic treatment for 8 years with continuous use of intermaxillary elastic bands. Severe root resorption was first assigned to a systemic cause or individual susceptibility. The continuous use of intermaxillary elastic bands, the constant change in planning and the length of treatment may have been associated with multiple and severe root resorption without any association with systemic changes in the patient.

and chemical or biological processes, but which is a local event⁷ (Figs 1 and 2). In human pathology, the absence or decrease of cementoblasts on the root surface does not characterize any systemic disease. For root resorption to occur, the first necessary step is the removal or local loss of cementoblasts.

The definition of a cause of root resorption requires a careful investigation of the patient's history to retrieve information about previous events, addictions, accidents, types of sports and leisure activities, previous treatments and associated local diseases. In the investigation of history, priority should be assigned to relevant details, such as mild trauma (concussion, subluxation), which the patient does not always remember and which cannot be detected by the clinical examiner. Mild trauma may occur due to several reasons: biting very hard objects during mastication; impact during leisure activities; surgical trauma due to leverage for extraction of neighboring teeth; and laryngoscope impact

during procedures for general anesthesia.

When the local cause of root resorption cannot be determined after all resources have been used, its etiology may be classified as idiopathic, a term which defines the impossibility of detecting the cause without assigning any systemic or iatrogenic origin to it.

In root resorptions assigned to a probable systemic cause, it is necessary to refer the patient to an endocrinologist,^{9,10,16} because endocrinopathies at an advanced stage may lead to death. The dentist is not expected to make an accurate diagnosis of endocrinopathies, but should refer patients to an endocrinologist for evaluation and final identification of the problem when it is suspected (Figs 1 and 2).

When studying the etiology of root resorptions, individual susceptibility, familial tendency and individual predisposition are sometimes mentioned, but no references are made to studies with clearly defined analytical methods. When there are signs or symptoms suggestive

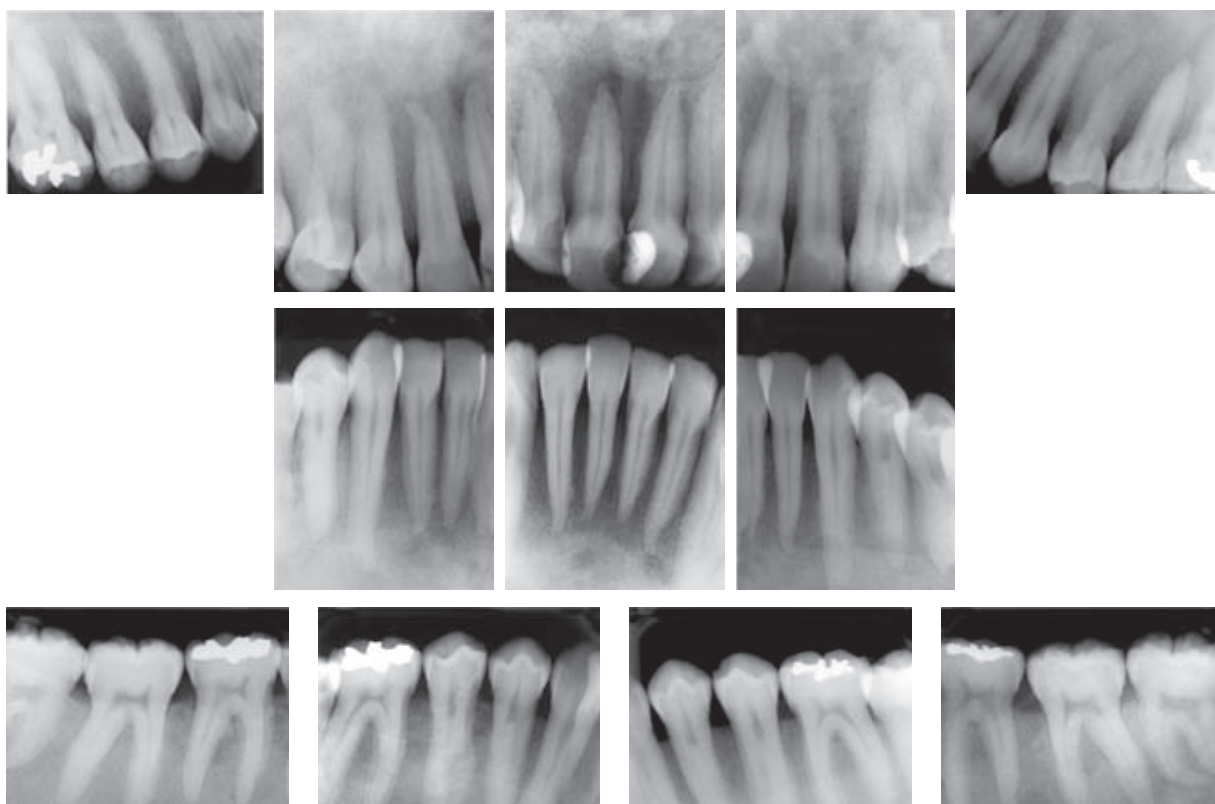


FIGURE 2 - Patient with hyperparathyroidism secondary to renal insufficiency and who underwent hemodialysis for many months. The severity of systemic conditions and their long duration led to involvement of maxillary and severe changes of trabecular bone. The lamina dura was not sufficiently organized to be visible using imaging studies; root structures were preserved and there were no resorptions.

of hereditary involvement or specific genetic changes, the patient should be referred to a geneticist for a careful evaluation and identification of the problem.

In terms of individual susceptibility, family tendencies and individual predisposition, local factors should not be ignored, such as root morphology, root apex shape, shape of the alveolar bone crest and crown-to-root ratio, which substantially affect the prognosis of root resorptions during future orthodontic treatment.¹¹ These morphological factors, which may predict greater or lower root resorption during orthodontic treatment, may be inherited or acquired during odontogenesis due to environmental factors. However, when individual susceptibility, family tendency and individual predisposition are

mentioned in root resorption in orthodontics in general, they are often classified as systemic, and not local, factors.

The publication of the characteristics of large orthodontic samples may be an important contribution to the literature:

1. How many patients are carefully examined during evaluation and diagnosis to check systemic conditions associated with diabetes and the functions of the thyroid, parathyroid, pituitary, ovaries and the other endocrine glands?
2. How many patients are seen by the endocrinologist before orthodontic treatment is started?
3. Numerous patients have asymptomatic endocrinopathies and underwent ortho-

odontic treatment, were discharged, and did not have any problems in the amount of bone and rate of root resorptions. How many of these patients underwent systemic evaluations later on, when endocrinopathies were detected?

4. How many had multiple or severe root resorptions, were evaluated by an endocrinologist and had any endocrine disorder?

If there is no evidence that systemic changes, individual susceptibility, family tendency and individual predisposition are causes of root resorptions, to what should the multiple or severe root resorptions seen in orthodontic clinics be assigned?

First explanation

Cementoblasts should be removed, eliminated or simply vanish from the region for root resorption to begin on the root surface. Cementoblasts are closely associated with the cement surface and, simultaneously, are laterally protected by collagen fibers that insert into or fusion with root cement. Trauma, surgical procedures and bacterial and chemical products applied to the root surface may remove cementoblasts.

In injured teeth, the large lesions of the cementoblast layer may be reconstructed, partly with cells from the osteoblastic line, which have receptors for the mediators of bone turnover. They will be cementoblast-like, but start an early local resorption process when there is a local inflammatory stimulus, and promote a greater loss of root structure every time tooth movement is induced than surfaces without cementoblast-like cells.⁷ Therefore, the following assumption may be made: injured teeth, when moved during orthodontic treatment, have a greater chance of more frequent and more severe root resorptions. This does not translate into a contra-indication, but greater care should be taken when applying orthodontic forces to teeth in such conditions, particularly, whenever

possible, their homogeneous distribution along the root and special attention to their intensity.

Second explanation

Cementoblast removal may also occur during induced tooth movement. An excessive force to prevent the periodontal ligament, compressed between the bone and the teeth, to receive blood supply. The cells of this compressed ligament segment, such as the cementoblasts, move away from the region and leave the surface or die before migrating, and consequently the root is exposed. Cell scattering or death leaves only a hyalinized extracellular matrix in the region. The root surface, without the protection of cementoblasts, becomes the site of resorptions in the process of periodontal reorganization in the region after the dissipation of the force applied.

After a few days, reorganization is over and a new layer of cementoblasts is produced and again protects the root from resorption. The surface may acquire an irregular outline, but the periodontal ligament is back to its normal function in the region. This root will not be susceptible to future root resorptions.

After about 21 days, the process described above may resume, and a new loss of mineralized dentinal tissue adds up to the previous loss. However, if the force is adequate and compatible with the life of cementoblasts, new root resorptions will not occur. Root resorption diagnosed at the end of the orthodontic treatment is the sum of the resorptions at each activation time, and does not represent a single process during orthodontic movement (Fig 2).

Every time the orthodontic appliance is activated, great expectation is raised in the cell and tissue community in the periodontal environment: will there be new attacks against cementoblasts or not? When the orthodontic treatment is over and the patient is discharged, all congratulate because the worst is over! And let us hope there is no accidental or occlusal trauma!

Final considerations

Cases of multiple or severe root resorption have been less often assigned to systemic factors or diseases, individual susceptibility, family tendency and individual predisposition. When any of these factors is suspected and affects the appearance and progression of root resorptions, patients should be referred to endocrinologists or geneticists for adequate medical examination. When this approach is adopted, patients usually return with the result that there is no association

between the multiple or severe root resorption and their systemic status or family history.

Although there are no associations of root resorptions with systemic factors, individual susceptibility, family tendencies and individual predisposition, cases of patients with controlled or uncontrolled systemic diseases and who underwent orthodontic treatment should be carefully selected and published to enrich the literature with evidence that root resorptions are not part of the clinical signs and symptoms of endocrinopathies.

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An interview with Didier Fillion

- Graduate from the Paris V University.
- Specialist from the Paris V University.
- The only orthodontist practicing lingual orthodontics exclusively for over 30 years (Paris-London).
- Member of the American Association of Orthodontists (AAO).
- Member of the American Lingual Orthodontics Association (ALOA).
- President of the British Lingual Orthodontic Society (BLOS).
- Honorary President of the French Lingual Orthodontic Society (SFOL).
- Honorary Secretary of the European Society of Lingual Orthodontics (ESLO).
- Founding Member of the World Society of Lingual Orthodontics (WSLO).
- Adjunct Professor, Paris V University.
- Adjunct Professor, New York University (NYU), USA.
- Visiting Professor, University of Ferrara (Italy).



Dr. Didier Fillion began his career after graduating from the Paris V University at Sams, a small French town and his homeland. After having developed his basic training at the Tweed Foundation, he decided to devote himself to Lingual Orthodontics encouraged by the courses administered by Dr. John C. Gorman, which he attended seven times in a row. Determined to work exclusively with lingual orthodontics, he settled in Paris and for over 30 years has garnered worldwide acclaim for the excellence of his clinical results using this technique, by melding together quality and aesthetics. Although his first choice was to be a full time clinician, his professional brilliance opened the doors to an academic career, and Dr. Fillion has been invited to give classes and courses on lingual orthodontics at the Paris V University, New York University, University of Ferrara, University of Coimbra, among others. In seeking to teach this technique with utmost expertise and thereby strengthen its worldwide presence, he invested considerable hard work to found the French Lingual Orthodontic Society and was instrumental in the process of establishing similar organizations around the globe, including the Brazilian Association of Lingual Orthodontics (ABOL) and the World Society of Lingual Orthodontics (WSLO). He currently administers courses in several countries around the world, educating his audiences on the progress experienced by lingual orthodontics while disseminating the increasingly predictable and consistent clinical outcomes achieved with this technique.

Recently he once again visited Brazil at the invitation of the Brazilian Association of Lingual Orthodontics (ABOL) for a course in which he presented his new virtual set-up and bracket transfer system. On that occasion he kindly gave us an interview fielding some questions posed by Brazilian orthodontists who practice the lingual technique. I hope you enjoy it.

Luiz Fernando Eto

1) Why choose lingual orthodontics? Carla Melleiro

Because it is a completely invisible technique and there is great demand for aesthetic treatment by adult patients.^{11,13}

2) How do you assess the current status of lingual orthodontics? Luiz Fernando Eto

Today, adults have just become aware that they can get their teeth straightened at any age, and that this can be accomplished with aesthetic appliances.^{12,13} Why is it then that only very few patients get treated with this technique if several lingual advocates out there have shown for years that results are pretty similar to conventional (buccal) techniques? There are three reasons: Experience, laboratory and costs. Experience is related to teaching. Today, only a handful of universities have incorporated the teaching of lingual orthodontics in their graduate programs. Lingual brackets require specific laboratory procedures. Thanks to digital technology and the Internet, study models can be scanned in any country and sent over to Lingual Lab Centers, where all the procedures are performed. Thus, laboratory issues are being simplified and sorted out little by little.^{2,3,8,10} Costs are related to patient chair time. Chair time is 2 to 3 times longer than in conventional orthodontics. The reasons are numerous, but with experience you can cut it down to 1.5x the service time for conventional orthodontics.

So I'm sure that lingual orthodontics is bound to increase in popularity over the next five years, and will become just as popular as—if not more than—traditional (buccal) techniques. This is already true in some European countries where many orthodontists treat their adolescent patients with lingual orthodontics, while other orthodontists leave it up to their patients to decide on the choice of technique, since the results are the same.^{4,9}

3) How comfortable is it for orthodontic patients who wear brackets on the lingual sur-

face of their teeth? Marcelo Marigo

All orthodontic appliances generate a certain amount of discomfort, and lingual braces require an adjustment period involving a sore tongue and speech adaptation. The severity of these problems is commensurate with the thickness of the brackets.^{11,13} For 4 years now mini-brackets with a thickness of 1.5 mm have been available on the market. This is the smallest size that can be used, but brackets with a thickness of 2 mm help to reduce discomfort. The lingual Straight Wire technique renders the appliance more comfortable because incisor brackets are closer to the lingual surface, as well as less prominent. And since bends on the archwires (which are softer, with a better polish) are not necessary, patient comfort is increased. Figure 1 shows low profile lingual brackets that can also be used in the lingual Straight Wire technique.

4) What is the best bracket for lingual orthodontics? Valter Arima

To ensure patient comfort brackets should be small, with a maximum of 2 mm thickness. You don't need hooks on all teeth, only canines



FIGURE 1 - Straight Wire lingual appliance.

and second molars.⁶ Slot size must be very precise and with minimal variation because torque control in this technique is more difficult than when brackets are bonded to the buccal surface. Whether or not brackets are self-ligating, with active or passive clips does not matter. I prefer a ligated appliance of outstanding quality to an inefficient self-ligating appliance. Moreover, avoiding the loss of clinical time is an issue worthy of consideration.

5) Taking into account that the latest lingual brackets have no bite plane, is there any correlation between build-ups on molars and the occurrence of TMJ dysfunction? Rita Thurler

I never noticed any correlation between build-ups and TMD during therapy in patients who had good function prior to orthodontic treatment.⁷ If I see a patient that has a dysfunction I always refer them to a TMJ specialist to determine whether or not they are eligible for orthodontic treatment. Anyway, build-ups should not be left in the mouth for longer than 3 to 4 months, and must be removed as soon as alignment and leveling are complete.

6) Is biomechanical control similar to conventional techniques (brackets on buccal)? Andréia Cotrim

The key difference is in the position of the bracket relative to the center of resistance. When performing retraction in the lingual technique you will find a stubborn lingual inclination that can be hard, although possible, to avoid. Moreover, lower alignment and intrusion of mandibular incisors are facilitated because the brackets are in line with the center of resistance. We need not incorporate a reverse curve of Spee in the archwires if incisors are not upright. If they are upright, intrusion force will increase uprighting. It is therefore advisable to procline the incisors first.

7)) What is your favorite bonding material?

Alexander Macedo

Excellent bonding materials are available and I can't recommend any one in particular. I have used 4 different materials over the past 20 years. At first I used a two-paste product, then two liquids, then glass ionomer cement and now I use liquid composite. A very accurate laboratory procedure is fundamental to ensure as little space as possible between the resin pad and the enamel surface, and then filling this space with the product, avoiding any excess that might irritate the gums. I managed to increase adherence by extending the pad resin across a large area of the lingual surface using Komori's method. Currently, debonds are extremely rare.¹⁴

8) How do you see the use of retraction loops in cases of premolar extraction to prevent incisors from uprighting? Graça Guimarães

As is the case with any retraction system, one essential point in the lingual technique consists in generating enough force to counteract the spontaneous lingual inclination that occurs when positioning the brackets closer to the center of resistance. The use of retraction loops is good but it takes up more chair time and so I tend to select the simpler procedures, especially those that allow me to avoid archwire bends. I use sliding mechanics with the combined use of wires: rectangular in the anterior segment (0.018x0.025-in) and round in the posterior segment (0.018-in), and incorporate the curve of Spee to help with vertical control.

9) Some people say that case finishing with lingual orthodontics is less than good. Is this really true? Alexandre Moro

Outcome quality depends on how well you start treatment. In other words, it depends on planning and correct bracket positioning.^{1,2,5} Just like in the conventional (buccal) technique,

training and experience are very important to achieve good results.

10) What is your opinion about the Straight Wire lingual technique? Marcos Prieto

In my view, the Straight Wire lingual orthodontic technique is the necessary evolution of lingual orthodontics. Orthodontists should not go on wasting their time bending wires when you can accomplish the same treatment results using unbent Straight Wire. It's a major step towards streamlining this technique. It will probably take another couple of years to create awareness among orthodontists, but there is no turning back.¹⁴

11) Since there is a decrease in the amount of wire between lateral incisor and first premolar in the Straight Wire technique, wouldn't it be convenient to indicate the conventional technique with a "mushroom" archwire configuration in cases where canines need torque or rotation correction?

Carla Melleiro

The presence of 2-4 mm in/out bends on the archwire is not common in the buccal technique. I think the fact that these bends weaken the archwires raises transverse control issues. Additionally, it is a causative factor in the increased occurrence of the "bowing effect", the vertical and transverse deformation of the archwire due to retraction forces applied to the lingual brackets.¹⁴

12) Do you believe that self-ligating appliances point to a new direction in lingual orthodontics? Luiz Fernando Eto

Yes, of course, but the design of self-ligating lingual brackets is more challenging because they must be smaller and the closure system must move with ease. And I should add that the archwire must fit into the slot so the clips can fully close, and this process is harder to perform lingually. But I am sure that these issues will soon be addressed by

the orthodontic companies, some of which have already shown interest.

13) What is the significance of the laboratory phase in lingual orthodontics? Marcelo Marigo

Brackets are positioned during the laboratory phase, so it would be safe to say that this is the most important phase.²

14) Considering the use of self-ligating brackets in clinical practice, how lingual orthodontics has evolved and the credibility of this technique, in your opinion, how has CAD/CAM technology contributed to proper placement of lingual brackets? Valter Arima

The "famous lingual orthodontics" would benefit immensely if professionals could have a lab where they could control the placement of brackets in all cases. For 25 years I have held the belief that the key to lingual orthodontics is the proper placement of brackets and the possibility of incorporating overcorrections. Being able to check and modify the virtual set-up and placement of brackets favors orthodontists by affording them greater control. Besides, through the Internet, they become their own lab technicians.⁸ Figure 2 shows a three-dimensional scanner used to create virtual set-ups.

But it is important to note that this feature is not available in all digital systems, so you need to select an "open" system. The accuracy in bracket positioning provided by CAD/CAM technology enables faster alignment as well as the possibility of using unbent (straight) archwires. Figure 3 shows a virtual set-up with teeth in their ideal position, ready to receive lingual brackets.

Furthermore, I show my patients the virtual set-up and the finishing of vertical tooth positions before preparing their appliance. This technology streamlines the whole process, and is a great tool to help patient communication and understanding.



FIGURE 2 - Three-dimensional scanner.

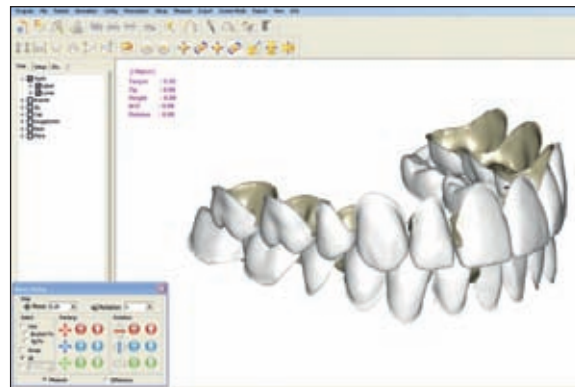


FIGURE 3 - Virtual set-up.



FIGURE 4 - Positioning brackets on virtual set-up.



FIGURE 5 - Transfer jig on malocclusion model.

Figure 4 shows the placement of brackets on the virtual set-up and Figure 5 shows the transfer jig mounted on the malocclusion model, ready for bracket transfer to the patient's mouth.

15) What role does the Orapix play in contemporary orthodontics? Graça Guimarães

Systems such as Orapix, or any other digital system for that matter, are poised to become the main tool for orthodontists in the near future. It is very useful for lingual orthodontics thanks to its indirect bracket positioning, but it is also becoming increasingly popular in buccal orthodontics. I could mention Ormco's "Insignia" system or the "Suresmile" by Orapix. The latter is the only system available for buccal and lingual orthodontics. In a few months or years direct mouth scanning will become

a reality. To answer your question, digital systems are the next step in the evolution of orthodontics.⁸

16) What is the most important difference between a treatment with Invisalign and lingual orthodontics, in your view? Rita Thurler

I could point out several differences:

- » Lingual orthodontics works with a completely invisible appliance.
- » Lingual orthodontics can successfully treat all types of malocclusions.
- » Treatment time is always shorter with lingual orthodontics.
- » Results are always better.
- » The Invisalign system allows no mechanical control by the orthodontist.

17) Would you say that any orthodontic specialist can treat patients using lingual orthodontics? Andréia Cotrim

Yes, but proper training is an absolute necessity. Just attending a course is not enough.

18) As regards the teaching of lingual orthodontics, do you think it would be better to add it as a discipline in specialist courses or should it be taught in an exclusive program geared to specialists? Here in Brazil there are courses for specialists. Alexander Macedo

At this time I think it is better to offer courses to specialists. This technique differs so radically from others that it is better learned when we are already specialists and have amassed some experience in traditional orthodontics.

19) What advice would you give to those Brazilian orthodontists who want to treat patients with lingual orthodontics? Marcos Prieto

My first advice is to start out with simple cases and gain familiarity with indirect bonding,

archwire insertion, ligation. Extraction cases should be dealt with later. And my second tip is that they should learn enough until they can fully master the technique. Lingual orthodontics is different from buccal orthodontics, and orthodontists should therefore learn about its unique features and differences.

There are many lingual orthodontics programs but to prove their worth they should show clinical cases because theory alone is not enough. Before I decided to limit my practice to lingual orthodontics, I had attended the same course taught by pioneers Kurz, Gorman and Smith 7 times in the 80s. Each time I learned more.

20) What is the future of lingual orthodontics? Alexandre Moro

Demand from adult patients is growing and so is the number of orthodontists. New technologies are increasingly improving and simplifying lingual orthodontics. It is therefore logical to predict that this technique will experience growth over the next five years, especially if technological advances help to reduce chair time and total cost.¹³ Price is a key element in this equation.

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Comparative study of complications during Herbst treatment with Cantilever Bite Jumper and removable mandibular acrylic splint

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Abstract

Objective: To assess and compare the type of complications during Herbst treatment with Cantilever Bite Jumper (CBJ) and removable mandibular splint. **Methods:** Twenty one consecutive Herbst patients treated with the CBJ were compared with twenty one consecutively treated Herbst patients with stainless steel crowns on the maxillary first molars and a removable mandibular acrylic splint. The initial mean age for the CBJ group was 12 years and 3 months and for the Splint group was 11 years and 3 months. Both groups used the Herbst appliance for 12 months. Based on the patients' clinical records an occurrence survey of complications during Herbst treatment was performed. **Results:** There were 24 complications for the CBJ and 53 for the Splint group, which were statistically different (Mann-Whitney test, $p < 0.05$). The prevalence of patients exhibiting complications during treatment was 66.67% in the CBJ and 85.71% in the Splint group. The frequencies of complications were also statistically different between the groups. **Conclusions:** The CBJ exhibited a significantly smaller number of complications during Herbst appliance treatment than the removable mandibular splint. Herbst appliance with first molar crowns and a cantilever on the mandibular molars is preferable to the removable mandibular acrylic splint because of savings in clinical and laboratory time.

Keywords: Herbst appliance. Class II. Complications.

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Editor's summary

Recent studies about Herbst appliances found that complications depend on the type of device used. The greatest frequency of fractures was found for banded appliances, but most cases of accidental debonding were found when metal splints were used. No differences were found in overall frequency of complications between banded appliances and designs with metal splints. So far, no study has compared the frequency of complications between cantilever bite jumper (CBJ) appliances and models that have removable acrylic lower splints. This study compared the occurrence of fracture between two types of Herbst appliances, and results provided data to support clinical decisions about the best choice. Group 1 comprised 15 men and 6 women that had Class II malocclusion and mean age of 12 years and 3 months at the beginning of the treatment. Patients were treated using the CBJ (Ormco, Glendora, CA), which has four steel crowns for the mandibular and maxillary first molars. Group 2 comprised 11 men and 10 women that had Class II malocclusion

and mean age of 11 years and 3 months at the beginning of the treatment. Patients in this group were treated using the Herbst appliance with steel crowns in the maxillary first molars and removable mandibular acrylic splint. Maxillary molars were connected using a transpalatal arch. The telescopic system used with these Herbst appliances was Dentaurem type I (Ispringen, Germany).

Seven patients (33.3%) in the CBJ group and 3 (14.29%) in the Splint group had no complications, and according to the results of the Fisher exact test, there were no significant differences in prevalence of number of patients with complications between the two types of appliances. However, the evaluation of total number of complications during treatment with Herbst appliances revealed 24 occurrences in the CBJ group (mean, 1.1 per patient) and 53 in the splint group (mean, 2.5 per patient), and this difference was statistically significant. Therefore, our findings confirmed the clinical impression that the CBJ appliance has greater resistance to fracture.

Questions for the authors

1) Fixed appliances, such as the Herbst appliance, do not require patient cooperation. However, patient compliance seems to be important to preserve the integrity of the appliance. Which complications of the Herbst appliance should be assigned to lack of patient cooperation?

The Herbst appliance is not indestructible, and, during insertion, the patient should always receive the same information about eat-

ing that is given to a patient that will use a conventional fixed appliance. If the patient eats hard or sticky foods, several complications may occur: accidental crown debonding, screw loosening, Rod distortion, crown fractures, lower splint fracture, and transpalatal arch fracture. These complications affect patients using CBJ as well as appliances with removable lower splints. In the splint group, patients might stop using the lower part of the appliance, which is removable to facilitate oral hygiene, but this is a rare situation.

2) Did the authors find any differences in clinical effects as the Herbst appliance design was changed?

A recent unpublished study¹ compared the effect of Class II correction using these two types of Herbst appliances and assessed results using Johnston superimposition cephalometric analysis. Several differences were found: apical base change and mandibular growth/displacement were greater in the splint (3.9 mm and 5.2 mm) than in the CBJ group (3.0 mm and 4.00 mm), but these differences were not statistically significant. Another important conclusion was that there were no differences in anterior movement of mandibular incisors: the value was 1.3 mm in both groups, although less protrusion was expected in the splint group.

3) Are technical advances expected in the near future for the treatment using the Herbst appliance?

Rollo bands (American Orthodontics, Sheboygan, WI) are currently used for appliance fixation. They have the same resistance as

steel crowns, but are much easier to remove because of an opening on the occlusal surface. Moreover, the mandibular axles of cantilevered systems are currently placed at a more posterior position, in the region of the mandibular second premolar, which gives the appliance a better esthetic effect and does not impinge on soft tissue. In regard to the telescopic system, appliances designed for direct attachment are currently preferred, as they obviate the need of screws to fasten the system. As previously seen, one of the most important causes of complications is screw loosening. Some companies have developed telescopic systems in a single piece, in which the tube (upper part) and the Rod (lower part) form a single block, like a shock absorber, and do not come apart. However, they are not yet clinically efficient, to justify the high prices charged for these appliances. A strong future trend is the attempt to use skeletal anchorage, particularly in the mandibular arch², to install the appliance, to maximize the desired skeletal effects and to minimize collateral dental effects.

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Comparison between cavum and lateral cephalometric radiographs for the evaluation of the nasopharynx and adenoids by otorhinolaryngologists

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Abstract

Introduction: The lateral cephalometric, as well as the cavum radiograph, allow the evaluation of the nasopharyngeal airway (NAW). Otorhinolaryngologists routinely use the cavum radiograph, even when the patient already has a lateral cephalometric headfilm. **Objectives:** The aim of this study was to (a) acknowledge which exams otorhinolaryngologists use for the evaluation and measurement of the NAW; (b) evaluate if the otorhinolaryngologists are acquainted to the cephalometric method; (c) compare both radiographs to see which one is preferred to visualize the NAW and adenoids and (d) correlate the visual analysis to the measuring method of Schulhof. **Methods:** For this purpose, cephalometric and cavum radiographs of 15 mouth-breathing children were taken on the same day. These radiographs were masked leaving only the NAW and the adenoids visible, and were blindly presented to 12 otorhinolaryngologists. They received the radiographs together with a questionnaire asking about their familiarity with the lateral cephalometric radiograph, which exams are used for NAW and adenoid evaluation and if they use any method for measuring the NAW obstruction level. They were also asked to visually classify the NAW and the adenoids according to their sizes into small, medium and large. **Results:** The results demonstrated that all otorhinolaryngologists in the sample use the cavum radiograph. Only one uses the cephalometric radiograph and two are familiar with this technique. The cephalometric radiograph was preferred by 49.4% of the otorhinolaryngologists, the cavum by 22.8%, and 27.8% did not see any difference between both methods. There was low correlation between the visual method and the Schulhof measuring method.

Keywords: Orthodontics. Otorhinolaryngology. Cavum radiograph. Cephalometric radiograph.

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Editor's summary

The radiographic evaluation, besides being the most used method in the medical literature to evaluate hypertrophy of adenoids, is also the most used method to plan an orthodontic treatment. But the doctor normally uses the cavum radiograph and the orthodontist uses the lateral cephalometric radiograph. Both are lateral radiographs of the cranium but the cephalometric radiograph is standardized by stabilizing the patient's head with a cephalostat. In the cavum radiograph, the lack of the cephalostat during the exam allows the patient to alter head position, which requires more attention during its acquisition.

The results of the present study showed that the otorhinolaryngologists have little knowledge

of the cephalometric technique, since only two of the twelve doctors interviewed knew this radiographic method. It's important to say that when both techniques were compared, most doctors picked as best view of the nasopharyngeal airway and adenoids the cephalometric radiograph (49.4% and 48.9%) and one forth of the otorhinolaryngologists didn't see any difference between both techniques for the two analyzed structures (27.8% and 27.2%).

This study also evaluated if the visual method used by the otorhinolaryngologists in the diagnoses of adenoid hypertrophy was compatible with the results found by measuring those anatomical structures with the Schulhof's method (1978). A low correlation between those two methods was found.

Questions to the authors

1) What evaluation techniques would result in a higher number of diagnoses of nasopharyngeal obstruction, the quantitative evaluation by the method reported or the visual assessment used by otorhinolaryngologists?

There are no differences among the number of possible diagnoses. The difference between the methods is related to the reproducibility of the diagnoses. Using the quantitative analysis increases the chances of several professionals achieving the same diagnosis for a specific case or of a single professional giving the same diagnosis for a case in different periods of time. In the visual analysis the differences among the diagnoses increases.

2) Interdisciplinarity among orthodontists and otorhinolaryngologists could be a benefit to the patient?

Yes. Because both areas could work together for the well being of the patient, discussing the best time for each approach and not making the treatment time longer than it should be.

3) How to enable the interdisciplinarity between these areas?

Maybe elaborating interdisciplinary courses or with mouth breathers treatment centers that included orthodontics as one of the disciplines involved.

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Brazilian consensus of snoring and sleep apnea – aspects of interest for orthodontists

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Abstract

The objective of this article is to clarify the positions of the medical societies that have worked together to establish a consensus regarding the clinical and laboratory parameters involved in sleep-disordered breathing, particularly snoring and obstructive sleep apnea syndrome (OSAS). Orthodontists have gradually come to take part in multidisciplinary teams that act in the area of human sleep, but few know about the uniformity coordinated by the Brazilian Association of Sleep. Clinical and scientific studies from the field of dentistry (particularly orthodontics) also must observe and follow these diagnosis and treatment criteria established by the Brazilian medical community.

Keywords: Sleep apnea. Obstructive. Snoring. Polysomnography.

Editor's summary

Orthodontists that work or plan to work in the area of sleep disorders should primarily acquire in-depth knowledge of the clinical and laboratory parameters to diagnose them, the definitions established so far, and the limits of their specialization in relation to the multidisciplinary teams that follow up and treat patients with respiratory sleep disorders.

Obstructive sleep apnea (OSA), a multifactor syndrome not fully understood yet, is partly

assigned to anatomic changes of the upper airways and the craniofacial bones associated with neuromuscular abnormalities of the pharynx. It is characterized by recurrent upper airway obstructive episodes during sleep. The obstruction is continuous and involves waking up due to the increased respiratory effort and the blockage, reduction (hypopnea) or complete cessation (apnea) of the airflow in the presence of respiratory movements. The events are often ended by brief awakenings. The most common symptoms

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are tiredness upon awakening and sensation of non-refreshing sleep regardless of its duration, excessive daytime sleepiness and poor quality of life. Predisposing factors are: obesity, and central obesity in special; male sex; craniofacial abnormalities, such as maxillary or mandibular hypoplasia; augmented pharyngeal soft and lymphoid tissues; nasal obstruction; endocrine abnormalities, such as hyperthyroidism; acromegaly; and family history. Associated factors are systemic hypertension; pulmonary hypertension; cardiac arrhythmia associated with sleep, nocturnal angina,

gastroesophageal reflux, impairment of quality of life, cognition and sleep.

Dentists may request a polysomnographic evaluation when OSA is suspected, and the final diagnosis of sleep disorder, its severity and the evaluation of comorbidities are made by a physician according to polysomnographic findings. Orthodontists play an important role in the detection of pharyngeal obstructive sites, in the orthopedic or surgical evaluation and treatment of the maxillary or mandibular disorders, as well as the treatment of OSA using intraoral devices.

Questions for the authors

1) Is the prevalence of OSA high in Brazil? What factors are involved in the etiology of this disorder?

Although epidemiological studies in other countries showed that the prevalence of obstructive sleep apnea (OSA) syndrome among adults may range from 2 to 10%, a recent study published by the Sleep Biology and Medicine team of UNIFESP (Department of Psychobiology) found alarming figures. According to that study, OSA prevalence was 32.9% among the adult population in the city of São Paulo, 40.6% among men and 26.1% among women. This study was very important and was conducted with a randomized population sample in which all volunteers responded questionnaires and underwent whole night polysomnography in a sleep laboratory, the standard criterion for OSA diagnosis. Notably, as expected, prevalence was greater among older individuals with a greater body mass index (BMI); that is, more advanced age and greater weight indicated higher chances of having OSA. Moreover, according to the same study, 60% of the adult population in the city of São Paulo has a BMI greater than 25 kg/m², and 22% of this population

is obese, with a BMI greater than 30 kg/m². For that reason, the rates mentioned above should not be extrapolated to the Brazilian population.

The physiopathology of OSA has not been fully determined because the narrowing of upper airways during sleep and their consequent collapse has multifactor causes. Anatomic, functional and neuromuscular factors are involved. The size and the spatial relations of the upper airways are defined by soft tissue, muscles and the craniofacial bones, which directly affect the shape and size of the pharynx. Some of the anatomic factors that may be directly associated with obstruction are: fatty tissue in the pharynx; tonsil or adenoid hypertrophy; increased tongue size (macroglossia); and factors associated with craniofacial development and growth, such as mandibular or maxillary retrognathism, micrognathia and narrowing of the dental arches.

Obesity seems to be the main risk factor for OSA; in non-obese patients, changes in the growth of the lower facial third seem to be the major factor in the development of this syndrome. Functional factors, such as augmented upper airway complacency, and neuromuscular factors have also been studied. Little is known about the latter, but studies have shown that there is a reduction in

the ventilator drive and in the activity of the dilating muscles of the pharynx. In OAS, a mechanism to compensate for the nocturnal obstructive episodes is active during waking hours and increases the activity of pharyngeal muscles. During sleep, the opposite is true, and a decrease in muscle tonus may lead to upper airway collapse. However, these factors are still under analysis. Collapse may occur in the retropalatal or retrolingual areas, or in both, and it is a dynamic process that involves anatomic changes and the neuromuscular activity of the whole pharynx. These concepts are fundamental to indicate and select the most appropriate treatment. The narrowing and collapsibility of the upper airway during sleep involves several factors, rather than only a previously narrow and short airway, easily detected during physical examination.

2) Has the role of orthodontists been clearly outlined in the treatment of sleep disorders?

Dentistry has gained room in sleep medicine in the last few years thanks to the work conducted by specialist in multidisciplinary teams who are directly or indirectly associated with teams that work with sleep medicine. The study published in this issue provides a good discussion of the role of dentists in general and orthodontists in particular in the diagnosis and treatment of respiratory sleep disorders.

3) What advances does the future hold for the treatment of sleep apnea?

Studies in the area of sleep medicine about the treatment of OSA have advanced towards new treatments, improvements in existing therapies, and attempts to demonstrate not only improvements in clinical conditions, but also the resolution of cardiovascular and cognitive consequences that affect individuals with OSA.

Besides the clinical treatments already widely accepted, such as CPAP and IOA, there are novel therapeutic approaches under investigation. Several of them aim at complementing treatment

that does not achieve totally effective results. Here we may include speech therapy, which, by means of exercises, aims at improving the tonus of the pharyngeal muscles. The same may be said of acupuncture, which may also help to improve respiratory sleep disorders. At the same time, surgical treatments, particularly orthognathic surgeries, have been studied in well designed trials to demonstrate their expected positive results.

At the same time, studies have confirmed results of clinical treatments using IOA or CPAP in the improvement of cognition, quality of life and cardiovascular parameters. In terms of cardiovascular conditions, several studies have evaluated the effect of treatment on blood pressure, heart rate and oxidative stress.

The clinical treatment of OSA using IOA and CPAP is unquestionably consistent according to the literature, whereas only a few studies have evaluated other treatments so far.

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Assessment of the effect of different surface treatments on the bond strength of brackets bonded to acrylic resin

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Abstract

Objective: To evaluate the influence of the surface treatment of acrylic resins on the shear bond strength of brackets bonded with composite resin. **Material and Methods:** Were fabricated 140 discs with autopolymerizing acrylic resin (Duralay®) and divided them into 14 groups (n = 10). In each group, the specimens received a different type of surface treatment. Group 1- untreated surface (control), Group 2- silane, Group 3- aluminum oxide blasting (AOB), Group 4- AOB + silane, Group 5- diamond bur, Group 6- diamond bur + silane, Group 7- hydrofluoric acid, Group 8- hydrofluoric acid + silane, Group 9- phosphoric acid, Group 10- phosphoric acid + silane, Group 11- methylmethacrylate monomer (MMA), Group 12- MMA + silane, Group 13- plastic conditioner (Reliance®); Group 14- plastic conditioner (Reliance®) + silane. After surface treatment the specimens were analyzed using a surface roughness tester. Subsequently, standard edgewise central incisor brackets (Morelli®) were bonded using Transbond XT® light-cure adhesive system, according to the manufacturer's instructions. **Results:** The silane-based wetting agent had no statistically significant effect on bond strength values. Treatments with AOB and bur generated the highest topographical changes on the surface of acrylic resin as well as the highest roughness values. A nonlinear correlation was found between bond strength and surface roughness. Monomer + AOB treatment yielded the highest bond strength values. **Conclusions:** Silane failed to increase the bond strength between brackets and acrylic resin. We encourage further studies on this subject since the bond strength achieved in our study was extremely low.

Keywords: Orthodontics. Acrylic resin. Composite resin. Brackets.

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INTRODUCTION

Given the increasing number of adults that seek orthodontic treatment some procedures used in the office have had to be modified to fit this new patient profile. This age shift means that orthodontics is no longer just sought as an end in itself but also as a means towards achieving other goals. In other words, orthodontic treatment is now multidisciplinary and, as such, the treatment plan, previously developed by the orthodontist alone, must be carried out in conjunction with periodontists, endodontists, surgeons, GPs and implant dentists.^{2,11} As a result, orthodontic treatment may serve as a pre-prosthetic activity as it is confronted not only with natural teeth but also extensive composite resin restorations, implants, metal crowns, ceramics and provisional restorations.^{6,7} In short, given the fact that archwires and brackets are still needed to achieve orthodontic movements, a wide range of surfaces exists where brackets need to be bonded. Moreover, effective bracket bonding still plays a key role in the success of orthodontic treatment.

Bonding techniques comprising etching, primer and adhesive have been widely accepted and documented for bonding brackets to the surface of natural teeth.^{1,3,9,12} They afford more than the necessary bond strength to enable orthodontic treatment.¹⁰ Many studies have been conducted in attempts to accomplish a similar performance when bonding orthodontic attachments to amalgam, porcelain, composite resin and metal surfaces.^{2,13,14} In fact, until recently, it was considered inconceivable that any clinically acceptable bond strength could be achieved in areas other than the enamel, particularly in the lower posterior region. However, advances in orthodontic materials and the development of new techniques have shown that the bonding of orthodontic attachments to surfaces other than enamel is also possible.^{8,13-17}

However, the literature is still rather sparse when it comes to the bonding of orthodontic attachments to acrylic resin provisional restorations. This dearth of scientific studies leads practitioners to resort to empirical protocols, which ultimately cause brackets to debond frequently, thereby hindering the orthodontic treatment.

This study was designed to perform an *in vitro* analysis to measure and compare the roughness of acrylic resin surfaces after applying different surface treatments. It also aimed to characterize these surfaces by scanning electron microscopy (SEM) and assess the bond strength of metal brackets bonded to pre-treated acrylic resin surfaces using composite resin. Furthermore, we assessed the effects of applying a silane-based wetting agent to the acrylic resin in terms of bond strength between bracket and acrylic resin.

MATERIAL AND METHODS

Table 1 lists the materials used in this study and their composition. All materials were used as received without adding any further formulation and/or treatment.

One hundred and forty acrylic resin (Duralay[®]) specimens were fabricated for bonding 40 central incisor standard Edgewise brackets (Morelli[®], slot 0.022x0.028-in). The specimens were fabricated using as matrix an acrylic disc with 25 mm diameter and 5 mm in height with a central hole of 8 mm diameter and 5 mm in height, where the heat-polymerized acrylic resin (Duralay[®]) was inserted (Fig 1). In keeping with the usual procedure of sample preparation, sanding was performed to homogenize the surface of the specimens. We utilized silicon carbide abrasive paper—in decreasing order of abrasiveness (400 and 600)—under refrigeration/lubrication with abundant water. The sanded specimens were cleaned in an ultrasound device with distilled water for five minutes and then dried with hot air.

TABLE 1 - Materials used for surface treatment and bonding of brackets.

Material (Manufacturer)	Composition
Phosphoric acid 37% (DENTSPLY® Indústria e Com. Ltda.) L156380	Phosphoric acid (in aqueous solution, 37 wt% in gel form), silicon dioxide and pigments
Porcelain Conditioner® (DENTSPLY® Indústria e Com. Ltda.) L244578	Hydrofluoric acid (aqueous solution 9.6% in gel form)
Transbond XT Primer (3M- Unitek, Monrovia) 712-035	Triethyleneglycol-dimethacrylate Bis-GMA
Transbond XT Paste (3M- Unitek, Monrovia) 712-035	Silica Bis-GMA Silane N-dimethyl benzocaine hexa-fluoride-phosphate
Duralay® Powder and Liquid (Reliance, Dental Mfg. Co. Worth) 60482	Powder - copolymer of methyl methacrylate color 81 Liquid - methyl methacrylate
Aluminum oxide blasting (BIO-ART® Ind. de Eq. Odont. Ltda.)	Aluminum oxide 50 µm / 220 mcsh
Plastic Appliance Conditioner® (Reliance, Ortho Prod. Inc) 0473	Composition was not informed
Ceramic Primer® (3M- ESPE, St. Paul) 551441000	Metacriloxipropil-trimetoxisilano (MPTS) 1 wt% Ethanol-water solution with acetic acid - pH = 4 - 99 wt%
Diamond bur # 3145 (KG- Sorensen) 1076/1103	Diamond and Stainless Steel

The surfaces were then treated in preparation for bonding the brackets. Fourteen different surface conditioning methods were used, which are summarized in Table 2. These conditioning methods are detailed in Table 3, by group. Ten samples were tested using 14 experimental conditions. The brackets were bonded to the acrylic resin using Transbond XT primer and adhesive (composite resin).

Before bonding the brackets, three specimens from each group were analyzed with a roughness tester to determine the effect of the various treatments on the surface topography of the samples. This procedure was adopted because the roughness of the substrate is a parameter that significantly influences how the adhesive spreads.¹⁷

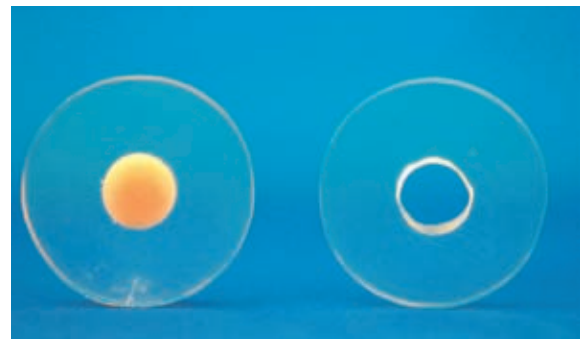


FIGURE 1 - Acrylic matrix with 25 mm diameter and 5 mm in height, containing a central 8 mm hole used as a basis for preparing the specimens.

TABLE 2 - Experimental conditions for bonding of brackets.

Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Primer	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Silane		x		x		x		x		x		x		x
Aluminum oxide blasting			x	x										
Diamond bur					x	x								
Hydrofluoric acid							x	x						
Phosphoric acid									x	x				
Monomer											x	x		
Plastic appl. conditioner													x	x

TABLE 3 - Description of surface treatments performed before bonding.

Group	Surface Preparation
1	(Control) - no surface preparation other than sanding
2	(Control) - with silane layer, allowed to act for 60 seconds. Subsequently, the specimens were dried with compressed air free of moisture and oil
3	Surface was abraded with aluminum oxide blasting (50 µm) for 10 seconds, using the Blast Microetcher®, Bio-art operating at a pressure of 80 pounds and at a distance of 1 cm from the surface with the tip of the device forming a right angle relative to specimen surface
4	Same as group 3 + application of silane as in group 2
5	Surface was abraded with diamond bur No. 3145 KG Sorensen positioned parallel to the surface of the specimen, with a rotation of 4000 rpm under water spray. Brushing bur movements were performed on the specimens
6	Same as group 5 + application of silane as in group 2
7	Surface was etched with hydrofluoric acid at 9.6% for 15 seconds. It was then washed with water jets for 60 seconds and dried with compressed air free of moisture and oil
8	Same as group 7 + application of silane as in group 2
9	Surface was etched with hydrofluoric acid at 37% for 30 seconds. It was then washed with water jets for 15 seconds and dried with compressed air free of moisture and oil
10	Same as group 9 + application of silane as in group 2
11	Application of Plastic Appliance Conditioner (plastic surface conditioner). After application there was a 60-second wait, as directed by the manufacturer
12	Same as group 11 + application of silane as in group 2
13	Methyl methacrylate monomer was applied for 60 seconds and dried with compressed air to remove any excess
14	Same as group 12 + application of silane as in group 2

Measurements were made in an automated Surface Roughness Tester, Mitutoyo (Illinois, USA).

In view of the fact that roughness can be characterized by several different parameters, in this investigation we used the arithmetic mean of roughness profiles, called Ra, which gives the arithmetic average of all profile departures from a given baseline (valley depth and peak height). Five roughness profiles of surface texture were measured in each sample in order to evaluate the uniformity of surface treatment of substrates, both in terms of cleaning and the treatment itself.

Topographic analysis of the treated surfaces was also performed using scanning electron microscopy (SEM). Analyses were performed on surfaces coated with a conductive metal layer using an electron acceleration voltage of 10-15 kV, 80 µA current, and secondary and/or backscattered electrons.

After completing surface treatment, we bonded the brackets using Transbond XT adhesive system, according to the manufacturer's instructions. The specimens were then attached to a device especially fabricated for bracket bonding.¹⁸ This metal device was used to help standardize the distance and parallelism between bracket and specimen while providing bond strength and homogeneous polymerization (Fig 2).

Small amounts of Transbond XT adhesive were placed on the bracket bases with the aid of a No. 5 explorer and then pressed against the specimens. The device ensured that each specimen axis remained in an orthogonal position relative to the bracket (Fig 2). The entire assembly was light-activated for 60 seconds through a slit in the device, using an Optilux 400® unit with a light intensity of 500±20 mw/cm². Five minutes after bonding,

the specimens were stored in zip lock bags and kept at room temperature. Twenty-four hours prior to shear bond strength testing, the specimens were stored in water at $37\pm2^{\circ}\text{C}$ in conformity with ISO/TS 11405, of 2003.

Shear bond strength tests were performed on a Universal Testing Machine set to apply the load onto the specimen at a speed of 0.5 mm/min.

RESULTS

In examining Table 4, we noted that it was only in the Phosphoric Acid + Silane and Plastic + Silane treatment groups that the combination with silane yielded increased bond strength. In all other groups, the addition of silane caused a decrease in both the mean and the median (Table 5).

For statistical evaluation, two-by-two sample comparisons were carried out in order to check whether or not the silane had any bearing on the bond strength of each surface treatment. The comparison was performed by the Mann-Whitney test (Table 5, p value). The choice of this test was due to the fact that the samples did not display a normal pattern.

Overall, silane application did not stabilize bond strength measurements, causing instead increases and decreases in measurement variability, as shown in Table 4.

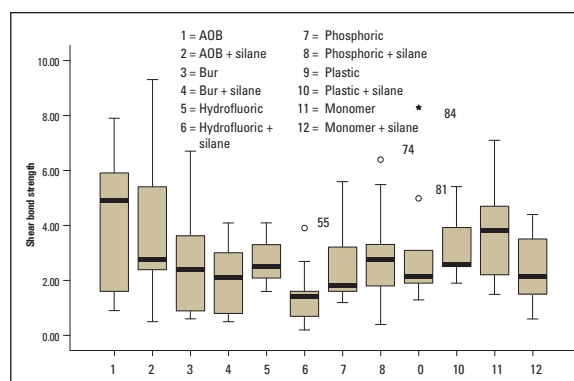


FIGURE 3 - Box plot chart showing variation in bond strength within and between groups.

DISCUSSION

The effect of various treatments on the surface roughness of acrylic resin is shown in Table 4. It is noted that the groups undergoing mechanical bur treatment yielded much higher roughness values than all other groups, including those whose surface was treated with aluminum oxide blasting (AOB).



FIGURE 2 - Bonding device used to ensure standardization. Illustration of how the brackets were bonded to the acrylic resin discs.

TABLE 4 - Roughness evaluation (μm).

Groups	Surface Treatment	Mean	Standard Deviation	Cv
G1	Control	0.35	0.02	0.057
G3	AOB	0.85	0.23	0.270
G5	Bur	7.77	1.48	0.190
G7	Hydrofluoric	0.38	0.04	0.105
G9	Phosphoric	0.47	0.06	0.127
G11	Monomer	0.55	0.14	0.254
G13	Plastic	0.45	0.03	0.066

TABLE 5 - Shear bond test experimental results and descriptive statistics of the influence of silane on bond strength (MPa).

Treatment	Observations	Mean	SD	Median	Cv	P-value
AOB	10	4.23	2.32	4.90	0.55	0.545
AOB+silane	10	3.65	2.48	2.75	0.68	
Bur	10	2.69	1.88	2.40	0.70	0.384
Bur+silane	10	2.07	1.24	2.10	0.60	
Hydrofluoric	10	2.75	0.86	2.50	0.31	0.006*
Hydrofluoric+silane	10	1.47	1.13	1.40	0.77	
Phosphoric	10	2.39	1.34	1.80	0.56	0.405
Phosphoric+silane	10	2.94	1.88	2.75	0.64	
Plastic	10	2.97	2.16	2.15	0.73	0.210
Plastic+silane	10	3.13	1.07	2.60	0.34	
Monomer	10	3.66	1.74	3.80	0.47	0.880
Monomer+silane	10	2.44	1.21	2.15	0.50	

It is noteworthy that although the roughness of bur-treated surfaces was far superior to the others, their uniformity was adequate since their coefficient of variation was less than 30%, similar to that achieved with other treatments. It was also noted that treatment using phosphoric and hydrofluoric acid etching was unable to significantly alter acrylic resin topography as the surface roughness of these groups was similar to the control group. Treatments using conditioner and monomer also produced little change in acrylic resin roughness in comparison with the control group.

Experimental shear bond strength test results are shown in Figure 3. We were unable to determine the shear bond strength of the control groups (groups 1 and 2) because the brackets came off as we were handling the samples. This means that these control samples with no surface treatment had very limited bond strength. As shown in Table 4, standard deviation was high for all groups although the bonding procedure was performed as reproducibly as possible. A similar behavior has been observed by other authors.¹⁹

Table 5 shows the minimum and maximum values for each group, the first and third quartile

and the median (represented by the solid line), as well as possible outliers. This chart shows shear bond strength variability within and between groups and reveals that the data do not follow a normal distribution and must therefore be analyzed by a nonparametric test.

By examining the data shown in Table 5 and in Figure 4 the influence of silane on the bond strength of the different surface treatments can be assessed. It becomes obvious that only the treatments using phosphoric acid and plastic conditioner yielded an increase in bond strength when the surface treatment was associated with silane. In the other groups, including the AOB treatment group, the use of silane caused a reduction both in mean and median bond strength. A statistical evaluation of these results was made by comparing the samples subjected to the same surface treatment, with and without the application of silane (e.g., groups 3 and 4).

This comparison was performed using the Mann-Whitney test to determine whether the use of silane was able to significantly alter bond strength. The Mann-Whitney test is indicated when samples do not show a normal distribution pattern, as was the case here. The test result is expressed by the p value in Table 5.

The hydrofluoric acid group ($p = 0.006$) was the only group that showed significant variation. However, the silane caused a decrease in bond strength, and not an increase, as is the case when bonding to porcelain.^{14,15,16}

Figure 4 shows the correlation between roughness and shear bond strength. The data indicate that initially a small increase in roughness results in a large increase in bond strength. However, as soon as a 'critical' roughness value is reached the bond strength remains stable.

Figure 5 shows the microstructure of the various surfaces investigated in this study. Figure 5A (A1, A2 and A3) represents the control group, i.e., the surfaces have been sanded and are now ready to receive surface treatment. A number of grooves can be seen which result from the initial sanding process. They are homogeneously distributed in a mostly unidirectional arrangement. Acrylic resin debris is also visible. Figure 5B (B1, B2 and B3) shows the

untreated areas where silane has been applied. As can be observed, the silane does not alter the acrylic resin topography since the surface features that can be viewed here are basically the same as in Figure 5A.

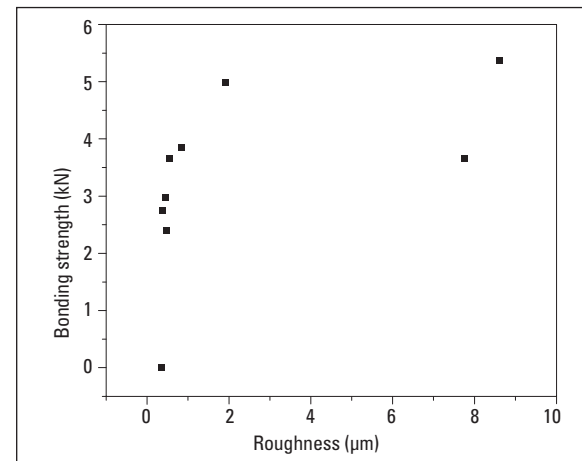


FIGURE 4 - Variation in bond strength / roughness.

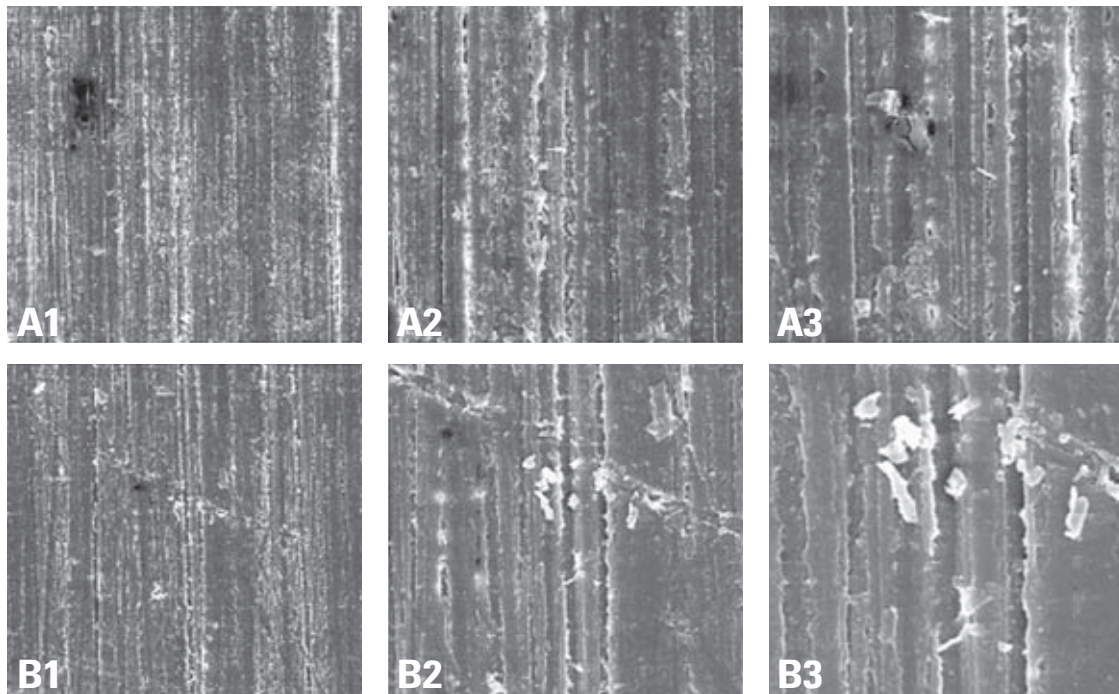


FIGURE 5 - Control groups surface topography: **A)** Group 1 (control), **B)** Control + Silane (Image magnification for each group: 1 = 200 times, 2 = 500 times and 3 = 1000 times).

When comparing the control group (Fig 6A) with the AOB group (Fig 6C) and bur-treated group (Fig 6D) we can see that these treatments were able to completely alter the topography of acrylic resin. In the AOB group, the surfaces were evenly blasted (C1), generating a uniform topography with a nearly equiaxed relief composed of valleys and peaks. The bur-treated surface (D) exhibits rounded lumps and a pronounced relief variation, which was confirmed by measurements taken with the roughness tester (7.77 Ra). As shown in

Figure 4, increases in roughness also increase shear bond strength. This finding is in agreement with results achieved using the mechanical inter-locking bonding mechanism.²⁰

Acid etching (hydrofluoric and phosphoric) resulted only in an apparent removal of impurities generated by the original sanding process, as can be shown in Figure 7. This seems to be the great advantage of using acid on the acrylic resin as the presence of debris on the surface has been known to affect bond strength.

Figure 8 shows the effect of monomer and

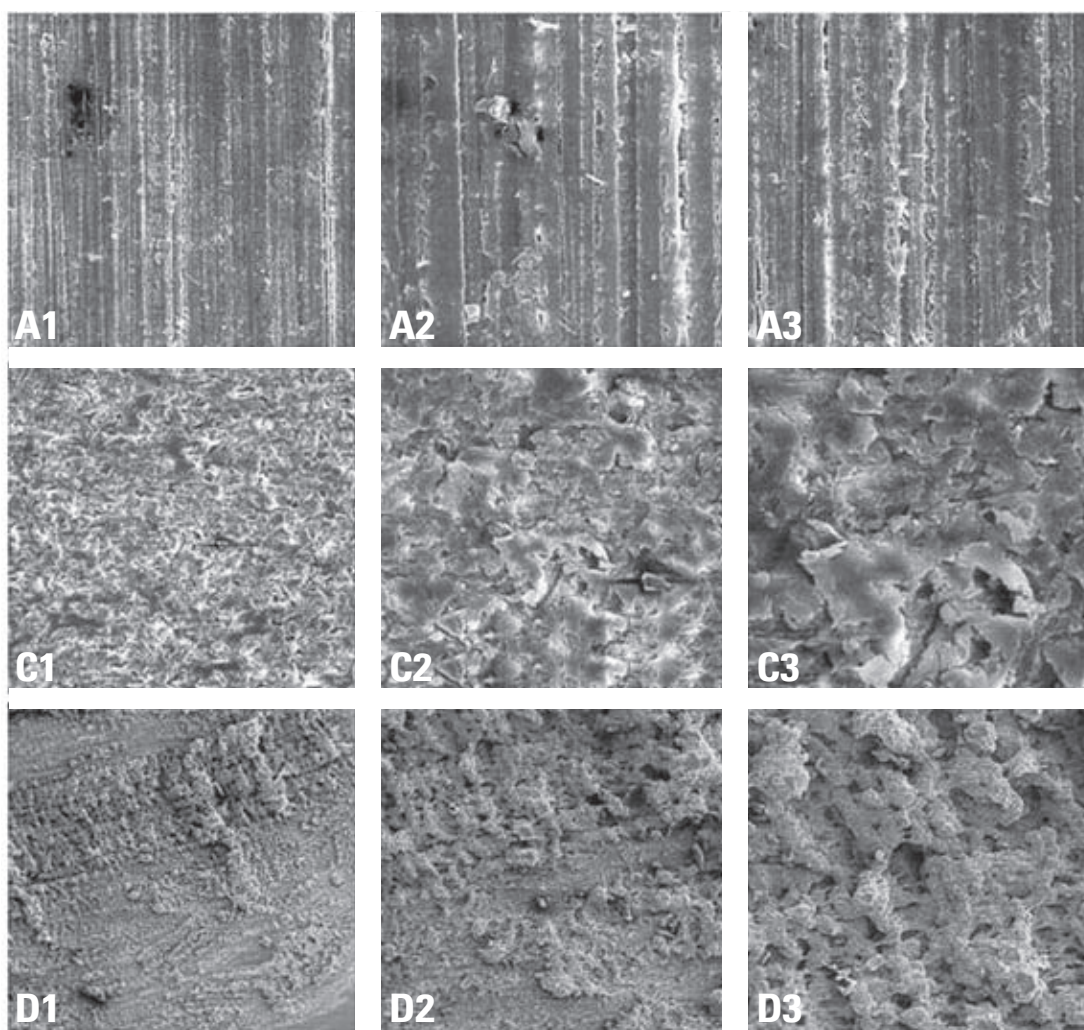


FIGURE 6 - Acrylic resin surface topography. **A** = Group 1 (Control), **C** = Group 3 (Aluminum Oxide Blasting), **D** = Group 5 (Bur).

plastic conditioner treatments on the topography of acrylic resin. A comparison between the control group (A) and the monomer coated group (G) shows a total change in the topography of acrylic resin with the formation of randomly distributed micro-cracks. This modification in the substrate increased the bond strength of the composite resin (3.66 MPa) and led to an increase in surface roughness compared with the control group (from 0.35 Ra to 0.55 Ra). Although not within the scope of this investigation, studies should be conducted

to find out whether these micro-crack substructures were generated in the acrylic resin or whether the application of the monomer covered the acrylic resin surface with a layer which, possibly by contraction, generated the system of micro-cracks. The area treated with surface plastic conditioner (group H) maintained the topographical structure (control A) originally caused by sanding. However, surface conditioning seems to produce a coating that acts as a glaze over the acrylic resin and negatively affects the bonding process.

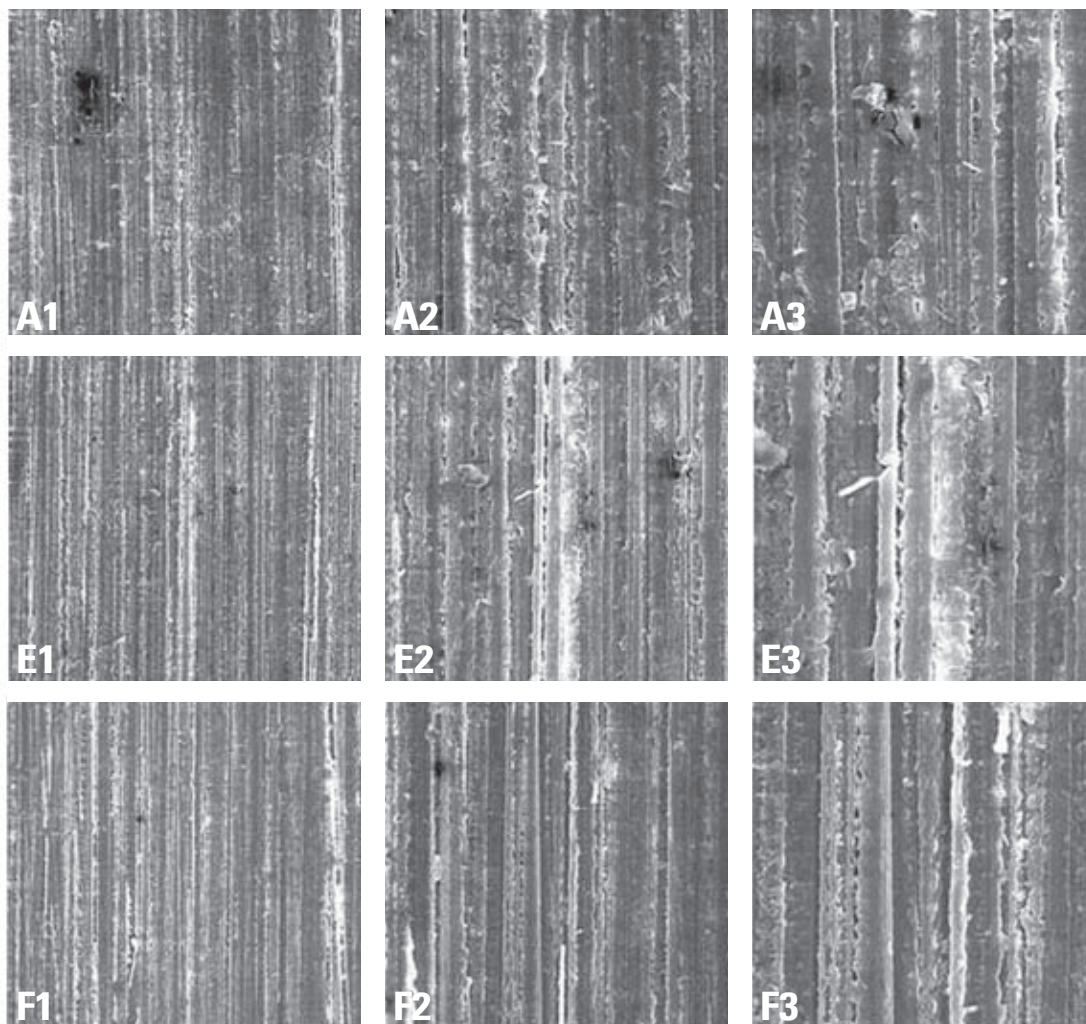


FIGURE 7 - Acrylic resin surface topography. **A** = Group 1 (Control), **E** = Group 7 (Hydrofluoric acid), **F** = Group 9 (Phosphoric acid).

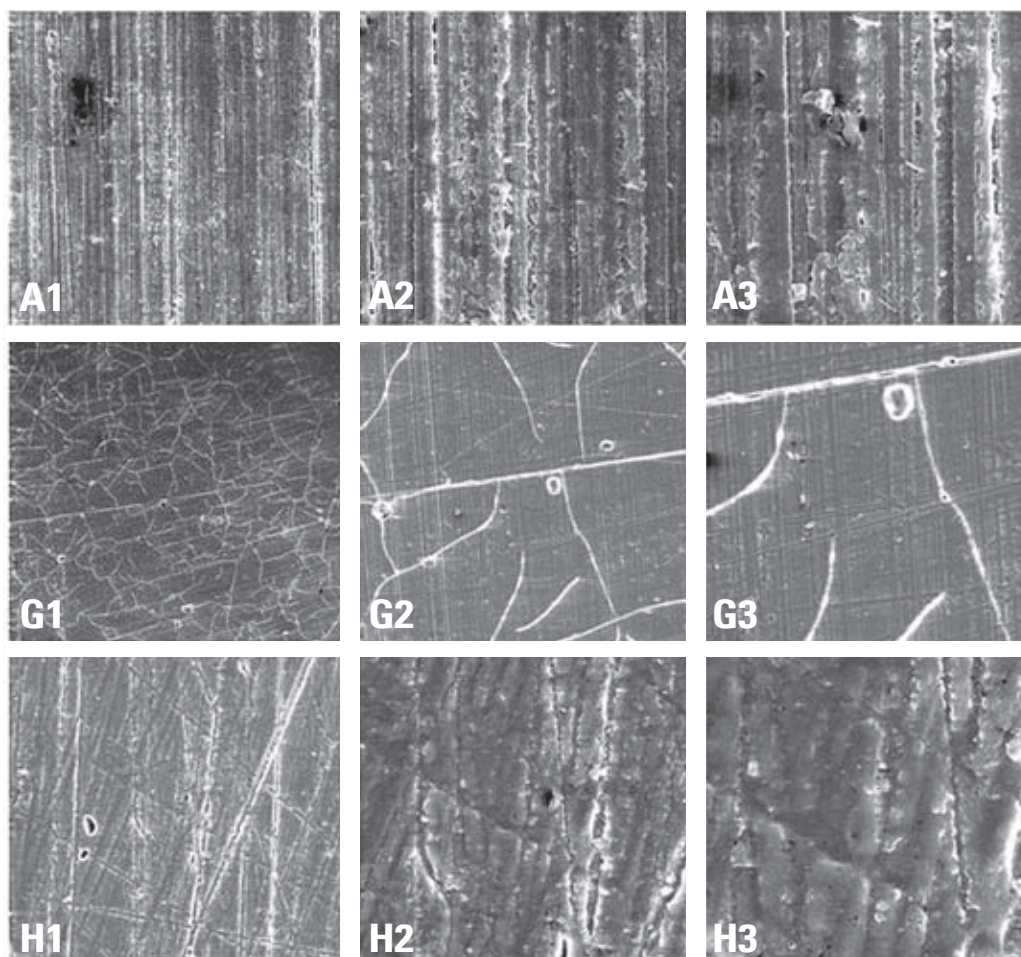


FIGURE 8 - Acrylic resin surface topography. **A** = Group 1 (Control), **G** = Group 11 (Monomer), **H** = Group 13 (Plastic Surface Conditioner).

CONCLUSIONS

Based on the experimental findings achieved through this study we have concluded that:

I) Silane application does not contribute to enhance bond strength values, leading only to non-significant variations. Thus, the use of silane after treating the acrylic surface, within the parameters of this study, does not improve the bond strength of orthodontic brackets.

II) No linear correlation was found between bond strength and surface roughness of acrylic resin. A critical roughness value was found

which must be reached if maximum bond strength is to be achieved. Within the experimental parameters used in this research, such critical roughness value is approximately 2 μm .

III) Treatments involving aluminum oxide blasting (AOB) and burs produced the greatest changes in acrylic resin surface topography and produced greater roughness, which contributes to increase the bond strength between resin and bracket.

IV) Acid etching did not alter the original topography significantly, acting primarily as a

means of cleaning debris generated by the process of preparing the original acrylic resin.

V) Treatment with monomer caused a series of micro-cracks on the acrylic resin surface. These micro-cracks actually increased surface

roughness and, consequently, enhanced bond strength. The plastic conditioner seems to produce a covering layer over the surface that hinders the contact between acrylic resin and bracket, thereby compromising bond strength.

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Effects of orthodontic ligation—using elastomeric and stainless steel ligatures—on periodontal health

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Abstract

Objective: This study aimed to conduct a clinical evaluation of the periodontal conditions of a test group and a control group using three periodontal indexing systems, namely: dental biofilm index (DBI), bleeding index (BI) and pocket probing depth (PPD). **Methods:** The test group consisted of 20 subjects with a mean age of 13.5 years undergoing fixed orthodontic treatment involving the use of two types of ligature: elastomeric ligature (EL) and stainless steel ligature (SSL). The results were compared with a control group without prior orthodontic treatment, comprising 15 subjects with a mean age of 15.3 years. The measurements were performed prior to orthodontic treatment (T1) and six months after placement of a fixed orthodontic appliance (T2); and in the control group, six months after the initial measurement (T2). Both groups were instructed about oral hygiene, according to the Bass technique, before treatment. **Results and Conclusions:** Dental surfaces showed a statistically significant increase in levels of biofilm ($P=0.000$), gingival bleeding ($P=0.000$) and probing depth ($P=0.000$), when T1 and T2 and the groups were compared, however, no statistically significant differences were found between EL and SSL in terms of these periodontal indexes.

Keywords: Orthodontic appliances. Periodontal diseases. Biofilms.

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INTRODUCTION AND LITERATURE REVIEW

The link between orthodontics and periodontics has been studied over the years, be it to address the role of orthodontic attachments as biofilm retainers and obstacles to proper oral hygiene,^{2,3,4,5,9,10,11,13,14,16,20,22,23,26,28,29} be it to address tooth positioning as a means to retain dental plaque, protect the gingival papilla or allow the proper delivery of forces to the periodontum.^{7,12,15,25,27}

Studies on periodontal changes caused by orthodontic treatment have yielded mixed results. The literature associates orthodontic appliances with mild gingival inflammation, even in patients with perfect health. Proximal and buccal areas are the most affected.²⁹ Moreover, some authors claim they did not observe significant changes in dental biofilm index (DBI) or in dental hygiene throughout a whole year of orthodontic treatment.¹⁸

Comparison between a group of women with and without fixed orthodontic appliances showed similar DBI and gingival inflammation index (GI) between groups, unlike pocket probing depth (PPD).²⁷

In another study, however, DBI and GI were higher in groups using orthodontic appliances when compared to the control group, but both within adequate hygiene levels.⁹

It is known that after removal of orthodontic attachments gingival health improves significantly with a reduction in PPD, which suggests that periodontal changes are transient and no permanent damage is caused to oral tissues.^{16,21,29}

Although few studies in the literature have compared elastomeric (EL) and stainless steel (SSL) ligatures, most of them used electron microscopy.

Measurement of the quantity of microorganisms accumulated on the teeth, as well as variations in the quantity of these microorganisms in saliva, in patients using EL and SSL showed that the former had the highest number of microorganisms in all samples and there was an increase in the number of *Streptococcus mutans* and *lactobacilli* in saliva.

But this is not reflected in an increase or decrease in bacterial colonization with either EL or SSL.¹⁰

Electron microscopy analyses of premolars extracted from patients undergoing orthodontic treatment with brackets bonded with composite resin using EL on one side and SSL on the opposite side disclosed no bacterial differences, although mature biofilms were observed in the resin, due to its rough exterior, as well as in the resin-enamel interface.²⁶

In another electron microscopy study, it was found that neither the application of stannous fluoride nor the use of these ligation materials (EL or SSL) affect the number of *Streptococcus mutans* colonies around the brackets.⁵

The aim of this study was to evaluate clinically the periodontal health of patients with total fixed orthodontic appliances using two ligation methods: elastomeric (EL) and stainless steel (SSL), which were compared with a control group. Periodontal evaluation criteria were based on: dental biofilm index (DBI), bleeding index (BI) and pocket probing depth (PPD), measured before and six months after placement of fixed orthodontic appliances. Both the test and control groups were instructed on oral hygiene using the Bass technique and dental flossing. This study was submitted to and approved by the Ethics Committee of UFJF.

MATERIAL AND METHODS

This study evaluated clinically the periodontal conditions of a test group, submitted to orthodontic treatment, using two ligation methods: elastomeric ligature (EL) and stainless steel ligature (SSL), whose results were compared with a control group, using the following periodontal indexes:

- » Dental Biofilm Index (DBI).²⁴
- » Bleeding Index (BI).¹
- » Pocket Probing Depth (PPD).¹⁹

The mesial, distal, buccal and lingual surfaces of all permanent teeth in the test and control groups were examined, except the second and third molars,

using a clinical mirror, artificial light, explorer and graduated periodontal probe (Newmar, São Paulo/SP, Brazil), Glickman No. 26, 10 mm.

The criteria for sample selection were: To be enrolled for treatment at the clinic of the Specialization Course in Orthodontics, School of Dentistry, UFJF; not using systemic medication for chronic diseases nor local or general antimicrobial medication; not undergoing periodontal treatment nor having a family history of periodontal disease; not smoking; not being pregnant.

The test group consisted of 20 Brazilian subjects, 9 males and 11 females, between 9 and 16 years with a mean age of 13.5 years. Periodontal evaluation was carried out prior to orthodontic treatment (T1) and six months after placement of the total fixed orthodontic appliances, using metal Standard Edgewise (Morelli, Sorocaba/SP, Brazil) and Roth (Abzil, São José do Rio Preto/SP, Brazil) brackets (T2). In this sample, T1 and T2 evaluations were performed in the upper and lower arches of 5 patients, in the upper arch of 9 patients and in the lower arch of 6 patients. This difference in the number of upper and lower arches that were assessed is due to the fact that some patients had fixed appliances installed in only one arch. Either that, or the appliance had been installed less than six months earlier.

Ligature types were alternated in each quadrant and maintained in such position throughout all consultations. In some patients the first quadrant was ligated with EL and in others, with SSL. In this manner, it was ensured that both types of ligature were alternately used in the second quadrant, since all participants in the test group were right-handed and subjects tend to brush best the buccal surfaces of the quadrant opposite to the hand holding the brush, especially in the maxillary arch.⁸

All stainless steel ligatures (Uniden, Sorocaba/SP, Brazil) were from the same manufacturing lot, size 0.010" (0.25 mm). Elastomeric ligatures (Uniden, Sorocaba/SP, Brazil) were also from the

same production lot and in the gray color. Each tooth was individually ligated.

The control group consisted of 15 patients who had never undergone orthodontic treatment, 10 females and 5 males, aged between 9 and 22 years with a mean age of 15.3 years. Evaluation was performed initially (T1) and then six months after the initial measurement (T2).

All participants and their parents were instructed about oral hygiene according to the Bass technique and flossing before treatment. They were given toothbrushes (Condor, São Bento do Sul/SC, Brazil), soft bristle, No. 30, all from the same manufacturing lot.

All participants in this study, or their legal guardians, signed a consent term, pursuant to UFJF Ethics Committee regulations.

Statistical analysis

Periodontal evaluation was performed by a single, properly calibrated professional. Statistical analysis provided a concordance index of Kappa = 1 for DBI, an index of agreement of Kappa = 0.974 for BI, and Student's t-test yielded P = 0.140 for PPD.

DBI results were statistically analyzed using the Wilcoxon test (comparison between T1 and T2), the nonparametric Mann-Whitney (comparison between groups) and chi-square test (comparison between groups and between ligatures).

BI results were statistically analyzed using the Wilcoxon test (comparison between T1 and T2) and chi-square test (comparison between groups and between ligatures).

PPD values were subjected to statistical analysis by Student's t-test for paired samples (comparison between T1 and T2) and t-test for unpaired samples (comparison between groups and between ligatures).

RESULTS

The measurements obtained in this study are displayed in tables with a view to comparing

DBI, BI and PPD. For each index, comparisons were made between the initial and final measurements (T1 and T2), the test and control groups, and EL x SSL.

Dental Biofilm Index (DBI)

In analyzing this index, only the scores 0 (no plaque), 1 (biofilm attached on the free gingival margin and adjacent tooth surfaces, and identified using a probe) and 2 (moderate accumulation of clinically visible biofilm) were observed. Score 3 (abundant biofilm located both above and beneath the gums) was intentionally omitted and is therefore not expressed in the following tables.

In the test group, at T1, 9.3% of the surfaces exhibited score 1 or 2, and at T2, this percentage increased to 23.8%, with a statistically significant difference ($P=0.000$). In the control group at T1, 5.8% of the surfaces displayed score 1 or 2, and at T2, this percentage increased to 7.0%. This increase was also statistically significant ($P=0.000$), although in this group variations were not as pronounced as in the test group. Comparison between groups was statistically significant ($P=0.000$) (Table 1).

Comparison of DBI variations showed that most surfaces remained unchanged in the test group (73.5%) and even more so in the control group (90.4%). In the test group, 4.4% and 1.5% of the surfaces improved their scores 2 and 1, respectively. This improvement was also noted in the control group in 0.8% and 3.2% of the surfaces. An increase in scores 1 and 2 was observed in 6.9% and 13.7% of the surfaces examined in the test group. This increase was more moderate in the control group, affecting 1.7% and 3.9% of the surfaces with score 1 and 2, respectively. Comparison of DBI variations between groups proved statistically significant ($P=0.000$) (Table 2).

Comparison of DBI variations showed that most of the surfaces tied with EL remained unchanged (75%), and likewise with SSL (72%). Surfaces tied with EL showed improvement in

scores 2 and 1, of 3.9% and 0.7%, respectively. This improvement was also observed in 4.9% and 2.3% of surfaces tied with SSL. Increases in scores 1 and 2 were observed in 6.5% and 13.9% of EL surfaces and in 7.4% and 13.4% of SSL surfaces. No statistically significant difference was found in DBI variations between the surfaces tied with EL and SSL ($P=0.242$) (Table 2).

Bleeding Index

In the test group, at T1, 1.2% of the surfaces exhibited gingival bleeding, and at T2, this percentage increased to 5.8%, with a statistically significant difference ($P=0.000$). In the control group the surfaces with gingival bleeding displayed percentages of 1.1% and 2.8% at T1 and T2, respectively. This change was also statistically significant ($P=0.001$), although variations were not as pronounced as in the test group. Comparison between groups was statistically significant ($P=0.000$) (Table 3).

Variations in BI were classified thus: worse (no bleeding at T1 and then bleeding at T2), improved (bleeding at T1 and then no bleeding at T2) and unchanged (no changes in bleeding at T1 and T2) (Table 4).

The values show that most of the surfaces examined in this study had the same BI at T1 and T2, both in the test (93.6%) and control (96.9%) groups. Some slight improvement was noted in

TABLE 1 - Frequency, mean (M) and standard deviation (SD) of the sites where biofilm was present at T1 and T2 in the test and control groups

Biofilm	Score	Test (N=1068)		Control (N=1296)	
		T1	T2	T1	T2
	0	90.7%	76.2%	94.2%	93%
	1	1.9%	6.9%	3.8%	1.5%
	2	7.4%	16.9%	2.0%	5.5%
	M	0.17	0.41	0.08	0.12
	SD	±0.536	±0.761	±0.335	±0.467
	P	*0.000		*0.000	
	*0.000				

* Statistically significant at the level of $P \leq 0.05$.

TABLE 2 - Frequency of variations in DBI scores between the two measurements (T1 and T2) in the test and control groups

Variation in Dental biofilm index (DBI) (T2-T1)	Test						Control	
	Total (%)		**EL (%)		***SSL (%)		Total (%)	
-2	4.4	5.9	3.9	4.6	4.9	7.2	0.8	4.0
-1	1.5		0.7		2.3		3.2	
0	73.5		75		72		90.4	
1	6.9	20.6	6.5	20.4	7.4	20.8	1.7	5.6
2	13.7		13.9		13.4		3.9	
Total	100		100		100		100	
P	0.242							
	*0.000							

* Statistically significant at the level of $P \leq 0.05$.

** EL = Elastomeric ligatures.

*** SSL = Stainless steel ligatures.

TABLE 3 - Frequency of sites with and without gingival bleeding at T1 and T2 in the test and control groups.

	Score	Test (N=1060)		Control (N=1296)	
		T1	T2	T1	T2
Gingival bleeding (%)	**_	98.8	94.2	98.9	97.2
	***+	1.2	5.8	1.1	2.8
	Total	100	100	100	100
	P	*0.000		*0.001	
		*0.000			

* Statistically significant at the level of $P \leq 0.05$.

** - = Without bleeding.

*** + = With bleeding.

TABLE 4 - Frequency of variations in DBI scores between the two measurements (T1 and T2) in the test and control groups.

Variation in bleeding index (BI) (T2-T1)	Test (%)			Control (%)
	Total	EL	SSL	Total
Improved	0.9	1.1	0.9	0.7
Unchanged	93.6	93.1	93.6	96.9
Worse	5.5	5.8	5.5	2.4
Total	100	100	100	100
P	0.788			
	*0.000			

* Statistically significant at the level of $P \leq 0.05$.

** EL = Elastomeric ligatures.

*** SSL = Stainless steel ligatures.

0.9% and 0.7% of the surfaces in the test and control groups, respectively. However, BI worsened in 5.5% of the test group surfaces, which also occurred in the control group, although not significantly (2.4%). Comparison of BI variations between groups proved statistically significant ($P=0.000$) (Table 4).

Most of the surfaces showed the same BI at T1 and T2, both in the EL (93.1%) and SSL (93.6%) groups. Some minor improvement was noted in 1.1% and 0.9% of the surfaces in the EL and SSL groups, respectively. However, BI worsened in 5.8% and 5.5% of the faces in the EL and SSL groups, respectively. No statistically significant difference was found in BI variations between the surfaces tied with EL and SSL ($P=0.788$) (Table 4).

Pocket Probing Depth (PPD)

In the test group, at T1, the mean linear PPD was 1.555 mm with ± 0.625 mm standard deviation, and at T2, 2.017 mm with ± 0.797 mm standard deviation, with a mean increase of 0.462 mm, which was statistically significant ($P=0.000$). In the control group at T1, the mean linear PPD was 1.500 mm with ± 0.585 mm standard deviation, and at T2, 1.639 mm with

TABLE 5 - Mean (M), standard deviation (SD), mean difference between T1 and T2 (T2-T1) and mean difference between test and control groups (MDG) in terms of total PPD.

		Test (N=1060)		Control (N=1290)	
Pocket probing depth (PPD) (mm)	M	T1	T2	T1	T2
		1.555	2.017	1.500	1.639
	SD	0.6251	0.7976	0.5857	0.6235
		0.4623 ±0.6402			
	(T2-T1) SD	***EL ****SSL		0.1391 ±0.4072	
		T2-T1	0.466 0.458		
		SD	0.5979 0.6817		
		**MD	0.0083		
		*P	0.832		
	MDG	0.3231			
P	*0.000		*0.000		
	*0.000				

* Statistically significant at the level of $P \leq 0.05$

** MD: Mean difference between elastomeric ligatures (EL) and stainless steel ligatures (SSL)

*** EL: Elastomeric ligatures

**** SSL: Stainless steel ligatures

±0.623 mm standard deviation, and a mean increase of 0.139 mm, which was statistically significant ($P=0.000$). The mean difference between groups was 0.323 mm, which was statistically significant ($P=0.000$) (Table 5).

Variation between the two measurements (T2-T1) of the mean linear PPD in the EL group was 0.466 mm with ±0.597 mm standard deviation. This variation, although more modest, was also noted in the SSL group, resulting in a mean of 0.458 mm with ±0.681 mm standard deviation. Given that the PPD mean was 0.008 mm, no statistically significant difference was found between the EL and SSL groups ($P=0.788$) (Table 5).

DISCUSSION

In the initial analysis (T1), the test group showed a mean DBI index of 0.17 ± 0.536 , which rose to 0.41 ± 0.761 at T2. The control group showed mean values of 0.08 ± 0.335 and 0.12 ± 0.467 at T1 and T2, respectively. These variations between T1 and T2 and between groups were statistically significant.

In a previous study, the DBI mean in the ex-

perimental group was 0.49 ± 0.41 , initially, dropping to 0.43 ± 0.34 during treatment, probably due to the implementation of an oral hygiene program after the initial measurement, which was reinforced during consultations, in addition to the prescription of fluoride rinsing. The control group was measured once and displayed a mean of 0.68 ± 0.61 .²⁹

In another analysis, the measurement of DBI in patients undergoing orthodontic treatment showed an initial mean of 0.40, and after one year, 0.36, also demonstrating a high standard of DBI control thanks to the intensive oral health program.¹⁸

Higher scores were noted in DBI analysis in a group with fixed orthodontic appliances. It was 0.76 initially, but increased to 0.78 one month later. The control group showed an average of 0.52 and 0.51, in the initial analysis and after one month, respectively.⁹

In the present study, the percentages of DBI in T1 show that 90.7% of the surfaces examined in the test group had score zero and 9.3%, scores 1 and 2; and at T2, these values were 76.2% and

23.8% respectively. In the control group at T1, the values were 94.2% for score zero and 5.8% for scores 1 and 2, and at T2, 93% and 7.0%.

However, in a previous study with no oral hygiene support, 27.8% of surfaces in the test group showed score zero and 72.2% had scores of 1 and 2; and in the control group, 20% and 80% respectively, which showed, according to the authors, few differences between the groups.²⁷

The total BI in the test group showed that, initially, 1.2% of the surfaces had bleeding, and at T2, this percentage increased to 5.8%. The control group showed bleeding in 1.1% of the surfaces at T1 and 2.8% of the surfaces at T2. These results were statistically significant when comparing T1 and T2 and in a comparison between the groups.

Previous studies also showed an increase in BI values in the group undergoing orthodontic treatment, even with an oral hygiene program in place, as well as the development of moderate gingivitis in the first two months of treatment.²⁹

In another study, the measurement of gingival index exhibited an initial mean of 0.25, and after one year of orthodontic treatment it increased to 0.37.¹⁸

However, in another analysis of this index, the group with fixed orthodontic appliance had an initial mean of 0.75, which decreased to 0.70 after one month. The control group showed an average of 0.20 and 0.23 in the initial analysis and after one month, respectively. Thus, although the initial results and the results found after one month remained virtually unchanged in both groups, comparison between groups showed a statistically significant difference.⁹

Moreover, the authors noted bleeding in 42.2% and 40.6% of the areas measured in the test and control groups, respectively, but these differences were minor and clinically insignificant.²⁷

The PPD measurements obtained in this study showed a mean value of 1.555 mm at T1 and 2.017 mm at T2, reflecting an increase of 0.462 mm in the test group. The control group

showed an initial PPD of 1,500 mm, very similar to the test group, and at T2, 1.639 mm, also demonstrating an increase in PPD, albeit more modest (0.139 mm). PPD variations were statistically significant when comparing T1 and T2, as well as the two groups ($P=0.000$).

Previous PPD evaluations also showed initial values that were lower than those obtained during orthodontic treatment,²⁹ in addition to test group means that were higher than in the control group.²⁷

In this study, radiographs were not performed to assess the bone level, nor were orthodontic appliances removed to observe changes in the gingiva, which makes it difficult to determine whether the increase in PPD during treatment was due to a loss of gingival attachment or to gingival hypertrophy, as reported,^{2,16,21,29} although this increase was observed clinically.

Comparative studies between the use of elastomeric ligatures (EL) and stainless steel ligatures (SSL) are scarce in the literature and the few that can be found are often associated with electron microscopy.

This study compared elastomeric ligatures with stainless steel ligatures and found no statistically significant differences in dental biofilm index ($P=0.242$), gingival bleeding index ($P=0.788$) and pocket probing depth ($P=0.832$).

These results corroborate those found with the aid of electron microscopy,^{5,26} but disagree with another study which showed that elastomeric ligatures held a higher number of microorganisms when compared to SSL.¹⁰

The results obtained in this study after comparing the two ligation methods suggest that other variables can play a role in affecting the periodontal health of patients undergoing orthodontic treatment, such as the use of brackets and bands, bonding technique and material used in bracket manufacture.^{4,13,14}

Although the dental biofilm index (DBI) and bleeding index (BI) showed a significant increase at T2, both were within adequate hygiene standards.⁶

Likewise, pocket probing depth (PPD) showed a significant increase, but within normal standards.¹⁷ Based on these findings, the need to implement an oral hygiene program geared to patients undergoing orthodontic treatment is hereby underscored with a view to preserving periodontal health.^{2,7,9,16,18,28,29}

CONCLUSIONS

After clinical evaluation of the periodontal condition of patients undergoing fixed orthodontic treatment with elastomeric and stainless steel ligatures, using the dental biofilm index (DBI), bleeding index (BI) and examination of pocket probing depth (PPD), comparing them to a control group, assessed prior to orthodontic treatment (T1) and six months

after placement of a fixed orthodontic appliance (T2), while the control group was assessed six months after the initial measurement (T2), the following results were found:

- » A significant increase in DBI when comparing T1 and T2, as well as when comparing the test group with the control group.

- » A significant increase in BI when comparing T1 and T2, as well as when comparing the test group with the control group.

- » A significant increase in PPD when comparing T1 and T2, as well as when comparing the test group with the control group.

- » No significant difference between the use of elastomeric ligatures and stainless steel ligatures after assessment of DBI, BI and PPD.

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Evaluation of the determinants of facial profile aesthetics

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Abstract

Objective: To evaluate the influence of age, gender, sagittal occlusal relationship, facial pattern and 8 facial profile measures on profile aesthetics. **Methods:** Contingency tables, chi-square test and Cramer's coefficient were used to evaluate the possible association between the scores assigned by 32 examiners (14 orthodontists, 12 laypeople and 6 artists) to the aesthetics of the profile of 100 Brazilian Caucasian adults, all patients with lip seal competence, and age, gender, sagittal occlusal relationship, facial pattern and the variables of the numerical analysis of the facial profile. **Results:** No association was found between age, gender and sagittal occlusal relationship and the aesthetics of facial profile. An association was observed between profile scores and facial pattern, facial convexity angle and lower face angle. **Conclusions:** Among the factors evaluated in this study, facial profile convexity and anterior chin projection were the key determinants of facial profile aesthetics.

Keywords: Facial profile. Aesthetics. Orthodontic diagnosis.

INTRODUCTION

Since the early twentieth century Case⁶ tried to establish the features responsible for a beautiful or perfect face:

- » Prominent chin with mild mentolabial furrow.
- » Lower lip slightly posterior to the upper lip.
- » Upper lip in balance with the cheek, malar prominence and nose.
- » Lip seal competence.

However, this concept of beauty is undergo-

ing constant change.^{2,17,18} Aesthetics can be defined as appreciation of beauty, or a combination of qualities that afford intense pleasure to the senses and the intellectual and moral faculties.¹⁰ This appreciation of beauty is influenced by individual factors, such as sex, race and education, and by social factors, such as the environment and, nowadays increasingly advertising (media). It therefore varies across different populations and historical periods.^{2,10,14,15,16}

Several studies have attempted to determine

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the facial features that account for a pleasant or unpleasant aesthetic appearance. Pleasant aesthetics is related to harmony and balance between the parts that make up the facial profile.^{4,15} Arguably, in the female profile, the shape of the chin and, in men, the mouth and lips are instrumental in assessing aesthetics.¹⁹

Increases in profile convexity have been associated with unpleasant aesthetic appearance.⁷ Apparently, the major components in evaluating facial esthetics would be, first and foremost, the mouth, followed by the eyes, facial structure, hair and nose, in the order given.²⁹

The aim of this study was to assess the possible influence of age, gender, occlusal sagittal relationship,¹ facial pattern⁵ and 8 facial profile measures on the aesthetic classification of facial profiles.

MATERIAL AND METHODS

Sample

The study sample consisted of 100 Brazilian Caucasian adults with competent lip seal, comprising 50 men and 50 women with a mean age of 23 years and 7 months, and ages ranging between 18 and 36 years.^{13,20} The mean ages in the female and male groups were 23 years and 4 months and 23 years and 9 months, respectively. The criteria used for inclusion in the sample were adequate facial muscle balance, reflected in lip seal competence, no prior orthodontic treatment or facial surgery, and willingness to participate in this study. All individuals who agreed to participate in this study signed a consent form that stated the research objectives and the exams they would undergo. In the consent form, participants also authorized the disclosure of their facial photographs for teaching and research.

Standardized profile photographs were taken, and plaster models of the upper and lower dental arches were fabricated for each individual.^{13,20}

Aesthetic Subjective Facial Analysis²³

The sample was subjected to aesthetic subjective

facial analysis through assessment performed by 32 individuals divided into 3 groups from different professional areas: Fourteen orthodontists (7 men and 7 women), 12 laypeople not linked to the dental area nor to any artistic activity (6 men and 6 women) and six female artists (one teacher and five postgraduate art students enrolled at the School of Fine Arts), all residing in the cities of São Paulo, São Bernardo do Campo or Santo André. Mean examiner age was 37 years and 6 months with a standard deviation of 9 years, ranging from 21 to 56 years.

Examiners were asked to provide their opinion by rating each photograph within 30 seconds. Scores should be given according to the following options:

- a) Aesthetically pleasing: Scores 7, 8 and 9.
- b) Aesthetically acceptable: Scores 4, 5 and 6.
- c) Aesthetically unpleasant: Scores 1, 2 and 3.

With the purpose of assessing intra-examiner agreement in a subjective evaluation of the profile, 10 facial profile photographs were randomly selected and examiners asked to repeat the aesthetic classification with at least one week interval between the two ratings.

Student's t-test for paired samples was employed to determine evaluation error. There was no significant difference between the first and second scores assigned by the examiners at a significance level of 5% ($p > 0.05$) (Table 1).

Table 1 presents the means, minimum and maximum values, and standard deviations for the first and second assessments.

The mean value for the 32 scores assigned by each individual in the sample was calculated for the present study.

Morphological Subjective Facial Analysis^{22,23,24}

Photographs of the individuals in the sample were classified by two authors, according to the Analysis of Facial Morphology suggested by Capelloza Filho.⁵ This author argues that faces

TABLE 1 - Evaluation of intra-examiner error in Subjective Facial Profile Analysis.

Measure	Descriptive measures				p
	Minimum	Maximum	Mean	SD	
First	1.0	9.0	4.9	1.6	
Profile					0.357n.s.
Second	2.0	9.0	4.9	1.5	F = S

Note: p-value refers to Student's t-test for paired samples. Captions: F - First evaluation; S - Second evaluation; n.s. - non-significant.

can be classified as Patterns I, II, III, Long Face or Short Face based on a direct evaluation of the face.

Pattern I consists of a normal face. Patterns II and III are characterized, respectively, by a positive and negative sagittal step between maxilla and mandible. The long face and short face patterns feature a vertical discrepancy.

The sample selection method excluded individuals with incompetent lip seal, which resulted in the exclusion of the long and short patterns in this study.

Numerical analysis of the facial profile^{22,24}

Profile photographs were traced and measured by two examiners.

After demarcation of the soft tissue landmarks a numerical analysis of the facial profile was performed using the following measures:

- 1) Nasolabial Angle.
- 2) Mentolabial Sulcus Angle.
- 3) Interlabial Angle.¹⁵
- 4) Facial Convexity Angle.
- 5) Total Facial Convexity Angle.
- 6) Lower Face Angle.
- 7) Ratio between the mid anterior facial height and lower anterior facial height (MAFH/LAFH).
- 8) Lower Face Ratio.

In assessing the method, Student's t-test was used to evaluate systematic error (bias) and Dahlberg's to evaluate random error (Table 2).

A statistical difference was observed between measurements taken of the following angles: mentolabial sulcus, facial convexity, total facial convexity, lower face, and in the ratio between the mid and lower face heights (Table 2). One should consider, however, that not only were the means found by the two raters for these variables very similar, but the random errors identified by Dahlberg's test justify using these measures in this study.

The values obtained for each of the variables for all individuals in the sample were used in this study.

TABLE 2 - Assessment of inter-observer error concerning variables of Numerical Analysis of Facial Profile.

Variables	Examiner A		Examiner B		P	Dahlberg
	Mean	SD	Mean	SD		
Nasolabial Angle	107.32°	10.71°	107.28°	10.83°	0.873	1.54°
Mentolabial Sulcus Angle	131.61°	10.91°	130.77°	11.01°	0.008**	2.23°
Interlabial angle	134.66°	13.37°	134.33°	12.55°	0.262	2.07°
Facial Convexity Angle	13.22°	4.97°	12.63°	5.07°	<0.001***	1.19°
Total Facial Convexity Angle	137.22°	4.72°	137.76°	4.73°	<0.001***	1.09°
Lower Face Angle	107.63°	9.43°	106.80°	9.75°	<0.001***	1.32°
MAFH/LAFH ratio	0.93	0.10	0.91	0.10	<0.001***	0.03
Lower Face Ratio	0.46	0.06	0.47	0.08	0.106	0.02

* p<0.05.

** p<0.01.

*** p<0.001.

Sagittal occlusal relationship²¹

The plaster casts of all sample individuals were assessed in occlusion with the primary objective of sorting them according to the classification proposed by Angle:¹

- » Normal occlusion.
- » Class I malocclusion.
- » Class II, Division 1 malocclusion.
- » Class II, Division 2 malocclusion.
- » Class III malocclusion.

Only those models were classified as belonging to the Normal Occlusion group which showed up to 3 mm of crowding, not located in any single region of the dental arches.

Statistical method

Contingency tables were constructed to perform the chi-square test and determine the influence of age, gender, sagittal occlusal relationship, facial pattern and the 8 variables of numerical analysis of the facial profile on the scores assigned to each subject in the evaluation of facial aesthetics.

To build the contingency tables, the mean of the subjective facial analysis for Pattern I individuals was calculated and served as a normality benchmark to study individuals with discrepancy.²⁴ This mean was 4.8.

Distribution of the sample individuals was then carried out for each of the features which had been assigned a facial aesthetic score above and below 4.8.

By means of the chi-square test, the frequency observed for each individual was noted in all groups where these features were being rated for gender, facial pattern and sagittal occlusal relationship with those whose scores for facial aesthetics were above and below 4.8 with the expected frequency.

For age and the 8 measures of numerical analysis of the facial profile, three groups were obtained for each variable, given the mean and standard deviation of the Pattern I sample.²⁴ The groups

were divided into scores that fell below, above or within a standard deviation derived from a given mean. The same assessment described above was performed for each variable, i.e., the frequency observed for subjects in each group whose facial aesthetic scores fell above and below 4.8 were compared with the expected frequency (Table 3).

In cases where the Chi-square test identified dependency relationship between the aesthetics of the profile and the factors studied, Cramer's test was applied to identify the strength of the association. Cramer's coefficient ranges from 0 to 1. The closer a coefficient is to 1, the stronger the association (Table 3).

The choice of this statistical method was based on the assumption that the measures of facial profile could negatively influence profile aesthetics when such measures diverged more or less from the standard deviation of Pattern I. This would not be applicable to other statistical methods that evaluate association between variables.

RESULTS

The results of this study showed an association between the score assigned to each individual for esthetic facial profile and facial pattern classification, facial convexity angle and lower face angle (Table 3).

No association was found between age, gender or sagittal occlusal relationship and the aesthetic evaluation of facial profile.

DISCUSSION

Aesthetics is the appreciation of beauty, or a combination of qualities that give pleasure to the senses.¹⁰ Several authors have attempted to determine the facial features that evoke pleasure and are therefore recognized as pleasant, or unpleasant, creating an unsightly appearance. The aim of this investigation was to highlight the facial features considered unpleasant by the population while providing guidance to professionals in the fields of orthodontics and surgery, as well as areas

TABLE 3 - Chi-square test and Cramer's coefficient results for all variables in relation to subjective facial analysis scores.

	Score <4.8 Obs.freq. (exp.freq)	Score > 4.8 Obs.freq. (exp.freq)	χ^2	P	Cramer
Pattern I	22 (31.50)	28 (18.50)	15.71	0.000	0.39
Pattern II	33 (25.83)	8 (15.17)			
Pattern III	8 (5.67)	1 (3.33)			
Gender 1	31 (31.50)	19 (18.50)	0.04	0.836	
Gender 2	32 (31.50)	18 (18.50)			
Age <269m	26 (27.72)	18 (16.28)	3.60	0.165	
Age 269 to 329	25 (26.46)	17 (15.54)			
Age > 329	12 (8.82)	2 (5.18)			
NLA < 98.38	12 (10.71)	5 (6.29)	0.96	0.619	
NLA 98.38 to 117.88	40 (42.21)	27 (24.79)			
NLA > 117.88	11 (10.08)	5 (5.92)			
MSA < 122.55	16 (15.12)	8 (8.88)	4.72	0.094	
MSA 122.55 to 142.19	30 (34.65)	25 (20.35)			
MSA > 142.19	17 (13.23)	4 (7.77)			
ILA <124.21	14 (14.49)	9 (8.51)	0.06	0.970	
ILA 124.21 to 146.49	40 (39.69)	23 (23.31)			
ILA > 146.49	9 (8.82)	5 (5.18)			
FC < 8.39	11 (10.08)	5 (5.92)	6.88	0.032	0.26
FC 8.39 to 16.25	32 (37.80)	28 (22.20)			
FC > 16.25	20 (15.12)	4 (8.88)			
TFC < 133.77	18 (14.49)	5 (8.51)	3.12	0.209	
TFC 133.77 to 141.93	35 (38.43)	26 (22.57)			
TFC > 141.93	10 (10.08)	6 (5.92)			
LFA < 95.29	2 (3.78)	4 (2.22)	15.24	0.000	0.39
LFA 95.29 to 111.53	33 (39.69)	30 (23.31)			
LFA > 111.53	28 (19.53)	3 (11.47)			
MAFH/LAFH <0.83	8 (8.19)	5 (4.81)	2.74	0.253	
MAFH/LAFH 0.83 to 1.03	42 (44.73)	29 (26.27)			
MAFH/LAFH > 1.03	13 (10.08)	3 (5.92)			
LFR < 0.39	6 (6.30)	4 (3.70)	0.28	0.866	
LFR 0.39 to 0.51	46 (46.62)	28 (27.38)			
LFR > 0.51	11 (10.08)	5 (5.92)			
SOR 1	5 (5.04)	3 (2.96)	3.68	0.450	
SOR 2	28 (29.61)	19 (17.39)			
SOR 3	21 (22.05)	14 (12.95)			
SOR 4	6 (4.41)	1 (2.59)			
SOR 5	3 (1.89)	0 (1.11)			

related to facial aesthetics, in making plans that are consistent with the expectation of patients, and result in treatments whose aesthetic benefits can be perceived by all.

Whereas 80% of patients seek orthodontic treatment for aesthetic purposes, regardless of their functional condition,¹⁰ evaluation of facial aesthetics should be a routine in orthodontic practice, not only in the diagnostic phase but during and after orthodontic treatment.

During diagnosis, professionals should try to identify unpleasant facial features that can be changed through orthodontic treatment. Pleasant features, however, should be preserved and where possible, enhanced by treatment. It is important to note, however, that this evaluation is performed in light of the ethnical and individual characteristics of each patient while endeavoring to apply the same aesthetic parameters embraced by the patient and his/her society.

This study found no association between gender and subjective analysis of facial profile. However, in assessing the distribution of individuals in the groups rated as aesthetically pleasing (scores 7, 8 or 9), acceptable (scores 4, 5 or 6) and unpleasant (scores 1, 2 or 3) it became clear that all those rated as aesthetically pleasing were women, while 6 of the 8 classified as aesthetically unpleasant (75%) were men. This finding may be explained by a higher frequency of male individuals in Patterns II (63.4%) and III (66.7%).²² These patients presented with sagittal skeletal discrepancies that negatively impacted on the assessment of facial profile aesthetics. Sixty-four percent of the individuals in the Pattern I group, which comprised patients with a balanced face, were women. This finding reinforces the association between facial pattern and aesthetics, but not between gender and aesthetic evaluation of the profile.

No association was found between gender and facial aesthetics in the literature. Meta-analysis of published studies on facial beauty found that the determinants of attractiveness would be the same

for women and men in all cultures.²⁵ These factors are related to symmetry, characteristics that emphasize sexual dimorphism and faces with features similar to the average population, construed as signs of health and quality that guide both genders in choosing a spouse.²⁵

Older individuals in this sample did not receive lower scores for facial profile aesthetics than younger patients.

As previously reported, mean sample age was 23 years and 7 months, ranging between 18 and 36 years. The sample was divided into three age groups (Table 3) for statistical analysis.

However, in order to better visualize the distribution of individuals between maximum and minimum ages, the sample was divided into six age groups (Group 1 - 18 to 21 years, Group 2 - 21 years and 1 month to 24 years, Group 3 - 24 years and 1 month to 27 years, Group 4 - 27 years and 1 month to 30 years, Group 5 - 30 years and 1 month to 33 years and Group 6 - 33 years and 1 month to 36 years). It was found that 20% of the sample belonged to Group 1, 49% to Group 2, 15% to Group 3, 12% to Group 4, 0% to Group 5 and 4% to Group 6. The small dispersion of individuals found in all groups, with greater concentration in the younger age groups may explain the lack of association between age and facial aesthetics. Further studies with more homogeneous distribution of the sample across different age groups should be conducted to substantiate the findings of this study.

A clear tendency was noted, however, of those individuals rated as aesthetically pleasing to be concentrated in the younger groups while the percentage of unattractive individuals increased in the older sample groups (Table 4), in agreement with longitudinal studies, which showed that attractiveness tends to decrease with age from 11 to 31 years. However, people tend to keep their relative level of attractiveness over their life time.²⁸

The correlation between facial aesthetics and sagittal occlusion relationship has been

TABLE 4 - Distribution of aesthetically pleasing, acceptable and unpleasant individuals in age groups.

Groups	Age Group	N (%)	Aesthetically pleasing(%)	Aesthetically acceptable (%)	Aesthetically unpleasant (%)
1	18y – 21y	20	10	90	0
2	21y1m – 24y	49	2	90	8
3	24y1m – 27y	15	0	93	7
4	27y1m – 30y	12	0	83	17
5	30y1m – 33y	0	0	0	0
6	33y1m – 36y	4	0	75	25

investigated since the beginning of the last century, when Angle¹ noted that the effect of malocclusion on the facial lines produced distinct deformities, which allowed orthodontists to classify malocclusion based on facial assessment alone. Angle also found that the quality of facial balance would be commensurate with normal occlusion.

Further studies have contradicted these observations by concluding that aesthetically pleasing features could be present in individuals with normal occlusion or malocclusion, suggesting that individuals belonging to the same occlusal class could exhibit considerably different faces.^{6,7} Further investigation found that the Class I malocclusion is associated with a more pleasant face, and Class III with the worst facial aesthetics, suggesting that the sagittal position of the mandible influences raters' opinions on profile aesthetics.⁹

In this study no association was observed between the sagittal occlusal relationship and the score assigned to facial profile aesthetics. One should take into account the fact that this result may have been influenced by the sample selection method, which excluded all individuals with dental or skeletal discrepancies that might compromise lip seal competence. It can therefore be argued that the Class II and Class III subjects found in the sample had dental and skeletal discrepancies of small magnitude. The latter were

naturally well balanced and not always noticeable on the face as they did not compromise facial profile aesthetics.

Also noteworthy is the fact that the selected sample was comprised of individuals whose socioeconomic status allowed them to undergo orthodontic treatment in case their malocclusion made them feel somehow aesthetically or functionally uncomfortable. It can be inferred therefore that the need for such treatment went unnoticed until adulthood due to dental and skeletal compensations that masked the malocclusion and ensured lip seal competence.²¹

One must consider, however, that facial pattern had a bearing on the score assigned to the profile (Table 3), indicating the presence of individuals in the sample who had sagittal skeletal errors that marred their profile aesthetics. It can be concluded that the lack of association between beauty and sagittal occlusal relationship found in this study reinforces the findings of Bittner and Panherz,³ i.e., that occlusal discrepancies are only partially reflected in the face. Many Class II or III malocclusions have a dental origin only and are not associated with any skeletal discrepancy, while other Class I patients exhibit skeletal errors that are adequately offset by occlusion. Diagnosis must begin in the face so as to avert errors likely to occur when priority is given to

the dental relationship. Normal occlusion alone is not indicative of profile attractiveness. Patients with Class II and Class III malocclusions, on the other hand, may display a balanced face with dental malocclusions only.³⁰

Among the profile variables assessed in this study, the only association was found to exist between the scores for facial profile aesthetics and facial convexity and lower face angles.

Facial convexity angle is extremely sensitive to sagittal skeletal discrepancies. Patterns II and III individuals showed this angle to be, respectively, increased and decreased in relation to the same angle in Pattern I individuals.^{22,24}

In this study, most individuals whose facial convexity angles were above 16.25° or below 8.39° (1 SD above and below the sample mean for Pattern I) were given scores lower than 4.8 for facial profile aesthetics (mean of scores assigned to Pattern I individuals). It can be deduced that profiles whose convexity is increased or decreased in relation to balanced profiles (Pattern I) are considered less aesthetically pleasing.

One hundred percent of individuals rated as aesthetically pleasing showed the value of this angle within a standard deviation equivalent to Pattern I patients ($12.32 \pm 3.93^\circ$), while 62.5% of those classified as aesthetically unpleasant had this angle either above (37.5%) or below (25%) the standard deviation of balanced patients.

Thus, a direct relationship exists between profile convexity and unpleasant aesthetic appearance.²⁶ The preferred facial profile for women is slightly convex, whereas in men, preference is given to a straight profile.⁸

Lower face angle enables assessment of chin protrusion relative to the midface. Evaluation of this angle is essential in planning the correction of sagittal skeletal discrepancies.^{22,24} This study disclosed that any increase in this angle above the standard deviation of the mean found for Pattern I individuals was associated with a reduction in the score assigned to profile aesthetics. This increase

in the angle is related to a smaller anterior projection of the chin, typical of Class II patients or of sub-mandibular tissue excess.^{22,24} Among the individuals in the sample classified as unattractive 62.5% had this angle above the standard deviation of the mean value. All these individuals were male. It can be inferred therefore that men with lower anterior projection of the chin are particularly less attractive, very often requiring surgical intervention associated with orthodontic correction to improve their profile.

No association was found between profile aesthetics and the angles that measure upper and lower lip protrusion (nasolabial, mentolabial sulcus and interlabial angles). It should be noted that this finding is not surprising since all individuals in the sample had lip seal competence and therefore no major imbalances in lip positioning.

Total facial convexity angle, which takes into account nasal projection, was also not associated with profile aesthetics. In an attempt to speculate why this angle showed no association, similarly to what was observed in the facial convexity angle, one should start by reasoning that the only difference between them is that the first takes into account nasal projection. The facial convexity angle is directly related to the maxillomandibular sagittal relationship, i.e. facial pattern, and therefore any changes in its measurement are directly related to sagittal discrepancies between maxilla and mandible. Total facial convexity angle, however, provides an evaluation of the nose projection in relation to the chin and forehead. Changes in its convexity can be related not only to skeletal discrepancies but also a larger or smaller nasal projection, which seemed not to influence in the same manner the aesthetic evaluation of the profile. This finding contradicts an earlier study with this same sample, in which examiners reported that the main factors responsible for an unpleasant aesthetics of the profile were the nose, in 38.35% of cases, and chin, for 18.9%.²³

Subjective Morphological Facial Analysis classifies patients' faces as Patterns I, II and III, Long Face and Short Face.⁵ Pattern I individuals are characterized by normal vertical and sagittal facial proportions. Any malocclusion in these patients will necessarily have a dental origin. Patterns II and III patients present with sagittal discrepancies, with positive and negative steps between the maxilla and mandible, respectively. The Long and Short Face patterns are characterized by excess and deficiency in vertical face growth, with several studies published in the literature referring to them as Long Face and Short Face Syndromes. Malocclusions present in patients with skeletal discrepancies (Patterns II, III, Long Face and Short Face) usually result from these imbalances.

The method for selecting subjects for this sample excluded patients with Long Face, Short Face as well as Patterns I, II or III with no lip seal competence.

This study therefore revealed that 50% of patients were Pattern I, 41% Pattern II and 9% Pattern III.^{22, 24}

After distributing the individuals in a Contingency Table and applying the chi-square test, an association was found between the score assigned to facial aesthetics and facial pattern ($p < 0.001$). Cramer's coefficient found a 0.396 association (Table 3).

In evaluating the distribution of Patterns I, II and III individuals, who were assigned facial aesthetics scores below and above 4.8, it was observed that among Pattern I patients, 56% received scores above 4.8. For those classified as Class II this percentage was reduced from 19.5% to 11.1% among Pattern III patients.

The most simplistic explanation for this finding corroborates several authors who found that, from a strictly aesthetical viewpoint, balanced profiles are the most widely preferred, followed by Pattern II profiles, whereas Pattern III profiles were considered the least aesthetic. The literature also suggests that Pattern III individuals are more likely to accept orthognathic surgery than Patterns II patients due to the impact of this discrepancy on facial aesthetics.^{11,27}

A published study²² showed, however, that Pattern III individuals in this sample exhibited more striking discrepancies in their profile than those with Pattern II, when compared with Pattern I individuals. This may be one of the reasons why Pattern III individuals received lower scores than Pattern II.

In distributing aesthetically pleasing, acceptable and unpleasant individuals among Patterns I, II and III, it was noted that all subjects in the sample who were classified as having an aesthetically pleasing pattern belonged

to Pattern I. Moreover, 85.4% of Pattern II individuals were rated as aesthetically acceptable, and 14.6% as aesthetically unpleasant, all of whom were men. Regarding Pattern III, 88.9% were considered aesthetically acceptable and 11.1% unsightly, all of whom were women. All Pattern II women and all Pattern III men were considered aesthetically acceptable, showing that a reduction in the facial convexity of women, and an increase in men's are aesthetically acceptable.

CONCLUSIONS

An association was observed between scores for facial profile aesthetics and facial convexity angle, lower face angle and facial pattern. Increases in facial convexity in men and decreases in women resulted in a aesthetically unpleasant appearance, which might require surgical procedures combined with orthodontics to enhance aesthetics.

There was no association between profile aesthetics and age, gender, sagittal occlusal relationship, lip protrusion and total facial convexity angle.

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Perception of changes in the gingival plane affecting smile aesthetics

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Abstract

Objective: This study investigated how 80 dental professionals and 80 lay persons, patients from private practice offices and from the School of Dentistry, Federal University of Espírito Santo (UFES), perceived the presence of changes in the gingival plane. **Methods:** A photograph of a smiling young woman was digitally modified to produce symmetrical changes in the gingival height of the central incisors and lateral incisors, thereby causing the gingival plane to ascend progressively. Individuals were asked to choose the most pleasant looking picture and thereafter the interviewer questioned each individual to find out if they knew what was being changed in the sequence of pictures, i.e., whether or not they were able to identify changes in the gingival plane. **Results:** The results showed a significant prevalence in the selection of a harmonious gingival plane in the group of dentists and patients ($p < 0.001$ and 0.05 , respectively). Furthermore, there were no significant differences between the specialties comprised in the group of dentists ($p = 0.538$), which was the case in the lay group ($p = 0.05$), showing a greater perception on the part of the group of dental office patients. Identification of changes in the gingival plane was significant in the group of dentists ($p < 0.001$) without significant differences between group specialties. Neither was it significant in the lay group ($p = 0.100$). The results also highlight a significantly higher ability to identify problems in the group of dentists compared to the lay group ($p < 0.001$). **Conclusion:** It was therefore concluded that symmetrical changes greater than 2 mm can be perceived by both dentists and lay people. Moreover, no differences were found in this perception among the dental specialties. Finally, the group of dental office patients was significantly more perceptive than UFES patients.

Keywords: Orthodontics. Dental esthetics. Gingival plane.

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INTRODUCTION

The current situation in the field of dentistry is such that many individuals are seeking quality cosmetic improvement for their smiles. Dentists play a key role as they undertake to meet these patients' expectations. To this end, many prosthetic products and services have been developed over the years.⁵ However, it is important to note that in many situations orthodontic treatment can achieve results not attainable by cosmetic dentistry, especially when the problem is related to the patient's gingival margin and heights.²

In many situations, complaint of disproportion between the gingival margins may lead patients to seek treatment, even though they may not be capable of adequately pointing out the issue to the dentist.⁸ However, in other situations it may have been caused by corrective orthodontic treatment such as, for example, when canines are moved mesially to replace missing lateral incisors. More importantly, however, in these two situations one should be aware of the patient's tolerance regarding the discrepancy they wish to address, which, in general, will guide the orthodontist in his/her therapeutic options.⁸

In gingival contours that are considered aesthetic the gingival margin of the lateral incisor is located below and along a tangent drawn from the gingival margin of the central incisor to the corresponding canine region.¹ The ideal gingival height of the lateral incisors is numerically 1 mm below the central incisors and canines.^{3,7} Unsightly patterns show the margins of the lateral incisors above the margins of the central incisors and canines—either unilaterally or bilaterally—with overerupted central incisors, and the margins below the lateral incisors and canines creating the appearance of a seagull.¹ These unsightly contours are classified as the flat and reverse types of the gingival margin, respectively.¹⁰

In a study on the degree of aesthetic perception of dentists (general practitioners and orthodontists) and lay persons relative to changes in the

gingival margin, it was concluded that none of the three changes, with progressive symmetrical increments of 0.5 mm in the margin height of lateral incisors, totaling up to a 1.5 mm difference, could be statistically perceived by orthodontists, dentists, general practitioners or lay persons.⁶ Moreover, in assessing the perception of asymmetric changes in the gingival margin it was concluded that these changes are easily perceived by orthodontists, who identified unilateral changes in increments of 0.5 mm, and are also perceived by clinical dentists and lay people starting at 1.5 mm.⁷

With the purpose of determining the degree of perception of the aesthetic discrepancies in the gingival height of anterior teeth by dentists, and patients seeking dental treatment, this study aimed to evaluate the perception of symmetrical changes in the gingival plane—based on photographs showing only smiles—by lay persons, orthodontists, periodontists, prosthodontists and general practitioners.

MATERIAL AND METHODS

Characterization of the sampling plan

The sample of dentists consisted of four groups:

- » Group DI: Orthodontists.
- » Group DII: Prosthodontists.
- » Group DIII: Periodontists.
- » Group DIV: General Practitioners.

Each group comprised twenty participants totaling eighty dentists altogether. The dentists were randomly selected from among those registered in the city of Vitória, Espírito Santo State, and the sample was stratified in order to include the same number of dentists by specialty.

The sample of lay individuals was composed of two groups:

- » Group LI: Patients treated at the Integrated Clinic for Adults (UFES).
- » Group LII: Patients treated in private dental offices.

Each group was comprised of forty participants. Patients in group I were randomly selected

from among the patients undergoing treatment at the time of the research at the Integrated Clinic for Adults, Federal University of Espírito Santo. Patients in group II were selected from those present in dental offices visited by the researchers and who met the inclusion criteria (convenience sample).

Inclusion and exclusion criteria

Dentists who were registered as specialists at the Regional Council of Dentistry-ES and whose dental offices were located in Vitória/ES were included, whereas those dentists who had either witnessed or been informed of another dentist's evaluation were excluded from the sample.

Patients undergoing treatment at the Integrated Clinic or in the dental offices visited by the researchers were included and assigned to their respective groups. Patients who had witnessed or been informed about the evaluation of another patient and those who had undergone any training or experience, or who had previously worked in the dental field were excluded.

Variable

To test the aesthetic perception of these professionals and lay persons a female patient was selected, who agreed to participate in the study after signing a form of informed consent. This patient had an aesthetic gingival margin in which the central incisors and canines were at the same height as the gingival margin, and whose lateral

incisors were 1 mm below the tangent that connected the gingival margin of these teeth.

Digital manipulation of the patient's smile was performed using Adobe Photoshop 7.0 by changing the height of the gingival margin of the lateral and central incisors. Changes were measured relative to the canines, which were therefore kept at a constant height. In the first alteration, the margin of the maxillary central incisor was reduced by 2 mm and the lateral incisor was increased by 0.5 mm in relation to the canines. In the second alteration, the margin of the maxillary central incisor was reduced by 4 mm and that of the lateral incisor was increased by 1.0 mm in relation to the canines. During manipulation, the chin and nose were deleted to avert confounding factors, so that only a portion of the patient's skin, her lips and teeth remained apparent.⁴

The evaluators were given an album with photos in the following order:

1. Harmonious gingival margin with the central incisors and canines at the same level, and lateral incisors 1 mm below the tangent between central incisors and canines (Fig 1).
2. Central incisors with margin 4 mm below the margin of the canines, and lateral incisors 1 mm above their original position, in an ascending aspect (Fig 2).
3. Central incisors with margin 2 mm below the margin of the canines, and lateral incisors 0,5 mm above their original position, in a flat aspect (Fig 3).

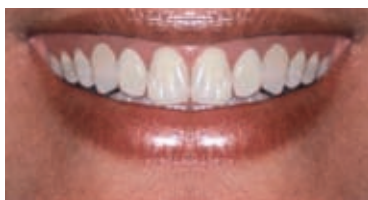


FIGURE 1 - Harmonious gingival margin.



FIGURE 2 - Ascending gingival margin: Central incisors reduced by 4 mm and laterals increased by 1 mm.



FIGURE 3 - Flat gingival margin: Central incisors reduced by 2 mm and laterals increased by 0.5 mm.

Data collection

After photo manipulation, two albums were created containing the photos that were printed in size 10X15 cm on photographic paper so as to ensure that both albums would be made in the same location and with the same quality.

From then on data collection was started through blind and standardized interviews where two researchers, each responsible for half of the sample from each specialty and lay group, paid visits to show the album.

The evaluators were asked to choose the picture that pleased them most and were thus given a choice of one, all or none, and 90 seconds to assess each picture without the possibility of seeing again any previous pictures. After that, the interviewer questioned each evaluator in an attempt to find out whether or not they perceived what was being changed in the sequence of pictures, i.e., if they were able to identify changes in the gingival plane, with the following question: "What do you think is being altered in these pictures?". Each response was noted but, in order to facilitate statistical data analysis, a "yes" was assigned when changes were perceived (any alteration in the gingival plane) and a "no" when the evaluator responded somewhat differently than expected. Up to 90 seconds were allowed for these questions.

The statistical analysis included descriptive and inferential analyses, using a 5% significance level. Associations between categorical variables were tested using chi-square or Fisher's exact tests.

RESULTS

As regards the selection of the photographs that most pleased the evaluator, in the lay group the choice fell predominantly on the harmonious gingival plane, indicating that differences between the smiles were indeed perceived ($p = 0.05$). Moreover, significant differences were also observed in the overall results exhibited by the groups ($p = 0.05$), with the group of private

patients more prevalent in choosing the harmonious gingival smile than UFES patients (Table 1). Percentage-wise, fewer people in both groups chose the ascending gingival plane, with a significant difference between groups (Table 1).

In the group of dentists there was also a significant prevalence in the selection of the harmonious gingival plane option ($p < 0.001$), no selection of the ascending gingival plane option while a low percentage opted for the flat gingival plane (Fig 1). A higher percentage of subjects in the groups of orthodontists and prosthodontists selected the harmonious gingival plane option without, however, any significant differences between the groups of dentists (Table 2 and Fig 4).

The results showed a statistically significant difference between the groups of dentists and lay persons ($p < 0.001$), indicating a higher aesthetic perception by the group of dentists (Table 3). Furthermore, selection of the harmonious gingival plane option was statistically higher in the group of dentists ($p = 0.01$), and selection of the ascending gingival plane option was observed only in the groups of patients, where a statistically significant difference was also found (Tables 2 and 3).

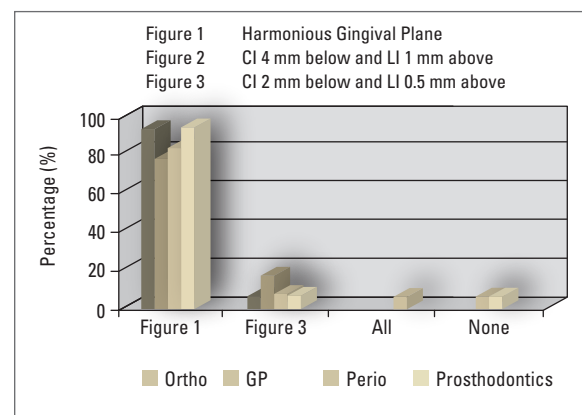


FIGURE 4 - Analysis of the group of dentists.

TABLE 1 - Dental office patients vs. UFES patients.

	Office Patients	UFES Patients	p-value
Harmonious	56.8%	31.1%	0.05
CI 4 mm below and LI 1 mm above	2.6%	18.4%	0.05
CI 2 mm below and LI 0.5 mm above	28.2%	21.6%	0.05
All	12.6%	26.3%	0.05
None	—	2.6%	0.05

TABLE 3 - Dentists vs Patients.

	Dentists	Patients	p-value
Harmonious	88.5%	44.2%	<0.001
CI 4 mm below and LI 1 mm above	—	10.4%	<0.001
CI 2 mm below and LI 0.5 mm above	7.7%	24.7%	<0.001
All	1.3%	19.5%	<0.001
None	2.6%	1.3%	<0.001

TABLE 2 - Analysis of the group of dentists.

	Orthodontists	General practitioners	Periodontists	Prosthodontists	p-value
Harmonious	95%	79%	84.2%	95%	0.538
CI 4 mm below and LI 1 mm above	—	—	—	—	0.538
CI 2 mm below and LI 0.5 mm above	5%	16%	5.3%	5%	0.538
All	—	—	5.3%	—	0.538
None	—	5.3%	5.3%	—	0.538

Identification of changes in gingival plane height

At this point in the interview the researchers wished to determine whether or not dentists and lay people were able to see the changes made in the photos. The chi-square test was performed to measure statistically significant associations between the groups. Statistically significant results were found regarding identification of the presence of a non-harmonious gingival plane in the group of dentists (58.8%, $p < 0.001$). Percentage-wise, prosthodontists were more vigilant in this identification than other groups of dentists, although no statistical significance was found in this group ($p = 0.385$) (Figs 5 and 6).

Values for problem identification in the lay group were not significant (25%, $p = 0.100$), but a significant difference was found between the group of private practice patients and UFES patients ($p = 0.010$) (Table 1 and Fig 6). The difference between the group of dentists and the lay group was statistically significant ($p < 0.001$) (Table 2 and Fig 5).

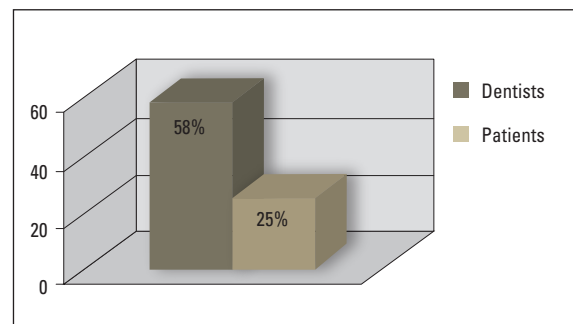


FIGURE 5 - Identification of changes in Gingival Plane height: Dentists vs. Patients.

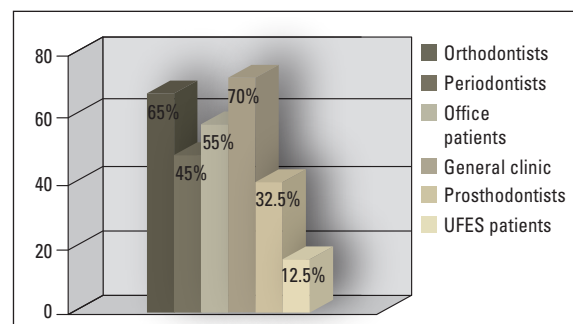


FIGURE 6 - Identification of changes in Gingival Plane height: Evaluation of the groups of Patients and Dentists.

DISCUSSION

The orthodontist's role in the correction and improvement of gingival aesthetic problems has not been adequately explored as it should have been. An innovative approach should be disseminated across all areas of dentistry so that all specialties are made aware of the possibility of achieving aesthetic improvements in gingival contour as well as biological improvements in support tissues by means of orthodontic treatment.²

With the purpose of assessing patients' expectations and the amount of discrepancy in abnormal symmetrical changes made to the gingival plane, a study was conducted which introduced progressive 0.5 mm to 1.5 mm changes in the position of lateral incisors, and concluded that these were not perceived by dentists nor lay persons. This study raised a debate on the possibility that these symmetrical changes are beyond perception at all levels.⁶

The present study, however, demonstrated that changes starting at a 2 mm decrease and a 0.5 mm increase, symmetrically applied to central and lateral incisors, respectively, by modifying the gum contour, would be significantly noticeable to lay people and dentists of all specialties investigated in this study, corroborating other findings in the literature^{1,4,9} and showing that changes in the anterior region, including at the gingival level, would be perceived by most dentists and patients. In the group of dentists, as well as a significant prevalence in the selection of the harmonious gingival plane option ($p < 0.001$), no selection of the ascending gingival plane option was made. Similarly, the significant prevalence of the harmonious smile option and low percentage rates of the options "all" and "no" in the group of lay patients showed that there is indeed the perception of changes in the gingival plane starting from this level of manipulation.

According to the literature symmetrical changes would only be noticeable in large mag-

nitudes.⁷ However, changes made in more than one tooth, which generate a conspicuously unsightly gingival contour,^{1,3} become visible starting from 2 mm. In fact, the reverse gingival margin plane, with its ascending form, is significantly unsightly in the opinion of lay individuals.¹⁰ On the other hand, asymmetrical changes become visible at much lower levels by dentists and lay persons alike.⁷

When it comes to identifying changes in the gingival plane a significant identification by dentists was observed, although with no statistically significant difference among the different specialty groups. In addition, the group of dentists was statistically more perceptive in identifying the changes than the group of lay persons. In the patient group identification was not statistically significant, but it was significantly higher in dental office patients. By the same token, from a statistical standpoint, the latter group predominantly selected the harmonious gingival margin option during the first part of the interview, demonstrating that these patients are more aware and demanding than patients from public institutions in terms of changes in the gingival plane.

These findings showed that symmetrical changes equal to or greater than 2 mm deserve special attention by orthodontists in their daily practice as they are identified as unsightly by the patient, especially in private practice, although the patient is not always capable of defining the problem. Moreover, the dentist who referred such patient can perceive and understand changes in the gingival plane, knowing that such changes can be corrected. Therefore, the options for orthodontic correction of these differences in the gingival margin should be presented cautiously since neglecting these issues might be construed as a treatment failure.

Although the present study shows that patients prefer harmonious gingival margins, it is not clear whether the correction of changes in

the gingival margin would be among the initial expectations of the patient seeking orthodontic treatment, or even if it would be a differentiating factor that could lead him/her to seek treatment. Further studies are required to shed light on these issues.

CONCLUSIONS

The authors concluded that for the population researched in this study:

» Symmetrical changes in the gingival plane

greater than 2 mm can be perceived by dentists and lay people.

- » Dentists were significantly more perceptive to the changes in the gingival plane than lay patients.
- » No differences were found in the perception of the gingival plane among the dental specialties investigated in this study.
- » The group of dental office patients was significantly more perceptive than UFES patients.

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Orthodontic treatment plan changed by 3D images

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Abstract

Introduction: Cone-Beam Computed Tomography (CBCT) was introduced in the 90's and studies have improved its use in dentistry. **Objective:** The aim of this article was to investigate the influence of three-dimensional (3D) images in orthodontic treatment planning. **Methods:** Two clinical situations (bone dehiscence and cervical resorption) were described by 3D images. **Results:** The orthodontic treatment plan was redirected to a simplified mechanics and control of the lesions during orthodontic treatment. **Conclusion:** 3D images are able to increase diagnostic accuracy and redirect orthodontic treatment plan.

Keywords: Orthodontic treatment plan. Cone-Beam computed tomography. Cervical resorption. Bone dehiscence.

INTRODUCTION

Conventional (or medical) computed tomography (CT) was developed in 1972 by the English engineer Hounsfield and the American physicist Comark.² It represented great progress, and for this reason, its creators were recognized with the Nobel Prize for Medicine in 1979. Despite the advances, conventional CT has been applied in dentistry with restrictions due to high radiation doses, excessive size of the device, the need for the patient to be in supine position during the

shot and its cost.^{2,10,19} Towards the end of the 90's, technological advances led to a new version that met the needs of dental and maxillofacial regions, and became known as Cone-Beam Computed Tomography (CBCT).^{4,6,10}

As the name suggests, the CBCT produces radiation in the shape of a cone that rotates around the patient to acquire volumetric data. A specific amount of absorbed X-rays corresponds to a three-dimensional cuboid structure, called voxel—corresponding to the pixel in the

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two-dimensional images. The computer volumetric reconstruction is obtained by using software algorithms to reproduce the three dimensional image (3D) in high resolution.¹⁸ The radiation dose emitted by CBCT depends on the desired field of view, exposure time, kilovoltage and milliamperage, but it has been reported that it corresponds to approximately 20% of a conventional CT and it is equivalent to the complete exposure of periapical radiographs.¹⁷ The differential in the CBCT is also the possibility of shooting in real size in all three planes of space, unlike the two-dimensional X-rays that project the image of the structures in one plane, often distorted and overlapped.⁴

The literature is rich in clinical applications for the CBCT.¹³ In orthodontics, it allows for the visualization of impacted teeth,^{10,13,18,19} detection of root resorption, ankylosis and dentoalveolar fracture,^{7,10} assessment of height and bone volume,^{10,13} investigation of temporomandibular joint and upper airway,^{4,13,19} accurate determination of bone-tooth discrepancies in non-erupted teeth¹⁰ and diagnosis of pathologies.^{13,18}

The aim of this paper was to evaluate the influence of 3D exams in redirecting the orthodontic treatment plan. For this, two clinical situations were described, in which the clinical examination and/or conventional radiographic exams suggested complementation with tomographic images. In both cases, images were acquired by the tomograph i-CAT® (Imaging Sciences International,

Hatfield, USA) whose data were exported to Xoran software version 3.1.62 (Xoran Technologies, Ann Arbor, USA) for 3D reconstruction.

CASE 1

A 40 year-old male patient sought orthodontic treatment. His main complaint was the poor distribution of spaces in the lower arch for proper rehabilitation with dental implants. His medical history had no significant remarks and dental records showed history of tooth loss (teeth 12, 36 and 37), endodontic treatment (teeth 11, 22 and 46) and the presence of an implant (region of tooth 12). He presented a Class II division 2 left subdivision malocclusion, with a lower midline deviation to the left side, distal migration of the teeth 33, 34 and 35, and mild crowding in the upper and lower arches (Figs 1 and 2).

The initial orthodontic treatment plan aimed to obtain ideal occlusion. However, a depression was observed in the sub-gingival buccal surface of tooth 22 during periodontal probing, suggestive of perforation or cervical root resorption. Since the lesion was not detected radiographically and its extension had not been defined clinically, a CBCT was requested. CT imaging confirmed the presence of a defect (dehiscence of labial cortical bone) and labial cervical root resorption of tooth 22 (Figs 1 and 2). Based on the risk of losing the affected incisor during orthodontic movement and the main complaint of the patient, the decision was shared with the patient and redirected to treatment simplification.

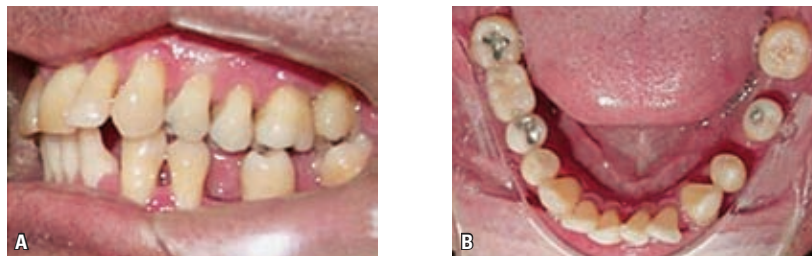


FIGURE 1 - **A)** Left lateral view and **B)** lower occlusal view. Distal migration of teeth 33, 34 and 35 and buccal tipping of the tooth 22. Lower spaces as a result of early loss of permanent teeth.

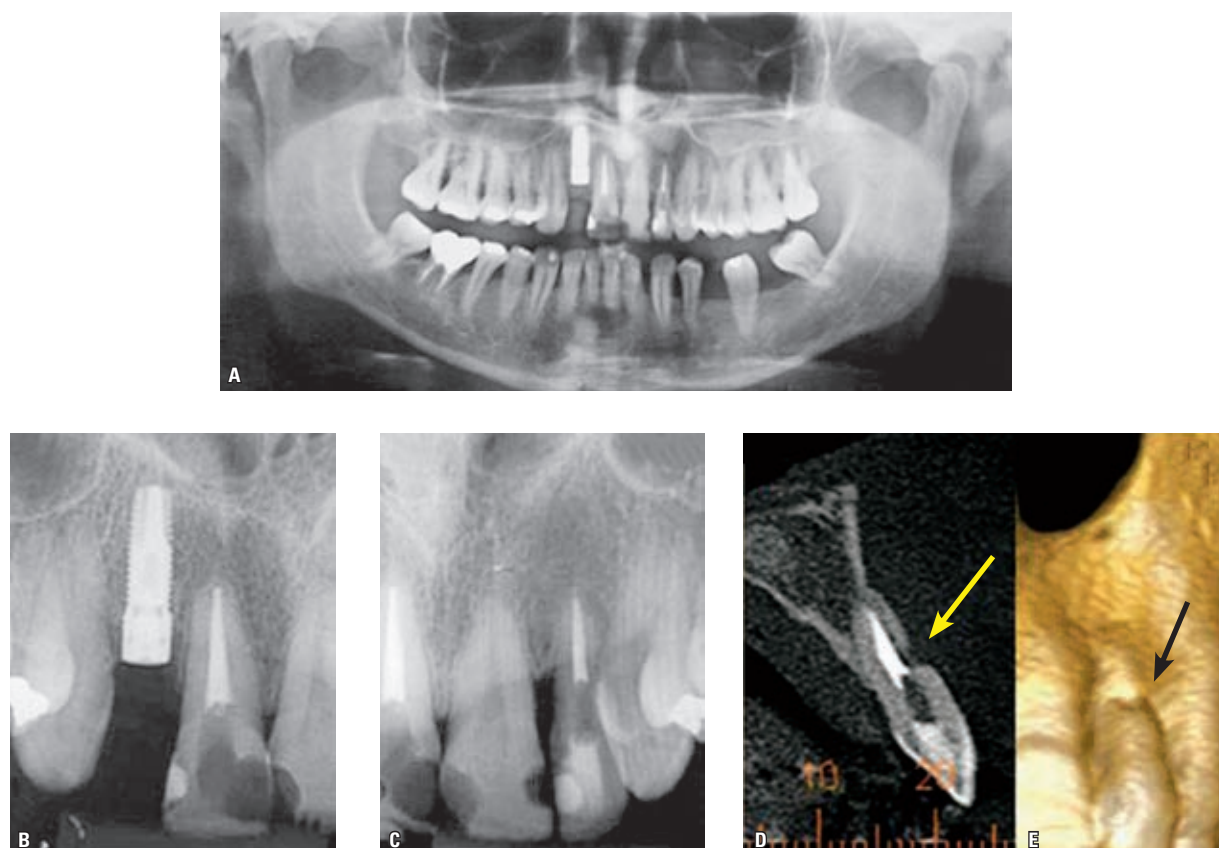


FIGURE 2 - **A)** Endodontic treatment of teeth 11, 22 and 46. Increased periodontal space on tooth 46 and **B)** presence of implant in the region of tooth 12. **C)** Detail of the region of upper anterior teeth. **D)** CBCT of tooth 22. Absence of vestibular cortical bone and root resorption in the middle third of the buccal root of tooth 22 and **E)** 3D reconstruction. Note the bone loss and root resorption in tooth 22.

The fixed appliance was installed only in the lower jaw to preserve the integrity of the tooth affected by resorption and promote the redistribution of adequate space for installation of dental implants with appropriate functional guide.

CASE 2

A 41 year-old old male patient sought orthodontic treatment after two years of a previous treatment with upper first premolar extractions. He complained of not having completed the treatment adequately. His main complaint was the “spaces between front teeth” (Fig 3). His medical history had no significant remarks. Regarding the dental pattern, he had an Angle Class II malocclusion with

spaces between the upper teeth and lower crowding. Horizontal bone loss was observed on the radiographic survey in the upper anterior region and apical root resorption in teeth 11, 12, 13, 15, 21, 22, 23 and 25 (Fig 3).

Due to doubts about the amount of insertion of the remaining teeth, a CBCT was requested. The 3D images additionally showed extensive bony dehiscence in teeth 13, 16, 23 and 26, undetected by previous clinical examination and conventional radiography (Fig 3). The patient was informed of his dental and periodontal tissue conditions, and consented on the orthodontic treatment focused on solving his complaint. Light and intermittent forces were applied in longer intervals of

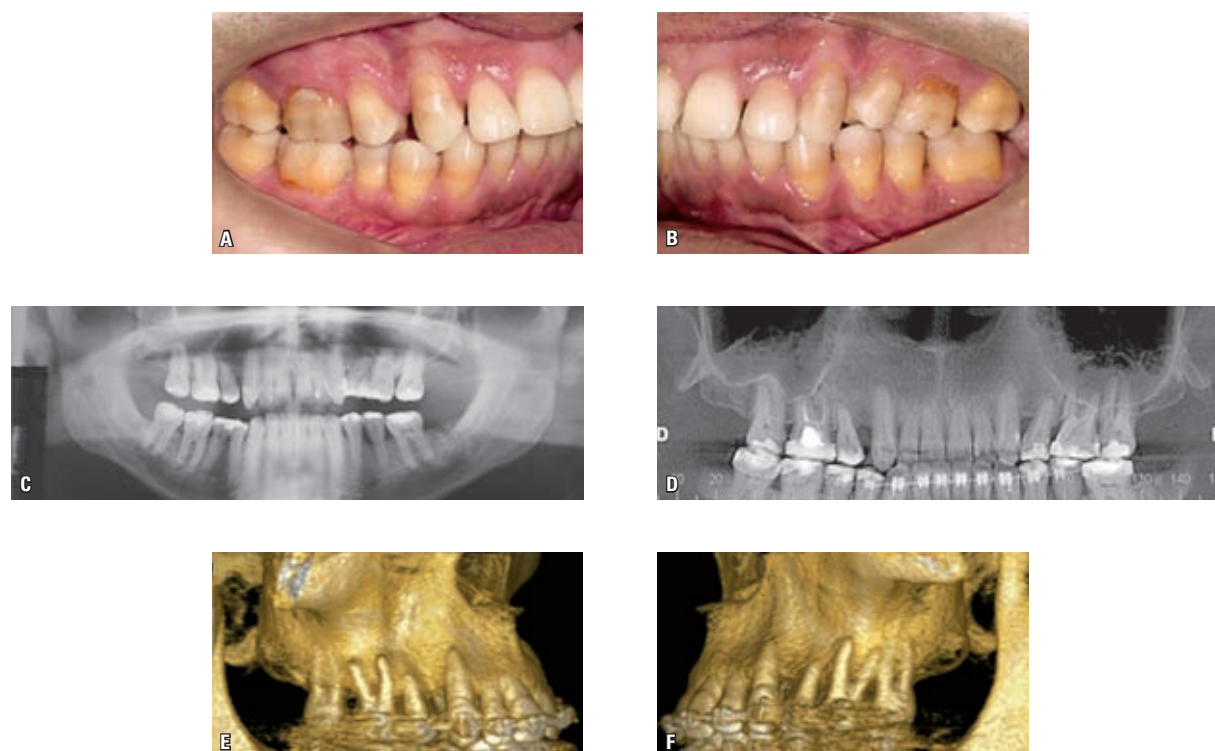


FIGURE 3 - **A, B)** Detail of the region of anterior teeth and diastema between teeth. **C)** Initial panoramic radiography. **D)** CBCT showing uniform horizontal bone loss and root resorption of the elements 11, 12, 13, 15, 21, 22, 23 and 25. **E, F)** CBCT reconstruction (right and left). Note the horizontal alveolar bone loss and dehiscence in buccal roots of the elements 23, 26, 16 and 13.

activation for the control of pre-existing apical root resorption, and expansion and buccal root torque were avoided in view to bone dehiscences.

DISCUSSION

Diagnostic information is essential for the valid decision of a treatment plan. Accurate images lead to a better treatment plan and enhance more predictable and appropriate results. The CBCT is an emerging technology appropriate for the dental region and maxillofacial structures, which can offer the most relevant clinical information when compared with conventional radiographs.

As the demand for orthodontic treatment in adults has increased dramatically in the last two decades, the need for a more detailed diagnosis

is necessary.³ The adult patient has features, such as higher prevalence of periodontal disease, tooth loss, endodontically restored teeth, restored teeth and trauma sequelae, coexisting with malocclusion. Orthodontic retreatment cases raise the possibility of iatrogenic injuries, such as external apical root resorption and bone dehiscence.

In cases of resorption due to orthodontic treatment, it is suggested by a clinical study that clastic activity is activated with orthodontic force and paralyzed with its discontinuation.¹⁵ As shown by Giannopoulou et al,⁸ tooth movement is also able to induce cervical root resorption. For that reason, the tooth with cervical root resorption was not included in the orthodontic movement in Case 1 and, for Case 2,

a periodical radiographic control¹⁶ and biomechanics for external apical root resorption control were performed. Among the biomechanical measures for protection, the use of longer intervals for appliance activation,¹⁵ the use of light and intermittent forces instead of heavy and continuous^{1,5} forces and restricting the intrusive movement were included.⁹

Bone dehiscence and fenestration are potentially detected during surgical procedures. In a recent study,¹⁴ the accuracy and reliability of CBCT in the diagnosis of bony dehiscence and fenestration have been tested and is effective as a non-surgical diagnostic method. Case 2 showed extensive bone dehiscence through 3D images, not detected radiographically. The diagnostic information led to caution in the expansion movement and root torque, during orthodontic treatment, to prevent dehiscence aggravation.

The changes in treatment plan for the reported cases resulted from information of 3D images. Clinical examination and conventional

radiography were unable to diagnose or determine the extent of the injury, but originated issues that justified the indication of CT scan.

Criteria for the request of CBCT are still being established. Guidelines from the British Orthodontic Society¹² and the European Academy of Dental and Maxillofacial Radiology¹¹ recommend that the CBCT should be used cautiously, without repetition or routinely, but as a complementary tool for conventional exams.

CONCLUSION

The CBCT is a technological advance in obtaining dental and maxillofacial imaging. Three-dimensional imaging can identify lesions masked by two-dimensional limitations of conventional exams and can redirect the orthodontic treatment plan. However, the routine use of CBCT should still not be recommended, but it should be used as a complementary tool when questions arise after clinical examination and/or conventional radiography.

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Evaluation of the effect of rapid maxillary expansion on the upper airway using nasofibroscopy: case report and description of the technique

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Abstract

The aim of the present investigation is to evaluate the effect of rapid maxillary expansion on the upper airway. A clinical case is presented to describe how patients with atresic maxilla and reduced naso-respiratory function can have benefits from rapid maxillary expansion. In order to better understand the morphological alterations present in patients with respiratory disorders, it is necessary to understand the anatomy and physiology of the respiratory system. However, it is relevant to mention that this patient undergoes a multidisciplinary treatment, involving the orthodontist, the otorhinolaryngologist and the speech therapist.

Keywords: Nasofibroscopy. Rapid maxillary expansion. Buccopharynx. Nasopharynx. Nasorespiratory function. Upper airway.

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INTRODUCTION

The breathing pattern may have influence on the craniofacial development, affecting the maxillary transverse relation, which may cause a posterior crossbite.¹⁴ In the patients with reduced nasorespiratory function, the most frequently observed craniofacial alterations are the reduction of the maxillary transverse width and the uni or bilateral posterior crossbites.^{12,15} The posterior crossbite usually occurs in the deciduous dentition and presents a narrowing of the upper arch transverse dimension that, usually, does not correct itself. Based on this concept, this malocclusion shall be corrected as early as possible, preferably during the deciduous and mixed dentition period.^{21,23}

The opening procedure of the midpalatal suture by rapid maxillary expansion, performed for more than a century, has aroused the interest of many researchers for its effects on morphology and nasal function. This technique introduced by E. H. Angell in 1860 was clinically consolidated by the studies of Haas.^{7,8} Since the early studies, it has been shown the effect of rapid maxillary expansion (RME) in the arch's transverse dimension, in the arch perimeter and in the nasal cavity. Several studies have associated the RME with the enlargement of the nasal cavity and a possible improvement in the nasal patency.^{29,30}

There is no doubt that the rapid maxillary expansion provides an increase in the interdental distance and, consequently, in the arch perimeter. However, calculating this increase resultant from the expansion procedure is a questionable method, given the diversity of results found on several existing papers in the literature.^{13,21,30,32}

During the first six months of life, the lead cause of nasal obstructions arises from the ingestion of proteins extraneous to the organism, causing allergic rhinitis.^{19,20} During childhood and adolescence, the respiratory insufficiency, which affects an expressive number of children at different levels, may be associated with several etiologic

factors, such as palatine tonsillar hypertrophy, pharyngeal tonsillar hypertrophy, nasal concha hypertrophy, nasal septum deviation, chronic allergy, sinusitis, nasal trauma, nasal polyps and extraneous organisms. Consequently, these several factors may cause a long and narrow face, maxillary atresia, mandibular retrognathia, increase in the anterior facial height, increase of the mandibular plane angle, deep palate, overjet and high incidence of posterior crossbite.^{2,15,22,25}

The pharyngeal complex, called Waldeyer's lymphatic ring, formed by the lingual, tubal, pharyngeal and palatine tonsils, may be influenced by genetic and environmental factors that lead to a temporary or prolonged increase of these tissues with consequent obstruction of the upper airway.^{4,5} The lymphoid tissue presents rapid growth during the first three years of life, keeps growing gradually, and reaches a growth peak before adolescence; beginning to gradually decline up to its full atrophy in the adult phase of life.⁵ Studies by Handelman and Osborne⁹ showed that the nasopharynx grows in girls until the age of thirteen and in boys until the age of seventeen. The highest pharyngeal tonsil growth peak occurs between 10 and 15 years of age,^{26,27} and the nasopharyngeal airway space increases in early adolescence, due to the simultaneous growth of the nasopharynx and the involution of the adenoid tissue.⁹ Many authors consider the pharyngeal tonsil hypertrophy as one of the triggering factors of mouth breathing and malocclusion.^{3,15,24,26,27} However the palatine tonsil hypertrophy may have the same obstructive effect of the pharyngeal tonsil hypertrophy, besides causing changes in the position of the mandible and in the positioning of the tongue down and forward. However, if these postural changes persist for long periods, especially during the active stage of growth, they may cause dentofacial disorders of different severity levels.^{2,5,12,26,33}

Therefore, before any attempt of treatment, it is important to determine whether the cause of the nasal obstruction is in fact obstructive or

just habitual. For that, it is necessary to perform a detailed anamnesis, clinical exam, functional tests, supplementary exams and follow-ups by a multidisciplinary team involving the pediatrician, the otorhinolaryngologist, the orthodontist and the speech therapist,^{19,24,25} for only then an accurate diagnosis is obtained so that the patient is treated properly, avoiding incorrect procedures that might compromise the treatment.

The frontal cephalometric radiography (posteroanterior) has been used in several studies for being a diagnostic method that allows the differentiation of the alterations produced by the rapid maxillary expansion (RME) in the orthodontic and orthopedic treatment, besides quantifying the transverse increase of the nasal cavity.^{7,8,23,30}

However, nasofibroscopy has revolutionized the diagnostic method nowadays, for the use of small-sized flexible or rigid telescopes connected to a micro-camera and a light source through optical fiber cables enables viewing and recording in VHS tape the images obtained from the buccopharyngeal and nasopharyngeal regions, allowing a direct visualization of the palatine tonsils, nasal cavities, pharyngeal tonsil, with an excellent image quality, thus making the highest diagnostic accuracy possible. Therefore, this extremely important exam has been shown to be more effective than the lateral radiograph of the pharyngeal cavum in the evaluation of size and shape of the pharyngeal tonsil.³ While the lateral cephalometric radiograph and the pharyngeal cavum radiograph are efficient to evaluate the buccopharynx and nasopharynx adjacent structures only in the two-dimensional aspect, being ineffective to provide a reliable indication of the nasal obstruction,²⁸ the nasofibroscopy, in addition to the ability to evaluate the nasopharyngeal region in three dimensions, is able to show a large variety of etiologic factors that cause the obstruction of the upper airway.^{3,6,10,11,17,31}

Therefore, the aim of the present article is to assess if any changes occurred in the upper airway of the patient who presented transverse alteration

of the upper arch and indication for rapid maxillary expansion.

RAPID MAXILLARY EXPANSION

Rapid maxillary expansion device

The device used for rapid maxillary expansion was a tooth-tissue supported device.⁷ The device was made of acrylic resin with an 11-mm expansion screw centered in the middle of the appliance. Orthodontic bands were used on the first premolars and on the first upper permanent molars.

Installation and activation of the rapid maxillary expansion device

A 12 year and 2 month old female Caucasian patient was referred to the orthodontic clinic with a view to improving her smile and the positioning of her teeth. The clinical exam showed that the patient presented Angle Class I malocclusion, anterior crossbite, atresic maxilla, lower and upper anterior dental crowding with lack of space for the left and right lateral upper incisors and the right upper canine tooth. At this first consultation, the patient reported suffering from mouth breathing, thus, she was referred to the otorhinolaryngologist.

In the first phase of the treatment a Haas-type rapid maxillary expansion device was designed. On the day of installation, the patient's parents received the due recommendations in relation both to oral hygiene and the procedures for the device activation. However, the activation was only initiated on the next day.

Regarding oral hygiene, it was explained to the patient that she should always perform her oral hygiene after meals, brushing the teeth and the device. While brushing, a 20 ml plastic syringe with water shall be used to perform the removal of food debris that may remain between the palate and the device. In relation to the activation of the device, the patient's parent or guardian was called and requested to sit beside the patient in order to receive the necessary orientations and to

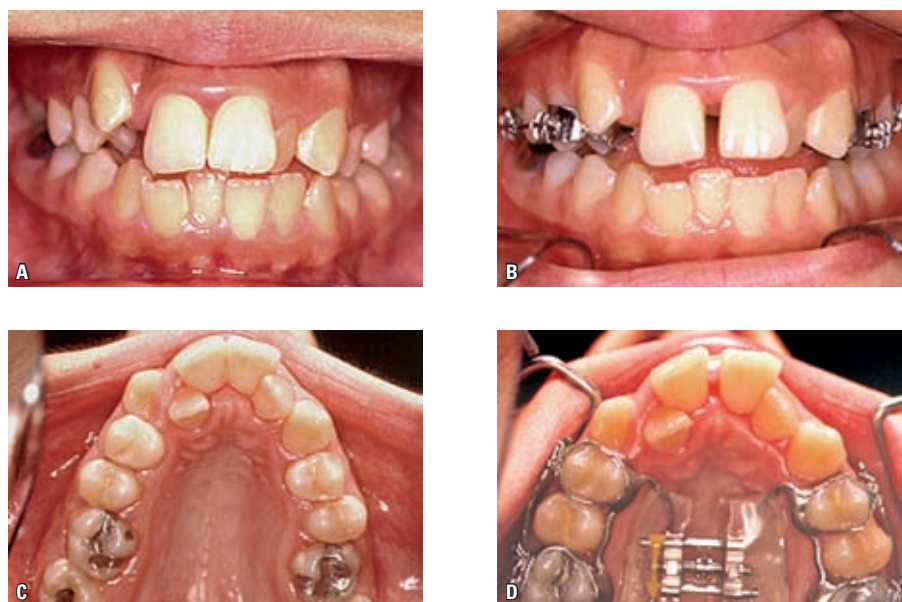


FIGURE 1 - Intraoral photos: **A)** Frontal, severe upper anterior crowding with lack of space for the left and right upper lateral incisors and the right upper canine tooth; **B)** frontal with opening of the diastema between the upper central incisors; **C)** upper occlusal showing the reduction of the upper arch transverse distance due to maxillary atresia and upper lateral incisors with lingual inclination; and **D)** upper occlusal after the opening of the midpalatal suture.

observe how the activation of the expansion device should be carried out. First, it was explained that the procedure should be performed by tying the screw activation key to a piece of dental floss that should be tied to one of the fingers of the person who will perform the activation. This procedure is necessary in order to avoid the accidental swallowing of the key. The father was instructed that for the activation of the device the key shall be activated from the anterior to posterior, being two quarter turns in the morning and two quarter turns in the evening, totalizing a full turn of the screw per day. After the initial explanation, the activation of the screw was performed, and then the patient's father was requested to perform the same procedure, in order to observe if he would not have any doubts while performing the activation at home. After all the doubts had been clarified, the patient was dismissed from the clinic.

Recall appointments were scheduled every three days for periodical control of the expansion and to verify if the activation was being performed properly.

NASOFIBROSCOPY

Nasofibroscopy exam

Type of device

The following devices were used to perform the patient's nasofibroscopy: 1) a Xenon Nova 20131520 Karl Storz Endoskope light source; 2) a microcamera Watec WAT-202B Color Camera; 3) two types of 0-degree wide-angled telescopes—(a) a 3 mm Machida EN6500, when there was no obstruction or the nasal cavities obstruction was mild or moderate and (b) a 2 mm Karl Storz 7208A when the nasal cavities obstruction was severe; 4) a Toshiba CM 1300 K television; 5) a Toshiba M 447 VCR; 6) Sony T-120 EDC videotape cassettes.

Examination

Before starting the examination, it was verified if the patient had a cold, because in that case, the exam would have to be postponed to another date, when the patient is presenting normal health conditions.



FIGURE 2 - Equipment used to perform the nasofibroscopy exam.

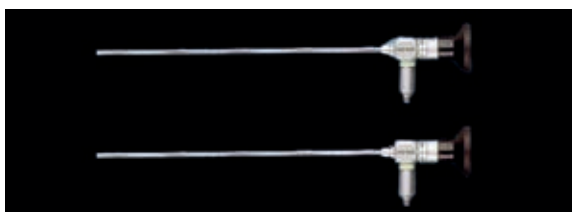


FIGURE 3 - 0-degree wide-angle telescopes.



FIGURE 4 - Karl Storz (Xenon Nova) light source and Watec color microcamera.

The procedure was fully explained to the patient, who was instructed to sit comfortably in a chair in front of the television.

The examination was initiated by the oral cavity, where the otorhinolaryngologist, using a telescope, verified the shapes of the arch and the palate, if there was overbite or overjet, the size of the uvula, the presence or absence of the palatine tonsils. And if they were present, if they were normal-sized or hypertrophic. If they were not within the normal range, it was verified if the hypertrophy was mild, moderate or severe. After the completion of the oral cavity examination, the nasal cavities examination was initiated.

The nasal cavities examination was initiated by the right nostril; the doctor, using a telescope, observed the nasal morphology, if the nasal valve was open or closed, if the nasal septum was within the normality or if there was septum deviation, if the lower and median nasal turbinates were normal or hypertrophied and, finally, the presence or absence of the pharyngeal tonsil. If it were present, it should be verified if its size was normal or altered. If it was not within the normal range, it was verified if the hypertrophy was mild, moderate or severe. Then the left nasal cavity examination was carried out, just as previously described.

When the 3 mm telescope was not able to perform the exam completely, due to nasal conchae hypertrophy, septum deviation or spur, it was replaced by a 2 mm telescope in order to conclude it.

The examination was recorded on a Sony T-120 EDC videotape cassette.



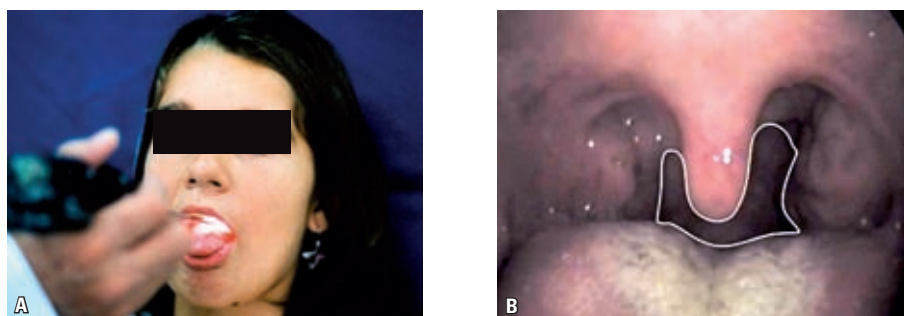


FIGURE 5 - **A)** Buccal cavity nasofibroscopy examination. **B)** Examination performed with 0-degree telescope, showing the buccopharyngeal gap.



FIGURE 6 - Nasofibroscopy Examination. **A)** Right nasal cavity exam and **B)** left nasal cavity exam.

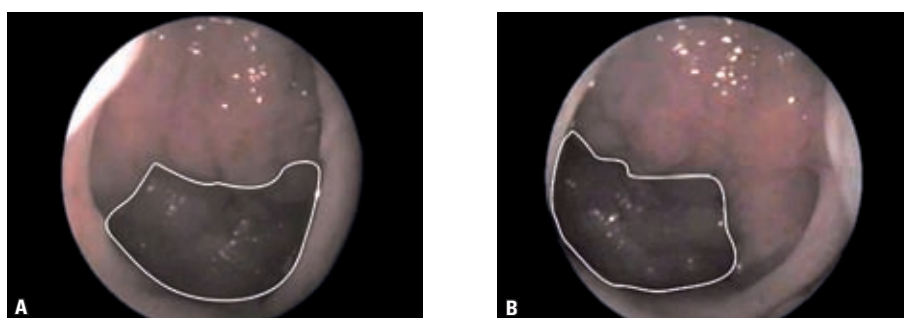


FIGURE 7 - **A)** View of the right nasal cavity of the nasopharyngeal gap and **B)** View of the left nasal cavity of the nasopharyngeal gap.

Method for calculating the percentage of buccopharyngeal and nasopharyngeal gaps

In order to calculate the percentage of the buccopharyngeal and nasopharyngeal total spaces and gaps before and after the rapid maxillary expansion (RME) using the Haas-type device, the nasofibroscopy exam was previously performed, generating images that were recorded on

Sony T-120 EDC videotape cassettes. The conversion of these videos to DVD was carried out through the software Xilisoft Video Converter 2.1.46 build 520B, with the following video codec specifications: Mpeg2 video and 640 X 480 pixels video resolution. Thus, the buccopharynx and nasopharynx's images were analyzed through the software Windows Movie Maker,

part of Windows XP Professional SP2. For the analysis of the nasofibroscopy exam, the three better images of both the buccopharynx and nasopharynx were frozen within a 3 second interval and saved in a small file in order to, posteriorly, calculate the percentage of buccopharyngeal and nasopharyngeal total spaces and gaps visualized through the left and right nasal cavities, using the software UTHSCSA developed in the "Department of Dental Diagnostic Science at the University of Texas Health Science Center". A 1000 dpi Microsoft notebook optical mouse 3000 was used to accurately delimit the buccopharyngeal and nasopharyngeal total spaces and gaps.

Thus, the average of values obtained from the three images of the buccopharynx and nasopharynx visualized through the left and right nasal cavities was considered to obtain the study variables. Then, after obtaining the palatine tonsils and the buccopharyngeal total areas, the gap was calculated by the difference between these two areas. Likewise, after obtaining the nasopharyngeal total area viewed through the right and left nasal cavities and the pharyngeal tonsillar area, the gap was calculated by the difference between these two areas.

FINAL COMMENTS

After the rapid maxillary expansion (RME), an increase of the buccopharyngeal and nasopharyngeal gaps viewed through the left and right nasal cavities was observed.

Therefore, an increase of the buccopharynx-

geal and nasopharyngeal airways^{11,16,17} as well as a reduction in the nasal resistance were demonstrated after the rapid maxillary expansion procedure, event previously reported in existing publications.^{17,18} However, we must be aware that this orthopedic procedure, despite the benefit of the nasal resistance reduction and consequent increase in the nasal patency, should not be performed for the sole purpose of providing an improvement in the nasal function in patients with breathing difficulties, but only when it is associated to a correct indication for rapid maxillary expansion.^{29,30}

Thus, one of the purposes of this study is to emphasize the fact that the expansion device, used for rapid maxillary expansion (RME), besides correcting uni or bilateral posterior cross-bites—its main function—, also contributes to the nasal resistance reduction and the nasal conductance increase. Another relevant aspect to be mentioned is the fact that through the nasofibroscopy examination it is possible to diagnose the etiologic factors that cause the obstruction and reduction of the nasorespiratory function.

However, this work was developed in a context of orthodontist-otorhinolaryngologist interdisciplinary collaboration, whereas the respiratory changes and their consequences represent a common interest in the craniofacial development. However, it is important to mention that the otorhinolaryngologist is the most capable and qualified professional to diagnose and treat respiratory disorders.

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Analysis of the rotational position of the maxillary first permanent molar in normal occlusion and Class II, division 1 malocclusion

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Abstract

Objective: The purpose of this study was to evaluate and compare the rotational position of maxillary first permanent molars (U6) in subjects in the permanent dentition presenting normal occlusion and Class II, division 1 malocclusion. **Methods:** Casts of 60 subjects with normal occlusion (Group 1, mean age 15.1 years) and 120 with untreated Class II, division 1 malocclusion (Group 2, mean age 15.5 years) were evaluated. The maxillary dental casts were scanned and the position of maxillary molars was analyzed using three angular measurements and one linear measurement, named indicators 1, 2, 3 and 4, respectively. The mesiopalatal rotation of maxillary first molars was evidenced by an increase in the values of indicators 1 and 4 and decrease in the indicators 2 and 3. Comparisons between groups were performed using Student's t test for measurements with normal distribution and by the Mann-Whitney test for non-normal distribution, at $p < 0.05$. **Results:** Statistically significant differences were found between Groups I and II for all indicators, on both right and left sides. **Conclusion:** It was concluded that individuals with Class II, division 1 malocclusion present greater mesiopalatal rotation of the maxillary first molars.

Keywords: Molar rotation. Normal occlusion. Class II, Division 1. Orthodontics.

INTRODUCTION

Good treatment finishing requires knowledge on the characteristics of an ideal occlusion. Andrews¹ reported the six keys to normal occlusion to describe the ideal relationship between the dental arches, contact points between maxillary and mandibular teeth, individual positioning of teeth concerning their tipping and angulation, tooth rotation and curve of Spee. It should be highlighted that an ideal occlusion

should present all these characteristics described by Andrews.

The maxillary first molars are important teeth for the occlusion and the following questions should be answered: What is the ideal rotation of the maxillary first molar? How can the orthodontist diagnose the molar rotation? Therefore, the rotational position of first molars in the normal occlusion should be known to determine a reliable diagnosis.

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Rotations of first molars are observed in most cases of Angle Class II division 1 malocclusion, which increases the space occupied by the teeth in the dental arch.^{3,6} Despite the good positioning of premolars and canines, in some cases, rotation of the first molar occurs due to incorrect positioning induced by local etiologic factors, such as proximal caries, during development of the mixed or permanent dentition.⁷

Several authors^{6,9,11,13,17} specifically addressed the rotation of the permanent maxillary first molar. In addition to a thorough literature review, they have conducted measurements on maxillary dental casts and concluded that the position of the first molar is very important for the orthodontic practice. Three positions of this tooth are significant: positioning in the maxilla, axial inclination and rotation in the long axis. A guideline for clinical evaluation of the position of maxillary first molars on the occlusal view has been proposed¹⁹ using a line traced through the tips of distobuccal and mesiopalatal cusps of the permanent maxillary first molar. It was observed that, in normal occlusion, this line should pass through the distal third of the canine on the opposite side, and that this was a good guideline to analyze the mesiopalatal rotations characteristic of mesial displacement of first molars in malocclusions. Cetlin and Ten Hove⁴ described that, when the two maxillary first molars are well positioned, their buccal aspects are parallel to each other.

In another study,¹⁰ the rotations of maxillary first molars were quantified by measuring the angle formed by the intersection of two lines, namely one formed by the union of two points corresponding to the tips of buccal cusps and the other to the midpalatal suture. The means observed for this angle were 14.08° and 12.76° for the right and left maxillary molars, respectively, in patients with acceptable occlusions.

Based on data in the literature, this study evaluated and compared the rotation of the maxillary first molar in patients with permanent

dentition with normal occlusion and Class II division 1 malocclusion.

MATERIAL AND METHODS

This study was approved by the Institutional Review Board of University Cidade de São Paulo, under protocol number 13180098. The study was conducted on sixty pairs of dental casts with normal occlusion not submitted to orthodontic treatment, in the age range 11 years 11 months to 31 years 10 months, with mean age 15 years 1 month, being 32 females and 28 males, from the files of the Department of Orthodontics of Bauru Dental School, University of São Paulo, which comprised the sample in Group 1 (Control). The study also included 120 pairs of dental casts before corrective treatment, presenting Class II division 1 malocclusion, being 70 females and 50 males, in the age range 10 years to 35 years 1 month, with mean age 15 years 6 months (Group 2), from the files of the Training and Specialization Courses in Orthodontics of Prev Odonto Study and Research Center at the city of Rio de Janeiro, state of Rio de Janeiro, which constituted the sample in Group 2.

The sample in Group 2 met the following inclusion criteria: permanent dentition with all present teeth (regardless of the presence of second and third molars); trimmed dental casts with defined occlusion; bilateral molar Class II division 1 relationship; no congenital malformations; no surgical skeletal dysplasias; no teeth with ectopic eruption; no abnormalities of shape and size of the molars, premolars and canines; no unilateral or bilateral posterior cross-bite; absence of anterior and posterior open bite; no hypodontia, tooth extractions and supernumerary teeth; no fractures or severe wear of the cusps of molars and premolars; and no prosthetic restorations on the molars, premolars and canines.

All maxillary dental casts in both groups were scanned and their images were digitized in grayscale at a resolution of 300 DPI, after marking the previously determined points with a pencil to allow the reliable identification of points on the digitization.

Fourteen points were marked on each digitized image, being 2 on the midpalatal suture and 12 divided between the right and left sides of the maxillary dental arch (Figs 1 and 2), which were later measured on the Radiocef software.¹⁸

The following points were used:

- » RP1: most anterior region of the midpalatal suture, close to the first or second premolars.
- » RP2: posterior region of the midpalatal suture, close to the first or second molars.
- » MV: mesiobuccal cusp tip of maxillary first molar.
- » DV: distobuccal cusp tip of maxillary first molar.
- » ML: mesiolingual cusp tip of maxillary first molar.
- » P1: most external point tangent to the buccal aspect of the first premolar, marked on the occlusal view.
- » P2: most external point tangent to the buccal aspect of the second premolar, marked on the occlusal view.

- » R: most distal point on the distal aspect of the maxillary canine.

The lines defined for the analysis were generated by the union of marked points, being one central and the others on the right and left sides of the dental arch (Figs 3, 4, 5 and 6).

- » Line A: union of points RP1 and RP2.
- » Line B: union of points MV and DV.
- » Line C: union of points MV and ML.
- » Line D: union of points P1 and P2.
- » Line E: union of points DV and ML.

Each line was traced on the right and left sides of the dental arch, except for line A, which were then named Bd, Be, Cd, Ce, Dd, De, Ed and Ee.

The angles defined for the analysis were generated by the intersection of the aforementioned lines, bilaterally (Figs 3, 4 and 5).

- » Angle 1: intersection of line A with line B.
- » Angle 2: intersection of line A with line C.
- » Angle 3: intersection of line B with line D.

Angle 1 indicated mesial rotation when increased, while angles 2 and 3 indicated rotation

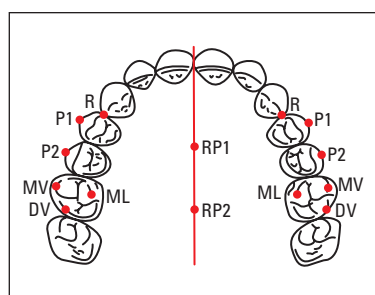


FIGURE 1 - Points marked on the digital images of dental casts.



FIGURE 2 - Scanned image of dental cast on the computer screen with the points marked.

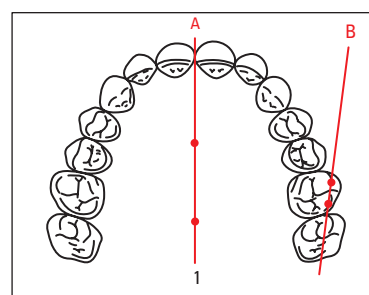


FIGURE 3 - Angle 1 (Line A.Line B).

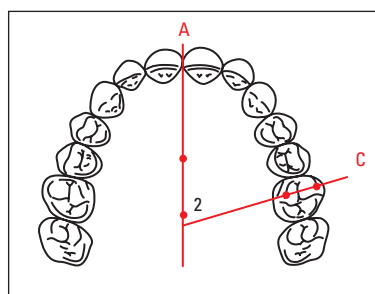


FIGURE 4 - Angle 2 (Line A.Line C).

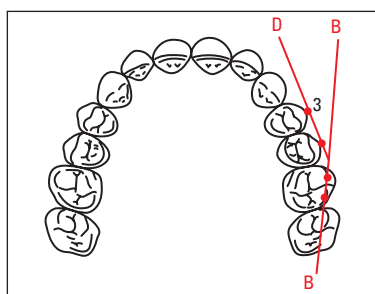


FIGURE 5 - Angle 3 (Line B.Line D).

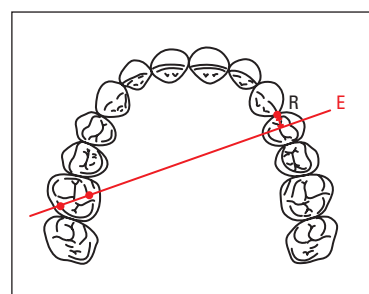


FIGURE 6 - Linear measurement (R).

when decreased in relation to the values found for normal occlusion.

A linear measurement was defined for the analysis (Fig 6), for both sides of the dental arch, as the distance perpendicular to point R at one side to the line generated by points DV and ML on the opposite side. These were named Rd (for the right side) and Re (for the left side). Thus, the distance Rd is the distance from point Rd to line Ee and vice-versa. This measurement indicates that, the greater the distance found, the greater is the mesial rotation of the molar.

STATISTICAL ANALYSIS

The groups of normal occlusion and Class II malocclusion were analyzed by descriptive statistics, with achievement of arithmetic means, medians, standard deviations, minimum and maximum values of measurements obtained for each indicator of the rotational position of the first molar, between the components in the two groups.

The results of measurements of each indicator obtained on the right and left sides were compared by the Student t test for indicators with normal distribution and by the non-parametric Mann-Whitney test for the others.

To determine the proper statistical test to be applied, the Kolmogorov-Smirnov test was initially applied to each set of measurements for analysis of their distribution. It was established that measurements presenting coefficient of variation above 30% would be submitted to non-parametric statistical analysis.

INTRA-EXAMINER ERROR

The method error was evaluated by re-analysis of 20 dental casts randomly selected from the two groups. This allowed the achievement of data on the same dental casts at two moments, T1 and T2, indicating the first and second analyses, respectively, obtained at a 30-day interval. Based on the data in T1 and T2, the Dahlberg

formula (1940) was applied to estimate the casual errors. Thereafter, the measurements were compared by the paired t test and Wilcoxon test for evaluation of systematic errors, at a significance level of 5% ($p < 0.05$).

To compare the results of measurements of each indicator obtained on the right and left sides, Student's t test was applied for indicators whose measurements presented normal distribution and the non-parametric Mann-Whitney test for the others.

In order to compare the rotation of first molars between groups with normal occlusion and Class II malocclusion, comparisons were performed between the measurements obtained for each indicator. Student's t test was applied for indicators with normal distribution, while indicators with wide variation in the values were analyzed by the non-parametric Mann-Whitney test. The characteristics of distribution of values were determined by application of the Kolmogorov-Smirnov test. The arithmetic mean and standard deviation were used to identify the group with highest value for indicators with normal distribution, while the median, minimum and maximum values were used for the others.

A significance level of 5% ($p < 0.05$) was considered for all statistical analyses.

RESULTS

Evaluation of intra-examiner error

Analysis of the intra-examiner error was performed by re-analysis of 20 dental casts at two moments, T1 and T2, being 5 dental casts with normal occlusion and 15 dental casts with Class II, division 1 malocclusion, which were randomly selected. The results of the Kolmogorov-Smirnov test indicated normal distribution for the variables 1d, 2d, 2e, Rd and Re, thus the paired t test could be applied. The test did not indicate normal distribution for the indicators 1e, 3d and 3e, which were thus analyzed by the non-parametric Wilcoxon test (Table 1).

Table 2 presents the arithmetic means, medians, standard deviations, minimum and maximum values of indicators related to the rotational position of maxillary first molars in the group with normal occlusion. Considering the means between the right and left sides, the values of the indicators were, respectively, 10.07, 61.54, 12.69 and 5.75, with standard deviations ranging from 6.22° to 7.35° for angular measurements and 5 mm for indicator 4.

Table 3 demonstrates the results of the rotational position of maxillary first molars in the group with Angle Class II, division 1 malocclusion (Group 2). In this group the measurements exhibited different values compared to group 1, with means of 14.97, 57.44, 5.52 and 11.38. However, the standard deviation values were similar, ranging from 6.55° to 8.72° for the indicators 1, 2 and 3, and 5 mm for the linear measurement.

Table 4 presents the comparison between groups according to the results of Student's t test and Mann-Whitney test, which revealed statistically significant differences between the two study groups for all indicators analyzed ($p < 0.01$).

DISCUSSION

Rotational position of maxillary first molar in normal occlusion

The rotational position of the maxillary first molar was evaluated in a sample of Brazilian Caucasoid individuals with normal occlusion. No difference was observed between the right and left sides for the four indicators used to evaluate the position of the molar (Table 5). These indicators have been previously used by some authors for clinical evaluation or in studies, in both normal occlusion and Class II samples.^{4,6,9,10-13,19}

The mean between measurements on the right and left sides for the angle 1 was 10.07°. Considering the normality values of means and standard deviations, minimum and maximum values of the angles 1d and 1e, demonstrated in Table 3, it was observed that in dental casts with normal occlusion the guideline on the parallelism between the buccal aspects suggested by Cetlin and Ten Hooe⁴ was confirmed in only a few cases. This evidence is based on the fact that the line used in this study for angle 1 and the line of Cetlin and Ten Hooe⁴ are nearly parallel to each other.

TABLE 1 - Arithmetic means, medians, standard deviations, minimum and maximum values of the rotational position of maxillary first molars in the normal occlusion sample.

	1d	1e	2d	2e	3d	3e	Rd	Re
Mean	11.11	9.03	61.36	61.72	11.97	13.42	5.16	6.35
Median	10.70	8.24	61.20	62.63	11.22	13.78	4.51	6.30
Standard deviation	6.99	6.90	6.22	6.54	7.35	6.84	4.99	5.06
Minimum value	-8.69	-7.86	49.67	45.00	-2.11	-2.32	-3.62	-4.62
Maximum value	24.78	23.57	75.78	72.92	29.01	32.17	18.62	16.31

TABLE 2 - Arithmetic means, medians, standard deviations, minimum and maximum values of the rotational position of maxillary first molars in the Angle Class II division 1 sample.

	1d	1e	2d	2e	3d	3e	Rd	Re
Mean	14.98	14.97	58.20	56.69	5.11	5.93	10.89	11.88
Median	15.00	14.83	58.68	56.38	6.08	6.66	10.89	11.49
Standard deviation	6.79	6.55	6.85	7.15	8.50	8.72	5.38	5.21
Minimum value	-2.65	-1.43	39.88	39.88	-16.24	-18.03	-5.97	-6.63
Maximum value	33.94	30.96	72.67	80.56	26.86	24.44	23.13	22.31

TABLE 3 - Unpaired t test (t) and Mann-Whitney test (U), significance levels (p), arithmetic means and medians for each indicator analyzed, for groups 1 and 2.

Indicator	Test	P	Group 1	Group 2
			Mean or Median	Mean or Median
Angle 1d	U = 3.18	0.001**	10.70	15.00
Angle 1e	U = 5.25	0.000**	8.24	14.83
Angle 2d	t = 3.01	0.003**	61.36	58.20
Angle 2e	t = 4.57	0.000**	61.72	56.69
Angle 3d	U = 4.86	0.000**	11.22	6.08
Angle 3e	U = 5.43	0.000**	13.78	6.66
Distance Rd	U = 6.39	0.000**	4.51	10.89
Distance Re	U = 6.00	0.000**	6.30	11.49

** significant at 1% level.

TABLE 4 - Paired t and Mann-Whitney tests and significance levels (p) for each indicator analyzed, between the right and left sides for dental casts of groups 1 and 2.

Indicator	Group 1		Group 2	
	Test	p	Test	P
Angle 1	U = 1.64	0.104 ^{ns}	U = 1.25	0.211 ^{ns}
Angle 2	t = -0.31	0.758 ^{ns}	t = 1.66	0.098 ^{ns}
Angle 3	U = 1.11	0.269 ^{ns}	U = 0.74	0.461 ^{ns}
Distance R	U = 1.30	0.197 ^{ns}	U = 1.46	0.144 ^{ns}

ns = non significant.

TABLE 5 - Comparison of means of indicators on the right and left sides for normal occlusion in this study and results of other authors.

	Indicator 1	Indicator 2	Indicator 3	Indicator R
Junqueira et al. (present paper)	10.07°	61.54°	12.69°	5.75 mm
Henry ¹¹ (1956)	11.15°			
Friel ⁹ (1959)		58.25°		
Lamons and Holmes ¹³ (1961)		61°		
Orton ¹⁷ (1966)*			10° *	
Ricketts ¹⁹ (1969)				0 to -2.6 mm
Dahlquist, Gebauer and Ingerwall ⁶ (1996)	11.11°	61.5°	9.9° *	7.4 mm
Hansen et al. ¹⁰ (1997)	13.42°	64°		
Nery and Barbosa ¹⁶ (2003)	12.2°	63.2°		

TABLE 6 - Comparison of means of indicators on the right and left sides for Angle Class II division 1 malocclusion in this study and results of other authors.

	Indicator 1	Indicator 2	Indicator 3	Indicator R
Junqueira et al. (present paper)	14.98°	57.45°	12.69°	5.75 mm
Henry ¹¹ (1956)	18.8°			
Nery and Barbosa ¹⁶ (2003)	15.5°	55.79°		
Kanomi et al. ¹² (2004)		63.5°		

Angle 2 presented a mean value between sides of 61.54° . Values reported in the literature^{6,9,10,13} range from 58.2° to 64° , similar to the present results (Table 6). The same was observed for indicator 3 (mean 12.69°), which presented similar values as those described in the literature^{16,17}, nearly 10° . These different results observed in different studies may have occurred due to slight differences in the methodology employed to evaluate the rotation of the molar.

The linear measurement in the present study (indicator 4) exhibited a mean value of 5.75 mm. This measurement was suggested by Ricketts¹⁹ in 1969, characterizing the normal positions of maxillary first molars. The author considered that the first molar was well positioned when a line passing through the tips of distobuccal and mesiopalatal cusps intersected the distal third of the canine on the opposite side. Therefore, considering that a maxillary canine presents an average mesiodistal dimension of 8 mm,⁸ this line should fall within a range between the distal aspect of the canine and a point up to 2.6 mm mesially to this tooth. The values obtained in this study ranged from -4.62 mm (line passing 4.62 mm mesially to the distal aspect of the canine) to 18.62 mm (line passing distally to the distal aspect of the canine), being that all cases presented Angle Class I molar relationship, according to key I of Andrews¹. Therefore, these results differ from the values demonstrated in previous studies.^{6,19} Analysis of the sample distribution revealed that only 10% of the cases followed the guideline proposed by Ricketts,¹⁹ confirming the findings of a previous study¹⁰. The wide variation in the values of this measurement indicates that it may impair the definition of the molar positioning in relation to the malocclusion.

Rotational position of maxillary first molar in Angle Class II division 1 malocclusion

The same indicators of the rotational positioning of the first molar in normal occlusions were applied for evaluation in the Class II malocclusion.

The angle 1, with mean of 14.98° , was slightly lower than the values observed in previous studies^{11,16}, which reveal values ranging between 15.5° and 20° . Only one study¹² described values higher than 60° , probably because the study sample included 148 pretreatment dental casts of patients with different malocclusions, thus not limited to Class II division 1 malocclusion.

The angle 2 exhibited mean value of 57.45° , close to the values reported in the literature (63.5° , 55.79°),^{12,16} confirming that the maxillary first molar presents a different positioning in the Class II malocclusion compared to normal occlusion.

The indicator 3 presented the wider variation, on both right and left sides. The reason for such variation in this angle was that different buccolingual positions of the premolars were observed, which caused variations in the position of points P1 and P2 bilaterally. Therefore, there were also variations in the inclination of line D and consequently of angle 3. By the practical analysis of dental casts, it was thus considered that this was the least reliable among all indicators for evaluation of molar rotation, because it depends on unstable reference points located on teeth that may be malpositioned.

The angle 3 and linear measurement R exhibited mean values of 5.52° and 11.38 mm which differed from the group with normal occlusion yet no data in the literature are available for comparison, as displayed in Table 6.

Comparison of rotational position of maxillary first molar in Class II division 1 malocclusion and normal occlusion

The molar rotation in mesiopalatal direction implies higher values for the angle 1 and for the linear measurement R, with lower values for angles 2 and 3 compared to the values of the same indicators in the normal occlusion.

The values observed for Group 2 in this study were higher for indicators 1 and R and lower

for 2 and 3, compared to the values observed for the group with normal occlusion ($p < 0.001$). These results were compatible with the values expected for molars with mesiopalatal rotations, which evidences a greater tendency to rotation in the Class II division 1 malocclusion. The groups presented statistically significant differences for all indicators.

The literature unanimously states that the mesiopalatal rotations of molars are common characteristics in malocclusions, especially in the Class II, division 1 malocclusion.^{1,3,6,10,13,15} Liu and Melsen¹⁴ reported a rate of 85% of molars with mesiopalatal rotations in a sample with Class II, division 1 malocclusion.

Considering the values of arithmetic means, standard deviations, minimum and maximum values of indicators 2d and 2e in both groups, it is observed that there is a range of measurement values that is common to both groups, even though their means exhibited statistically significant differences ($p < 0.003$). This observation occurred due to the wide variation in the measurements obtained and their ranges of standard deviation. Thus, analysis of the magnitude of a single indicator does not allow to state if it is a case of normal occlusion or Class II malocclusion, or if it refers to a molar with or without rotation. Probably there

are other factors that, associated to the indicators, are determinant for the diagnosis of molar rotation, such as the dental arch shape, anatomical shape of the first molar crown, early loss of deciduous molars and proximal caries in the deciduous and mixed dentition, which may be addressed in future studies.

Based on the present results, the greater mesiopalatal rotation of maxillary first molars in the Class II division 1 malocclusion was confirmed. This highlights the need of careful analysis of dental casts and investigation of the involvement of molar positioning in the malocclusion.

When the rotation of molars is diagnosed, the treatment plan should be directed to this problem, which may be solved by the utilization of different appliances as the headgear, transpalatal bar or even distalizers that may correct the rotation of molars and reach the Class I molar relationship desired in the orthodontic treatment.

CONCLUSIONS

It was concluded that the group with Class II division 1 malocclusion presented greater mesiopalatal rotation of the maxillary first molar compared to the group with normal occlusion. The diagnosis of this rotation may be helpful for a more accurate treatment planning.

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Evaluation of facial proportions in the vertical plane to investigate the relationship between skeletal and soft tissue dimensions

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Abstract

Objective: To determine the relationship between facial heights by evaluating the soft tissues and underlying skeleton and by analyzing vertical facial proportions in the anterior region.

Methods: The study used 24 lateral cephalometric x-rays and 48 photographs of the face, 24 in profile view and 24 in front view, belonging to 24 Brazilian individuals, 7 men and 17 women whose ages ranged from 19 to 38 years. Cephalometric tracings were performed and linear measurements obtained according to the analyses suggested by Schudy, Wylie and Johnson, and Thompson and Brodie. The anatomical landmarks glabella, subnasal and menton were identified on the photographs, which allowed the measurement of linear distances between these points. The data were then statistically analyzed. **Results and Conclusions:** A positive correlation was found between evaluations of the soft tissues and underlying skeleton based on the analyses advanced by Schudy ($r=0.619$, $p<0.001$), Wylie and Johnson ($r=0.595$, $p<0.002$) and Thompson and Brodie ($r=0.630$, $p<0.001$), although, individually, some discrepancies were identified due to variability in soft tissue thickness.

Keywords: Cephalometry. Lower facial height. Soft tissue profile.

INTRODUCTION

In the late nineteenth and early twentieth century, analysis of soft tissue profile aroused the interest of leading orthodontists, trailblazers the likes of Angle and Case. The sculpture of Apollo Belvedere was elected by Angle as a benchmark for body and facial beauty. However, Case was reluctant to pursue a single beauty standard and

therefore attempted to individualize the aesthetic goals of each one of his cases. He would study the facial contours of his patients and note all details in trying to integrate occlusal and facial goals, establish diagnosis and a proper treatment plan.⁸ Researchers have long focused most of their attention on anteroposterior balance, probably spurred by the widespread use of Angle's classification.

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Over the years, however, research and clinical experience have revealed the close interdependence of facial proportions in the three dimensions of space.²²

In 1942, Thompson and Brodie,²⁶ after performing measurements on radiographs of 50 adults and 300 dry skulls, concluded that nasal height (nasion-anterior nasal spine) accounts for 43% of the total facial height (nasion-gnathion). Moreover, Wylie and Johnson,²⁸ in 1952, studied 171 patients and found that in harmonious individuals total facial height (TFH) is divided into 45% of nasal height (anterior nasal spine) and 55% of dental height (anterior nasal spine-menton), i.e., upper facial height (UFH) and lower facial height (LFH), respectively. Later, in 1964, Schudy²³ examined cephalometric radiographs of 270 subjects, including both retrognathic and prognathic individuals with normal growth pattern. The results indicated that UFH varied very little between the three facial types, although 2 mm higher in the prognathic group. LFH accounted for 56% of TFH (nasion-menton) in the group with normal growth pattern, 59.5% in the retrognathic group and 54.1% in the prognathic group.

Before the advent of cephalometric radiography, anthropometric measures were frequently employed to help establish facial proportions.¹⁹ However, soft tissue compressibility can lead to errors during measurement, which underscores the limitations of anthropometrics.² After the aluminum filter was first introduced for taking cephalometric radiographs,⁴ soft tissue measuring became part and parcel of cephalometric analysis. It allowed information to be obtained about the relationship between soft tissue profile and the underlying dentoskeletal profile since it was believed that certain hard tissue abnormalities could be masked or even heightened by the soft tissues.

Soft tissue profile does not always follow skeletal profile as it differs from the latter in some areas.²⁵ This is due to a wide variability in soft tissue thickness,⁷ which renders inadequate the

exclusive use of hard tissue analysis.^{12,13} Thus, evaluation of facial proportions and aesthetics should be conducted during clinical examination and the findings should be compared with cephalometric radiographs and photographs.¹⁹

Accurate measurements can also be obtained from standardized photographs.² These photos are useful for recording and analyzing significant asymmetries and for checking proportionality between the vertical thirds, making them an essential element for diagnosis in orthodontics.¹⁰ However, their validity as a means of pre- and post-treatment evaluation only emerges when measurements are undertaken to prevent distortion. If a reasonably standardized work methodology is not set in motion, photographs will be insufficient to provide accurate representation of anatomical elements and their actual proportions. Camera position, patient distance and position, and focus control are some of the elements which, if well understood and controlled, make for accurate reproduction.³

Orthodontists must recognize that the complexity of certain orderly, pleasant-looking arrangements present in all portions of the face cannot be fully expressed by numbers or measures,¹¹ and that normal occlusion is not necessarily a criterion for beauty since some patients exhibit normal occlusion whose faces do not fall within acceptable aesthetic limits.²⁰

Due to major individual variations in soft tissue thickness, length and postural tone, the cutaneous contour of the face must be studied directly if facial balance is to be properly assessed.⁷ In light of the fact that many authors have proposed different methods to assess the facial thirds, this study aimed to analyze, quantify and compare skeletal and soft tissue features by measuring vertical facial proportions to identify potential differences between these two aspects.

MATERIAL AND METHODS

This study used 24 lateral cephalometric x-rays and 48 photographs of the face, 24 in profile

view and 24 in front view, belonging to 24 Brazilian individuals, 7 men and 17 women whose ages ranged from 19 to 38 years.

The cephalometric radiographs were acquired according to the technique described by Broadbent⁶ and the patients were instructed to keep their teeth in maximum intercuspation. A sheet of acetate paper was attached to each cephalogram and cephalometric tracings were then performed. The cephalogram used for the tracings (Fig 1) outlined the contours of the frontal, nasal, maxillary and mandibular bones, maxillary and mandibular central incisors, and soft tissue profile. The following anatomical landmarks were identified on the cephalogram: nasion (N), anterior nasal spine (ANS), pogonion (Pog), menton (Me) and gnathion (Gn). Once these points had been identified, the facial plane (N-Pog) was traced as well as the nasion-menton (N-Me) and nasion-gnathion (N-Gn) lines, in black, blue and red, respectively. Linear measurements were then obtained according to the analysis advocated by Schudy,²³ Wylie and Johnson,²⁸ and Thompson and Brodie.²⁶ To standardize the sample and minimize errors all cephalometric measurements were performed twice by the same examiner with a one-week interval. With the values obtained in the first and

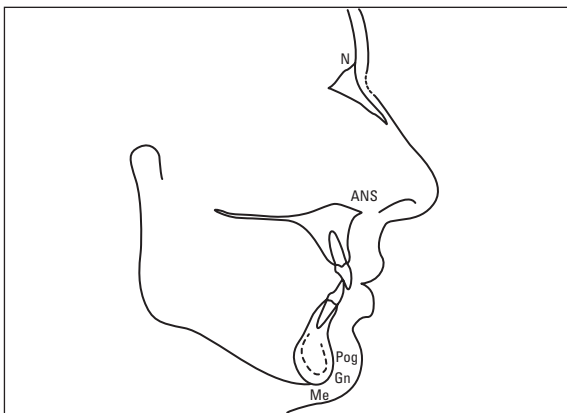


FIGURE 1 - Cephalogram showing anatomical structures and cephalometric landmarks used for evaluating facial proportions in vertical direction.

second measurements, scatter diagrams were constructed for each variable and Pearson's correlation coefficient calculated, whose value, in each case was 0.99 ($p < 0.001$).

The elements used for cephalometric evaluation of facial proportions in the vertical direction according to Schudy's analysis are depicted in Figure 2. Namely:

- » Points N, ANS, Pog and Me;
- » Facial plane;
- » Orthogonal projection of point ANS on the facial plane (ANS');
- » Orthogonal projection of point Me on the extension of the facial plane (Me');
- » TFH = distance between N and Me' measured in the facial plane;
- » UFH = distance between N and ANS' measured in the facial plane;
- » LFH = distance between N and Me' measured in the facial plane.

The elements used for cephalometric evaluation of facial proportions in the vertical direction, according to Wylie and Johnson's analysis are depicted in Figure 3. Namely:

- » Points N, ANS and Me;
- » Nasion-menton line;
- » Orthogonal projection of point ANS on the nasion-menton line (ANS'');
- » TFH = distance between N and Me measured on the nasion-menton line;
- » UFH = distance between N and ANS' measured on the nasion-menton line;
- » LFH = distance between ANS' and Me measured on the nasion-menton line.

The elements used for cephalometric evaluation of facial proportions in the vertical direction according to Thompson and Brodie's analysis are depicted in Figure 4. Namely:

- » Points N, ANS and Gn;
- » Nasion-gnathion line;
- » Orthogonal projection of point ANS on the nasion-gnathion line (ANS'');

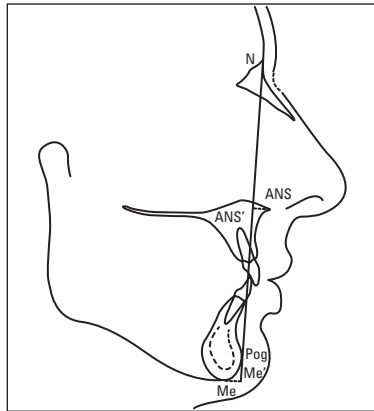


FIGURE 2 - Cephalogram depicting evaluation of facial proportions in vertical direction, according to Schudy's analysis.

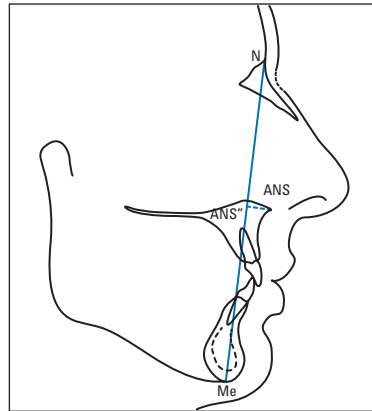


FIGURE 3 - Cephalogram showing evaluation of facial proportions in vertical direction, according to Wylie and Johnson's analysis.

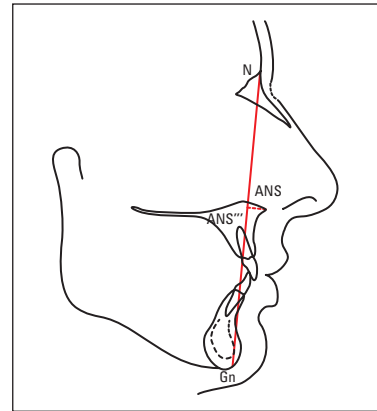


FIGURE 4 - Cephalogram depicting evaluation of facial proportions in vertical direction, according to Thompson and Brodie's analysis.

- » TFH = distance between N and Gn measured on the nasion-gnathion line;
- » UFH = distance between N and ANS''' measured on the nasion-gnathion line;
- » LFH = distance between ANS''' and Gn measured on the nasion-gnathion line.

For the facial photographs, patients were positioned in the cephalostat with the Frankfort plane parallel to the ground and then instructed to keep their teeth in maximum intercuspation. For profile view photographs, the head was rotated 5° towards the camera.⁹ This position was established by having two previously marked points on the cephalostat coinciding, with the aid of a protractor, i.e., one on the fixed base and one on the swivel base. Similarly, two points were set for acquiring front view photographs, thus ensuring that the midsagittal plane would remain oriented towards the camera lens.

A conventional camera used for routine clinical photography was utilized. It was equipped with 35 mm film and a 100 mm macro lens. The focus cylinder was removed and adapted to a bellows mounted on a slider with a millimeter ruler, which allowed standardization (in this case, 50 mm). The diaphragm was set to an opening of f/5.6 and the flash positioned at 12 o'clock for

front view photos and 3 o'clock for profile view photos.⁹ The equipment was mounted on a fully adjustable tripod positioned at fixed markings drawn on the ground. Its joints were also fixed so that the lens was kept perpendicular to the center of an imaginary line joining the ear-rods of the cephalostat, thus averting image distortion that might compromise the true facial contour. The distance between the camera's objective and the ear-rods of the cephalostat was standardized at 1.36 m.

The following points were identified on the photographs:

- » Glabella (G): most prominent or anterior point in the midsagittal plane of the forehead, above the supraorbital crest.¹⁶ It can also be identified in front view photos as the midpoint between the eyebrows, also in the midsagittal plane, and at the level of the supraorbital crest.
- » Subnasal (Sn): the point where the upper lip joins the columella.⁸ It is identified as the point located at the junction of the lower edge of the nose and the edge of the upper lip, in the midsagittal plane.¹⁶
- » Menton (Me): the inferior-most point of the lower contour of the chin⁸ marked on front view photographs in the midsagittal plane.

Lines running tangent to these points and perpendicular to the lateral edges of the photograph were traced, allowing the measurement of linear distances between them (Figs 5 and 6).

In keeping with the same method applied to the radiographs to standardize the sample and minimize errors, landmarks and measurements were identified on the photos twice by one and the same examiner with a one-week interval. The resulting values were also treated statistically. The results showed a strong positive linear correlation between the values obtained in the first and second measurements, further confirmed by the Pearson correlation coefficient which, in all cases, was 0.99 ($p < 0.001$).

RESULTS AND DISCUSSION

The teeth and facial bones form a framework upon which the muscles, connective tissue and soft tissues rest. Thus, analysis of either skeletal or dental pattern alone can lead to misdiagnosis given a wide variation in the thickness of soft tissues overlying these structures. Even if an infinite number of anatomical landmarks were to be used in the study of dentoskeletal patterns, soft

tissue contour would only be predictable if soft tissues were to form a uniform veneer over teeth and bones, which is not the case.⁷ Thus, soft tissue in facial profile may not accurately reflect the growth pattern of underlying skeletal tissues,¹⁴ although a close relationship has been proven to exist between the two.^{5,21}

Therefore, when evaluating the success of orthodontic treatment, data related to soft tissues are as important as hard tissues in determining facial balance and harmony.^{1,17,29} Moreover, visual impact stems from soft tissues and their relative proportions.^{18,29} Soft tissues are the last compensating factor in the morphology of facial contour. Its analysis is therefore of paramount importance in orthodontic diagnosis and treatment planning.²⁷

Although many studies have been conducted with the aim of studying the relationship between the soft tissues that make up the skeletal facial profile and the underlying tissue, controversies still abound. With the purpose of visualizing and quantifying this relationship, the present study correlated soft tissue and skeletal measurements through statistical analysis using LFH measurements taken only in profile



FIGURE 5 - Profile view photo illustrating points and lines used for determining linear measurements.



FIGURE 6 - Front view photo illustrating points and lines used for determining linear measurements.

view photographs, given the results depicted in Figure 7. The scatter plot and Pearson's correlation coefficient showed strong positive linear correlation ($r = 0.963$, $p < 0.001$) between LFH values obtained from the analysis front view photos (FVLHF) and profile view photos (PVLHF). Furthermore, anatomical landmarks are easier to identify in a lateral view. Scatter plots were then constructed with percentage LFH values obtained by analyzing profile view photos (PVLHF) and using the analyses suggested by Schudy (SCLFH), Wylie and Johnson (WJLFH), and Thompson and Brodie (TBLFH). Pearson's correlation coefficient was also calculated and the coefficient tested.

The results indicated a positive correlation, significant at a 1% level, between variables PVLHF and SCLFH (Fig 8), PVLHF and WJLFH (Fig 9), and PVLHF and TBLFH (Fig 10), suggesting interdependence between the soft tissue profile and the underlying skeleton, thereby corroborating Riedel.²¹

On the other hand, in a private analysis of the individuals comprising the study sample it was found that two such individuals who exhibited the same increased percentage LFH values in the skeletal analyses (LFH, Schudy = 58% and 58%, LFH, Wylie and Johnson = 58.5% and 58.5%, LFH, Thompson and Brodie = 58% and 58%), showed different values for this measure

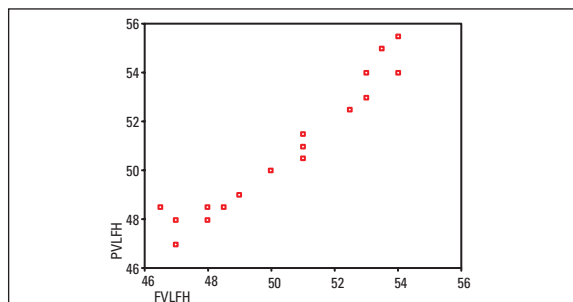


FIGURE 7 - Scatter diagram between percentage LFH values, obtained from analysis of front and profile view pictures in women and men ($r=0.963$, $p<0.001$).

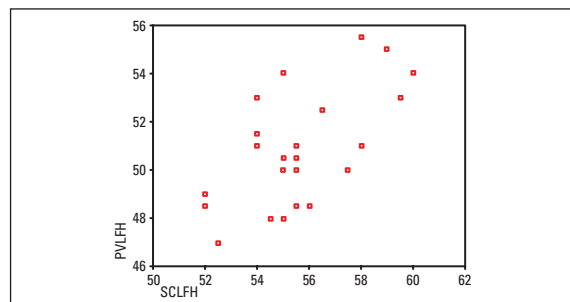


FIGURE 8 - Scatter diagram between percentage LFH values, obtained from analysis of front and profile view photos and Schudy's analysis in women and men ($r=0.619$, $p<0.001$).

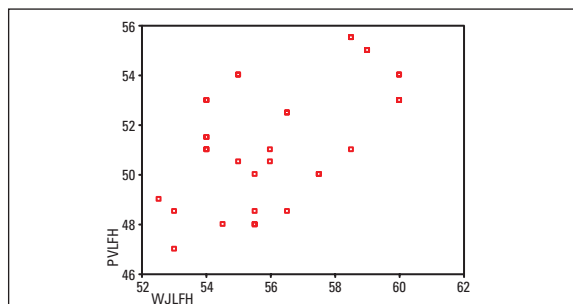


FIGURE 9 - Scatter diagram between percentage LFH values, obtained from analysis of front and profile view photos and Wylie and Johnson's analysis in women and men ($r=0.595$, $p<0.002$).

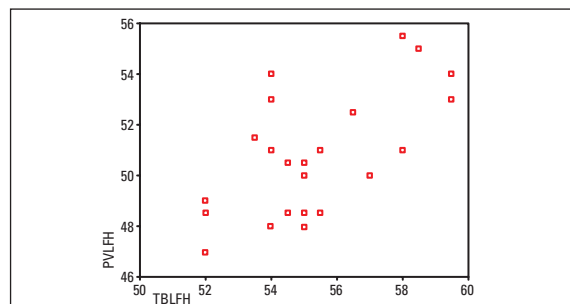


FIGURE 10 - Scatter diagram between percentage LFH values, obtained from the analysis of profile view pictures and Thompson and Brodie's analysis in women and men ($r=0.630$, $p<0.001$).

in profile view photographs. If, on the one hand, one of them displayed an LFH value of 51%, very close to 50% (considered normal),^{15,19,24} another individual exhibited a value of 55.5%, which can be construed as an increased LFH. By the same token, two other individuals displayed different percentage LFH in the skeletal analyses (LFH, Schudy = 54% and 59.5%, LFH Wylie and Johnson = 54% and 60%, LFH, Thompson and Brodie = 54% and 59.5%). These percentages were not found in the analysis of their profile view photographs, in which both showed

the same increased LFH value (53%). The data point to a variability in soft tissue thickness while indicating that soft tissues do not always reflect the underlying dentoskeletal profile, which is consistent with findings by Burstone,⁷ Kuyl et al,¹⁴ and Subtelny.²⁵

CONCLUSIONS

The soft tissue profile tended to follow the contour of the underlying skeletal profile, although in some cases this was not the case, probably due to variations in soft tissue thickness.

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Evaluation of friction in self-ligating brackets subjected to sliding mechanics: an in vitro study

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Abstract

Introduction: Friction generated at the bracket/archwire interface during sliding mechanics can reduce the efficiency of orthodontic movement. The ligation method employed to tie the archwire to the bracket plays an important role in determining this friction. **Methods:** This study compared the frictional force generated by four different types of self-ligating brackets (Time®, Damon 2®, In-Ovation R® and Smart Clip®) with a group of conventional orthodontic brackets (Dynalock®) that require the use of traditional elastomeric ligatures (ExDispens-A-Stix®), which served as the control group. Static friction force was measured using an EMIC DL® 500 universal testing machine using stainless steel round 0.018-in and rectangular 0.017x0.025-in archwires. **Results:** ANOVA and Tukey's test showed low levels of friction in the four self-ligating brackets in tests with the 0.018-in wire ($P < 0.05$). However, the results noted when the self-ligating brackets were tested using 0.017x0.025-in archwires showed high resistance to sliding in the self-ligating groups.

Abstract: Friction. Orthodontic brackets. Self-ligating brackets. Sliding mechanics.

INTRODUCTION

The presence of friction in orthodontic sliding mechanics poses a clinical difficulty to orthodontists since high levels of friction reduce the effectiveness of mechanics, affecting the rate of tooth movement and rendering anchorage control difficult. Under these circumstances, orthodontic treatment becomes more complex.⁴

The search for ideal conditions to conduct orthodontic therapy involves reducing the frictional

force created at the bracket/wire/ligature interface.¹² This would imply the use of lighter forces, but still sufficient to promote tooth movement. Thus, there will be increased biological compatibility and less patient discomfort.

According to Rossouw,¹⁴ friction is a force that resists the movement of one surface against another and acts in the opposite direction of the desired movement. Frictional force is classified into static and kinetic. Static friction is the smallest force

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needed to start a movement between solid objects at rest. Moreover, kinetic friction force resists the sliding motion of a solid object against another at a constant speed.¹¹ Kinetic friction is always smaller than static friction since it is more difficult to draw a body from a resting position than to perpetuate its movement.¹¹ In orthodontics, a tooth subjected to sliding motion along the archwire is alternately inclined and uprighted, moving in small increments.¹⁰ Therefore, space closure depends more on static than kinetic friction.

Among the numerous attempts to reduce friction by changing bracket design, the concept behind so-called self-ligating brackets, i.e., requiring no ligature to tie the orthodontic archwire, first emerged in 1935 with the Russell Lock appliance. Since then, other appliances have been developed along the same line (Table 1).

Self-ligating brackets are orthodontic appliances that do not require ligatures to hold the wire

in the bracket slot thanks to a mechanical device built into their buccal surface, which closes the bracket slot, thereby preventing the archwire from disengaging. Some self-ligating bracket systems do not push the orthodontic archwire against the inner wall of the slot and are appropriately called passive self-ligating appliances.^{1,2} In these appliances the cap or cover simply creates a barrier to keep the archwire inside the slot. With the introduction of active self-ligating bracket systems, the slot cover might or might not apply pressure onto the archwire depending on archwire diameter.^{1,2}

This study aimed to: 1) Assess the static friction force delivered in passive and active self-ligating brackets when using stainless steel round 0.018-in orthodontic archwires, and 2) assess the static friction force delivered in passive and active self-ligating brackets when using stainless steel rectangular 0.017x0.025-in orthodontic archwires during in vitro sliding mechanics simulation.

TABLE 1 - Development of self-ligating brackets.

Trade Name	Manufacturer	Launched in (year)	Bracket Design
Speed	Strite Industries(Ontário, Canada)	1975	Active
Activa	A Company (San Diego, CA, Estados Unidos)	1986	Active
Time	American Orthodontics (Sheboygan, WI, USA)	1994	Active
Damon SL	Ormco Corporation (Glendora, CA, USA)	1996	Passive
Twin Lock	Ormco Corporation (Glendora, CA, USA)	1998	Passive
Damon 2	Ormco Corporation (Glendora, CA, USA)	1999	Passive
In-Ovation	GAC internacional (Bohemia, NY, USA)	1999	Active
Damon 3	Ormco Corporation (Glendora, CA, USA)	2004	Passive
Smart Clip	3M/Unitek (Monrovia, CA, USA)	2004	Passive
Damon MX	Ormco Corporation (Glendora, CA, USA)	2005	Passive
In-Ovation C	GAC internacional (Bohemia, NY, USA)	2007	Active

METHODOLOGY

Material

Four types of self-ligating brackets were evaluated, two active systems—Time 2® (American Orthodontics, Sheboygan, WI, USA) and In-Ovation R® (GAC International, Bohemia, NY, USA)—and two passive systems—Damon 2® (Ormco Corporation, Glendora, CA, USA) and Smart Clip® (3M Unitek, Monrovia, CA, USA) (Fig 1).

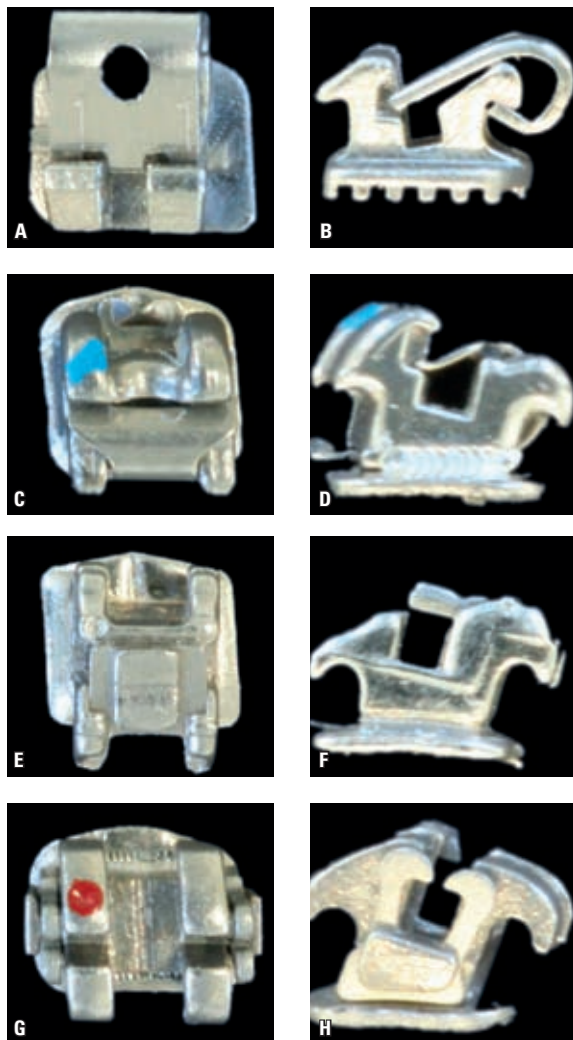


FIGURE 1 - Self-ligating brackets tested in this study: Time 2® in (A) front and (B) lateral view; In-Ovation R® in (C) front and (D) lateral view; Damon 2® in (E) front and (F) lateral view; Smart Clip® in (G) front and (H) lateral view.

The control group used conventional stainless steel orthodontic brackets (Dynalock®, 3M/Unitek, Monrovia, CA, USA) tied with conventional grey-colored elastomeric ligatures (Dispens-A-Stix®, TP Orthodontics, La Porte, IN, USA).

All brackets were for maxillary central incisors with 0.022x0.028-in slot in Roth prescription (5° angulation and 12° torque). Since Smart Clip® appliances are not available in Roth prescription, MBT brackets—with 4° angulation and 17° torque—were used instead, given their close similarity.

Stainless steel round 0.018-in and rectangular 0.017x0.025-in archwires (3M / Unitek, Monrovia, CA, USA) were employed in the tests. There were altogether 20 units of each type of bracket. Ten were tested using the round archwires and the other ten, rectangular archwires. Each sample, comprising bracket/wire, was subjected to five consecutive tests in order to increase the reliability of results, totaling 400 tests.

Methods

To assess friction force, the authors used an EMIC DL 500 universal testing machine (EMIC Equipamentos e Sistemas de Ensaio Ltda., São José dos Pinhais, PR, Brazil), which belonged to the Laboratory of Structural Analysis, Department of Mechanical Engineering, Pontifical Catholic University (PUC), Minas. A 5N load cell was used, with a speed of 1 mm/min (Fig 2A). The results pertaining to static friction force were transmitted to a computer connected to the testing machine.

To simulate sliding mechanics, a straight line static traction test was implemented while each bracket remained at rest relative to its base and the wire slid along the bracket slot. To this end, an aluminum device was fabricated, which was connected to the load cell through grippers. This device contained two plates, i.e., a lower plate where brackets were bonded, and which remained motionless, and an upper plate, connected to the orthodontic wire segment of the test specimen undergoing displacement (Fig 2B).



FIGURE 2 - **A)** EMIC Universal Testing Machine and **B)** testing device.

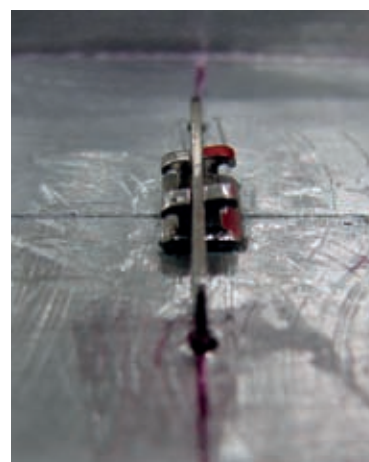


FIGURE 3 - U-shaped stainless steel 0.021x0.025-in wire device used for bonding the brackets.

All test specimens were prepared by the same operator. The brackets and wires were cleaned with 70% ethyl alcohol so as to keep them free of grease or dirt that might interfere with the results. Bracket bonding was performed using instant cyanoacrylate ester based adhesive (Super Bonder, Loctite Henkel, SP, Brazil). When positioning the brackets care was taken to keep the bracket base parallel to the aluminum plate.

Bracket placement was standardized with the aid of a U-shaped stainless steel 0.021x0.025-in wire device, which was placed in the bracket slot with its ends fitted into holes in the plate, as can be seen in Figure 3. As the bracket slot and orthodontic archwire became collinear, as a result of the bonding position, archwire entry angle was equal to zero. These auxiliaries ensured accuracy and reproducibility of bracket placement procedure for all specimens. Moreover, it was important in ensuring that the archwire remained passive in the bracket slot prior to ligation. It is known that resistance to friction during tests stems from friction produced by the ligation method (either elastomeric or self-ligating) added to any inclination

between archwire and bracket caused by a non-passive archwire in the bracket slot.⁸ Therefore, in order that only the friction produced at the bracket/wire or bracket/wire/ligature interface could be measured, the archwire was passively aligned, i.e., with no angulation inside the slot.

The segment of orthodontic wire used in the specimens was 3 cm in length. At its upper end a standard hook was fashioned, which was fitted onto the upper plate of the device. Each wire segment was evaluated using a profile projector (Micro VU Model H14, São Paulo, Brazil) (Fig 4). The aim of this evaluation was to standardize wire bends and determine with accuracy the long axis of the wire segment. These factors are important in driving vertical forces applied by the universal testing machine.

When preparing the control group specimens, ligature insertion occurred in a standardized fashion. To this end, an elastomeric ligature application device was used (Straight Shooter® Ligature Gun, TP Orthodontics, La Porte, IN, USA), which allowed all ligatures to be stretched to the same length at the time of insertion.

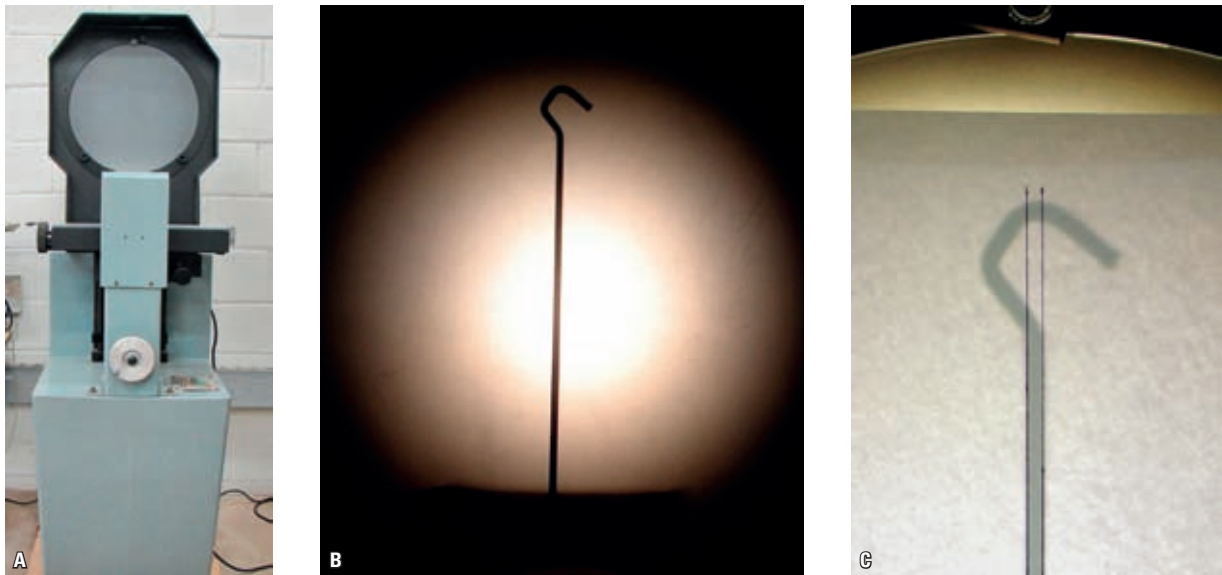


FIGURE 4 - **A)** Profile projector, **B)** Projection of wire segment with hook and **(C)** Checking the long axis of the hook by using a sheet of white paper with a checkout diagram.

RESULTS

The non-parametric Kruskal-Wallis test disclosed that even when tests on the same specimen were repeated up to five times no significant change occurred in static friction force ($p < 0.05$). Because friction was not influenced by the number of times a test was repeated (i.e., whether it was the 1st, 2nd, 3rd, 4th or 5th test repetition), the mean test results of each specimen were used to evaluate differences between the materials being tested.

Descriptive analysis showed that rectangular 0.017x0.025-in wires exhibited higher mean friction force than round 0.018-in wires ($p < 0.05$). The bracket In-Ovation R[®] displayed the highest friction values, as shown in Figure 5, but only when testing with rectangular wires.

The least significant difference (LSD) method, at a significance level of $p < 0.05$, was used with the purpose of identifying significant differences between the combinations used in the study. Comparison between the four types of

self-ligating brackets using the round wires yielded no significant friction force differences ($p < 0.05$). Furthermore, all self-ligating brackets exhibited significantly lower friction force than the control group (Fig 5). The self-ligating brackets showed a friction force approximately 95% smaller than conventional brackets.

Considering the tests using rectangular wire, the brackets In-Ovation R[®] and Time[®] showed friction force levels that were statistically similar to the control group ($p < 0.05$), whereas the groups comprising Damon 2[®] and Smart Clip[®] brackets displayed significantly lower levels of static friction ($p < 0.05$) compared to the control group.

DISCUSSION

In orthodontics, when teeth undergo sliding mechanics along an archwire, cyclical inclination and uprighting movements occur while displacement develops in small increments.¹⁰ Since kinetic friction occurs between two objects in uniform motion and at constant speed,

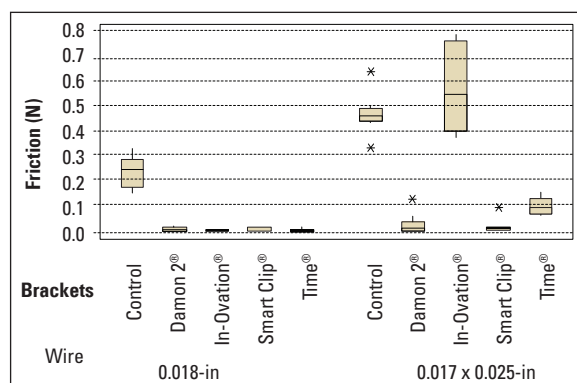


FIGURE 5 - Box plot chart showing the frictional force produced by the different brackets and wires in the tests.

orthodontic movement seems to depend more on static friction than kinetic friction, rendering the latter of little relevance in clinical practice.¹³ Therefore, this study focused on recording static friction force only.

As regards the materials tested in this study, no significant relationship was found between up to five test repetitions on the same specimen, and increases in static friction force. Kapur et al,⁷ however, noted, using scanning electron microscopy, the presence of changes in the bracket and/or archwire surface, such as scratches and wear on the slot walls and archwire surface, when they twice used rectangular wire segments in titanium or stainless steel brackets. They ascribed increases in friction force to these surface changes. Nonetheless, it is known that interaction between friction resistance and wear resistance is uncertain since this relationship is also influenced by material stiffness.¹² In this study, given the fact that only low friction systems were tested, which entail less interaction between archwire and bracket slot, the influence of possible changes in the bracket surface might not bear any special significance.

All brackets tested in this study had built-in angulation and torque. All brackets were bonded using the stainless steel 0.021x0.025-in device described before. This ensured the same archwire entry angle in all brackets, thereby eliminating the influence of the built-in angulation. It is known that the higher the torque, the lower the contact between archwire and slot walls. Although the Smart Clip® self-ligating brackets had 17° built-in torque and the other brackets 12°, this difference does not seem to have influenced the levels of friction found in this investigation. This may be linked to the fact that the archwires (0.018-in and 0.017x 0.025-in) do not fill the entire bracket slot (0.022x0.028-in).

The results showed that all self-ligating brackets exhibited similar friction force levels when tested with round 0.018-in stainless steel archwires, with values close or equal to zero. This finding may be related to the fact that there was 0° angulation between archwire and bracket slot walls during the tests. Since the archwire diameter was smaller than the slot size, the low friction reflects the absence of normal force.¹²

When tested with rectangular 0.017x0.025-in archwires, the In-Ovation R® and Time® brackets showed significantly higher levels of frictional force when compared with Damon 2® and Smart Clip®. This difference may be associated with the slot ligation system, which is considered active in the former two and passive in the latter two systems. It is known that the passivity of self-ligating brackets is determined by wire gauge (Fig 6).

Some studies^{5,15,16} comparing passive and active self-ligating bracket systems found results that resemble those found in this study. According to these investigations, conducted using small diameter wires, no significant difference was found between friction values. However, when rectangular arches were tested, active brackets showed more resistance to sliding than passive appliances.

In assessing the In-Ovation R[®] appliance, a significant friction force discrepancy was found between the use of 0.018-in and 0.017x0.025-in, underscoring the effect its ligation system has on friction, since this effect depends on the presence or absence of contact between ligation system and archwire, the surface structure of the wire, and the normal force exerted by the ligation system. It is

important, however, to consider the angulation of the archwire relative to the bracket slot since this variable was not included in this study, although it significantly affects resistance to sliding.^{3,17,18} Despite the fact that the In-Ovation R[®] appliance exhibited high levels of friction with rectangular wires in certain biomechanical conditions, this can mean an advantage in cases, for example, where the need arises to control torque in posterior teeth.

The results of this study showed that self-ligating brackets produce less friction than conventional orthodontic appliances. Since the efficacy of therapy using fixed orthodontic appliances depends, among other things, on the force fraction released relative to the applied force, theoretically, one can assert that low levels of friction force could render treatment more effective. However, one of the few studies that compared self-ligating brackets with conventional brackets⁹ during the alignment and leveling phase failed to clarify the true implications of these appliances in orthodontic practice. Other important issues involving the use of self-ligating brackets should also be considered, such as possible technical difficulties in handling these brackets, and especially, their higher cost.

Clinicians should be cautious when interpreting the results of laboratory studies on friction. In vitro studies on resistance to sliding using straight line static traction applied to the bracket/wire interface do not reflect with complete accuracy the complexity of tooth movement. However, it is still a widely used method of assessment, which may be applied to address issues raised by orthodontists with respect to friction reduction. Jost-Brinkmann and Miethke⁶ after in vivo and in vitro comparisons, concluded that friction forces of motionless brackets in laboratory appliances were similar to forces exerted in clinical appliances. This finding confirms that laboratory results contribute to a better understanding of the behavior of new orthodontic materials, especially when associated with subsequent clinical studies.

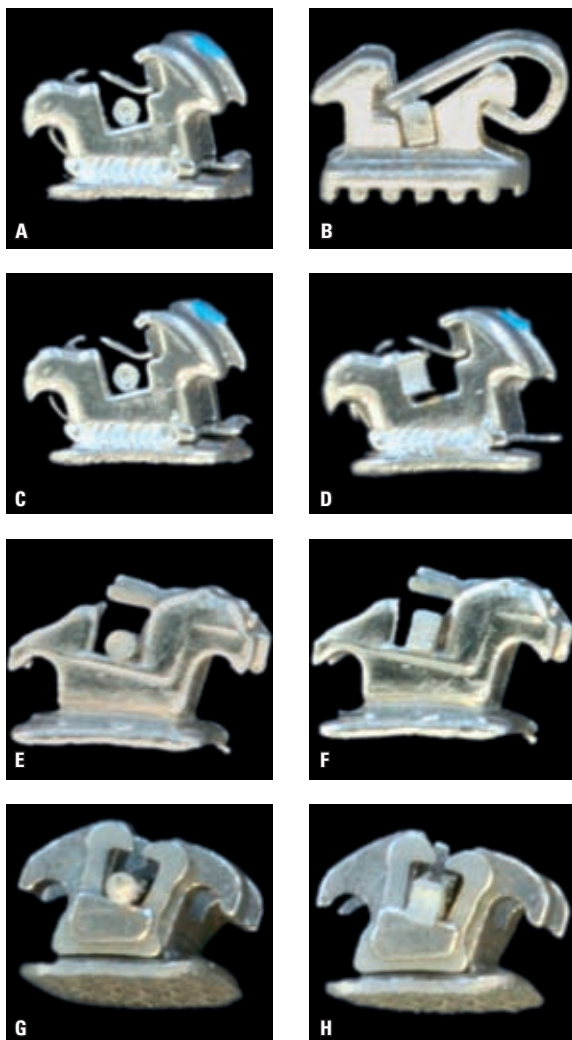


FIGURE 6 - Characteristics of the ligation systems of self-ligating brackets. In **A**, **C**, **E** and **G**, the Time[®], In-Ovation R[®], Damon 2[®] and Smart Clip[®], respectively, in tests using a round archwire do not show contact between ligation system and archwire. **B** and **D** show that the ligation systems of Time 2[®] and In-Ovation R[®] exert pressure on the rectangular wire; and **F** and **H** show no contact between the ligation system and the archwire when rectangular archwires are used with Damon 2[®] and Smart Clip[®].

CONCLUSIONS

- » All self-ligating brackets showed a significant reduction in friction with round 0.018-in archwires and can be considered a clinical alternative to minimize the undesirable effects of friction generated by conventional brackets when sliding mechanics is employed.
- » When tested with rectangular wires, active self-ligating brackets showed significantly higher friction than passive self-ligating brackets, with results statistically similar to conventional brackets using same caliber archwires.

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Qualitative evaluation in photoelastic experimental models of the force system generated by T-springs placed in the center of the interbracket space with pre-activations advocated by Burstone

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Abstract

Objective: To evaluate the force system generated by T-springs placed in the center of the interbracket space using the pre-activations advocated by Burstone. **Material and Methods:** Photoelastic models were used to assess T-springs fabricated with 0017"x0.025" rectangular titanium-molybdenum alloy wire (TMA), centrally positioned, with 6.0 mm activation, 3 mm activation, and in neutral position. To ensure reliable results, tests were repeated on three photoelastic models equally duplicated and fabricated by the same operator. An interbracket distance of 27.0 mm was used. For a better understanding of the results, the fringes were viewed in a polariscope, then photographed and qualitatively analyzed. **Results:** Through qualitative analysis of the fringe order in the photoelastic model it was noted that both the retraction and anchorage ends displayed force system symmetry across the full extent of the root.

Keywords: Orthodontic space closure. biomechanics

INTRODUCTION

When orthodontic treatment is administered with the aid of a detailed diagnosis premolar extraction is sometimes performed, which requires that orthodontists have an accurate knowledge not only of biomechanics for the closure of remaining spaces but of histological, anatomical and physiological principles.²⁴

Space closure may occur by distalization of anterior teeth, mesial movement of the posterior segment or a combination of both.^{4,21} At this stage it is important that health professionals choose the device to be used in accordance with the type of anchorage needed, noting the force system being released, so as to ensure adequate movement control without damaging the structures adjacent to the teeth.^{1-7,12,13,15,16,21,27,28,30}

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Considering this force system and the principles of the segmented arch technique,³ Burstone,⁶ in 1982, envisioned the T-spring, fabricated with titanium-molybdenum wire, cross-section size 0018"x0025" or 0017"x0.025", which would allow clinicians to work with enhanced predictability. Arguably, the force system thus released would be closely related to the amount of activation and incorporation of pre-activation bends,⁶ thereby making it possible to control the center of rotation of the teeth with a greater degree of accuracy.

In a unique manner, T-springs provide low force magnitude in high activation quantities.^{6,7,21,25,26,27,28,30} This is due to the type of alloy used and the substantial quantity of wire incorporated into its design. Clinically, this is very positive since the amount of activation is considerable while the loss of force is relatively low when compared to other space closure devices. Therefore, this device continues to provide satisfactory levels of moment/force (M/F) and load/deflection (L/D) ratios.

Scientific literature on studies of mechanical testing and clinical research shows that the Tspring advocated by Burstone⁶ delivers an efficient force system for controlled tooth movement, but little has been studied on this device using the photoelastic method.¹⁸ This method is

the qualitative observation and / or quantitative areas of tension in resin models that are optically visualized by order of the fringes, when subjected to tension.^{2,8,9,10,11,14,16,19,23,29}

Thus, the purpose of this study is to evaluate, in experimental photoelastic model, the system of force generated by spring T Burstone, centered in space interbracket, seeking, through qualitative analysis, support to complement the existing research.

MATERIAL AND METHODS

The photoelastic experimental analysis technique was used as it transforms internal mechanical forces into visible light patterns that indicate the location and magnitude of stress. It is based on the principle that when a beam of polarized light passes through a birefringent material differences in the speed of the beams can be observed with a polarizing filter. The equipment used for viewing the photoelastic effect was a circular polariscope (Fig 1) consisting of a lighting system (Fig 1A): A pair of polarizers (Fig 1B), a support to sustain the photoelastic model (Fig 1C) to be observed, and a camera to acquire images and analyze results^{19,23} (Fig 1D).

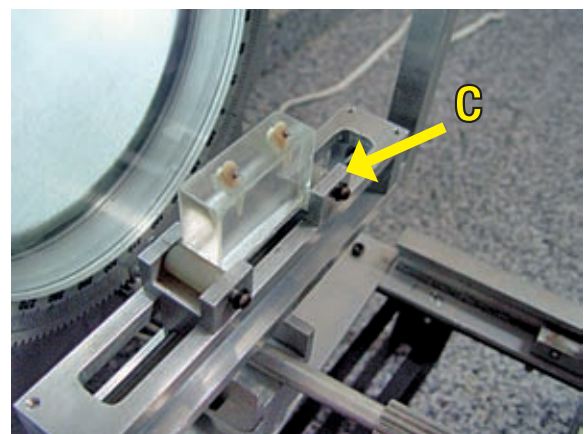
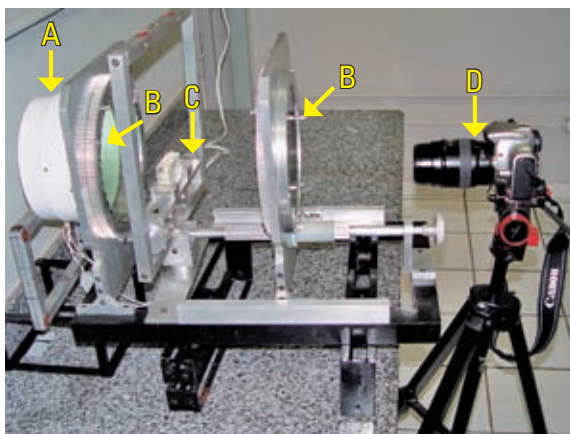


FIGURE 1 - Circular polariscope, designed and manufactured by Faculty of School of Mechanical Engineering, Federal University of Uberlândia, Minas Gerais State.

Initially, tests were performed on 5 experimental pilot models in order to determine proper methodology research, materials to be used, number of repetitions needed, model fabrication technique, reading technique and researcher calibration to ensure result accuracy.²³

The pilot study and literature review enabled the definition of criteria for obtaining the ideal materials and models in order to conduct the photoelastic tests, namely:

1. Fringe overlap was avoided. This phenomenon occurs when multi-rooted teeth are used, or else when the distance between the teeth is too small, causing fringes to overlap when forces are applied.
2. Materials were used that quickly return to their initial condition when force delivery ceases, and which do not exhibit residual stresses before and after such forces are suspended.²³
3. Ideally, the material used in fabricating the model should provide a high optical constant, low elasticity modulus, high optical and mechanical resistance, high strain and flexibility ratio. Moreover, it should be readily available, easy to machine, transparent, free from stains and residual stresses, and affordable.²³

After fabrication of the pilot models three photoelastic models were made with Formica based on a master model, measuring 60.0 mm in length, 40.0 mm in height and 20.0 mm thickness. To simulate and reproduce the position of canines in the photoelastic model two canine crowns were positioned and bonded with Loctite® universal instant adhesive (SUPER BONDER) at a distance that would allow the brackets to be positioned at 27.0 mm in future (Fig 2).

A utility wax box was made with the following dimensions: 120.0 mm wide, 140.0 mm long and 90.0 mm in height so that the master model could be positioned, and subsequently ASB-10 blue silicone rubber manufactured by Polipox Indústria e Comércio Ltda., São Paulo, Brazil, was poured and properly handled with a rubber catalyst man-

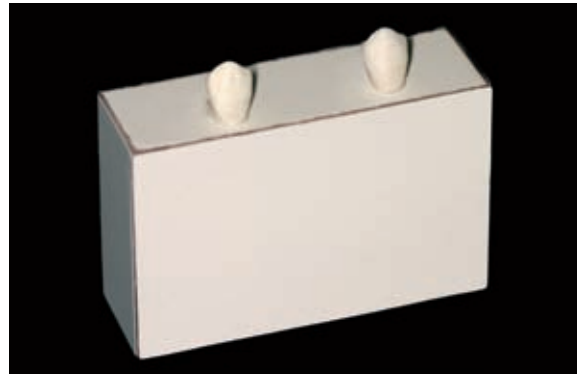


FIGURE 2 - Master model fabricated with Formica to serve as duplicator. Note position of canine crowns that will serve as parameters for photoelastic model.

ufactured by the same company (Fig 3) according to manufacturer's specifications, thus obtaining a negative mold. At this stage, other teeth were positioned in their respective sites while carefully preventing contamination by moisture and/or grease on the root surfaces of the canines and on the silicone. At this point, photoelastic epoxy resin was manipulated and used as inlay (Fig 4) to obtain the definitive photoelastic model.

In manipulating photoelastic resin, component A was gradually blended (20.0 ml) with component B (10.0 ml (Fig 5A and 5B) in a glass container scaled in milliliters. The two components were placed in a Becker and carefully manipulated for 10 minutes to prevent the incorporation of air bubbles. The mixture was then placed in an oven at a constant temperature of 25° C for 24 hours to complete the setting reaction. After this time period the model was removed from the mold. At this stage one needs to check the optical conditions of the photoelastic model in a polariscope. If the model does not display satisfactory optical properties,²³ which may interfere with the analysis, one should discard it and repeat the same steps over again until an ideal model is produced.

Once the photoelastic models had been defined and the insertion of a T-spring was in order, the authors chose to use crossed tubes. To this end, a vertical slot was drilled on the crowns of

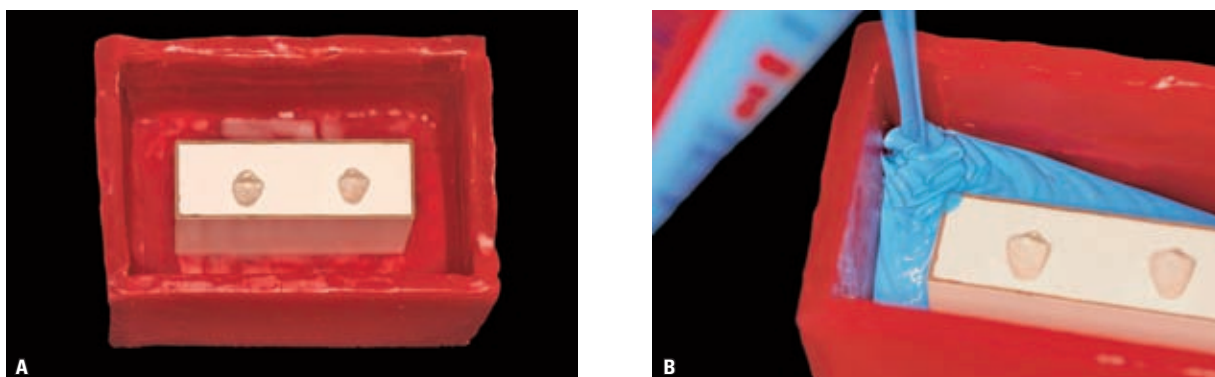


FIGURE 3 - ASB-10 Blue silicone rubber, poured after proper manipulation to obtain negative mold.

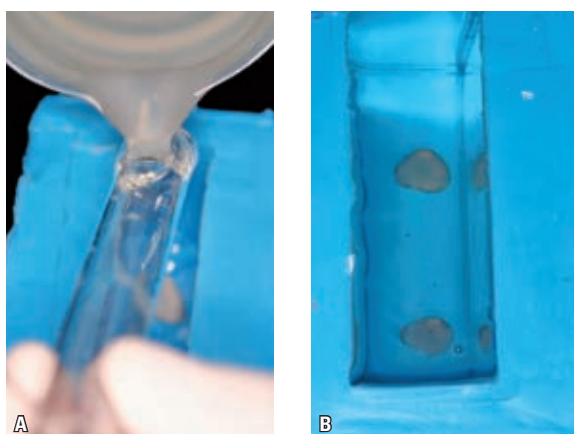


FIGURE 4 - After placement of teeth in their respective places, resin with photoelastic properties was manipulated and inserted it in negative mold to obtain photoelastic model.



FIGURE 5 - Photoelastic resin: **A)** COMPONENT "A" EPOXY resin, flexible CMR-201 and **B)** Component "B" Flexible CME-252 Hardener

the teeth where the tubes were fitted and bonded with acrylic resin (Fig 6).

For each model, a T-spring was used, made with titanium-molybdenum wire (TMA), with a cross-section of 0017"x0.025". In order to maintain the T-spring standard defined by Burstone⁶ when he first fabricated it, a template was made with the following measurements: 10.0 mm in length and 7.0 mm in height. At this point, pre-activation bends were incorporated into the spring, following the standard set by Burstone⁶ (Fig 7).

After checking the T-springs in neutral position, they were inserted into the horizontal slots of the crossed tubes, centered at an interbracket

distance of 27.0 mm and evaluated under three different activations: 6.0 mm, 3.0 mm and in neutral position (0.0 mm).

The tests were performed in the laboratory of Mechanical Engineering, Federal University of Uberlandia-MG (Department of Physics). Evaluation was conducted with a refraction polariscope and photographed with a digital camera.

After application of stress resulting from the installation and activation of the T-spring, reading of the fringe order was performed through the violet and blue interface as far as the distal, mesial and apical surface of each tooth. This distance would be used as reference to produce the

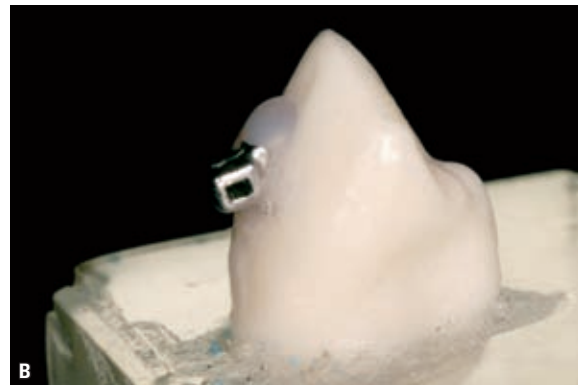
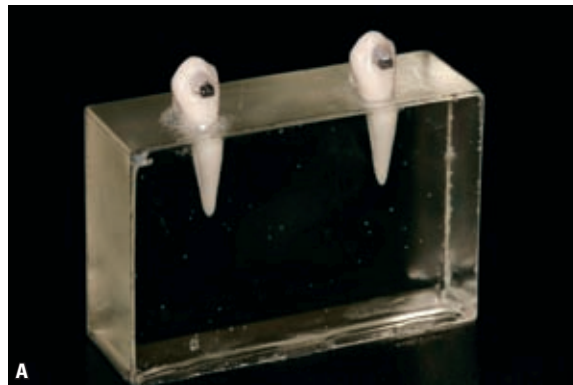


FIGURE 6 - **A)** Photoelastic model with crossed tubes in position. **B)** Close up of crossed tubes inserted to the crowns of acrylic teeth.



FIGURE 7 - Template for standardizing spring fabrication.

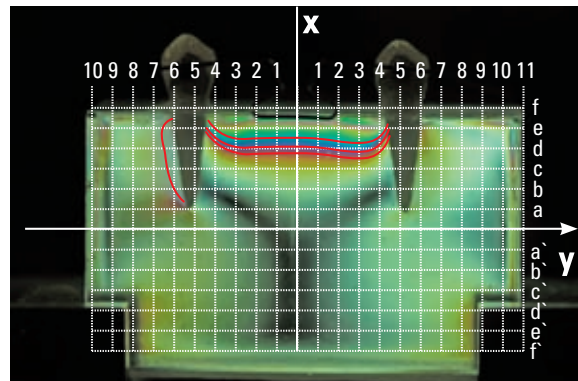


FIGURE 8 - Layout of Cartesian axis to facilitate reading of fringe order points on photoelastic model. **X Axis**, reading of fringe order with 0.5 mm variation. **Y Axis**, reading in millimeters with numerical and alphabetical nomenclature.

analysis charts. Between the lowest stress level and the highest stress level the following colors are formed: black, yellow, red, blue, yellow, red, green, yellow, red, green (Fig 8).

RESULTS AND DISCUSSION

Orthodontic literature has shown that several techniques are currently used for assessing the force system generated by the T-spring.^{6,7,12,15,17,21,25,27,28,30} On the one hand, mechanical tests^{4,6,7,15,21,25,27,28,30} and the finite element¹⁷ have proven that the T-spring can provide predictable results, thereby assuring its safe clinical use. On the other hand, clinical research¹² has demonstrat-

ed such efficiency through adequate results with no damage to adjacent tissues.

In this study, evaluation of the force system generated by the T-spring was performed according to the pre-activations suggested by Burstone,⁶ with the T-spring centered in the interbracket space and using the photoelastic experimental method for qualitative analysis of pressure and stress areas.^{1,2,8,9,10,11,14,16,19,23,29} This method is widely used in dentistry in the research of biomaterials, especially in the areas of prosthodontics, dental implants and occlusion, and consists of a method for direct visualization, in photoelastic models, of the effects occurring in these materials

when subjected to forces and/or stresses.^{2,8,9,10,19,23} Just as importantly, this method is also used in dentistry in the fields of surgery¹¹ and periodontics.¹⁴ It has been used in orthodontics since 1935, by Zak,³⁰ to assess the types of tooth movement that take place when forces are delivered from different points to the teeth. Since then, much research has been conducted in all dental specialties using photoelasticity. As a result, this evaluation method has been increasingly refined. However, studies often fail to clarify their methodologies. This tends to complicate the work of researchers, who are often unaware of such experiments and are therefore led to withdraw from them.

In this study, the results were obtained through qualitative reading of the fringes formed in the photoelastic models with the use of T-springs, centrally positioned and under the pre-activations recommended by Burstone⁶. Each spring was analyzed under three different activations, i.e., the first in neutral position, the second with a 3.0 mm activation, and the last with a 6 mm activation.⁶

Interpretations were evaluated descriptively and depicted in charts. Charts were made for the mesial, apical and distal root surfaces and analyzed separately, one at a time (Fig 9). The order of the fringes formed in the photoelastic model resulting from the stress caused by the activations was represented in a Cartesian axis showing a yellow line (neutral position), a blue line (3.0 mm activation) and a red line (6.0 mm activation).

Figure 10 shows that in the absence of a T-spring no photoelastic fringes are formed. The point located at the vertex of Figure A depicts a stress-free photoelastic model where the fringe order is 0.0 mm across the entire root surface of both teeth.

Upon insertion of Burstone's T-spring in neutral position (Fig 12), a fringe order with less than 0.5 mm was formed across the root surface. This means that in this qualitative analysis, although stress was equally distributed from the cervical region down to the root apex, apparently only a

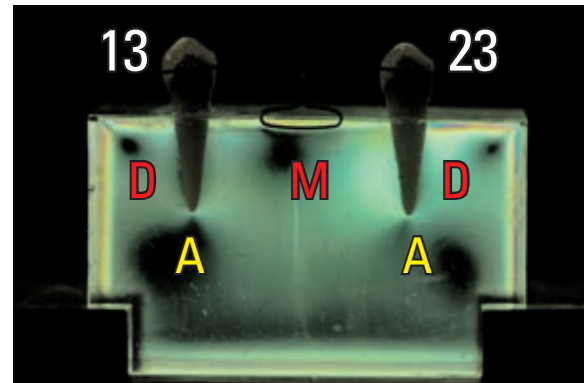


FIGURE 9 - Nomenclature suggested for reading and interpreting fringe orders on photoelastic model. **13** - Left tooth – observer's view. **23** - Left tooth – observer's view. **D** - Distal surface of teeth. **M** - Mesial surface of teeth. **A** - Apical surface of teeth.

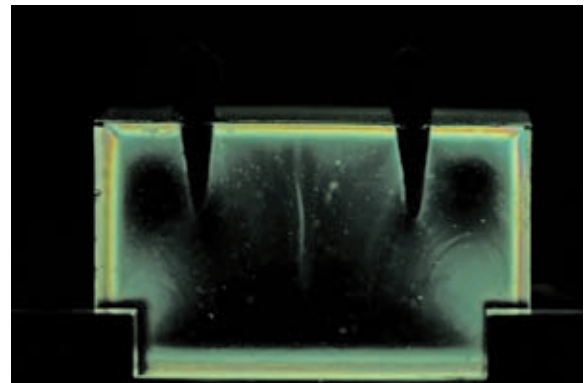


FIGURE 10 - In the absence of T-spring, fringe order of 0.0 mm observed through the polariscope, indicating absence of forces and moments.

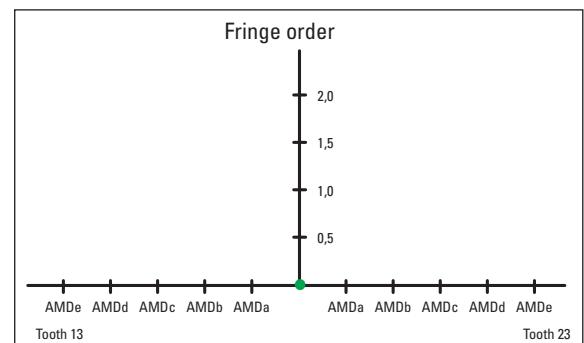


FIGURE 11 - The green dot at the vertex of the graph represents the fringe order zero.

small amount of energy or a very low force magnitude was applied to these teeth (Fig 15, 16, 17).

When the T-spring was given a 3.0 mm activation, stress was formed symmetrically with a fringe order of 1.5 mm in the cervical-most region of the mesial surface (Fig 13 and 15). In this

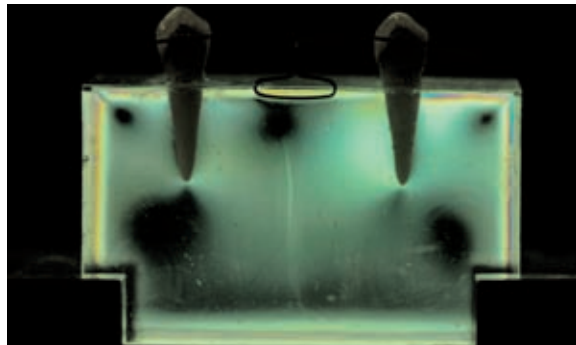


FIGURE 12 - Insertion of T-spring in neutral position generated fringe order very close to zero over entire root surface.

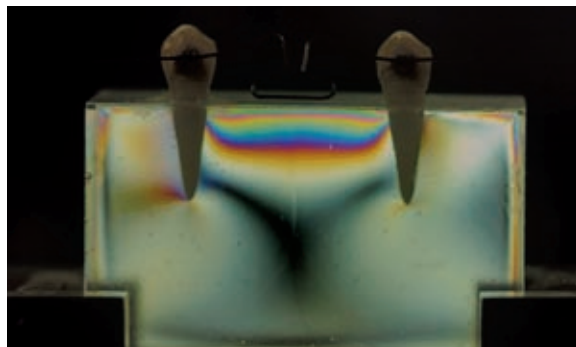


FIGURE 13 - View of photoelastic model with 3.0 mm activation.

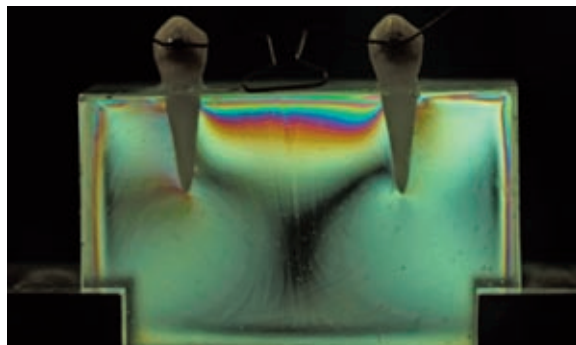


FIGURE 14 - 6.0 mm T-spring activation.

same activation, the fringe order on the apical surface (Fig 16) and on the distal surface of the roots (Fig 17) was smaller than 0.5 mm, showing that the stress generated in these regions is lower than the stress formed on the cervical region of the mesial surface, demonstrating that the onset of movement had characteristics indicative of controlled inclination.

The 6.0 mm activation (Fig 14) showed fringes across the entire mesial surface that were also symmetrical for both teeth. There was a fringe order of nearly 0.5 mm on the apical surface of tooth 13 and lower for tooth 23, suggesting a slight asymmetry in Burstone's T-spring or an asymmetry in its activation, or even an asymmetry during the fabrication process. This difference, however, was barely perceptible, indicating that this activation is likely to perform its expected functions, such as space closure through controlled inclination. The fringe order in the mesial region of the root located closest to the cervical third was 2.5 mm, suggesting that stress concentration is higher in this region. On the distal surface of the roots the fringe order was 0.0 mm, indicating that no significant stress occurs on this surface.

Scientific literature shows that when a T-spring is given maximum activation it promotes a controlled inclination movement and the greater its deactivation, the greater the M/F ratio in the tooth, bodily movement and root correction. Burstone and Pryputniewicz⁵ asserted that in anterior teeth the center of resistance is found at 1/3 of the space between the alveolar crest and tooth apex. They also stated that if a controlled inclination movement is to be achieved the device should release an M/F ratio of 7.1/11, and in order to generate translational movements and root correction this ratio should be, respectively, 9.9 / 1 and 11.4 / 1.

In 1984, Smith & Burstone²⁶ advanced that to attain a controlled inclination movement the M/F ratio should be 8/1, and for translation and

root movements the ratio should be 10/1 and 12/1, respectively. In this study, T-spring deactivation resulted in a loss of energy in the cervical mesial region and an increase in energy in the distal apical region. A change was observed from controlled inclination movement to bodily

movement, and finally root correction. At no time during this study was the formation of a fringe greater than 0.5 mm ever noted in the distal apical region of the tooth roots, which in this case would have demonstrated a tendency towards uncontrolled inclination movement.

Asymmetries were negligible, with a fringe order below 0.5 mm. Hypothetically, the emergence of these asymmetries may have been due to some interference in the central position of the T-spring, or else some asymmetry during fabrication in the final design of the T-spring.

Another important finding in the tests using photoelastic models was the symmetrical formation of photoelastic fringes under all activations. In comparing the results depicted in the charts, similar values could be found for both teeth (13 and 23) in the distal, mesial and apical regions, suggesting that, regardless of the T-spring activation, when the T-spring is centered in the interbracket space, the M/F and L/D ratios will be identical for both the active unit (retraction) and the reactive unit (anchorage). This force system released between the segments of the active and reactive units was also observed in studies using mechanical tests^{4,7,24,27,28} i.e., moments of equal magnitude and in opposite directions are generated by a symmetrical V-shaped pre-activation bend. Moreover, when this end is inserted in the bracket slots an activation moment will be released. In 2006, Thiesen et al³⁰ reported that the greater the pre-activation bend, the greater the M/F ratio.

The use of a T-spring to close spaces is efficient in the opinion of many researchers. Hence the orthodontic community's interest in researching this type of orthodontic device from different angles, such as which wire cross-section to use, the type of alloy, moment/force and load/deflection ratios, the incorporation or not of helices into these springs, and height and length increases in its design.^{6,7,12,15,20,21,22,25,27,28,30}

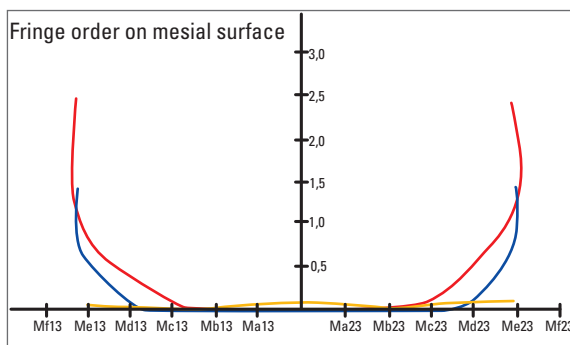


FIGURE 15 - Representation of the mesial surface.

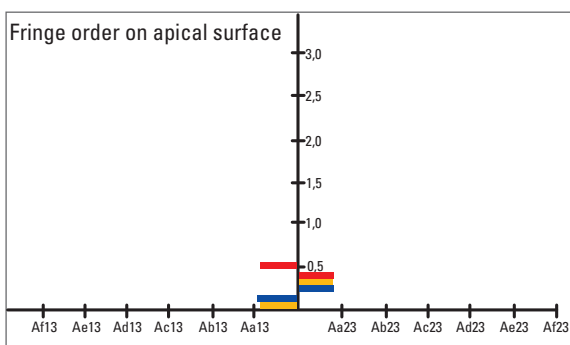


FIGURE 16 - Representation of the apical surface.

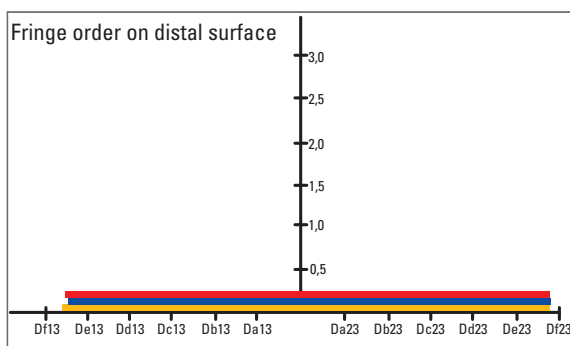


FIGURE 17 - Representation of the distal surface.

CONCLUSIONS

After implementing the experimental photoelastic method for qualitative analysis of the force system delivered by centered T-springs fabricated with 0.017"x0.025" TMA wire, the following conclusions could be drawn:

1. In neutral position, the T-spring displayed a very low fringe order across the entire root surface,
2. With a 3.0mm activation, the fringe order exhibited a tendency towards controlled inclination movement.
3. At 6.0 mm activation, the concentration of energy or force was clearly higher.
4. The fringe order did not show any characteristics indicative of uncontrolled inclination movement under any of the activations.

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Angle Class I malocclusion, with anterior open bite, treated with extraction of permanent teeth*

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Abstract

Open bite is an anomaly with distinct characteristics which, in addition to involving complex, multiple etiologic factors, entails aesthetic and functional consequences. Many alternative approaches have been employed to treat open bite, including palatal crib, orthopedic forces, occlusal adjustment, camouflage with or without extractions, mini-implants or mini-plates, and orthognathic surgery. By determining accurate diagnosis and etiology professionals can set the goals and ideal treatment plan for this malocclusion. This report, describing the two stages treatment of Angle Class I malocclusion with Class II skeletal pattern and anterior open bite, was presented to the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO), representative of category 2, as partial fulfillment of the requirements for obtaining the title of BBO diplomate.

Keywords: Angle Class I malocclusion. Open bite. Corrective orthodontics. Tooth extraction.

INTRODUCTION

Patient was a 12-year-old Caucasian girl referred by a speech therapist for orthodontic treatment and presented with a chief complaint of “lack of contact between the anterior teeth and altered position of canines.” During the interview, she reported having had a pacifier sucking habit until 5 years of age and having undergone adenotonsillectomy at age four. She was in good general health, with no history of serious illnesses or trauma.

DIAGNOSIS

Clinical examination revealed an increased lower face, lip incompetence, a slightly convex profile, obtuse nasolabial angle and good cervical-mandibular line (Fig 1).

Intraoral evaluation disclosed low risk for caries, healthy gums, molars and canines in normal occlusion, open bite that extended to the premolar region, maxillary atresia, 6 mm overjet, 2 mm lower midline deviation to the right side, and upper midline coinciding with the mid-palatine raphe (Figs 1 and 2).

* Case report, category 2 - approved by the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

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From a functional standpoint, she exhibited mixed breathing, predominantly oral, tongue thrusting and adapted swallowing and speech.

Panoramic radiography showed all permanent teeth, third molar crowns in formation, maxillary primary second molars in exfoliation phase and lower right second deciduous molar with ankylosis (Fig 3). It was also noted that the patient was in the stage of maximum pubertal growth spurt (Fig 4).

Cephalometric analysis was performed and revealed that both the maxilla and mandible were retruded in relation to the skull base. She had a Class II skeletal pattern ($ANB = 6^\circ$), predominance of vertical growth ($SN.GoGn = 43^\circ$), protruding upper and lower incisors ($1-NA = 5.5$ mm and $1-NB = 6.0$ mm), with decreased axial inclination ($1.NA = 19.5^\circ$ and $1.NB = 22.5^\circ$) (Fig 5 and Table 1).

TREATMENT GOALS (PHASE 1)

Initially, the goal was to eliminate the orofacial myofunctional disorder (adapted swallowing and speech), redirect facial growth by stimulating mandibular rotation in the counterclockwise direction to counter a growth tendency noted in the lower face and correct the anterior open bite.

TREATMENT PLAN (PHASE 1)

Planning for the first phase consisted in redirecting facial growth, correcting the Class II skeletal pattern and growth tendency in the lower face, using a modified Thurow appliance. This appliance was intended to prevent further vertical alveolar growth and stimulate mandibular rotation in the counterclockwise direction. The installation of a palatal crib was also planned, with



FIGURE 1 - Initial facial and intraoral photographs.

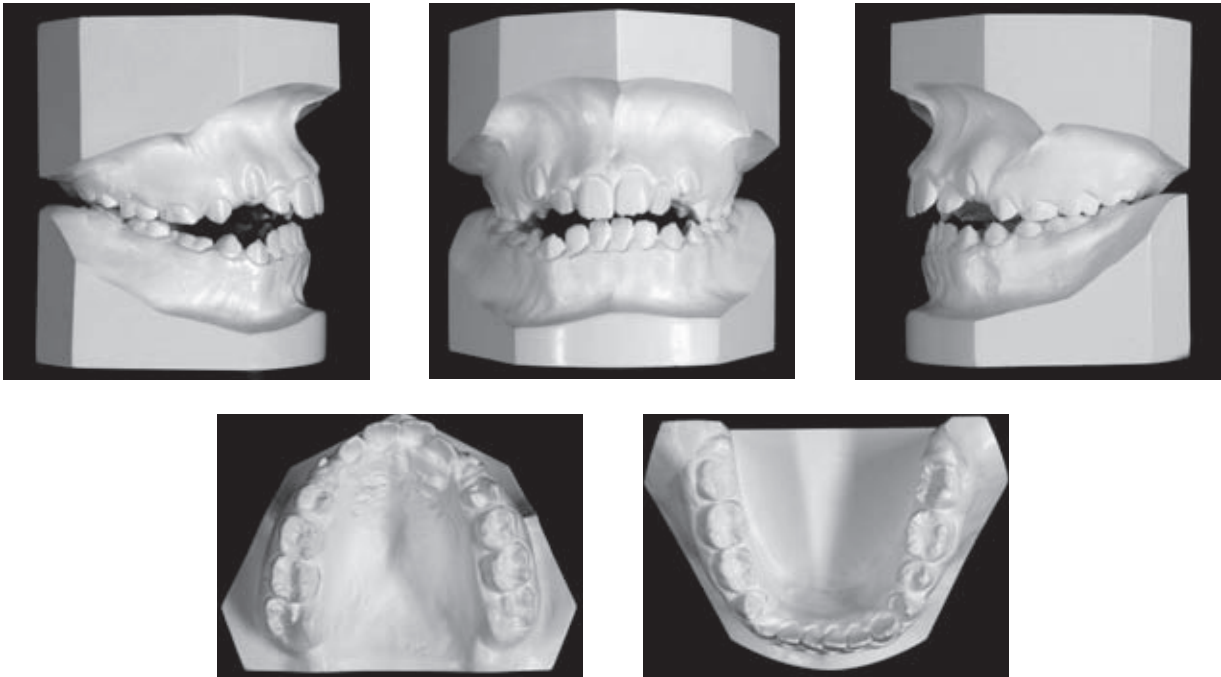


FIGURE 2 - Initial models.

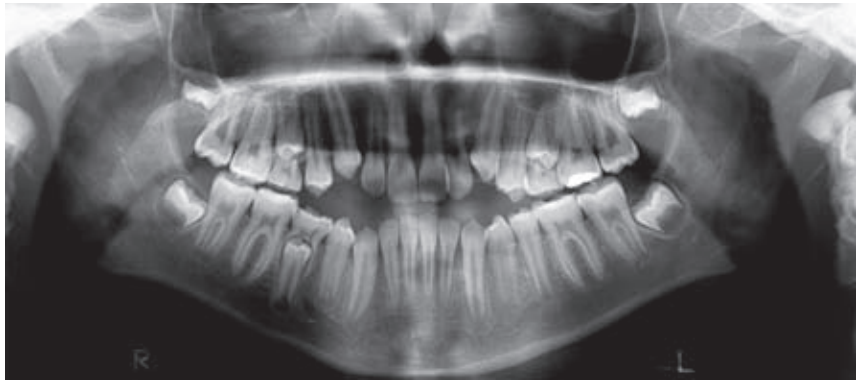


FIGURE 3 - Initial panoramic radiograph.



FIGURE 4 - Initial hand and wrist X-ray.

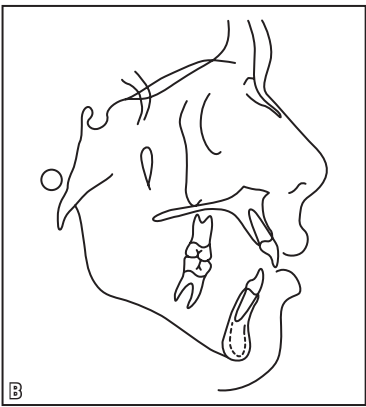


FIGURE 5 - Initial lateral cephalogram (A) and cephalometric tracing (B).

referral of the patient to a speech therapist to intercept the tongue thrusting habit. Additionally, her lower right second deciduous molar was extracted as it showed an abnormal root resorption pattern and ankylosis.

TREATMENT PROGRESS

A modified Thurow appliance was installed, combined with a palatal crib from premolar to premolar to control maxillary vertical growth and prevent the tongue from being placed in the anterior region. In addition, speech therapy was started to treat the orofacial myofunctional disorder. The patient was followed up on a monthly basis during the treatment period, which lasted for twelve months.

The use of a modified Thurow appliance was discontinued when all permanent teeth had erupted.

The Class III molar relationship was evident due to a distalization component in the Thurow appliance, and a slight posterior crossbite which appeared over time.

RESULTS (PHASE 1)

After evaluating all models and radiographs at the end of this phase it was found that the proposed objectives had not been achieved since the bite remained open and vertical growth was not reduced (SN.GoGn rose from 43° to 44°, Y-axis, from 65° to 68°, and FMA, from 33° to 37.5°). This result was probably due to the sharply vertical growth pattern displayed by the patient. Overjet was reduced from 6 mm to 4 mm and a slight improvement was noted in the Class II skeletal pattern, with ANB dropping from 6° to 5.5° (Figs 6 – 10).



FIGURE 6 - Intermediate facial and intraoral photographs.

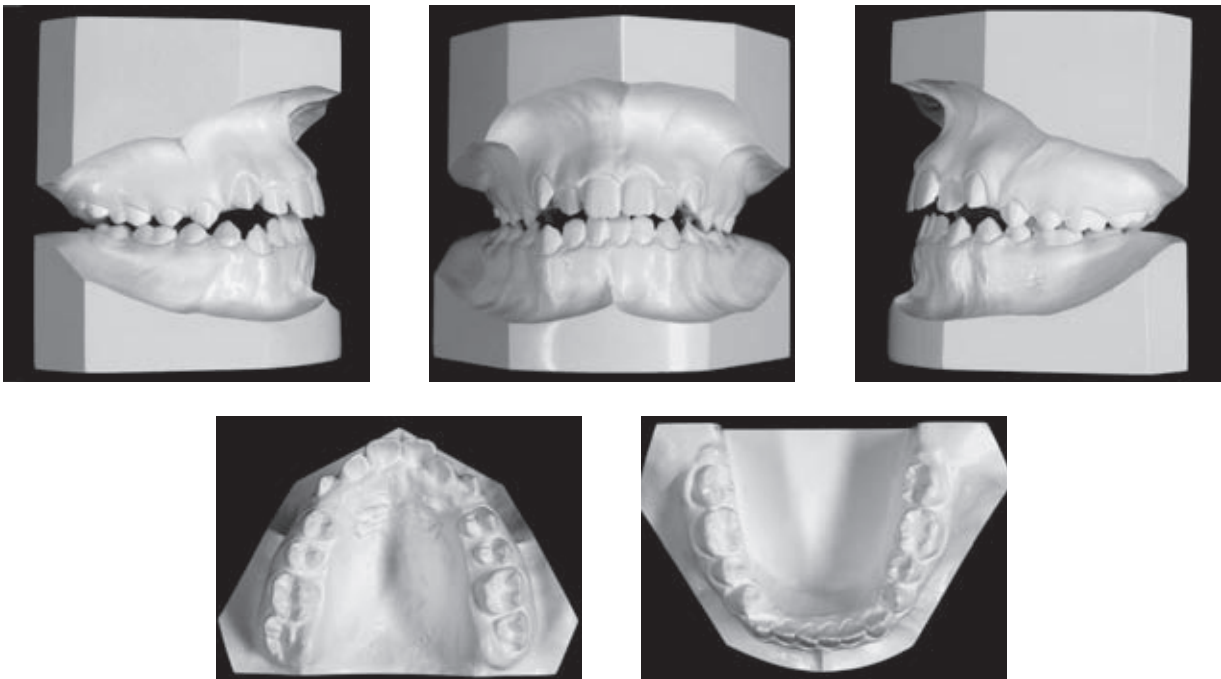


FIGURE 7 - Intermediate models.

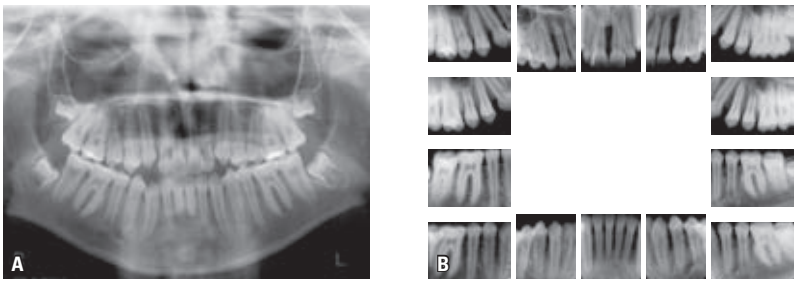


FIGURE 8 - Intermediate panoramic (A) and periapical (B) radiographs.



FIGURE 9 - Intermediate hand and wrist X-ray.

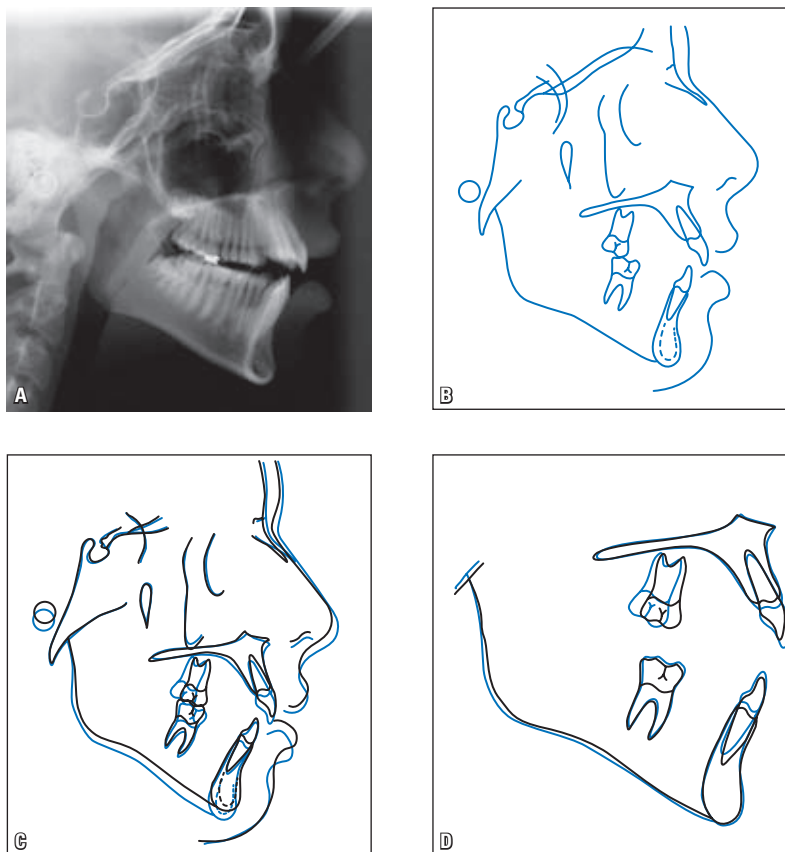


FIGURE 10 - Lateral cephalogram (A) and cephalometric tracing (B). Total (C) and partial (D) superimpositions of initial (black) and intermediate (blue) cephalometric tracings.

TREATMENT GOALS (PHASE 2)

In the second phase, the goal was to correct the mild crossbite that resulted from wearing the modified Thurow appliance, control the clockwise rotational tendency in the mandible and balance the lower face, eliminating the orofacial myofunctional disorder (adapted swallowing and speech) to establish correct overbite and overjet, normal molar and canine occlusion, correct the Class II skeletal pattern, as well as align and level all the teeth, thereby correcting the lower midline.

TREATMENT PLAN (PHASE 2)

At this treatment stage, correction of the slight crossbite was planned by installing a Haas expander. Mandibular growth control was achieved with

an anterior vertical-pull chin cup, while speech therapy was maintained to correct the orofacial myofunctional disorder. Concurrently, fixed orthodontic appliances were set up on both arches to perform corrective treatment with extraction of the first upper and lower premolars.

TREATMENT PROGRESS

The anterior vertical-pull chin cup was installed for night use, with an orthopedic force of 400 g on each side, to redirect mandibular growth. Then a Haas expander was cemented to correct the slight crossbite, with 0.25 mm activation until overcorrection was achieved. A standard Edgewise fixed orthodontic appliance was set up (no torques or angulations, slot 0.022x0.028-in), with bands cemented to

the first upper and lower molars and brackets bonded to the other teeth, except for the first upper and lower premolars, which were extracted.

Alignment and leveling were performed as well as torque correction using nickel-titanium 0.012-in and 0.014-in wires, and stainless steel 0.016-in to 0.020-in wires. From the moment that round 0.020-in wires began to be utilized, elastic chains were inserted for closure of extraction spaces, with anchorage loss. Next, stainless steel 0.019x 0.025-in archwires were fabricated for incisor and canine retraction, with posterior anchorage loss. At this stage, intermaxillary elastics were used to improve intercuspation and finishing. After completion and verification that the main treatment goals had been achieved, the fixed orthodontic appliance was removed. A removable maxillary retainer was installed

with a wraparound-type archwire, in addition to a fixed lingual canine-to-canine retainer made with 0.032-in stainless steel wire. The patient was instructed to wear the upper retainer 24/7 during the first year, and at night during the second year. The mandibular bonded retainer was kept indefinitely.

TREATMENT RESULTS

Crossbite correction was accomplished with the Haas expander, and redirection of mandibular growth performed with anterior vertical-pull chin cup. Upon orthodontic treatment completion, adequate improvement was achieved in lip competence and facial profile (Fig 11). Occlusion was deemed very satisfactory (Figs 11 and 12), showing molars and canines in normal occlusion, adequate overjet and overbite, good dental arch



FIGURE 11 - Final facial and intraoral photographs.

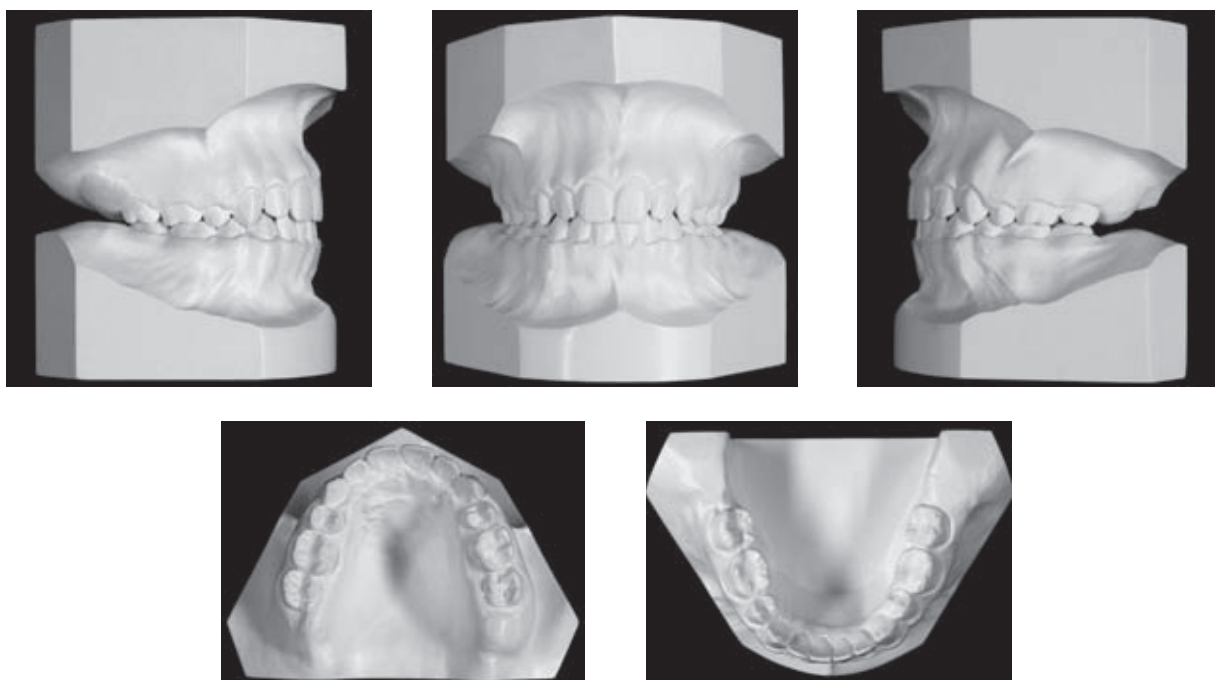


FIGURE 12 - Final models.



FIGURE 13 - Final panoramic radiograph.

FIGURE 14 - Final lateral cephalogram (A) and cephalometric tracing (B).

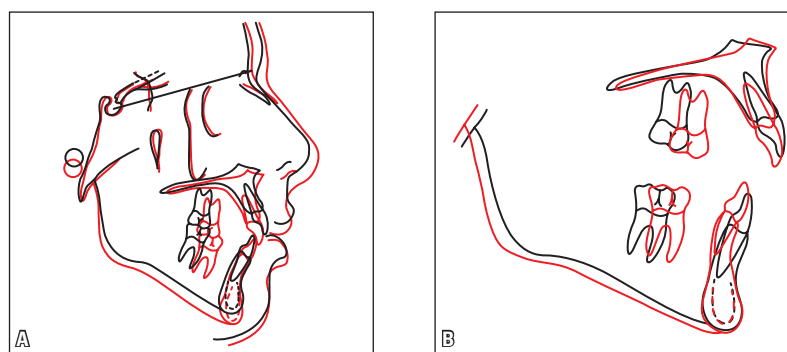


FIGURE 15 - Total (A) and partial (B) superimpositions of initial (black) and final (red) cephalometric tracings.



FIGURE 16 - Facial and intraoral control photographs taken two years and three months after treatment completion.

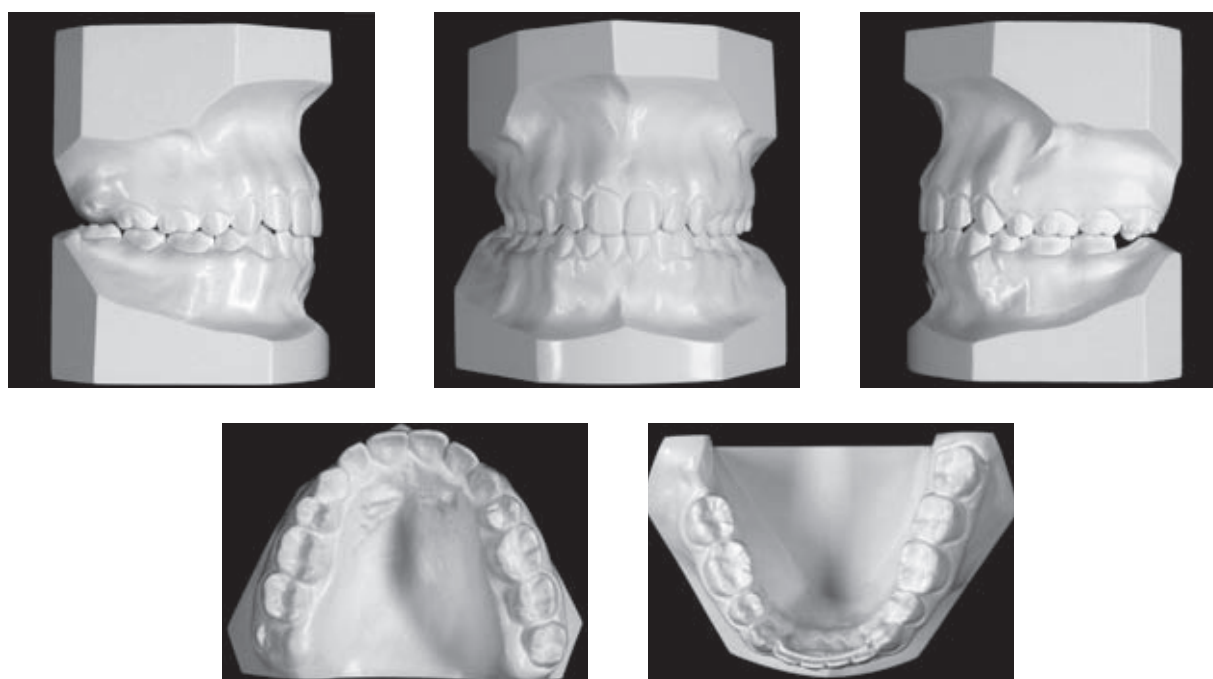


FIGURE 17 - Control models, two years and three months after treatment completion.

form and no undesirable effects to the periodontium. Cephalometric measurements did not experience major changes as ANB remained at 5.5° , SN.GoGn remained at 44° and Y-axis increased from 68° to 70° (Fig 14 and Table 1). Two years and three months after the end of treatment,

cephalometric measurements suffered minimal changes (Table 1) and occlusion remained stable (Figs 16 – 19). It is noteworthy that the patient had been instructed to have maxillary and mandibular third molars extracted, but had hitherto extracted only tooth 38 (Fig 18).

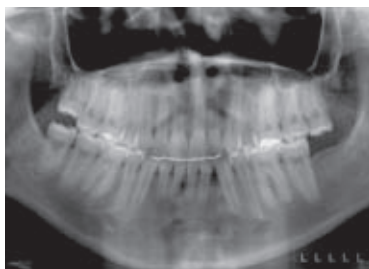


FIGURE 18 - Control panoramic radiograph two years and three months after treatment completion.

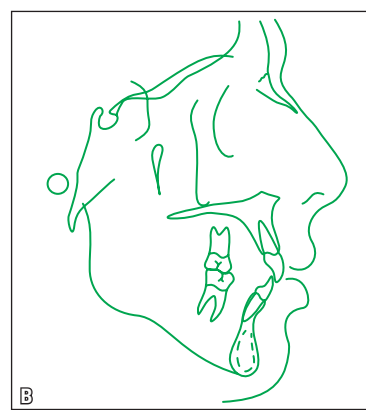


FIGURE 19 - Control lateral cephalogram (A) and cephalometric tracing (B), two years and three months after treatment completion.

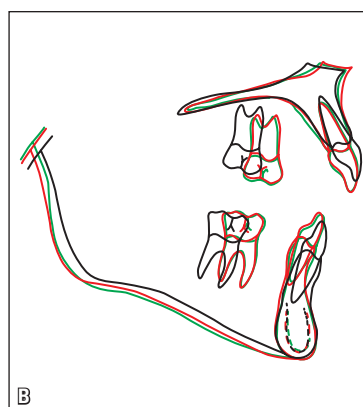
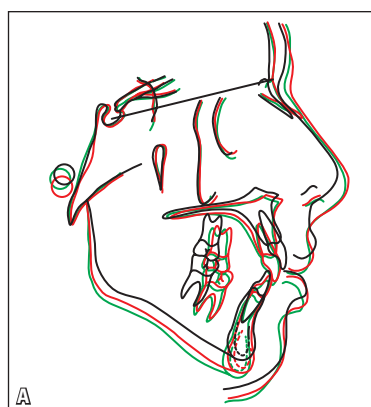


FIGURE 20 - Total (A) and partial (B) superimpositions of cephalometric tracings: initial (black), final (red) and two years and three months after treatment completion (green).

TABLE 1 - Summary of cephalometric measurements.

	MEASUREMENTS	Normal	Initial (A)	A ₁	Final (B)	Difference A/B	C
Skeletal Pattern	SNA (Steiner)	82°	79°	77.5°	77°	2°	76°
	SNB (Steiner)	80°	73°	72°	71.5°	1.5°	70.5°
	ANB (Steiner)	2°	6°	5.5°	5.5°	0.5°	6.5°
	Convexity Angle (Downs)	0°	8°	9°	9°	1°	9°
	Y-Axis (Downs)	59°	65°	68°	70°	5°	68°
	Facial Angle (Downs)	87°	84°	80°	79°	5°	82°
	SN – GoGn (Steiner)	32°	43°	44°	44°	1°	44.5°
	FMA (Tweed)	25°	33°	36°	35.5°	6.5°	35°
Dental Pattern	IMPA (Tweed)	90°	86.5°	89.5°	92°	5.5°	94°
	$\underline{1}$ – NA (degrees) (Steiner)	22°	19.5°	19.0°	15°	4.5°	15°
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	5.5 mm	5.5 mm	2.5 mm	3 mm	3 mm
	$\overline{1}$ – NB (degrees) (Steiner)	25°	22.5°	25°	28°	5.5°	28°
	$\overline{1}$ – NB (mm) (Steiner)	4 mm	6 mm	6.5 mm	7 mm	1 mm	6.5
	$\frac{1}{1}$ – Interincisal Angle (Downs)	130°	132°	131°	133°	1°	131°
	$\overline{1}$ – APo (mm) (Ricketts)	1 mm	2 mm	2.5 mm	2 mm	0 mm	2.5
Profile	Upper Lip – S Line S (Steiner)	0 mm	1 mm	1 mm	0 mm	1 mm	0 mm
	Lower Lip – S Line (Steiner)	0 mm	3 mm	3 mm	2.5 mm	0.5 mm	2 mm

FINAL CONSIDERATIONS

Open bite is an anomaly with distinct, easily recognizable features that can be found in 25% to 38% of orthodontic patients.¹⁻⁴ Several etiological factors are involved in this type of malocclusion, such as: Facial growth pattern, sucking habits, tongue posture, mouth breathing, enlarged adenoids, syndromes, occlusal and eruption forces, dental ankylosis and mandibular posture imbalance. Other factors such as case severity and timing of treatment initiation can render correction harder and produce unstable results.^{5,6,7} Palatal crib⁵⁻⁸, bite-block,^{9,10} modified Thurow appliance,¹¹

orthodontic camouflage,^{12,13,14} magnets¹⁵, mini-implants¹⁶, mini-plates^{17,18} and orthognathic surgery.¹⁹ To ensure that the most appropriate therapy is employed, it is necessary to establish a correct diagnosis and treatment plan.^{14,20,21}

With advances in surgical techniques and the growing popularity of mini-implants^{14,16} many patients with anterior skeletal open bite do not favor any options that might subject them to a surgical procedure and prefer to undergo camouflage orthodontic therapy, as was the case with this patient.

When the surgical option is rejected, treatment requires a longer period of time and greater

patient compliance. Some authors, like Subtelny and Sakuda,⁵ and Epker and Fish²² argue that palatal cribs are unable to correct open bite, with the exception of cases with a favorable growth pattern and Class I malocclusion. In this case report, tongue thrusting was treated with a palatal crib combined with a modified Thurow appliance and speech therapy. The modified Thurow appliance has the function of controlling maxillary vertical growth and, consequently, displacing the mandible in the counterclockwise direction. After twelve months, it was observed that the mechanics employed in this case was not effective in closing the bite and was not able to promote cephalometric changes (Table 1), probably due to lack of patient cooperation and her excessive vertical growth.

In general, stability is the most important criterion in choosing the method for treating open bite as this malocclusion can prove difficult to control. Authors such as Goto et al.²³ argue that treatments with extractions do not show stability since retraction of anterior teeth can encroach upon the tongue area. On the other hand, Janson et al.³ and Vaden²⁴ claim that treatments with extractions allow greater stability since retraction, associated

with anchorage loss, promotes bite closure, thereby decreasing the need for vertical elastics and the need to perform correction by extruding anterior teeth. In addition, extractions can often help in achieving lip seal¹⁴ as they allow retraction of the upper and lower incisors.²³

Camouflage orthodontic therapy is a treatment option and as such obviously has indications and contraindications. Factors such as age, bone maturation, facial profile and pattern should be considered before opting for this method.¹⁴ In this case, it could be stated that a successful orthodontic treatment was performed with extraction of upper and lower premolars since normal occlusion of molars and canines, as well as normal overjet and overbite were ultimately achieved. It is noteworthy that the occlusion observed on treatment completion was achieved through controlled orthodontic mechanics and the brief use of intermaxillary elastics limited to finishing rectangular archwires. Restraining the use of vertical elastics was designed to prevent extrusion, uneven teeth and damage to the periodontium, such as gingival recession. The stability achieved in this case can be attested by the control records two years and three months after treatment (Figs 16 and 17).

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Rapid canine retraction

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Abstract

Introduction: Rapid canine retraction through distraction of the periodontal ligament is a tooth movement technique that allows space closure of first premolar extraction space within a period of two to three weeks while providing significant reduction in orthodontic treatment time. **Objective:** To propose changes in the original surgical technique and in the placement of distractors. **Conclusions:** Rapid canine retraction is a technique that provides significant reduction in orthodontic treatment time. Changes in the surgical technique provided greater speed and safety in surgery. As a minimum benefit, when positioned palatally, distractors helped to preserve the buccal bone plate and prevented canine proclination.

Keywords: Distraction osteogenesis. Tooth movement. Orthodontic space closure.

INTRODUCTION

Distraction osteogenesis is a process whereby new bone is grown by mechanically stretching a pre-existing bone tissue. It was made popular in studies by Ilizarov,⁶ who showed in hundreds of patients that new bone could be formed after surgical corticotomy followed by distraction osteogenesis.

In 1998, Liou and Huang¹¹ introduced the concept of distraction osteogenesis in tooth movement. These authors noted that the process of periodontal ligament osteogenesis during tooth

movement induced by orthodontic forces is similar to that of the midpalatal suture during rapid palatal expansion performed for crossbite correction. The key difference is in the amount of movement. While in orthodontic tooth movement the teeth move at a rate of approximately 1 mm per month,^{14,15} in rapid palatal expansion the suture is separated by 1 mm per day. Thus, the authors devised a way to stretch the periodontal ligament at the same speed as the midpalatal suture to enable rapid canine movement in patients who required

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first premolar extraction. This technique has been named dental distraction (DD).

In 2002, Kisinisci et al⁸ introduced another technique for rapid canine retraction. In this approach, known as dentoalveolar distraction (DAD), the segment that contains the canine is transported as a bone block. It differs from the technique advanced by Liou and Huang¹¹ to the extent that the periodontal ligament is not stretched. They performed a bone separation from the bone block containing the canine using corticotomies to allow the tooth to move along with the bone that surrounds it through a distraction osteogenesis process.

Regardless of the technique, Rapid Canine Retraction (RCR) has proven well suited for the following clinical situations: Severe crowding, Class II Division 1 malocclusions, bialveolar protrusion, root shortening and malformation, as well as in patients presenting with periodontal problems.^{2,3,7,8,11,16} These indications are justified by the fact that, since tooth movement is accomplished very quickly, with the canine being completely distalized in about two to three weeks without anchorage loss, the remaining space can be used for the rapid resolution of crowding. During conventional orthodontic movement, the process of root resorption only begins two or three weeks after the application of a given force, and may continue for as long as this force continues to be delivered.^{9,11,15} Moreover, since RCR allows canines to complete all distal movement while the remaining teeth are still stationary,⁴ both the mesial movement of molars, i.e., loss of anchorage, and root resorption either have not yet taken place or are still just beginning.^{7,8,11,12,13,16,17} This benefits those patients who require premolar extractions and present with major periodontal issues.

RCR features the following key advantages: A significant reduction in treatment time from 6 to 9 months, elimination of intra or extra oral anchorage during the procedure, which ensures nearly

complete anchorage preservation, added to the fact that it does not damage the periodontium, nor does it affect pulp vitality.^{2,3,8,10,11,16,17,18} Disadvantages include the need for a specific surgical procedure and a supervised activation protocol, in addition to difficulties in fabricating distractors using Hyrax-type expanders, as devices suitable for this purpose are not yet available on the domestic market.

The aim of this study was to suggest changes to the surgical technique and the placement of distractors used in RCR, and demonstrate through clinical cases the reduction in treatment time afforded by this new tooth movement protocol.

DISTRATOR FABRICATION

The distractor has been fabricated in the manner described by Faber² from a conventional Hyrax expander. The latter should be opened according to the number of millimeters that one wishes the canines to distalize, plus at least 2 mm. Preferably, a 13 mm screw should be used, which due to its greater length provides greater stability after opening. A longitudinal section is performed eliminating one of the rods of the Hyrax and the sharp edges are then rounded off (Fig 1). Proper polishing is required to ensure greater patient comfort.

Bands are fabricated for the canines and first molars, and a transfer impression is made to allow the welding of the distractor to the bands once these have been positioned on the working model. The original arrow on the screw should be pointing towards occlusal to facilitate activation and prevent forces from moving the distractor during the activation process. Thus, as activations will be made in the opposite direction of the arrow, it decreases the likelihood that the device be displaced.

After verifying that the distractor is properly installed, but before cementing it, it is important that the screw be once again completely closed and opened. To this end, an anti rust spray for use on screws is applied (White Lub® - Sema Produtos Químicos/ Mogi of Cruzes/ SP/ Brazil). This procedure removes any residues that may have

become attached to the screw thread during the manufacturing process, and that might compromise device operation. After this, it is washed with detergent and a brush, and sterilized before cementation.

ORIGINAL SURGICAL TECHNIQUE

During surgery, as originally described by Liou and Huang¹¹ in 1998, the first step to be performed is premolar extraction (Fig 2A). Then the premolar alveoli are deepened with a round bur until the entire length of the canine is exceeded by about 2 mm (Fig 2B). The interdental septum

located distal to the canine is then stripped till it is thin and fragile (Figs 2C and D).

The next step consists in performing corticotomies (grooves) in the interdental bone septum distal to the canine with a #701 bur (KG Sorensen/Cotia/SP/Brazil). Initially, two vertical grooves are made, one at the buccal edge and one in the palatine bone on the alveolar wall (Fig 3A). These corticotomies are then interconnected by a third (horizontal) corticotomy at its base, performed through intra-alveolar access (Fig 3B). Once the structure of the interdental septum is thus weakened, it facilitates canine movement (Fig 3C).

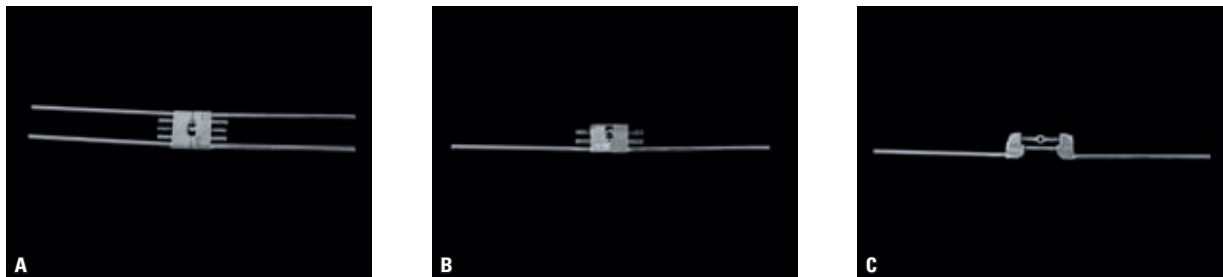


FIGURE 1 - Distractor fabrication: Original Hyrax screw (A), removal of one rod (B), and opening with edges which were rounded (C).



FIGURE 2 - Premolar extraction (A), tooth socket deepening (B) and reduction of interdental septum thickness (C, D).

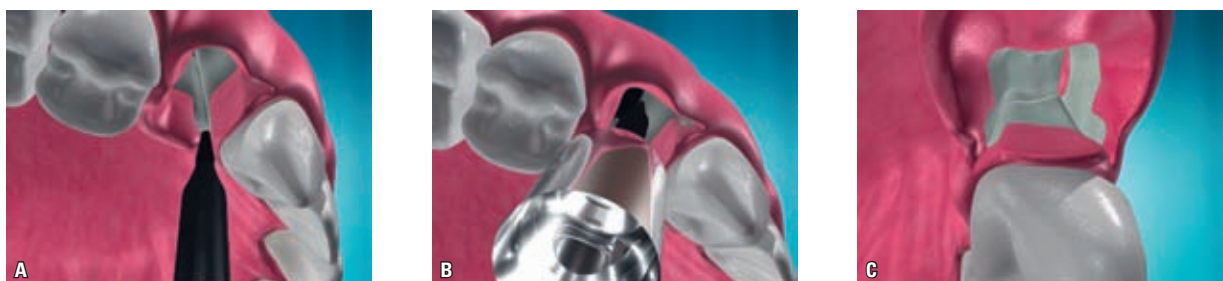


FIGURE 3 - Buccal and palatal vertical corticotomies (A); performance of horizontal corticotomy through intra-alveolar access (B) and occlusal view of prepared alveolus and three corticotomies (C).

MODIFIED SURGICAL TECHNIQUE FOR THE UPPER ARCH

After it was observed, in some cases, that the maxillary sinus was too close to the roots of premolars and canines, a slight modification in the surgical technique was proposed in 2007. Through an opening made in the buccal bone plate above the apex of the first premolar the sinus membrane was lifted to avoid the risk of injuries to this structure.¹⁶

After noting the ease of access in performing the buccal access, and considering the existence of bone fenestrations in the premolar region due to the thinness of the buccal bone plate in this region, this modification was incorporated in order to minimize the risk of injury to the root of the canine. This risk is due to technical difficulties involved in performing a horizontal corticotomy (above the apex of the canine) by intra-alveolar access in the upper arch (Fig 4).

After premolar extraction, before starting to deepen the alveolus, a 1.5 cm crescent-shaped incision is made in the alveolar mucosa above the root of the first premolar. By removing the periosteum the buccal bone plate is exposed. Normally, one finds an extremely thin cortex with some fenestrations already present at the extraction site, which facilitates the opening of a bone chamber (Fig 5A). From this opening, one can directly observe the deepening of the socket, as described above (Fig 5B). By increasing this opening in the apical direction, one can also accomplish through it, under direct vision,

a horizontal corticotomy above the apex of the canine without risks (Fig 5C).

This modification imparts increased speed and security to the surgery, although it does not completely eliminate the need for transoperative radiographs to verify that the alveolus is properly deepened above the apex of the canine. Such radiographs (Fig 6) are essential to ensure freedom from bone interference in the apical third. Should this not occur, regardless of the technique, the canine will not undergo bodily movement and will simply incline distally (Fig 7), which will cause the procedure to fail.



FIGURE 4 - Lateral view indicating difficulty in performing horizontal corticotomy via intra-alveolar access.



FIGURE 5 - Buccal access (A), direct visualization of deepening procedure (B) and horizontal corticotomy performed through buccal access (C).

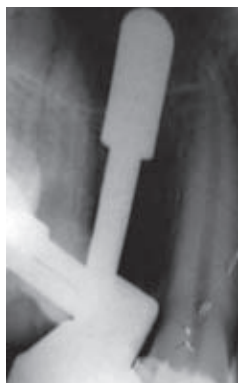


FIGURE 6 - Transoperative x-ray showing deepening of the tooth socket above canine apex.



FIGURE 7 - Panoramic x-ray indicating steep canine inclination after RCR due to difficulty in surgical technique.

ACTIVATION PROTOCOL

Distractor activation can be initiated immediately after surgery or after a latency period of up to seven days. The literature is not conclusive in this respect.^{1,2,3,7,8,11,16,17} The authors of this article have used this latency period in cases where the procedure was more invasive with considerable tissue manipulation.

Activations are always performed at the rate of 0.75 mm per day (three turns on the screw) at once, or divided into three activations of 0.25 mm during the day, for patient comfort.^{2,16} The process is painless and patients only report discomfort or pressure that dissipates within minutes.

BIOMECHANICAL CONSIDERATIONS

Although no specific work in the literature has ever evaluated the biomechanics of canine movement using this technique some important observations can be made based on the evaluation of cases treated by the authors.

According to the original work by Liou and Huang¹¹, which was confirmed by other authors,^{1,2,8,13,17,18} canines experience an average inclination of 15 to 20 degrees during distalization. This can be confirmed both in panoramic radiographs (Fig 8), and in Cone-Beam CT (Fig 9). This inclination, which decreases root apex movement, and therefore decreases neurovascular bundle

stretching may explain why no endodontic complications arise when using this technique.

In the vertical plane a significant extrusion of canines during retraction was clinically observed (Fig 10). To avoid inadvertent trauma until it is safe to perform a suitable leveling of the canines, it is necessary in some cases to temporarily raise the bite using glass ionomer cement (GIC) on molars during the procedure.

In the transverse plane, with the use of distractors placed through buccal access, distal rotation was observed, as well as canine proclination. This displacement simulates canine movement when using a segmented arch ("T" loop) for distalization in conventional orthodontic mechanics, without adequate control. Although RCR requires the use of a rigid device (distractor), and despite the existence of a tunnel formed by the buccal and palatal bone plates, since the distractor is positioned too buccally relative to the center of resistance of the canine, it depicts a movement with distal rotation and buccal inclination. In the upper arch, as shown in the occlusal photographs, the main side effect was buccal inclination, and the amount of inclination was directly related to the initial position of canines in the transverse plane, i.e., the more buccal, the greater the final inclination (Fig 11).

In the lower arch, the main side effect was distal rotation (Fig 12). Buccal inclination also

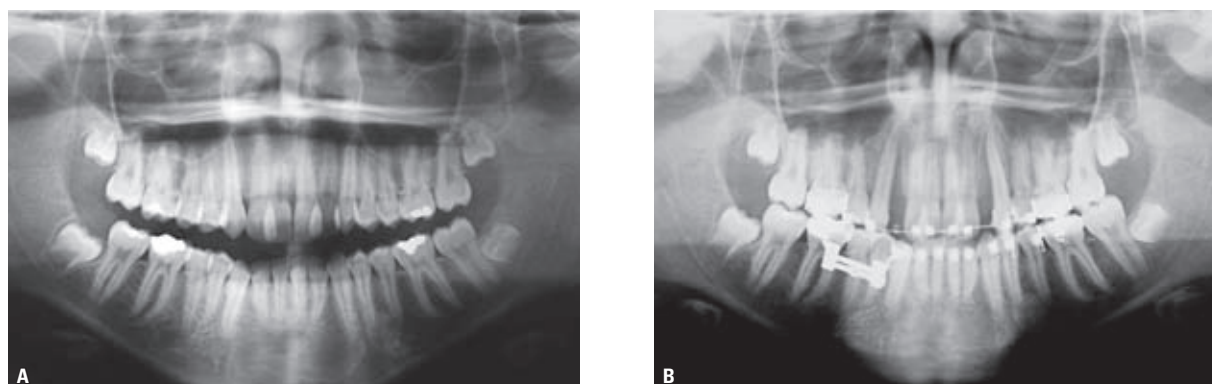


FIGURE 8 - Initial (A) and post-RCR (B) panoramic x-rays in upper arch showing change in axial inclination of canines.

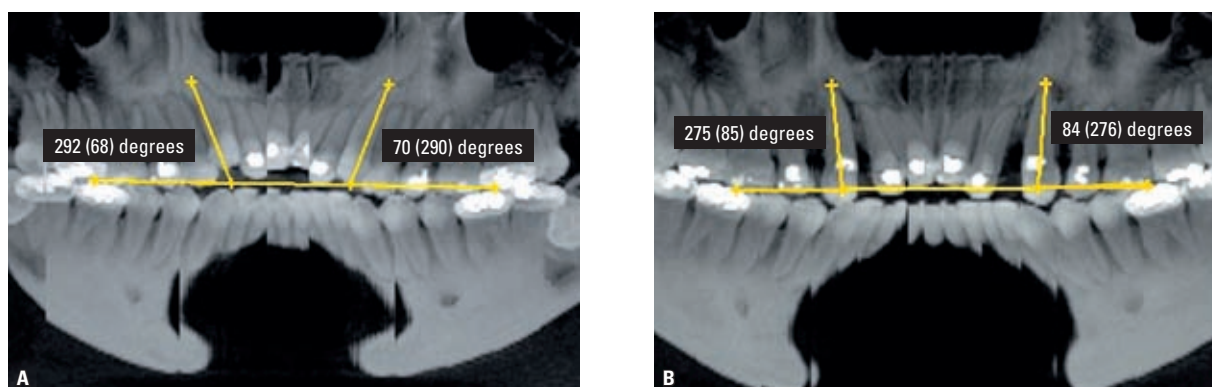


FIGURE 9 - Panoramic CBCT sections showing change in axial inclination of canines. Before (A) and after (B) RCR.

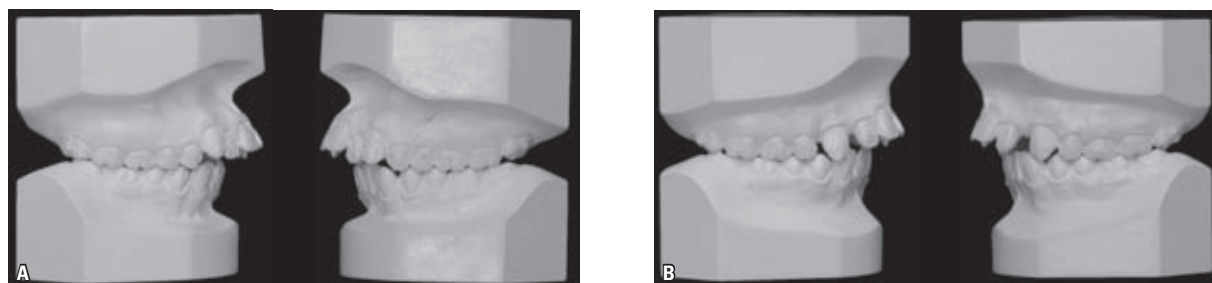


FIGURE 10 - Initial (A) and post-RCR (B) models showing significant retraction and extrusion of canines.

occurred, albeit with lower magnitude and variation. The fact that the initial axial inclination was more vertical in the lower canines, and the buccal bone plate thicker, may be explained by this difference between upper and lower canines. No effects of this procedure were noted on molars.

CHANGES IN DISTRACTOR

In order to avoid proclination of the maxillary canines during RCR in cases where canines are well positioned in the buccopalatal direction, or else to move them into the alveolar process in cases where they are initially proclined, some

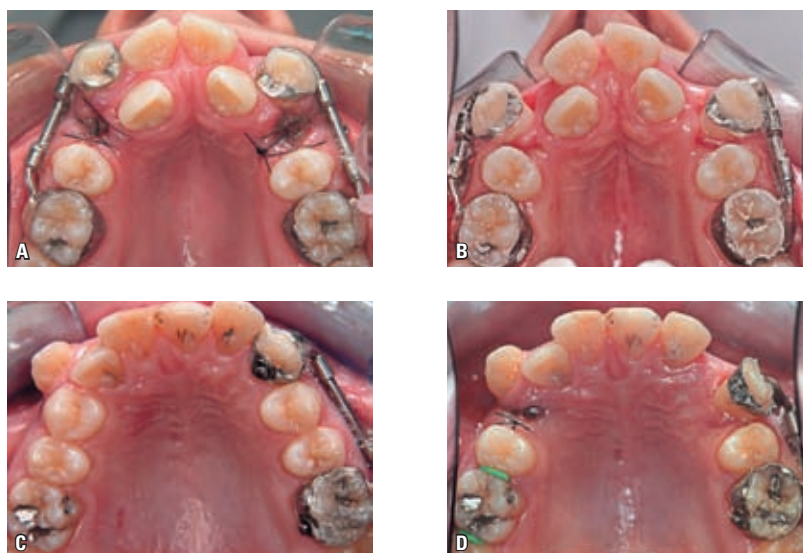


FIGURE 11 - Occlusal photos of movement of maxillary canines in two different cases, showing proclination. Before (A and B) and after (C and D) RCR.

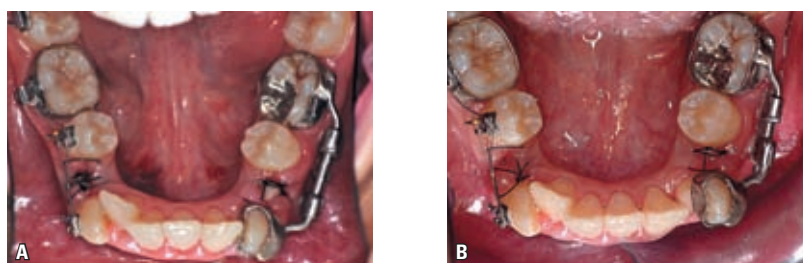


FIGURE 12 - Occlusal photos before (A) and after (B) RCR in lower arch, showing canine rotation.

changes were proposed in the manner in which distractors are fabricated and placed as a measure to prevent buccal inclination of the canines and thus preserve the thin buccal bone plate:

1) Palatal distractor: Made from a Hyrax screw without any clipping. Just turning it 90 degrees allows it to be used for retraction (Fig 13). Recommended for cases where the two canines are initially proclined as it enables moving both teeth into the alveolar process.

2) Asymmetrical palatal distractor: Similar to above, but with the addition of a slight turn when placing the device. Recommended for cases where one canine is proclined and the other well positioned (Fig 14).

3) Unilateral palatal distractor: Identical to the device advocated by Faber² and described above, but positioned via the palate. Suitable for canines in any position when the goal is to prevent buccal inclination (Fig 15).

These changes were designed to be a part of the RCR learning curve. Palatal distractors 1 and 2 feature the advantage of being easy to fabricate while eliminating the need for trimmings and adjustments, since these devices are nothing but Hyrax screws used in the sagittal direction. However, the cementation process is delicate because of differences between the positions of the canines and molars (mesial and buccal axial inclinations of canines) and if any interference occurs

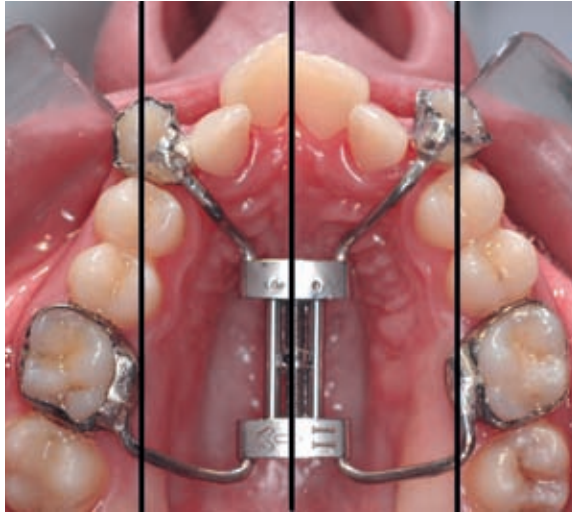


FIGURE 13 - Occlusal photograph of palatal distractor. Black lines indicate canine movement path.

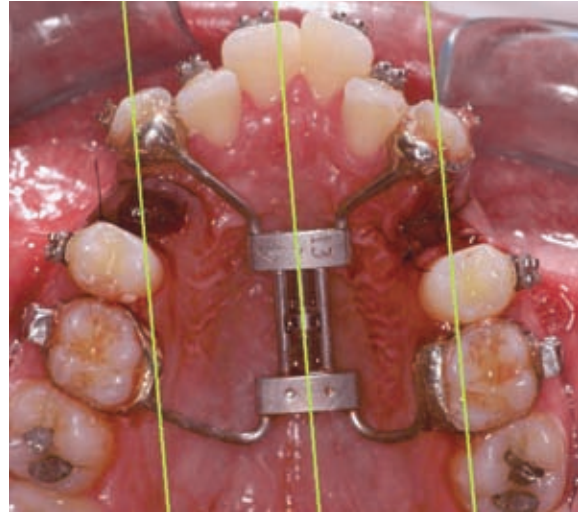


FIGURE 14 - Occlusal photograph of asymmetric palatal distractor. Green lines indicate canine movement path.



FIGURE 15 - Occlusal photograph of unilateral palatal distractor.

in canine movement linked to difficulties in the surgical procedure of deepening the tooth socket, simultaneous movement of the right and left canines will be impaired. The unilateral palatal distractor was launched recently and has proved to be a good choice as it allows good control in the transverse plane while maintaining each side independent from each other.

In the lower arch, given the difficulty in using distractor lingually, distractors have been used buccally. To avoid the rotation observed during canine movement, one usually seeks to weld the distractor as far toward the distal side of the canines as possible, thus minimizing the occurrence of rotation (Fig 16).

USE OF CONE-BEAM COMPUTED TOMOGRAPHY

CT has proven to be an important ally in the study of RCR. It allows for the proper planning of surgical time as it becomes possible to accurately determine how much the alveolus needs to be deepened in order to completely eliminate any interference with canine movement (Fig 17).

In conjunction with the buccal access proposed in the modified surgical technique, in some cases CT avoids the need for transoperative radiographs, thereby rendering the surgical procedure much faster and safer. It also provides an assessment of sinus and nasal floor proximity (Fig 18), enabling professionals to determine in advance the maximum drill length to be employed



FIGURE 16 - Lateral (A) and occlusal (B) photographs showing RCR prior to welding distractor to distal side of canine band. Occlusal photograph taken immediately after RCR showing good canine rotation control (C).

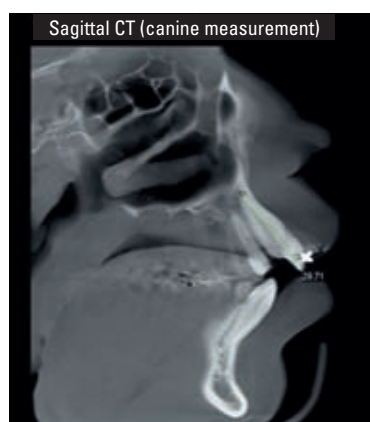


FIGURE 17 - Sagittal CT section for canine measurement.

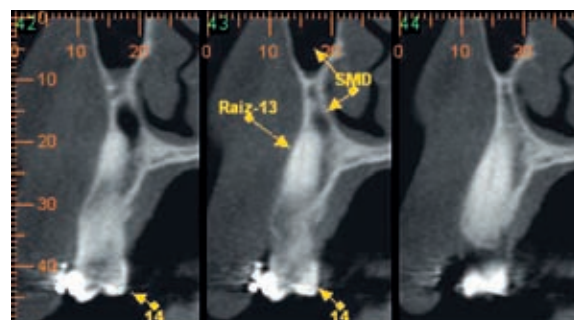


FIGURE 18 - Parasagittal CT scans indicating proximity of maxillary canine root to right maxillary sinus (RMS).

in the deepening procedure. Based on the standardization of the scans and measurements, CT allows a precise comparison between before and after RCR, in addition to serving as a valuable tool for result assessment.

CLINICAL CASES

Case 1

The female patient was 20 years and 11 months old and presented for orthodontic treatment in March 2008 with a chief complaint of “chin forward and crooked teeth.” The patient had consulted an oral and maxillofacial surgeon and was aware of her facial involvement. However, she expressed her desire to undergo

orthognathic surgery as soon as possible, preferably before the end of the year. The initial photographs (Fig 19) showed a concave profile with absence of significant asymmetries. On intraoral examination (Fig 20) an Angle Class III molar relationship was observed, with crossbite and anterior open bite, anterosuperior crowding with incisor proclination and lack of space for the lateral incisors.

In addition to the standard orthodontic records, a Cone-Beam CT scan was requested for evaluating structures, planning surgery and comparing results (Fig 21).

The proposed treatment consisted of extraction of maxillary first premolars (14 and 24) and



FIGURE 19 - Extraoral photographs.



FIGURE 20 - Intraoral photographs.

rapid canine retraction to reduce treatment time during ortho-surgical preparation.

A symmetrical palatal distractor was mounted due to the initial buccal position of both canines and surgery was performed to prepare for RCR (Fig 22).

After RCR (15 days), a nylon tread was bonded through buccal access to allow distractor removal and a new CT scan (Fig 23). Canine stabilization is essential, and even after bonding the orthodontic appliance it is customary to keep the archwire



FIGURE 21 - Initial sagittal CT sections.

in position for a few more days to ensure proper bonding and thus prevent brackets from debonding. After removal of the stabilization archwire, the canine is kept in position with bilateral molar-to-canine laceback.

Comparison of CT scans before and after RCR shows adequate biomechanical control in the transverse plane due to the palatal distractor, with total preservation of the buccal bone plate (Fig 24).

Preparation for orthognathic surgery was completed in 7 months, having eliminated all dental compensations, according to initial plan-

ning, using heat-activated nickel titanium (NiTi) 0.014-in and 0.014x0.025-in archwires, TMA 0.017x0.025-in and stainless steel 0.017x0.025-in and 0.019x0.025-in archwires (Fig 25).

Treatment was fully completed in 16 months and all proposed goals were achieved (Fig 26). The use of RCR enabled rapid alignment and leveling of the upper arch, significantly reducing the duration of orthodontic preparation for surgery, and therefore eliminating the aesthetic discomfort that typically accompanies this type of treatment before primary surgery.

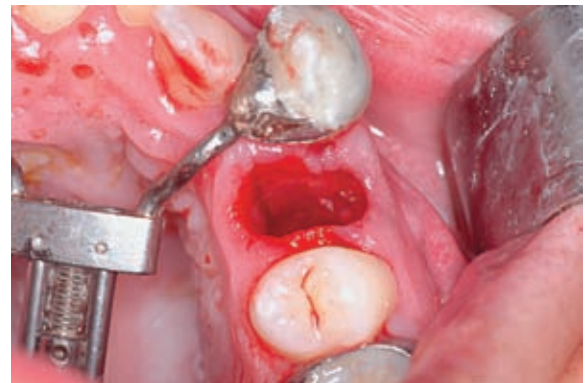


FIGURE 22 - Occlusal photographs of deepening and corticotomies used in surgical technique.



FIGURE 23 - Intraoral photographs after RCR (15 days) with stabilization archwire. Note the canine extrusion and good anchorage control.

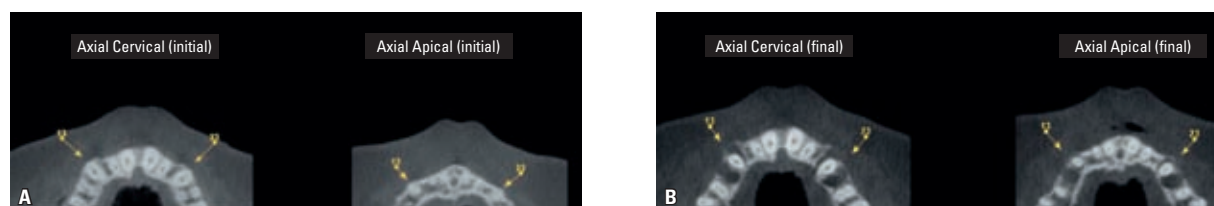


FIGURE 24 - Standardized axial sections of cervical and apical canine regions before (A) and after (B) RCR showing canine movement into alveolar process.



FIGURE 25 - Intra and extra oral preoperative photographs.





FIGURE 26 - Final photographs. Total treatment time was 16 months.

Case 2

A 20 years and 11 months old male patient presented for orthodontic treatment with a chief complaint of “teeth sticking out.” The initial photographs (Fig 27) showed a convex profile with absence of significant asymmetries, and deficient mandible. On intraoral examination, Angle Class II molar relationship was noted, in addition to anterior open bite, increased overjet (18 mm), anterosuperior crowding with excessive incisor proclination and mild mandibular crowding.

Initial planning comprised orthodontic preparation for orthognathic surgery in view of the mandibular deficiency and poor menton-cervical line. In light of the patient’s refusal to undergo surgery, a Class II orthodontic camouflage seemed the best choice, with retroclination of upper incisors after extraction of first premolars, total anchorage control, and interproximal stripping in the lower arch. RCR was thus performed given the outstanding anchorage control afforded by

this technique, in addition to a significant reduction in treatment time. A Cone-Beam CT scan was performed as in the previous case.

First premolars were extracted and RCR preparation performed using the conventional technique with the aid of the CT scan. An asymmetric palatal distractor was employed due to the initial positioning of the canines (Fig 28).

The intraoral photographs demonstrated complete anchorage control without the aid of any other resources (Fig 29), and the scans revealed canine movement and a well preserved buccal bone plate (Fig 30).

For alignment and leveling the same sequence of archwires described in the previous case was used. Maxillary incisor retraction was performed with the help of a temporary anchorage device (TAD). Interproximal stripping was performed in the lower arch (Fig 31). The patient was advised to undergo advancement genioplasty to improve his profile but reported being satisfied with the result.

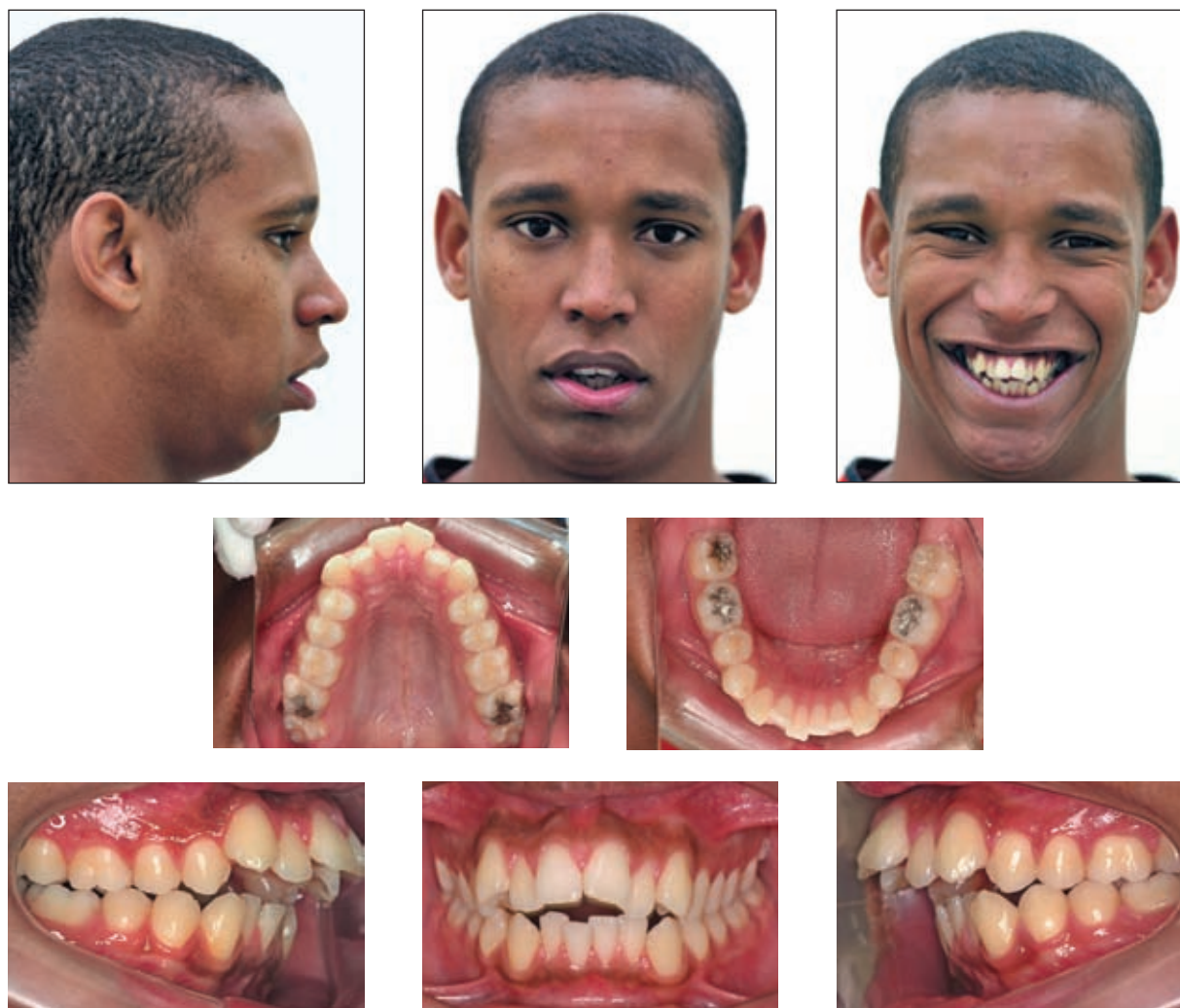


FIGURE 27 - Initial photographs.

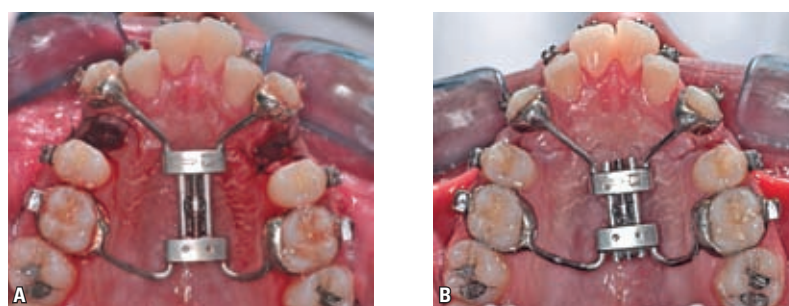


FIGURE 28 - Occlusal views of RCR immediately after surgery (A) and after seven days of activation (B).



FIGURE 29 - Intraoral photographs immediately after RRC, showing orthodontic appliance for alignment, and mini-implants for incisor retraction.

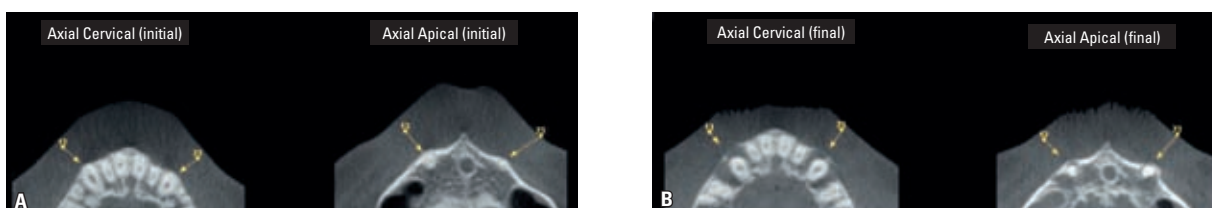


FIGURE 30 - CT axial sections of apical and cervical regions. Initial (A) and post-RCR (B) sections showing canine movement with preservation of buccal bone plate.

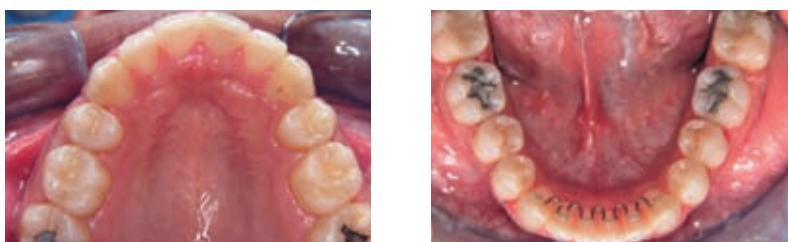


FIGURE 31 - Final photographs. Total treatment time was 14 months.

Case 3

The patient, a 45 years and 11 months old male, presented for orthodontic treatment with a chief complaint of “crooked teeth, especially those two upper ones, which are sticking out,” referred by the periodontics department. The initial photographs (Fig 32) showed a convex profile with absence of significant asymmetries. On intraoral examination, there was a complete canine Class II relationship, severe anterosuperior crowding and moderate crowding in the lower arch. Significant periodontal compromise was also noted, which was confirmed by the coronal view provided by

the panoramic CT scan (Fig 33).

Due to the bone loss observed in the periodontal and radiographic examination of the patient he had already been refused treatment by two other professionals. Taking into account the clinical situation, and in agreement with the periodontist and the patient, a commitment was reached whereby treatment would include extraction of first premolars with total anchorage control to allow alignment of the upper arch and of tooth 34 in the mandibular arch. The orthodontic set-up (Fig 34) demonstrated that such planning would generate less than ideal final relationships, but the



FIGURE 32 - Initial photographs.

patient would benefit from improved aesthetics and function, with improved control of his periodontal condition. RCR was the method of choice to move the maxillary canines as it ensured anchorage control and created sufficient space as to enable quick incisor alignment without delivering any forces to the remaining teeth.

A unilateral palatal distractor was inserted and surgery performed on one side at a time at the patient's request (Fig 35).

After the same procedure had been performed on both sides a fixed self-ligating orthodontic appliance was set up and a heat-activated 0.012-in

NiTi archwire was inserted to enable alignment of the incisors in the space created by rapid canine distalization (Fig 36).

Just 60 days after the appliance was set up the incisors were in a favorable position (Fig 37). It should be emphasized that this rapid incisor movement to occupy the canine space is mainly due to the existence of incompletely mineralized bone tissue,^{2,7,11,12,16,17} i.e., the mesial periodontal ligament of the canine, which in response to having been distended, is on the process of osteogenesis as originally described by Liou and Huang.¹¹

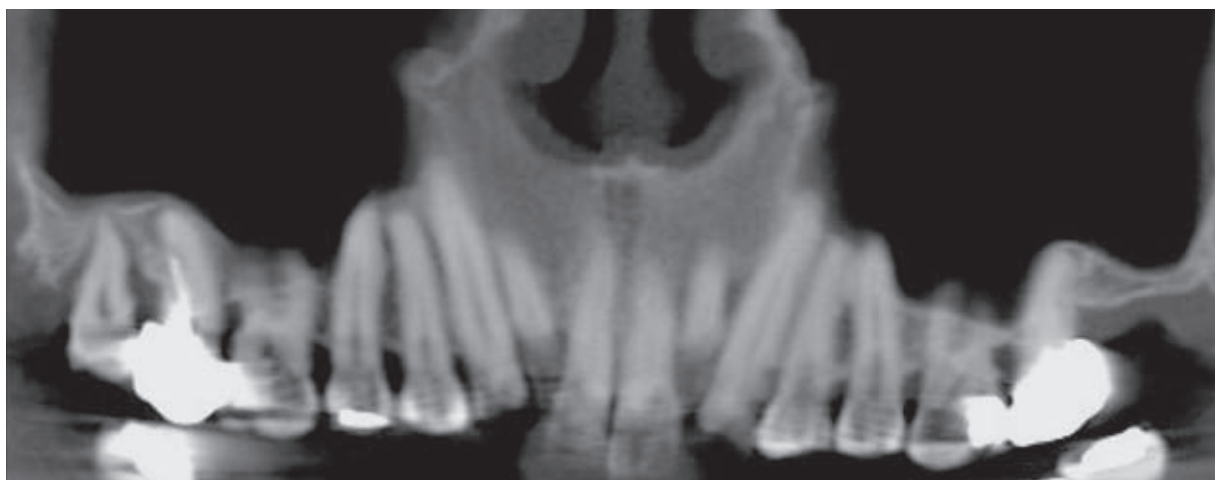


FIGURE 33 - Coronal panoramic view obtained from initial CT scan.

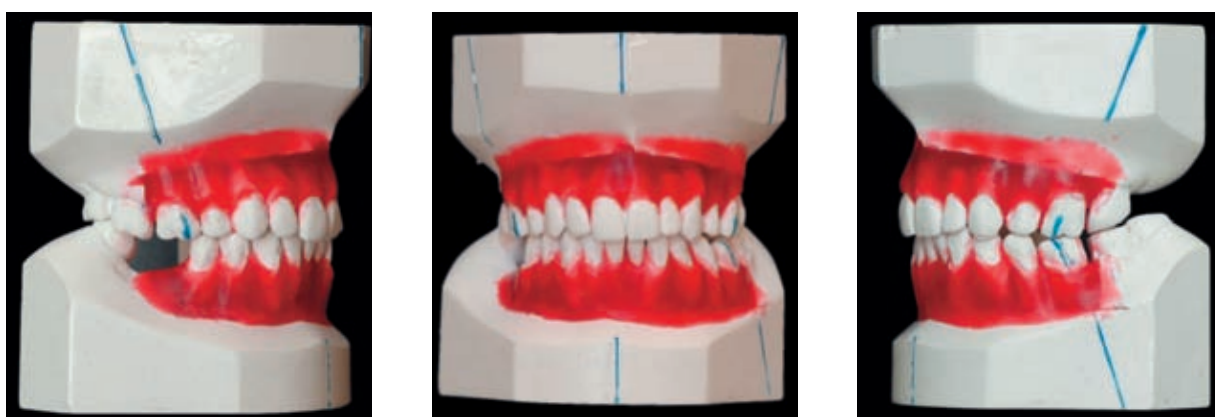


FIGURE 34 - Photos of orthodontic set-up.



FIGURE 35 - Occlusal view of palatal distractor on left side, immediately after surgery by modified technique.



FIGURE 36 - Extraoral photographs after RCR. Note that canines are still stabilized with archwire that allowed distractor removal.



FIGURE 37 - Intraoral photographs 60 days after RCR.

FINAL CONSIDERATIONS

Rapid Canine Retraction (RCR) is a technique that provides significant reduction in orthodontic treatment time. The use of Cone-Beam Computed Tomography (CBCT) significantly facilitates surgery, and in conjunction with buccal access, renders the procedure faster and safer. When positioned through palatal access, distractors are biomechanically

more effective than through buccal access. At the very least, the use of distractors helped to preserve the buccal bone plate. Despite the different clinical possibilities afforded by this technique, in the authors' opinion the greatest beneficiaries of this treatment protocol are ortho-surgical preparation, patients with severe anterior crowding and patients with periodontal involvement.

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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

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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:

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Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

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Comparative Study of Complications During Herbst Treatment with Cantilever Bite Jumper and Removable Mandibular Acrylic Splint

Alexandre Moro*, Guilherme Janson**, Ricardo Moresca***,
Marcos Roberto de Freitas****, Jose Fernando Castanha Henriques*****

Abstract

Objective: To assess and compare the type of complications during Herbst treatment with Cantilever Bite Jumper (CBJ) and removable mandibular splint. **Methodology:** Twenty one consecutive Herbst patients treated with the CBJ were compared with twenty one consecutively treated Herbst patients with stainless steel crowns on the maxillary first molars and a removable mandibular acrylic splint. The initial mean age for the CBJ group was 12 years and 3 months and for the Splint group was 11 years and 3 months. Both groups used the Herbst appliance for 12 months. Based on the patients' clinical records an occurrence survey of complications during Herbst treatment was performed. **Results:** There were 24 complications for the CBJ and 53 for the Splint group, which were statistically different (Mann-Whitney test, $p < 0.05$). The prevalence of patients exhibiting complications during treatment was 66.67% in the CBJ and 85.71% in the Splint group. The frequencies of complications were also statistically different between the groups. **Conclusions:** The CBJ exhibited a significantly smaller number of complications during Herbst appliance treatment than the removable mandibular splint. Herbst appliance with first molar crowns and a cantilever on the mandibular molars is preferable to the removable mandibular acrylic splint because of savings in clinical and laboratory time.

Keywords: Herbst appliance. Class II. Complications.

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INTRODUCTION

Since its reintroduction by Pancherz¹⁴ in 1979, the Herbst³ appliance has aroused considerable clinical interest. Several changes in the telescopic system have been proposed and different methods to insert the Herbst appliance mechanism in the dental arches have been described in the literature.⁴⁻¹³ Moreover, throughout the last 20 years much research^{1,12,14,16,17,20} has been conducted to evaluate the dental and skeletal effects of treatment using this appliance.

More recently, two investigations^{2,18} on the rate of complications during treatment with Herbst revealed that the pattern of complications depends on the type of appliance used, with more fractures affecting patients who wore the appliance with bands. More debonds were detected in patients who wore the metal splint model. Although no difference was found in the overall frequency of complications between the appliance with bands and with metal splint, the latter has been recommended as it saves both clinical and laboratory time.

In 2007, Schiöth et al¹⁹ compared the prevalence of type and frequency of complications with the use of total (canine to molar) and short

(canine to second premolar) metal splints. They concluded that the major complication that takes place during Herbst use concerned maxillary splint debond. Reducing the length of the lower splint does not increase the prevalence of complications but it reduces costs, and its use can therefore be recommended.

During the past year, various design models were tested for insertion of the Herbst telescopic system for Class II treatment. The challenge lies in finding a model better suited to Brazilian reality. Two models have earned the authors' preference: The Herbst appliance with Cantilever Bite Jumper (CBJ)^{5,10} and the Herbst appliance with lower removable acrylic splint (LRAS).⁹

To date, no study has compared the complications that take place with CBJ vs. LRAS models. The aim, therefore, was to compare the complications incurred by these two types of Herbst appliances in order to assess (a) whether one involves more breaks than the other, (b) whether the overall prevalence of patients who exhibited complications is different between the groups, and (c) whether either model would be more appropriate than the other for treating Class II cases.

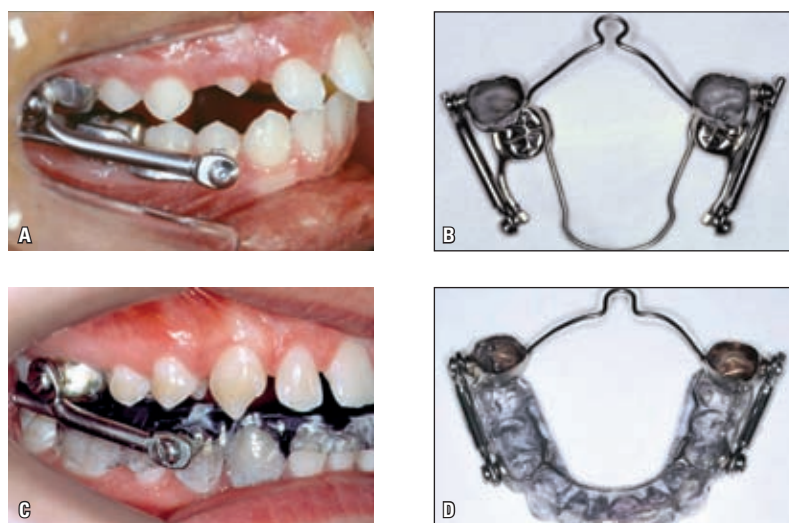


FIGURA 1 - **A)** side view of CBJ, **B)** occlusal view of CBJ; **C)** side view of Herbst appliance (LRAS), **D)** occlusal view of Herbst appliance (LRAS).

MATERIAL AND METHODS:

Sample

The sample used in this study was divided into two groups (Fig 1). Group I consisted of Caucasian patients of both genders (15 men and 6 women) who presented with Class II malocclusion, with a mean age of 12 years and 3 months at the beginning of treatment. These patients were treated with the Herbst appliance with Cantilever Bite Jumper (CBJ) (Ormco - Glendora, CA, USA), which consisted of four steel crowns on the first upper and lower molars. The maxillary molars were connected with a transpalatal arch (TA). The lower molars were connected by a lingual arch passing on the lingual side of the incisors with no occlusal support on the posterior teeth. The telescopic systems on the right and left sides were attached with an Allen-type screw on the upper and lower pivots. Treatment of these patients was administered at the X Orthodontics graduate clinic. Group I comprised Caucasian patients of both genders (11 men and 10 women) who presented with Class II malocclusion and mean age of 11 years and 3 months at the beginning of treatment.

These patients were treated with the Herbst appliance with steel crowns on the first molars and lower removable acrylic splint (LRAS). Maxillary molars were connected with a transpalatal arch. The telescopic system used in the Herbst appliance was a Dentaurum type I (Ispringen, Germany). The telescopic systems on the right and left sides were attached with a slotted screw on the upper and lower pivots. Treatment of these patients was performed at a private office by one single professional.

In both groups, patients wore the Herbst appliance for a period of 12 months. In both groups, the steel crowns were cemented with Fuji Ortho LC (GC America Inc. Chicago, IL, USA). All patients were treated until an overcorrected Class molar ratio was reached.

With the information gleaned from the patients' medical records a survey was conducted

of complications occurring during treatment with the Herbst appliance.

As regards the qualitative variables (prevalence and grouping of complications), the treatments were compared using Fisher's exact test or the chi-square test. P values < 0.05 indicated statistical significance.

For comparison of treatment with both types of Herbst appliance in relation to the total instances of complications, Mann-Whitney's nonparametric test was applied, which seemed warranted given the absence of the condition of normality of this variable in each group.

RESULTS

After reviewing the patients' clinical records it was noted that the total number of instances of complications was 24 in the CBJ group and 53 in the splint group.

Table I depicts the types and number of instances of complications for the CBJ and splint Herbst appliances.

To assess the prevalence of complications in each treatment the null hypothesis was tested, i.e., that the likelihood of any complication is the same for both types of treatment vs. the alternative hypothesis of different probabilities. Table II and Figure 2 show the results.

The statistical test results indicated the acceptance of the null hypothesis at a significance level of 0.05 ($p=0.277$). Thus, one cannot assert that there are significant differences between these treatments in terms of the likelihood of a complication occurring during treatment.

The above results may be construed as a prevalence of patients with some sort of complication during treatment. This prevalence is equal to 66.67% for patients treated with CBJ, and 85.71% for patients treated with splint.

The null hypothesis that the total number of instances of complications occurring during treatment was the same for both types of treatment vs. the alternative hypothesis of different totals was also tested. Table III provides descriptive statistics and p

TABLE 1 - Types and number of instances of complications for the CBJ and splint Herbst appliances.

Types of Complications	CBJ	Splint
Crown debond	6	1
Screw loosening	6	24
Lesion in palate due to transpalatal arch	5	6
Lesion in cheek due to cantilever screw	2	
Piston distortion	2	3
Lesion in cheek due to too long piston	1	1
Crown fracture	1	1
Lesion in gingiva due to cantilever	1	
Lower splint breakage		13
Poor use of splint (lack of use)		2
Pivot breakage		1
Breakage of transpalatal arch		1
Total	24	53

TABLE 2 - Prevalence of complications during each treatment using Herbst appliance, evaluated by Fisher's test.

Complications	GROUP	
	CBJ	SPLINT
None	7 33.33%	3 14.29%
At least 1	14 66.67%	18 85.71%
Total patients	21	21

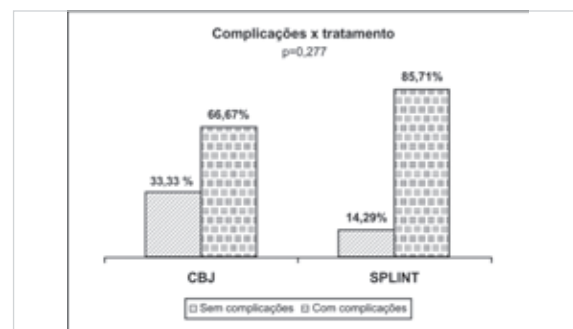
Fisher's exact test, $p < 0.05$ 

FIGURE 2 - Prevalence of complications in treatments with CBJ and splint.

TABLE 3 - Evaluation of total number of instances of complications during treatment with Herbst appliance.

	n	Sum	Mean	Mediana	Minimum	Maximum	SD	p
CBJ	21	24	1.1	1	0	3	1.0	0.009
SPLINT	21	53	2.5	2	0	6	1.8	

Mann-Whitney's nonparametric test, $p < 0.05$

values of the statistical test.

The statistical test results indicated rejection of the null hypothesis at a significance level of 0.05 ($p = 0.009$). Thus, one can assert that there were significant differences between treatments in terms of the total number of instances of complications occurring during treatment.

Table IV groups the instances of complications in intervals of 0-1, 2-3 and more than 3. The null hypothesis that distribution of the total instances of complications is equal for both types of treatment vs. the alternative hypothesis of different distributions was tested.

The statistical test results indicated rejection

TABLE 4 - Distribution (in %) of patients exhibiting 0-1, 2-3, or more than 3 complications during treatment with the Herbst appliance, evaluated by chi-square.

Complications	CBJ		SPLINT	
	Freq	%	Freq	%
0 or 1	12	57.1%	6	28.6%
2 or 3	9	42.9%	8	38.1%
> 3	0	0%	7	33.3%
Total	21	100.0%	21	100.0%

Chi-square test, $p < 0.05$

of the null hypothesis at a significance level of 0.05 ($p = 0.011$). Thus, one can state that distribution of the total instances of complications was different for both types of treatment.

DISCUSSION

Despite having been widely used in Europe and the United States for more than two decades it was only in this century that the Herbst appliance has caught on in Brazil.

One explanation for the delay in adopting this treatment modality was the cost of the appliance. A few years ago only one brand of telescopic system was marketed in Brazil, which cost tenfold the price charged in the United States. Today, several affordable brands of telescopic systems are available in Brazil.

Ease of fabrication is the key advantage¹² of the Herbst appliance with Cantilever Bite Jumper (CBJ) since the pivots come pre-welded to the upper crown and lower cantilever. In addition, from a clinical viewpoint, the appliance has proven rather sturdy. CBJ disadvantages¹² are as follows: - A steep price, a tendency of the lower cantilever to sink, causing molar inclination, and the tendency of the lower pivot to hurt the patient's cheek during the first week of use. On the other hand, the advantages⁹ of the Herbst appliance with lower splint are affordability, the possibility of removing the splint to brush the teeth (which facilitates hygiene), easier fit for patients, and a shorter learning curve for professionals. The downside⁹ clinically observed in the Herbst appliance with splint was that the lower acrylic splint showed decreased resistance.

To scientifically evaluate the impressions gained in clinical use, two groups of patients were compared. The CBJ group was treated by the students of the postgraduate (master's and doctoral) program in Orthodontics at Faculdade de Odontologia de Bauru-USP, under the supervision of (A.M.), one of the authors. All patients were treated with the same clinical protocol. The splint group was treated in the private practice of one of the authors (A.M.), using the same clinical protocol.

When assessing the prevalence of complica-

tions, none were observed in 7 patients (33.3%) of the CBJ group and in 3 patients (14.29%) of the splint group. Fourteen patients in the CBJ group and 18 in the splint group displayed some sort of complication. The Fisher test showed no significant difference between groups and also disclosed that both groups were equally likely to exhibit complications during treatment. In their study, Hagg et al² found that among the 14 patients treated with metal splints, only 2 showed no complications, and further noted that out of the 14 patients treated with the Herbst appliance with bands, only 3 had no complications. In their 2004 study, Sanden et al¹⁸ found that 33% of the patients who wore the Herbst with bands and 40% of the patients who wore the Herbst with metal splint exhibited no complications during treatment.

In evaluating the total number of instances of complications during treatment with Herbst appliances there were 24 instances of complication with the CBJ (mean of 1.1 per patient) and 53 with the splint (mean of 2.5 per patient), reflecting a statistically significant difference. Therefore, the clinical impression that the CBJ Herbst appliance was sturdier was confirmed. Hagg et al² observed a total of 53 instances of complication in 14 patients treated with the Herbst appliance with metal splint (mean of 3.7 per patient), and a total of 41 instances of complications in the 14 patients treated with the Herbst appliance with bands (mean of 2.9 per patient). Sanden et al¹⁸ found a total of 379 instances of complications in 134 patients treated with the Herbst appliance with bands (mean of 2.8 per patient), and 396 instances of complications in 182 patients treated with the Herbst appliance with metal splint (mean of 2.1 per patient). It can therefore be stated that the number of instances of complications with the CBJ appliance is lower than when Herbst appliances with metal splint, acrylic splint or bands are used.

In assessing individual instances of the most common complications in both groups, the CBJ group exhibited crown displacement and loosening of the screw on six occasions. One might avoid crown displacement by blasting the crown with aluminum oxide prior to cementation. As for the screws, some authors^{13,15} recommend the use of Ceka Bond adhesive (Preat Corp., Santa Ynez, CA, USA) prior to screw fixation. On 5 occasions, a lesion was found on the palate due to the transpalatal arch (TA) despite the fact that the TA had been fabricated to allow for a 4 mm distance from the palate. This is due to the intrusion force developed by the appliance. Some authors¹³ recommend against the placement of a TA, which may risk producing greater molar intrusion on one side than on the other.

In the splint group there were 24 instances of screw loosening. To explain this increased frequency, one might speculate that slotted screws are less efficient than Allen-type screws. Another likely explanation is the fact that as the patient removes the lower splint after meals for oral hygiene, removal and placement may end up forcing the telescopic system and facilitating the loosening of the screw. Another frequent occurrence with the splint appliance was fracture, which took place was on 13 occasions. This happened even though the appliances were fabricated with lingual wire reinforcement on lower anterior teeth and a thicker layer of acrylic was applied to the anterior splint. Similarly to the CBJ group, the splint group had a lesion on the palate due to the TA on 6 different occasions. It is also noteworthy that although the lower splint is removable, two patients did not use it correctly and reported not having worn for it for some periods of time. Theoretically, this should not happen, because the upper crown with the tube is cemented to the upper molars, and if patients fail to put on the splint, the tube could hurt the lower vestibule.

Schiöth et al¹⁹ compared the complications with the use of total (canine to molar) and

short (canine to second premolar) metal splints by dividing the patients into four categories according to the frequency of complications: Low frequency (1-3 complications), moderate frequency (4-6 complications), high frequency (7-10 complications), very high frequency (over 10 complications). Most of the patients exhibited low frequency. About 10% of patients in both groups¹⁹ showed high frequency. Sanden et al¹⁸ found that 55% of the patients experienced 1 to 3 complications, 29% 4 to 6, 13% 7 to 10, and 3% more than 10 instances of complications. After reviewing the 14 patients treated with CBJ and 19 patients treated with splints who exhibited complications, the patients were divided into three groups: 0 to 1, 2 to 3, or more than 3 complications during treatment with the Herbst appliance. In the CBJ group no patient had more than three individual instances of complications, which attests to the good clinical performance of the appliance. In the splint group, 33% of the patients had more than 3 instances of complications during treatment, and the maximum number of 6 was observed in two patients. A comparison between the results of this study and those by Schiöth et al¹⁹ and Sanden et al¹⁸, one can conclude that both Herbst appliances, viz. with cantilever and with lower splint, displayed a good clinical performance when compared to the Herbst appliance with metal splint and bands.

CONCLUSIONS

- 1- The CBJ group showed fewer complications during treatment with the Herbst appliance.
- 2 - No patient in either group had a large number of individual complications.
- 3 - The Herbst appliance with steel crowns on the first molars and cantilever on the lower molars (CBJ) is preferable to the model with lower removable acrylic splint (LRAS) given the savings it provides in both clinical and laboratory time.

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Comparison between cavum and lateral cephalometric radiographs for the evaluation of the nasopharynx and adenoids by otorhinolaryngologists

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Abstract

The lateral cephalometric as well as the cavum radiograph allow the evaluation of the nasopharyngeal airway (NAW). Otorhinolaryngologists routinely use the cavum radiograph, even when the patient already has a lateral cephalometric headfilm. The aim of this study was to (a) acknowledge which exams otorhinolaryngologists use for the evaluation and measurement of the NAW; (b) evaluate if the otorhinolaryngologists are acquainted to the cephalometric; (c) compare both radiographs to see which one is preferred to visualize the NAW and adenoids and (d) correlate the visual analysis to the measuring method of Schulhof. For this purpose, the cephalometric and the cavum radiographs of 15 mouth-breathing children were taken on the same day. These radiographs were masked leaving only the NAW and the adenoids visible, and were blindly presented to 12 otorhinolaryngologists. They received the radiographs together with a questionnaire asking on their familiarity with the lateral cephalometric, which exams are used for NAW and adenoid evaluation and if they use any method for measuring the NAW obstruction level. They were also asked to visually classify the NAW and the adenoids according to their sizes into small, medium and large. The results demonstrated that all otorhinolaryngologists in the sample use the cavum radiograph. Only one uses the cephalometric radiograph and two are familiar to this technique. The cephalometric was preferred by 49.4% of the otorhinolaryngologists, the cavum by 22.8% and 27.8% did not see any difference between both methods. There was low correlation between the visual method and the Schulhof measuring method.

Keywords: Orthodontics. Otorhinolaryngology. Cavum radiograph. Cephalometric radiograph.

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INTRODUCTION

Mouth breathing is a functional problem considered relatively common. 85% of children present some degree of nasal insufficiency, as it has been demonstrated by functional tests, and 20% are total mouth breathers.²⁰ A child can become a mouth breather because of any obstructive factor or because of wrong habits like thumb sucking, and it can cause changes in the craniofacial normal growth and development.²⁶ Among the obstructive factors, the adenoid is the most described in the literature.^{9,18,25,27}

Because the mouth breather patient has both functional and occlusal changes, its treatment requires a multidisciplinary interaction, involving a speech therapeutic, an otorhinolaryngologist and an orthodontist, so that the primary causes of the malocclusion can be removed avoiding treatment relapses.¹³

The orthodontist uses in daily routine to decide the patient's treatment plan the lateral cephalometric radiograph described by Broadbent.⁴ This radiograph is obtained in a standard way, being always done with the same head position and with the same distance from the radiation cone, allowing the professional to make measurements and compare those measurements in different treatment's periods. This radiograph is considered by many authors as a simple exam, practical and with good results to diagnose the size of the nasopharyngeal airway.²⁷ Nevertheless, most of the otorhinolaryngologist uses to evaluate the nasopharyngeal airway the cavum radiograph,³ which is also a radiograph from the lateral part of the cranium like the lateral cephalometric, but without any stabilized patterns, giving the doctor the image to evaluate the nasopharyngeal airway but inadequate for orthodontic planning.

Because of a poor relation between both specialties and the absence of scientific researches comparing those two techniques, the professionals don't know which image would provide

the best view of the nasopharyngeal airway and which measurement technique would be more precise, leading to the patient having to do both of them.

Gurgel et al¹⁰ described that the mouth breather diagnostic should be done through specialized exams, like the oropharynx clinical exam, anterior rhinoscopy, nasofibroscopy and otoscopy, and by complementary exams, like blood exam, radiographs and patient clinical history. The radiographic exam described by the authors was the cavum radiograph.

Holmberg and Linder-Aronson¹⁴ studied if the lateral and frontal cephalometric radiographs would be useful to evaluate the nasal respiratory function and concluded that the lateral one would give good results about the nasopharyngeal dimensions and the frontal one would give good information about the capacity of the nasal airways.

Major et al²¹ concluded in a systematic review about diagnosing hypertrophy of adenoids and nasopharyngeal airway obstruction through the cephalometric radiograph that there is a good correlation in the findings about the size of the adenoid, but the ability to diagnose a small nasopharyngeal airway is not that good. The authors attribute those findings to the adenoid being an anatomic structure simpler than the nasopharynx and losing less information when transformed in a bidimensional image.

Some papers have been published comparing the cephalometric radiograph with the nasopharyngeal endoscopies. Ianni Filho et al¹⁵ compared both methods and concluded that the radiographic exam is important for the initial diagnostic of the nasopharyngeal obstruction, but it gives very limited information. The endoscope gives more information but would be harder to be obtained. Vilella et al²⁹ found very similar results regarding the anteroposterior size of the nasopharynx using both methods and suggested that when evaluating the child respi-

ratory pattern it should be done not only a clinical exam, but also cephalometric measurements of the nasopharyngeal space.

The computerized tomography can also be used in the diagnoses of nasopharyngeal obstruction, being a more precise exam but also more expensive. Montgomery et al²³ described that after evaluating the results obtained by the tomography, it becomes clear how the radiographic exam is poor in information. The authors suggests that the tomography should be used as a gold pattern, but the cephalometric exam should be used as a key to determine if a more detailed exam is needed or not, having in mind that this is a bidimensional exam, and so, very limited.²¹

The radiographic evaluation, besides being the first complementary exam doctors ask for patients with suspect of mouth breathing patterns, stands with the clinical exam as the most used method to evaluate hypertrophy of adenoids¹ and changes in the nasopharyngeal space⁷. The correct radiograph technique should always be followed to minimize possible adversities as bad positioning or moving of patient¹. The child should always be calm, straight, with mouth shot, inspiring air and with the head oriented in the horizontal plan and lateral to the x-ray.^{1,24,25}

Araújo Neto et al¹ affirmed that because of the variety and the complexity of the measurement methods for the radiographic diagnoses of adenoids, several radiologists prefer to use the subjective analyses. This way, the visual analyses of the cavum radiograph gives, most of the times, an imprecise diagnosis.

There are several methods described to evaluate nasopharyngeal radiographs and when the adenoids should be considered bigger than normal varies from author to author. The most used methods to measure adenoids in the cavum radiograph are: Johannesson's method,¹⁶ Fujioka's,⁸ Crepeau's⁶ and Cohen and Konak's.⁵

As when using the cephalometric radiograph, there are two methods described in the literature, McNamara's²² and Schulhof's.²⁶

Since the mouth breathing is a multidisciplinary problem treated by the orthodontist and the otorhinolaryngologist and both uses lateral cranium radiographs, it becomes necessary to compare the lateral cephalometric and the cavum radiograph to try to establish which exam should be asked for, so that the patient has to do only one radiograph instead of two, minimizing expenses and radiation exposure.

This way, this paper aimed to evaluate: (a) Which exams the otorhinolaryngologists are used to ask for to evaluate and measure the nasopharyngeal airway; (b) the percentage of otorhinolaryngologists that are familiar with the lateral cephalometric radiograph; (c) the visualization of the nasopharyngeal airway and adenoids of the mouth breather in the cavum and the lateral cephalometric radiograph by the otorhinolaryngologist; and (d) the correlation between the visual method of analyzing the nasopharyngeal airway and adenoids and the measuring method of Schulhof.²⁶

MATERIAL AND METHOD

To collect this sample, 150 children between 6 and 12 years old were evaluated in the city of Recife. The inclusion criteria's were: not be using orthodontic appliance, not be using any medications, couldn't have had the adenoids removed, not have any congenital anomalies and had to be a mouth breather.

Only 38 of the 150 could be included in the sample. The parents signed a consent term allowing the children to participate in the study. Two children didn't have the parents' approval, resulting in 36 children.

The sample was submitted to clinical exams by the orthodontist and a speech evaluation by the speech therapeutic to certify that all of them were mouth breathers.

The speech evaluation consisted in questions about the masticatory function and the ability to swallow, which kind of food the patient prefers eating during meals, time spent with meal and if there were any stomach aid; besides it was asked about their sleeping time, if the patient had sleeping problems, if he snored, if there was any wrong habits, how was his general health, if there was any respiratory disease, any nasal obstruction, congenital disease, pain in the temporomandibular joint, any history of face trauma and if he had being submitted to any surgery.

It was also done a clinical exam observing lips, tongue, cheeks, and speech test, breathing test, masticatory test and swallowing test.

The patients were submitted to two different radiographic exams in the same day: lateral cephalometric radiograph (Fig 1A) and cavum

radiograph (Fig 1B). If any child presented a cold in the day scheduled for the exam, it was postponed to when the child felt better.

The same operator with more than five years experience did the cephalometric radiographs. To evaluate the operator method error it was used a Kappa test that demonstrated an excellent concordance. The radiographs were done as described by Broadbent in 1931.⁴

The same operator did the cavum radiographs. The radiographs were done as described by Bontrager³ in 2003 with some adaptations for the patient breathing, the area submitted to the radiation and the distance to the radiograph machine.

It was selected 15 patients with ages closer to 10 years old and with different sizes of the nasopharyngeal airway, classified as small, medium and large according to the Schulhof²⁶

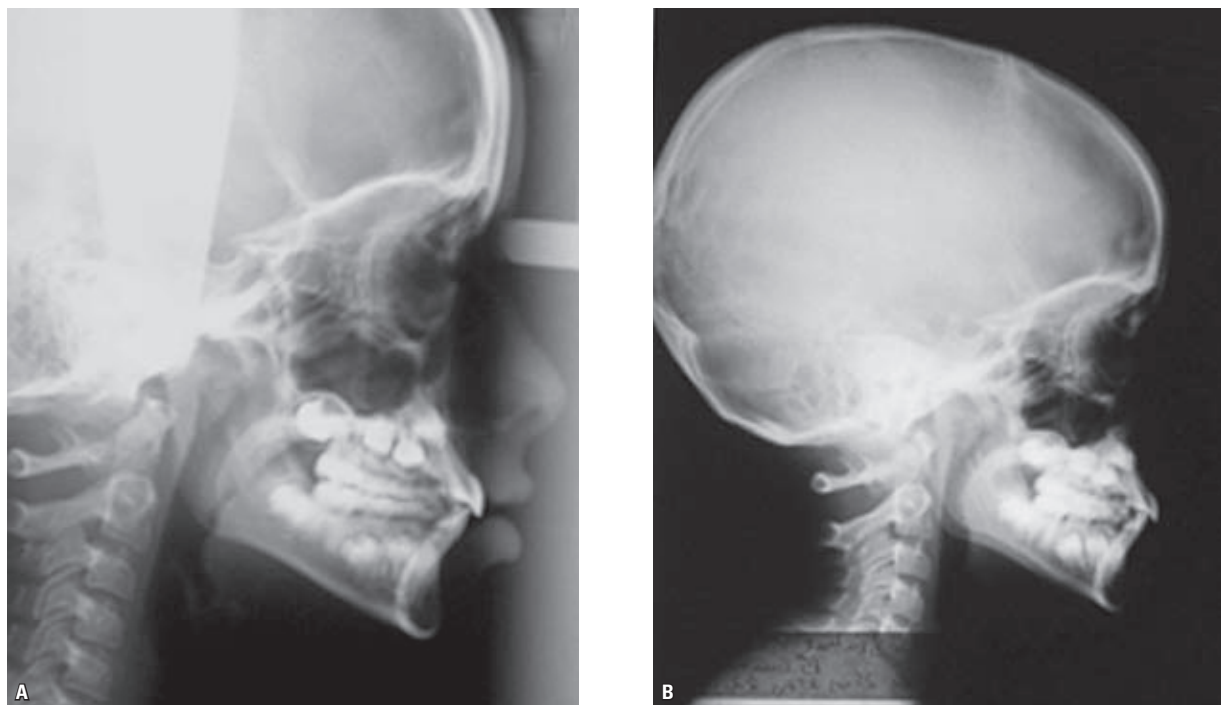


FIGURA 1 - Exemplo de radiografia cefalométrica de perfil (A) e de cavum (B) obtidas de um mesmo paciente respirador bucal, no mesmo dia.

analyzes (Fig 2) resulting in a total of 30 radiographs. This selection was done to diminish the time spent by the otorhinolaryngologists that participated in this study.

This radiographs were put in envelopes done with black thick paper and the area covering the nasopharyngeal space and the adenoids was removed so that this was the only area that could be seen in the radiograph. This was done so that the examiners couldn't know which radiograph they were evaluating, avoiding any tendency of picking the image they were more used to. The radiographs were denominated radiograph A (cavum) and radiograph B (cephalometric). It was asked for 12 otorhinolaryngologists of the city of Rio de Janeiro with at least two years of clinical experience to compare both radiographs and to answer the questionnaires.

The examiner received the radiographs with a presentation letter of the project, one general questionnaire and one to evaluate each pair of radiographs. In the general questionnaire there was questions about the familiarity of the doctor with the cephalometric radiograph, about which exams the doctor used to ask for to visualize nasopharyngeal airways and adenoids, and if he used any type of measurement of the airways. This questionnaire intended to evaluate the study sample. In the questionnaire to evaluate the radiographs there was questions about which one had the best quality in visualizing the adenoids and nasopharyngeal airways and it was asked for them to classify the size of the adenoids and nasopharyngeal airways as small, medium or large, through the visual method.

For the statistical treatment it was used a binomial distribution to see which radiograph was preferred by the otorhinolaryngologists to visualize adenoids and nasopharyngeal airways with absolutes and relatives frequencies of preferences. To evaluate the correlation between the results of the visual method and the Schulhof measuring method it was calculated the values of percent agreement and kappa.

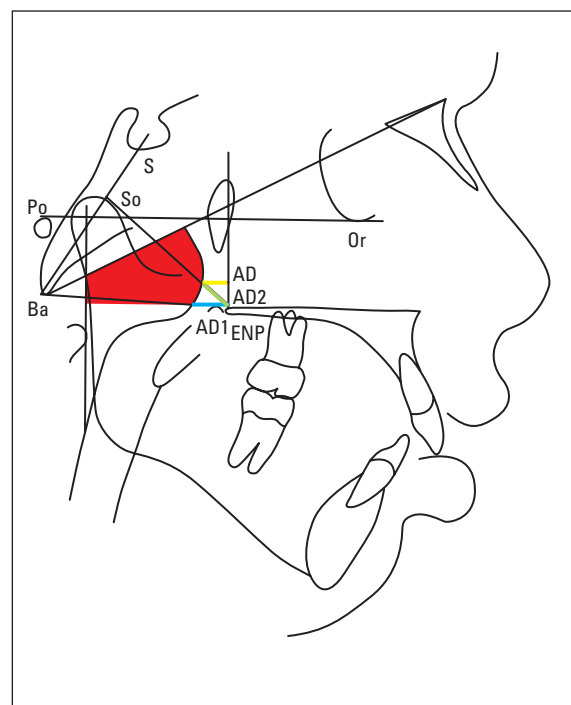


FIGURE 1 - Esquema representativo da análise de Schulhof: O 1º fator, representado em vermelho, corresponde a porcentagem da via aérea ocupada pelo tecido adenoideano na área da nasofaringe de Handelman e Osborne;; o 2º fator representado em azul seria a distância do ponto AD1 à espinha nasal posterior de Linder-Aronson e Henrikson, o 3º fator está em verde e seria a distância linear do ponto AD2 à espinha nasal posterior de Linder-Aronson e Henrikson, e o 4º fator representado em amarelo corresponde a distância linear do ponto AD a um ponto da linha vertical pterigóide 5mm acima da espinha nasal posterior de Ricketts.²⁶

RESULTS

The first part of the questionnaire had the aim to present which exams the otorhinolaryngologists of this sample are used to ask for to visualize nasopharyngeal airways and adenoids, if they use or not any measuring method and if they are familiar with the cephalometric radiograph.

This questionnaire showed that the cavum radiograph is the most asked for (100%), followed by endoscope (83%) and the cephalometric was only used by one of the doctors in this sample. Only one of them used any type of measurement to evaluate the degree of ob-

struction of the nasopharyngeal airway, while only two of them were familiar with the cephalometric technique as a method of diagnosing obstruction.

The sample preference in visualizing adenoids and nasopharyngeal airway are described in tables 2 and 3. They show the absolute and relative frequencies of the preferences related to the cavum and cephalometric. Table 1 shows the preference in visualizing the adenoids, where 49.4% preferred technique B (cephalometric), 22.8% preferred A (cavum) and 27.8% didn't observe any difference in both. As for the nasopharyngeal airway, 48.9% preferred technique B (cephalometric), 23.9% preferred A (cavum) and 27.2% didn't observe any difference between both of them (Table 2).

Table 3 shows concordance values between the visual analyses done by the otorhinolaryngologists when analyzing the radiographs and the values found using the measuring method of Schulhof. It was found a low correlation between both methods.

TABLE 1 - Absolutes and relatives frequencies of the preference of the otorhinolaryngologists (n=12) to visualize adenoids in mouth breathing children (n=15) in the cavum radiograph (technique A) and the lateral cephalometric (technique B).

Preference	N	%	Interval of trust 95%	
			Inferior limit	Superior limit
Technique A	41	22.8	16.9%	29.6%
Technique B	89	49.4	41.9%	57.0%
Both	50	27.8	21.4%	34.9%
Total	180	100		

DISCUSSION

Considering the controversies in accepting only the clinical signs to confirm the diagnosis of mouth breather, the professionals of medical and dental areas uses complementary exams to help in this diagnosis.

Despite the limitations, the radiographic exams are the most used and the first to be asked for when trying to make a diagnosis. After analyzing a radiograph the doctor will decide if any other exams are necessary.^{5,25,24,7,1}

The use of a radiographic technique to evaluate nasopharyngeal airway has been questioned because of its bidimensional visualization and static view to evaluate a tridimensional and dynamic structure. Several papers have demonstrated a significant correlation between the results obtained in the radiographic evaluation and the clinical evaluation,¹⁴ in the direct observation during the surgical procedure, in the posterior rhinoscopy^{18,19} and in the nasal endoscopy.^{29,15} Holberg and Linder-Aronson¹⁴ concluded that the lateral cephalometric radiograph would

TABLE 2 - Absolutes and relatives frequencies of the preference of the otorhinolaryngologists (n=12) to visualize nasopharyngeal airways in mouth breathing children (n=15) in the cavum radiograph (technique A) and the lateral cephalometric (technique B).

Preference	N	%	Interval of trust 95% 95%	
			Inferior limit	Superior limit
Technique A	43	23.9	17.9%	30.8%
Technique B	88	48.9	41.4%	56.4%
Both	49	27.2	20.9%	34.3%
Total	180	100		

TABLE 3 - Percent agreement values and Kappa between the visual method and the Schulhof measuring method to evaluate the size of adenoids and nasopharyngeal airways (NAW) of mouth breathing children (n=15).

Desfecho	Comparison	Observed agreement	Expected agreement	Kappa	P-value
Adenoid	Schulhof X Visual Cavum	62.78%	60.19%	0.06	0.1756
	Schulhof X Visual Cef	57.22%	59.81%	-0.06	0.8194
NAW	Schulhof X visual Cavum	36.67%	44.81%	-0.14	0.9927
	Schulhof X visual Cef	37.78%	45.19%	-0.13	0.9862

give satisfactory results about the dimensions of the nasopharynx, although Vig²⁸ sent a letter to the author questioning this result and saying that the cephalometric radiograph was not adequate to evaluate nasopharyngeal airways. But the research of those authors had a sample of 162 children, which is considered a relatively large sample and they found values for the size of adenoids very close to the clinical findings done after a posterior rinoscopy, which is a very interesting result.

Besides the radiographic evaluation being the diagnostic exam most used in the medical literature to evaluate hypertrophy of adenoids, it is also the most used method in planning orthodontic treatment. But the doctors usually ask for a cavum radiograph and the orthodontists ask for lateral cephalometric. Both of them are radiographs of the lateral cranium, but the cephalometric has a standard method to be obtained using the cephalostat to hold the patient's head in position. In the cavum radiograph the patient is able to move his head, and that required from the radiologist technician to be even more alert. According to Oliveira, Anselmo-Lima and Souza²⁵ a small change in the head position in the moment the exam is obtained can give important changes in the structures involved in the analyzes of the degree of obstruction of the nasopharyngeal airways. Being so, this lack of standard makes it impossible for the orthodontist to use the cavum radiograph, because the measurement analyses wouldn't be precise.

But the results of the present study shows that the otorhinolaryngologist are not familiar with the cephalometric technique, since only two of the 12 involved knew this radiographic method. It's important to notice that when both radiographs were compared, most of them picked as the best view of the nasopharyngeal airways and adenoids the cephalometric radiograph (49.4% and 48.9%) and approximately one forth didn't see any difference in both of

them (27.8% and 27.2%). This shows that the otorhinolaryngologists could use the same radiograph as the orthodontists, and the patient wouldn't need to be submitted to two radiographs, since the major part of treatments involving mouth breathers are multidisciplinary.

Araújo Neto et al¹ affirmed that because of the variety and complexity of the measurement methods preconized for the radiographic diagnoses of adenoids, many radiologists prefer to use the subjective analyses. But the present study showed that the subjective analyzes has low correlation with the measurement analyzes done, which shows that the subjective analyzes is not precise. It was found a lot of divergence between the doctors when classifying the size of the nasopharyngeal airways and adenoids by the visual method. This suggests that the same radiograph could have different diagnoses depending on who is analyzing it. The diagnoses would be more precise if the professionals got used to using any measuring method in their routine.

In this study, the nasopharyngeal analyzes was based in the work of Schulhof,²⁶ because this method combines four different measurements of different researchers. It was used the computerized result of the analyses of the nasopharyngeal airway since this doesn't exclude the basic knowledge of anatomic structures, besides diminishing the probabilities of errors as it was observed by David and Castilho.⁷ To evaluate the method error it was used Kappa indices, which demonstrated excellent correlation. This result was already expected because the professional was specialist in radiology with more than 5 years of clinical experience.

Regarding the results about the nasopharyngeal airway, the findings were inside the patterns of mouth breathers according to Handelman and Osborn¹², Linder-Aronson¹⁸ and Schulhof.²⁶ But the main objective of this study was not to verify the presence or not of hypertrophy of adenoids, those measurements were only done so

they could be compared with the visual method used by the doctors.

There are several other methods of measurements described in the literature that the professional may use, according to which one he finds easier to learn or has the best quality. Wormand and Prescott³⁰ compared the most used methods when using the cavum radiograph which are the Johanneson, Fujioka, Crepeau and Cohen and Konak and they found that the method of Cohen and Konak had the best results and the best efficiency, although the lack of patterns of the cavum radiograph may compromise the measurements.

If the cephalometric radiograph is used, there is the McNamara's²² and the Schulhof's²⁶ technique. Papers evaluating those methods are ambiguous. Kluemper, Vig and Vig¹⁷ concluded that both analyses are weak indicators of nasal obstruction when compared to clinical results, but they didn't compare those methods with computerized tomography, which would be the ideal golden pattern.

It would be interesting that the otorhinolaryngologists started using the measurement

methods that already exists and from there started to develop other methods better elaborated, more precise and easy to use that could turn the diagnoses of nasopharyngeal airways and adenoids more precise.

Having in mind that the otorhinolaryngologists picked the cephalometric radiograph over the cavum, they should consider starting using this technique so they could ask for the same exam as the orthodontists. This would facilitate the dialog between both of them and diminish the cost and radiation for the patient.

CONCLUSION

The present study concluded that according to the sample used, the otorhinolaryngologists are not familiar with the cephalometric radiograph and have the habit of using the cavum radiograph with no measurement technique.

When both techniques were evaluated in a blind way, most doctors chose the lateral cephalometric as the best one.

When compared the visual and the Schulhof measurement method it could be seen that there was low correlation between them.

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Email:

Brazilian consensus of snoring and sleep apnea – aspects of interest for orthodontists

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Abstract

The objective of this article is to clarify the positions of the medical societies that have worked together to establish a consensus regarding the clinical and laboratory parameters involved in sleep-disordered breathing, particularly snoring and obstructive sleep apnea syndrome (OSAS). Orthodontists have gradually come to take part in multidisciplinary teams that act in the area of human sleep, but few know about the uniformity coordinated by the Brazilian Association of Sleep. Clinical and scientific studies from the field of dentistry (particularly orthodontics) also must observe and follow these diagnosis and treatment criteria established by the Brazilian medical community.

Keywords: Sleep Apnea. Obstructive. Snoring. Polysomnography.

INTRODUCTION

Sleep disorders can be grouped and classified into diverse categories. Three classification schemes have been identified; currently, the International Classification of Sleep Disorders manual from the American Academy of Sleep Medicine, published in 2005 (ICSD-2, 2005),¹ is followed. Two other classifications preceded this manual, one from 1979² and one from 1990,³ with the last being reviewed in 1997.⁴ Sleep disorders are classified into eight groups, with obstructive sleep apnea syndrome (OSAS) classified in group II as a

sleep-related respiratory disorder, next to central sleep apnea syndrome and the sleep-related hypoventilation/hypoxia syndromes.¹

Sleep-related respiratory disorders are prevalent but are not always adequately diagnosed or treated.^{5,6} OSAS is one of the clinical entities that are most commonly encountered in the population, and its consequences involve extreme sleepiness, risk of transit and industrial accidents, cognitive deficits and cardiovascular diseases.^{7,8,9}

In 2007, an initiative of the Brazilian Sleep Association, the Brazilian Neurology Academy, the

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Brazilian Otorhinolaryngology and Facial Cervical Surgery Association, the Brazilian Pediatric Society, the Brazilian Pulmonology and Phthysiology Society and the Brazilian Clinical Neurophysiology Society sought to standardize the diagnosis and treatment of OSAS in adults, children and adolescents in Brazil. The field of dentistry was represented by three research dentists from the area of sleep who were invited by the Brazilian Sleep Association.

Meetings between the members of these societies and medical literature studies have guided the recommendations of this consensus. The final document had the evidence levels I-V as its basis, detailed in Table 1.

The purpose of this article is to clarify the guidelines of the medical societies with regard to the diagnosis and therapeutic treatment of sleep-related respiratory disorders, delimiting the orthodontists' area of operation on the basis of medical consensuses and evidence levels that have guided the established criteria.

SLEEP RESPIRATORY DISORDERS

Sleep-related respiratory disorders are classified as follows: central sleep apnea syndrome (CSAS), obstructive sleep apnea syndrome (OSAS), sleep-related hypoventilation/hypoxia syndromes, sleep-related hypoventilation/hy-

poxia syndromes due to medical conditions and other sleep-related respiratory disorders (Table 2). Some of these disorders, such as CSAS and hypoventilation syndromes, possess subtypes that are not the focus of this study; moreover, they are clinical entities that orthodontists do not treat. Thus, the primary emphasis is given to OSAS and to the respiratory disorders in which the orthodontist functions.

Primary snoring is defined according to the International Classification of Sleep Disorders (ICSD) as the presence of characteristic snoring noises during sleep in the absence of alterations in

STUDY DESIGN	EVIDENCE LEVELS
Randomized study, well-developed design, with low alpha and beta errors. I	
Randomized study, with high alpha and beta errors. II	
Non-randomized study, with simultaneous controls. III	
Non-randomized study, with historical controls. IV	
Study of series of cases. V	

TABLE 1 - Alpha error: probability (generally established as $\geq 95\%$) that a significant finding does not result from chance. Beta error: probability (generally established of $\geq 80\%$) that a non-significant finding is the correct result of the study. The beta error is dependent on the sample size. Modified from Sackett¹⁰.

Central sleep apnea syndromes
Primary central sleep apnea
Central sleep apnea caused by Cheyne-Stokes standard respiration
Central sleep apnea caused by high-altitude periodic respiration
Central sleep apnea caused by non-Cheyne-Stokes medical conditions
Central sleep apnea caused by drug or other substance use
Primary sleep apnea of infancy (newborn)
Obstructive sleep apnea syndromes
Obstructive sleep apnea, adult
Obstructive sleep apnea, pediatric
Hypoventilation/hypoxemia related to sleep
Non-obstructive alveolar hypoventilation related to sleep, idiopathic
Congenital central alveolar hypoventilation syndrome
Sleep-related hypoventilation/hypoxemia syndromes caused by medical conditions
Sleep-related hypoventilation/hypoxemia caused by parenchyma and pulmonary vasculature diseases
Sleep-related hypoventilation/hypoxemia caused by obstruction of the lower airway
Sleep-related hypoventilation/hypoxemia caused by neuromuscular and thoracic cavity diseases
Other sleep-related respiratory disorders
Sleep apnea/sleep-related respiratory disorders, nonspecific

TABLE 2 - Classification of Sleep-related Respiratory Disorders.¹

oxyhemoglobin saturation, as assessed by average ventilation and electroencephalogram measurements.⁴ Snoring and the presence of apneas can be exacerbated after alcohol ingestion or weight gain.

Upper Airway Resistance Syndrome (UARS) is a condition where airflow limitations occur with increased resistance of the upper airway (UA); it is associated with micro-awakenings and can cause sleep fragmentation and excessive sleepiness. By definition, these alterations occur in the absence of apneas, hypopneas and/or significant oxyhemoglobin desaturation.¹¹ Increased UA resistance is evaluated by increased respiratory effort (measured precisely through esophageal pressure or indirectly through a nasal cannula pressure transducer). UARS is generally considered as an initial stage of OSAS, as the two syndromes have the same physiopathological characteristics.

OSAS is a multifactorial illness and is not yet completely understood, as it is partially caused by anatomical alterations of the upper airway and the craniofacial skeleton associated with neuromuscular pharyngeal alterations. OSAS is characterized by recurrent upper airway obstruction events during sleep, which are associated with clinical signs and symptoms. The obstruction is continuously manifested, involving an awakening related to increased respiratory effort and a limitation, reduction (hypopnea) or complete cessation (apnea) of air flow in the presence of respiratory movements. The interruption of ventilation generally results in oxyhemoglobin desaturation and occasionally results in hypercapnia. These events frequently end in microarousals.¹²

CENTRAL SLEEP APNEA SYNDROME (CSAS)

CSAS is a sleep-related respiratory disorder in which respiratory effort is reduced or absent in an intermittent or cyclical form due to cardiac or central nervous system dysfunction.¹ It is not a clinical entity for which the orthodontist can intervene, but the orthodontist needs to understand

this disorder when establishing a differential diagnosis between various sleep disorders.

CSAS possesses six subtypes: primary central sleep apnea; central sleep apnea due to Cheyne-Stokes respiration; central sleep apnea due to high-altitude periodic respiration; central sleep apnea due to a non-Cheyne-Stokes medical condition; central sleep apnea due to drug or substance use and primary sleep apnea of infancy (newborn) (Table 2).

Sleep-related hypoventilation/hypoxia syndromes (which may or may not be caused by medical conditions) are included in a specific chapter of respiratory sleep disorders that are no less important but will only be mentioned briefly (Table 2). Their study requires a specific approach that will not be discussed here.

OBSTRUCTIVE SLEEP APNEA SYNDROME (OSAS)

OSAS occurs when there is an airway obstruction concomitant with continuous respiratory effort with inadequate ventilation. The adult and pediatric forms are identified separately, as they are diagnosed and treated differently. The description of OSAS this text will be directed toward adult OSAS, which is more prevalent than pediatric OSAS.

ADULT OSAS

OSAS is characterized by repeated episodes of complete or partial airway obstruction during sleep. These events frequently result in reductions in blood oxygen saturation and associated arousals. These events must last at least 10 seconds and can occur in any stage of sleep; however, they are more common in the N1 (stage 1 of non-REM sleep), N2 (stage 2 of non-REM sleep) and R (REM sleep) stages than in the N3 (stage 3 of non-REM sleep or slow-wave sleep) stage. When they occur during REM sleep, they are generally longer and associated with more serious oxygen desaturation. The oxyhemoglobin saturation gen-

erally returns to normal values after the resumption of normal respiration.¹³

The most common symptoms of OSAS are fatigue upon waking, the sensation of non-restful sleep (independent of sleep duration), daytime sleepiness and worsening quality of life.¹³ Household members often report snoring, choking episodes or respiratory cessation as well as frequent movements that interrupt sleep.¹⁴

PREDISPOSING AND ASSOCIATED FACTORS

The predisposing factors for OSAS are obesity (mainly central), male gender, craniofacial abnormalities such as maxilomandibular hypoplasia, increased soft tissue and lymphoid tissue in the pharynx, nasal obstructions, endocrine abnormalities such as hypothyroidism, acromegaly and previous family history of OSAS. The associated factors are systemic arterial hypertension (SAH), pulmonary hypertension, sleep-related cardiac arrhythmias, nocturnal angina, gastroesophageal reflux, cognitive impairment, decreased quality of life and insomnia.¹²

GENERAL PHYSICAL EXAMINATION

As part of the general physical examination to assess OSAS, anthropometric variables (weight and height), neck circumference and arterial pressure are measured. Among these variables, those that have the greatest predictive value are neck circumference, body mass index and the presence of arterial hypertension.^{15,16}

CRANIOFACIAL EVALUATION OF THE UPPER AIRWAY

It is fundamental to evaluate the craniofacial morphology of each individual, thus detecting alterations in maxillary (hypoplasia) and mandibular (mandibular deficiency or retroposition) development (Fig 1). Obese patients with fat concentrated in the trunk commonly present with a short neck, widened cervical circumference, excess fat in the submental region and an inferiorly dislocated hyoid bone.^{17,18}

Severe sagittal malocclusions (example: Class II with mandibular involvement) that are vertical (open bite) or transversal (cross bite, presence of ogival palate and maxillary atresia) can be related to inadequate growth of the base maxillary and/or mandibular bones; thus, their skeletal involvement should be evaluated.

A disproportionate oral cavity anatomy, due to soft tissue (principally tongue volume) or hypodevelopment of the maxillo-mandibular bone structure, can be assessed by applying the Modified Mallampati Classification. The patient is placed in a seated position with maximum mouth opening and a relaxed tongue; the examiner then observes the dimension by which the oropharynx is exposed and classifies the results from I to IV, in accordance with the greatest or least visibility of the free edge of the soft palate relative to the tongue base (Fig 2). The size of the palatine tonsils must also be evaluated (Fig 3), including the aspect of the pillars that can be voluminous or average and the uvula and soft palate, which can contribute to



FIGURE 1 - Patient with severe OSAS. Craniofacial and cervical morphology demonstrating a Class II standard with base mandibular bone involvement, short neck, widened cervical circumference and excess fat in the submental region.

a reduction in the retropalatal space, particularly if they are thick and elongated.^{17,18} Both the examination verifying the proportion between the oral cavity soft tissues and the oropharynx (Mallampati classification) and the evaluation of the palatine tonsils are routinely and preferentially completed by an otolaryngologist, but they can also be completed by an orthodontist.

Nasopharyngolaryngoscopy and cephalometry exams are recommended for evaluation of the upper airway. The first is performed exclusively by a medical professional; it is the endoscopic evaluation of the upper airway (UA) and must be performed to identify obstructions that may contribute to OSAS pathophysiology or hinder adaptation to CPAP. Spatial relationships, including those of the soft palate and tongue base to the posterior pharyngeal wall and the anatomical structures of the pharynx, are evaluated with a flexible endoscope. In addition to anatomical features, one can evaluate the tendency of the soft tissue of the pharynx to collapse and sag by forced inspiration with occlusion of the mouth and nostrils, creating negative pressure inside the UA (Müller maneuver). However, detection of the point of UA collapse is very subjective and nonspecific, and the importance of the Müller maneuver in evaluating patients with OSAS has been questioned¹⁹. Cephalometry may help to identify sites of pharyngeal

obstruction as well as contributing to an evaluation of the space posterior to the UA, the length of the soft palate, the hyoid bone position, and the verification of the growth pattern and spatial po-

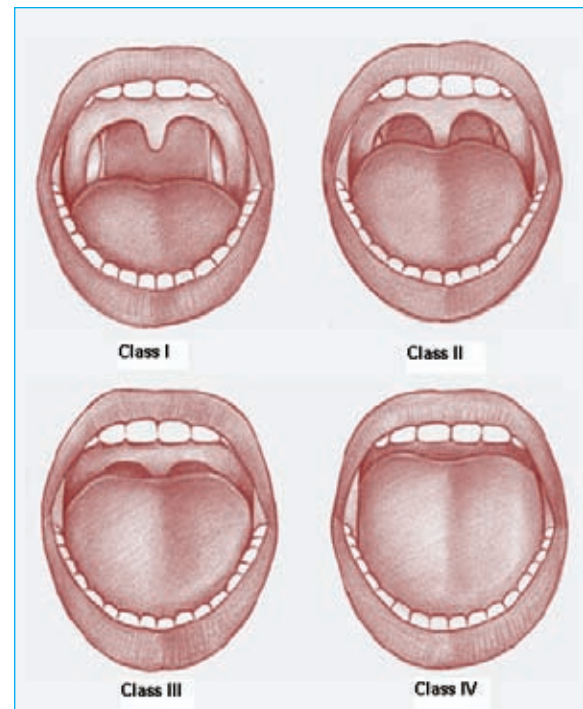


FIGURE 2 - Modified Mallampati Index:

Class I: the entire posterior oropharynx wall is visible, including the inferior pole of the tonsils.

Class II: part of the posterior oropharynx wall is visible.

Class III: the uvular insertion and soft palate are visible. It is not possible to observe the posterior oropharynx wall.

Class IV: only part of the soft palate and hard palate are visible.



FIGURE 3 - Graduation of palatine tonsils.

Degree I: Palatine tonsils occupy up to 25% of the oropharyngeal space.

Degree II: Palatine tonsils occupy between 25% and 50% of the oropharyngeal space.

Degree III: Palatine tonsils occupy between 50% and 75% of the oropharyngeal space.

Degree IV: Palatine tonsils occupy more than 75% of the oropharyngeal space.

sitioning of the maxilla and mandible. The present consensus stipulated that cephalometry should not be a routine test for evaluating patients with OSAS. This means that a cephalometric radiograph does not need to be requested. However, in cases of suspected craniofacial dysmorphism (abnormal craniofacial morphology), the preferred evaluation method is cephalometry.¹⁹ It should be noted that OSAS has a multifactorial etiology and that cephalometry is not capable of predicting the severity or presence of the disease. It is an important test in cases involving orthognathic surgery and to monitor possible changes in the position of dento-skeletal structures caused by intra-oral appliances. Other imaging studies, such as CT and MRI, are also used as complementary methods in the visualization of airway structures in patients with sleep disorders.

DIAGNOSIS

The entire night polysomnographic study (PSG), carried out in the laboratory under the supervision of a qualified polysomnography technician, constitutes the standard diagnostic method for the evaluation of respiratory sleep disorders (evidence level I).²⁰ A record of at least 6 hours is recommended, with monitoring of the following parameters at minimum:

- Eletroencephalogram: electrodes F3, C3 and O1 and contralateral mastoid reference;
- Left and right electrooculograms;
- Electromyogram of the chin region;
- Electromyogram of the lower limbs (tibial anterior muscle bilaterally);
- Nasal and oral air flow recorded by thermistor or thermocouple type sensors;
- Record of nasal pressure obtained by pressure transducer;
- Record of thoracic and abdominal movement by means of piezo-electric and inductance belts;
- Eletrocardiogram;
- Digital oximetry;

- Record of snoring with tracheal microphone;
- Record of body position.

The principal diagnostic OSAS severity criteria are presented in Tables 3 and 4.^{1,12} The diagnosis of adult OSAS requires the presence of criteria A+B+D or C+D, described below:

TREATMENT WITH ORAL APPLIANCES

Oral appliances (OA) are an option with a high evidence level for the treatment of respiratory sleep disorders. Treatment with positive pressure airway devices and surgical treatment of soft pharyngeal and/or facial tissues are also part of the therapeutic arsenal for respiratory disorders that occur during sleep. These treatment modalities will not be described here, as orthodontists principally use oral appliances as therapeutic tools.

The parameters currently used in conducting treatment with OA are those suggested by the most recent studies, consensus and task forces.²¹⁻²⁶ In the case that OA treatment is indicated, a medical referral is made in writing to the dentist. The dental treatment is composed of the medical history, physical examination, indication for treat-

Criteria (A+ B + D) or (C + D)
A) At least one complaint:
• Non-intentional sleep episodes during wakefulness, excessive daytime sleepiness (EDS), unrefreshing sleep, fatigue or insomnia
• Waking with respiratory pauses, choking or asphyxia
• Companion reports loud snoring and/or respiratory pauses in sleep
B) PSG: five or more detectable respiratory events (apneas and/or hypopneas and/or arousals related to respiratory effort)/sleep hour. Evidence of respiratory effort during all or part of each event.
C) PSG: 15 or more detectable respiratory events (apneas and/or hypopneas and/or arousals related to respiratory effort)/sleep hour. Evidence of respiratory effort during all or part of each event.
D) The disorder cannot be better explained by another sleep disorder, medical or neurological illness, medication use or disorder due to substance use.

TABLE 3 - OSAS Diagnosis Criteria.

SAOS Mild	PSG: AHI greater than or equal to 5 and less than or equal to 15 - Daytime sleepiness or involuntary sleep episodes occurring during activities that require little attention, such as watching television, reading or riding in a vehicle as a passenger. - Symptoms produce discrete alterations in social or occupational functions.
Moderate SAOS	PSG: AHI is greater than 15 and less than or equal to 30. - Sleepiness or involuntary sleep episodes occur during activities that require some attention, such as attending social events. - Symptoms produce alterations in social or occupational functions.
Severe SAOS	PSG: AHI greater than 30. - Daytime sleepiness or involuntary sleep episodes occur during activities that require greater attention, such as eating, speaking, walking or driving. - Symptoms provoke marked alteration in social or occupational functions.

TABLE 4 - OSAS Severity Criteria (PSG = polysomnography; AHI = apnea and hypopnea index).

ment (or contraindication and return of the patient to the original doctor), fabrication and installation of the OA, return and maintenance of treatment, monitoring and treatment of possible side effects, OA modifications and return to the original doctor to assess the treatment effectiveness. For cases in which the treatment was successful, long-term follow-up becomes essential.^{19,26}

Thus, the dentist performs the following roles:

- » Recognize a possible sleep disorder and/or associated risk factors, orient and appropriately recommend the patient, and direct the patient to a medical doctor;
- » Request a polysomnography, or forward to the doctor to do it whenever necessary;
- » Initiate and monitor the OA treatment as part of the joint consultation with the medical doctor;
- » Monitor and treat potential the side effects of OAs;
- » Complete the patient follow-up in long-term OA treatment;

- » Be involved in multidisciplinary teams in the surgical handling of patients with respiratory sleep disorders; Especially when there is need for orthognathic surgery.
- » Work with children or adolescents in a preventive or intervening manner to promote adequate bone growth to minimize the anatomical components of a future diagnosis of snoring and OSAS; in children already diagnosed with snoring or OSAS, the surgeon-dentist will carry out the indicated facial orthopediatric-orthodontic treatments.

» Prerequisites

To establish the baseline condition, the presence and gravity of OSAS, its complications and the patients at risk must be assessed. This initial evaluation must be obtained by a medical doctor through a clinical consultation and polysomnographic examination. Having a medical indication for treatment with OA, the patient will be directed to a dentist. The dentist will verify if the patient possesses the adequate dental conditions for OA therapy.^{14,19,21-24,26}

» OA adaptation

Most adequate OA indications, fabrications and adaptations for each patient must be conducted by a dentist with training in the treatment of respiratory sleep disorders (evidence level I). This professional must be able to conduct the case, which means being able to evaluate the collateral complications and effects that these patients may display, including occlusion alterations, temporomandibular dysfunction and eventual damage to associated structures. It is important to note that attainment of the final OA therapeutic position constitutes a delicate balance between side effects and effectiveness.^{21,22,26}

» OA Indications

• Primary:

Patients with primary snoring, UARS and mild-to-moderate OSAS (evidence level I).²¹⁻²⁴



FIGURE 4 - “BRD Appliance” (Brazilian Dental Appliance): mandibular repositioning appliance for the treatment of snoring and OSAS.²⁷



FIGURE 5 - “Tongue Retaining Device” (TRD).²⁸

- Secondary (evidence levels II and III):
Patients with moderate-to-severe OSAS:
 1. Who did not accept CPAP;
 2. Who are incapable of tolerating CPAP treatment;
 3. Who failed to undergo CPAP or behavioral treatment;
 4. Coadjuvant to surgical treatment.

Once the OA indication is confirmed, a choice must be made between the mandibular repositioning appliance (MRA) and the tongue retainer (TRA), which are the two currently available categories of OA (Figs 4 and 5). The gradual adjustment MRA presents scientific evidence for the treatment of snoring and OSAS, while the TRA only possess evidence for the treatment of snoring, especially in edentulous conditions.^{21-24,26}

» Contraindications of OA (evidence levels II and III).²¹⁻²⁴

- Diagnosis of predominantly central sleep apnea
- Active periodontal disease or accented bone loss
- Severe temporomandibular dysfunction

Objective of OA (evidence level I):

Patients with primary snoring without OSAS or UARS: to reduce snoring to a subjectively acceptable level.

Patients with OSAS: resolution of clinical signs and symptoms and AHI normalization, oxy-hemoglobin saturation and sleep fragmentation.

Accompaniment (evidence level I).^{21-24,26}

It is important to clarify that OAs constitute a form of continuous treatment for an indefinite time.

Patients with primary snoring: clinical dental accompaniment is recommended, without the need for polysomnographic accompaniment.

Patients with UARS or OSAS (any severity): polysomnography with OA in the final position is indicated to assure a satisfactory therapeutic benefit.

- After final adjustments and evidence of effectiveness through polysomnography:

Dental accompaniment: every six months in the first year and annually thereafter. The intention is to monitor the adhesion, to evaluate deterioration or misalignment of the OA, to evaluate the health of the oral structures and the integrity of the occlusion and to address the signs and symptoms of OSAS.

Medical accompaniment: periodic clinical and polysomnographic reevaluation when the doctor judges it to be necessary.

CONCLUSIONS

The orthodontist who acts or intends to act in the field of sleep study needs to have fundamental knowledge of the adopted clinical-laboratory diagnostic parameters, the established definitions and the limits of their area of performance together with the multidisciplinary teams that accompany and treat sleep-related respiratory disorders.

The orthodontist may request polysomnog-

raphy when deemed necessary, being the definitive diagnosis of sleep disorders, their severity and evaluation of comorbid, medical assignments, which are based on polysomnographic findings. The orthodontist is very important to identify sites of pharyngeal obstruction, in evaluating and treating orthopedic and/or surgical treatment of maxillo-mandibular disharmonies, as well as in therapy of OSA with oral appliances.

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