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Sections

DPJO

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Articles

Online Articles

DOI: *https://doi.org/10.1590/2177-6709.25.6.007-008.edt*

The new DPJO: New forms of publishing with the same commitment to science

Flavia Artese[1], Laurindo Zanco Furquim[2]

For those who were born and raised before the digital age, it is evident that nowadays information spreads itself extremely fast and effectively. In this universe of available data, generally within reach of the palm of our hands, it is sometimes difficult to separate false from truth. Communication today can be false, distorted and biased and still be dispersed in great speed, without frontiers or limits, gaining the same strength as what should be trusted.

In this scenario, scientific journals have gained force as a north, since their main objective is to disseminate information from the scientific world that has been analyzed and certified through peer reviewing. In addition, publications guarantee authorship and origin of the work, as well as serve as public archives for future searches.[1] In other words, well-structured scientific journals are essential educational tools that can ultimately improve the treatment of patients.[2]

The editorial process of scientific journals dates back to 1665 when the first issue of the Philosophical Transactions of the Royal Society was published and included nine articles, a dedication, a list of books and other correspondences.[1] Although the purpose of publications have been the same since then, the process of publishing a journal has improved over time, especially due to peer reviewing and search tools.

On the other hand, the academic pressure for scientific publication seems to blur the real purpose of the publication itself. This is understandable and legitimate regarding the publication of articles resulting from research, which are generally financed by development agencies. In addition, the number and quality of publications by a researcher or professor classifies him within the academic environment. This demand led to a great proliferation of journals of the same area, which ended up also being classified through the most diverse indexes, such as the impact factor.

Therefore, in this universe of multiple options, the editorial team of a journal is concerned with its ranking, in order to be chosen by authors with submissions of relevant articles. The DPJO was founded 25 years ago as a local journal, published in Portuguese, by a private publisher. Since then it has been published uninterruptedly every two months and has always tried to improve to maintain its focus: the dissemination of information within the area of Orthodontics.

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Along these 25 years, editors and reviewers have worked voluntarily to transform a local journal into a periodical with international reach. The DPJO is currently an open-access journal, published in English, and indexed in the main scientific databases. In the SCImago Journal Ranking the DPJO is the tenth journal in the area of orthodontics and the third open access journal in this area in the world.

This growth of the DPJO has attracted a significant number of submissions from all over the world in the past 5 years. Due to the limited space for publication and the demand for approved articles, the final publication time is longer than desired. In order to expedite our publications, the DPJO decided to make a series of changes. Starting in the first edition of 2021, the journal will no longer exist in print and will be published in a continuous flow model. That is, the articles will be made available in the databases before the completion of a number. This more modern model provides greater flexibility in the authors' publication and immediate access to the journal's readers. The sections by guest authors will also be reduced in number, allowing the publication of more original articles, and editorials will be published only in special situations. In addition, to celebrate its 25 years of existence, the DPJO will start 2021 with a new format, completely digital and adapted for tablets and smartphones.

This current year was surprised by instant changes and we participated in the establishment of an even more digital and possibly faster world. In this way, the DPJO's new formatting and editing process are adapted to these new times, but respecting the good old practices. With these changes, the journal reaffirms its commitment to science, to authors and readers, hoping for an even higher ranking and relevance for the journal. However, we continue with our main objective: to guarantee qualified information, in a democratic way, to those who have a commitment to orthodontics based on scientific evidence.

Long live the DPJO.

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3D

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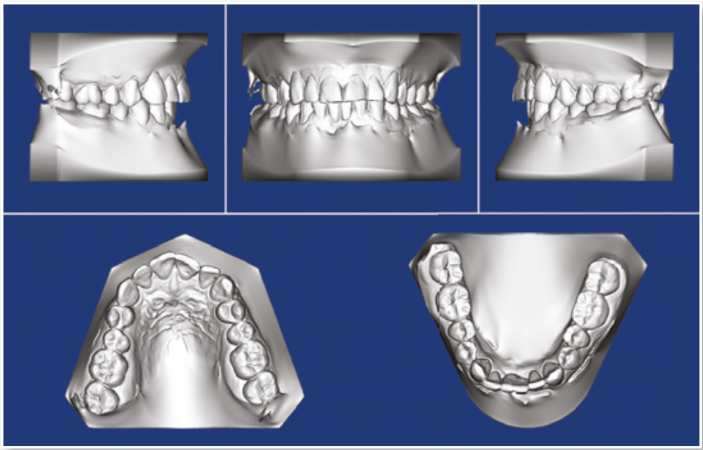

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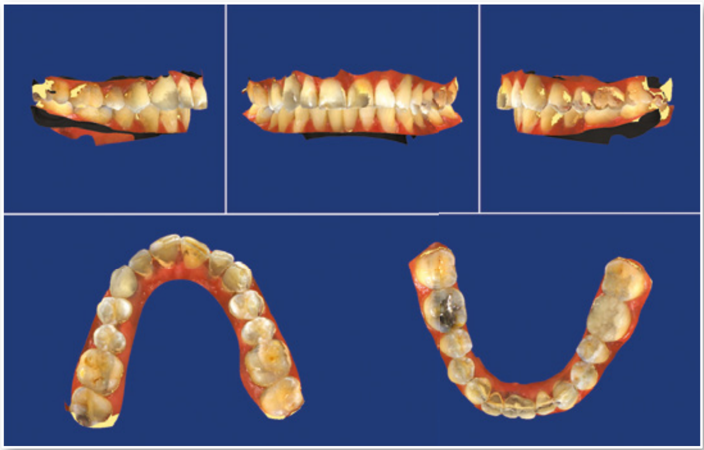

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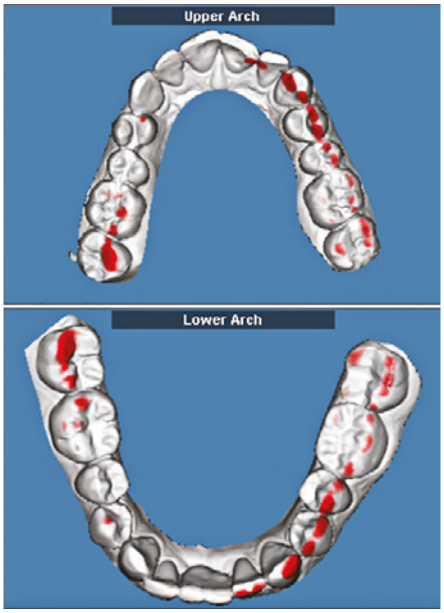

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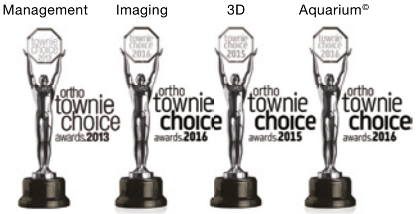

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Thiago Ottoboni

Victor Clavijo

Matheus Melo **Pithon**[1,2]

PRE-SURGICAL PREPARATION AFFECTS PATIENTS' QUALITY OF LIFE

The correction of maxillomandibular skeletal discrepancies by means of orthognathic surgery leads not only to occlusal and aesthetic improvements, but also improves patients' quality of life and self-esteem. Classically, treatment with orthognathic surgery requires orthodontic preparation, which aims to harmonize the teeth with their bone bases. However, in recent years, anticipated-benefit surgery has become popular. This technique opts for surgery before orthodontic treatment. Its supporters argue that it allows for immediate facial improvement, with a consequent improvement in patients' self-esteem and quality of life. However, little evidence is available to support these claims. To address this gap in the literature, English researchers developed a study[1] that aimed to determine whether early-benefit surgery improves or not quality of life, anxiety, and depression in patients with dentofacial deformities. A team of multidisciplinary researchers collected data from 32 patients with ages ranging from 17 to 47 years. The authors concluded that both treatment modalities (prior orthodontic preparation or surgery first) improved patients' quality of life and facial aesthetics after six weeks post-surgery. However, the authors point out that preoperative orthodontics worsened patients' quality of life and symptoms of anxiety and depression, although the timing of the operation did not affect those symptoms.

MOUTHGUARDS: AN ORTHODONTIC PATIENT'S ALLY WHEN PLAYING SPORTS

Playing sports benefits individuals and society, preventing disease and contributing to people's physical and psychological formation. Playing sports should be encouraged for everyone, including orthodontic patients. However, when playing sports, a patient using orthodontic appliance must take care to safeguard the integrity of the teeth and the orthodontic appliance. Orthodontic patients often use mouthguards, but doubts remain as to whether they are effective and whether the type of bracket influences their effectiveness. To answer these questions, Brazilian researchers developed a study[2] that aimed to analyze the influence of using a mouthguard and the type of orthodontic bracket (metallic or ceramic) on the biomechanical response during an impact. For this purpose, a two-dimensional model of a patient with an increased overjet was created based on a tomographic image (Fig 1). Then, the researchers conducted a finite element analysis of the dynamic impact, in which a steel object collided with the model at a speed of 1 m/s. Based on the results, the authors concluded that the presence and type of orthodontic brackets alter the stress distribution and deformation of the teeth during impact. Ceramic brackets generated greater tension than metallic brackets, and mouthguards reduced stress and deformation regardless of the composition of the bracket.

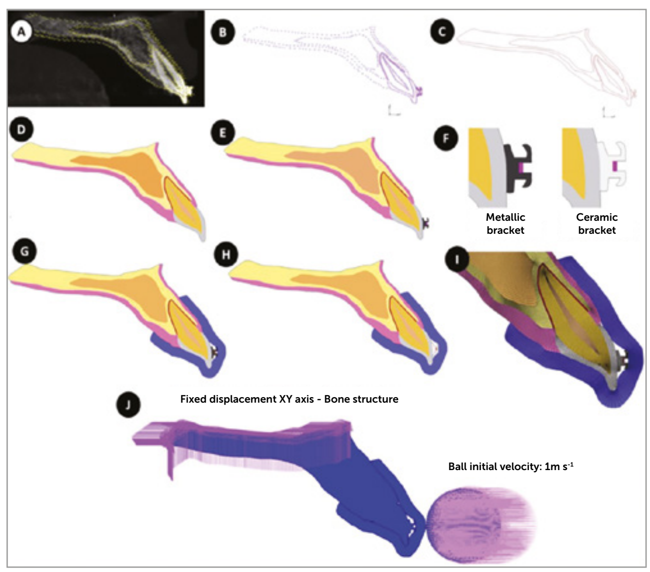

Figure 1 - Generation of two-dimensional finite element models. Source: Alves et al.[2], 2020.

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RAPID EXPANSION COMBINED WITH REVERSE MAXILLARY TRACTION PROMOTES FAVORABLE CHANGES TO THE AIRWAYS

The treatment of Class III malocclusion is one of the greatest challenges faced by orthodontists. A range of possibilities can be associated with this malocclusion, such as maxillary retrusion, mandibular prognathism or both. The gold standard for treating maxillary retrusion in a growing patient is rapid expansion combined with maxillary reverse traction. These therapies promote transverse and anteroposterior maxillary correction. Several studies have evaluated the effects of this treatment modality on the oropharyngeal and nasopharyngeal dimensions; however, they have yielded conflicting results. To verify this unconfirmed hypothesis, Italian researchers developed an study[3] in which they analyzed 47 patients with Class III malocclusion who were treated with rapid maxillary expansion followed by reverse traction (Fig 2) and compared them to 18 untreated control patients. Their results demonstrated that treatment with rapid maxillary expansion followed by reverse traction promoted favorable and significant sagittal changes in the oropharyngeal and nasopharyngeal airways in individuals with Class III malocclusion, compared to untreated controls. They also found that these changes were maintained long term.

EARLY SPACE CLOSURE AFTER TOOTH EXTRACTION INCREASES THE OCCURRENCE OF GINGIVAL CLEFTS

A frequent complication associated with space closure after permanent tooth extraction is the development of a gingival cleft, which can delay or prevent the complete closure of the space, cause recurrence (reopening) after the space closes, or impair the aesthetic result of the treatment. Few studies on this topic are found in the literature, and they tend to have conflicting results. Although hypotheses differ, orthodontists agree that the timing of space closure impacts aesthetics. Based on this assumption, researchers from Sweden and Austria developed a study[4] that aimed to assess whether prompt or delayed closure of the orthodontic space after the extraction of a permanent tooth affects the incidence of gingival cleft development. The study was conducted with 25 patients who required bilateral extraction of premolars due to orthodontic reasons. One premolar, chosen at random, was extracted eight weeks before beginning the space closure (delayed movement) while the contralateral premolar was extracted one week before the space closure (early movement). The presence or absence of gingival clefts was evaluated at three and six months. The results indicated that gingival clefts are found frequently during the closure of an orthodontic space and occur more frequently with early space closure after extraction.

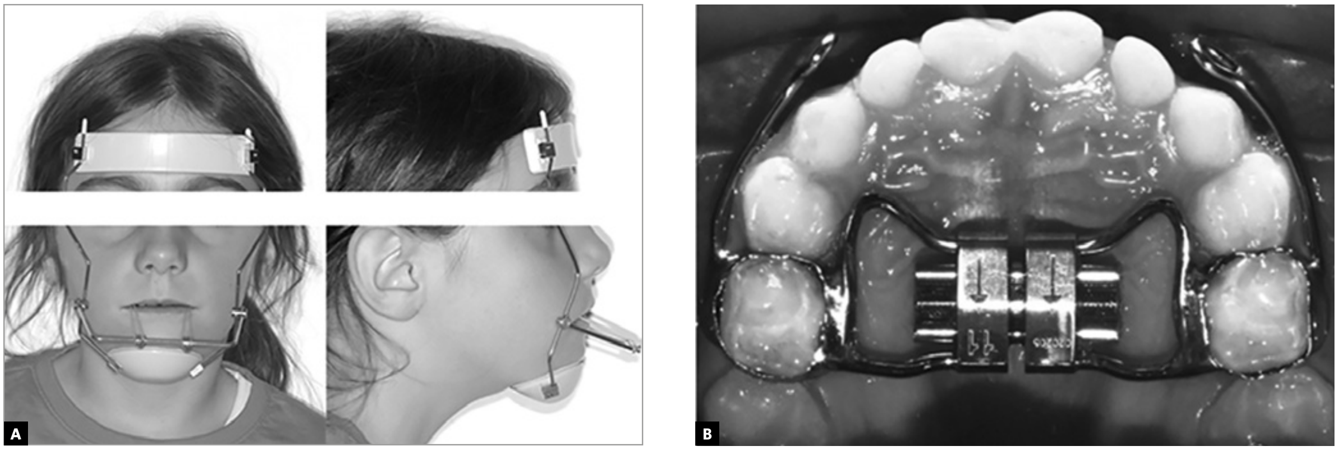

Figure 2 - Facemask (**A**) and expander appliance (**B**) used. Source: Cretella Lombardo et al.[3], 2020.

PRESENCE OF BRACKETS DOES NOT INTERFERE WITH THE QUALITY OF INTRAORAL SCANNING

The use of an intraoral scanner has become routine in orthodontic clinics. The advent of the intraoral scanner hastened diagnoses and enabled orthodontists to quickly send digital models anywhere in the world via the Internet. Models based on these scans have many uses, including serving as an initial and final study, fitting orthodontic devices, and in orthognathic pre-surgery. However, in the latter application, the question remains whether these models are accurate, since they are obtained in the presence of orthodontic brackets. To address this matter, Korean researchers developed a study[5] performing intraoral scans on 30 patients using iTero and Trios scanners. In sequence, the two scan sets, with and without brackets, were superimposed to assess any distortion. The results revealed that the general discrepancies between intraoral scans with and without brackets were within 0.30 mm, and the distortion of the images occurred within 0.50 mm around the brackets. This indicates that the accuracy of intraoral scanners, even in the presence of brackets, is clinically acceptable.

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Diagnosis of alveolodental ankylosis in unerupted canines: one of the answers to why the canine does not come

Alberto **Consolaro**[1,2], Omar **Hadaya**[3], Mauricio de Almeida **Cardoso**[4]

DOI: *https://doi.org/10.1590/2177-6709.25.6.019-025.oin*

Introduction: Teeth frequently fail to erupt and situations arise that prevent the canines from reaching the occlusal plane. **Objective:** Discourse about the three situations in which the canine does not reach the occlusal plane, and remains unerupted; and at the same time, point how to make a safe diagnosis of alveolodental ankylosis — one of the three causes —, based on tomography. **Conclusions:** Ankylosis occurs in impacted teeth by atrophy of the periodontal ligament, including the epithelial rests of Malassez. The tomographic signs of alveolodental ankylosis in unerupted canines are the interruption of hypodense periodontal space, discontinuity of the lamina dura and its continuity with the root surface, which gradually loses its regular shape.

Keywords: Dental resorption. Alveolodental ankylosis. Replacement tooth resorption. Canines. Impacted teeth.

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» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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

ORIGIN OF THE PERICORONAL FOLLICLE

The pericoronal follicle is adhered to the impacted canine (Fig 1). Previously, it was the organ that had already produced enamel and participated in the initial production of dentin, when it was named the enamel organ, which occurred during odontogenesis.

In the most cervical portion of the crown that is already completely formed, the enamel organ gives rise to a structure that becomes independent. Because the shape of this structure is similar to that of the cuff or fold of a sleeve, it received the name of Hertwig's epithelial root sheath (HERS). It becomes dislodged, or detaches itself, from the pericoronal follicle to orient and participate in formation of the root and form the important epithelial network of the epithelial cell rests of Malassez, which are responsible for maintaining the periodontal space.

After producing enamel and giving origin to Hertwig's epithelial root sheath, the mature enamel organ transforms its embryonic components into mature tissues, and as the set, receives the name of pericoronal follicle, and assumes another primordial function: that of being the main entity responsible for tooth eruption.

IN WHAT WAY IS THE PERICORONAL FOLLICLE RESPONSIBLE FOR TOOTH ERUPTION?

Adhesion of the pericoronal follicle to enamel by the reduced epithelium of the enamel organ is performed by hemidesmosomes and assumes the following characteristics:

1. Without blood vessels, this epithelium is nourished by diffusion, from the tissue or interstitial liquid of the fibrous connective tissue that supports and surrounds it.

2. In this fibrous connective tissue organized in the form of capsules, there are numerous islets and remnant epithelial cords or vestiges of the dental lamina, which was eliminated by apoptosis soon after giving origin to the dental germ, but some of its cells persisted, and thus, organize themselves.

3. The reduced epithelium of the enamel organ plus the epithelial islets continually release the mediator EGF, or Epidermal or Epithelial Growth Factor.

4. EGF has the property of inducing bone resorption around it, and does not allow the bone to come near the enamel, that is, the tooth. In the root, EGF released by the Epithelial Rests of Malassez prevent the bone from arriving on the cement surface.

As odontogenesis occurs, by continually releasing EGF throughout the follicular tissue structure, the pericoronal follicle stimulates bone resorption around the crown, and thereby opens the pathway in bone for the tooth to make its way through to the occlusal plane. EGF interacts with other mediators, resulting in coordinated, efficient bone resorption.

The organ responsible for tooth eruption is the pericoronal follicle. If the pericoronal follicle is removed from any tooth, it loses its eruptive capacity, but if the root is removed, eruption continues normally.

WHY DO THE CANINES SOMETIMES NOT ARRIVE?

When the canines do not arrive, in general, the failure does not lie in the structure and function of the pericoronal follicle, but due to the following three situations that will be described: 1) Due to the lack of space for it and its crown; 2) Due to the inadequate position and direction of the long axis of the tooth; or 3) Due to the fact that alveolodental ankylosis has become established in the periodontal ligament.

FIRST SITUATION

There is no space for the canine and the pericoronal follicle together. If this space is provided, the canine comes through naturally, without applying traction.

The position and direction of the canine frequently appear to be adequate based on the space available for its crown in the dental arch, but the tooth continues to be impacted. The crown does not erupt; this event is promoted by the pericoronal follicle and its mediators.

For canine eruption to occur, the mesiodistal distance of its crown plus the thickness of the pericoronal follicle on both sides need to be contemplated in terms of the space in the dental arch. In order to have a calculation parameter, it could be said that the space in the dental arch required for the canine to erupt normally must be equal to 1.5 x the mesiodistal distance of the crown.

This measurement is a point of reference that makes it possible to calculate what can be achieved in clinical practice; and does not represent a closed and unrestricted point, which could be smaller, but the closer this measurement were to being equal to the mesiodistal distance of the crown, the less chance there would be for this canine to arrive naturally in the dental arch.

If there were 1.5 x the mesiodistal width of the canine in the arch, and the position were more or less favorable, the canine would come through alone, and not require the application of traction.

SECOND SITUATION

There is adequate space, and the canine does not arrive: traction is required.

Providing adequate space, as mentioned in the previous item, if the canine does not come through naturally after two to three months, without applying traction, the cause must be related to the unfavorable position or the direction of the tooth. In this case the application of orthodontic traction would lead to arrival of the tooth in its place.

Orthodontic traction represents a movement equal to any other orthodontic movement — even more favorable, by being an extrusion controlled by adequate forces in favor of the periodontal fibers orientation. However, orthodontic traction must be preceded by the necessary, adequate and controlled surgical procedures, in order to prevent consequences due to:

1. An unfortunate surgical manipulation of the cementoenamel junction; consequently, there would be external cervical resorption induced by surgical exposure of the dentin window found naturally in all the teeth in this region. These windows are microscopic.

2. If the tooth to be submitted to traction were luxated without planning, in an unfortunate and inadequate manner, this would be transformed into a surgically induced dental trauma. Consequently — before or after the tooth arrives in the dental arch —, this would lead to ankylosis and replacement resorption, and consequent loss of the tooth.

3. Do not allow acids and the bracket bonding products to reach the cementoenamel junction, thereby exposing the dentin windows naturally present in all human teeth, including the canines.

When bonding brackets, the ideal would be to leave a "band" approximately 2-mm wide, with the pericoronal follicle intact on the cementoenamel junction.

THIRD SITUATION

There is inadequate space, the canine does not come through naturally, not even with orthodontic traction applied: in this case, planned and adequate surgical luxation is required.

For luxation in canines, or other teeth, to have a good prognosis, this procedure needs to be most skillfully performed, in order to break only the points and areas of the alveolar bone adhered to the root. The movement must be firm and secure. Once luxation has been perceived, in order to check that it has been obtained, a delicate instrument is used for subtly evaluating whether the tooth has gained mobility. If this were not done, the procedure would be transformed into an intrasurgical dental trauma.

Surgically-assisted luxation alone brings no benefits to patients; this must be followed by the application of normal orthodontic traction. Should this not be possible, the above-mentioned procedure must not be performed. During the process of orthodontic traction, the movement induced promotes remodeling and repair of the bony bridges and areas of ankylosis. This considerably increases the chance of ankylosis being reverted in areas of the ligament repopulated by Epithelial Rests of Malassez from the neighboring areas.

In cases in which surgically-assisted luxation brought no benefit to the patients, even in teeth submitted to orthodontic traction, this needs to be taken into consideration at the time of planning the cases. These cases must be reanalyzed in an endeavor to discover where the failure occurred, which led to unsuccessful treatment.

When verification is required during the surgical procedure for performing intentional luxation of an ankylosed tooth, which will subsequently be submitted to traction, the tooth must not be moved in and out of the alveolus, an no exaggerated lateral movements of the luxated tooth must be promoted, because they would characterize dental trauma, and the consequences may be:

1. Persistence of the alveolodental ankylosis because of having killed more Epithelial Rests of Malassez, and evolution of the tooth to replacement resorption, of which the main cause is dental trauma.

2. External cervical resorption by intrasurgical dental trauma.

3. Calcific metamorphosis (CM) of the pulp due to partial lesion of the vessels that enter the dental pulp, during the maneuver.

4. Aseptic pulp necrosis, due to complete rupture of the vessels that nourish the dental pulp, characterizing a dental trauma.

5. Internal resorption, induced by dental trauma only.

WHY DOES ANKYLOSIS OCCUR IN IMPACTED TEETH?

The bone cannot touch the tooth because, if this were to occur, it would include the tooth in the continuous process of bone remodeling, promoting resorption of the root and simultaneously forming bone in its place, characterizing replacement resorption (Fig 1).

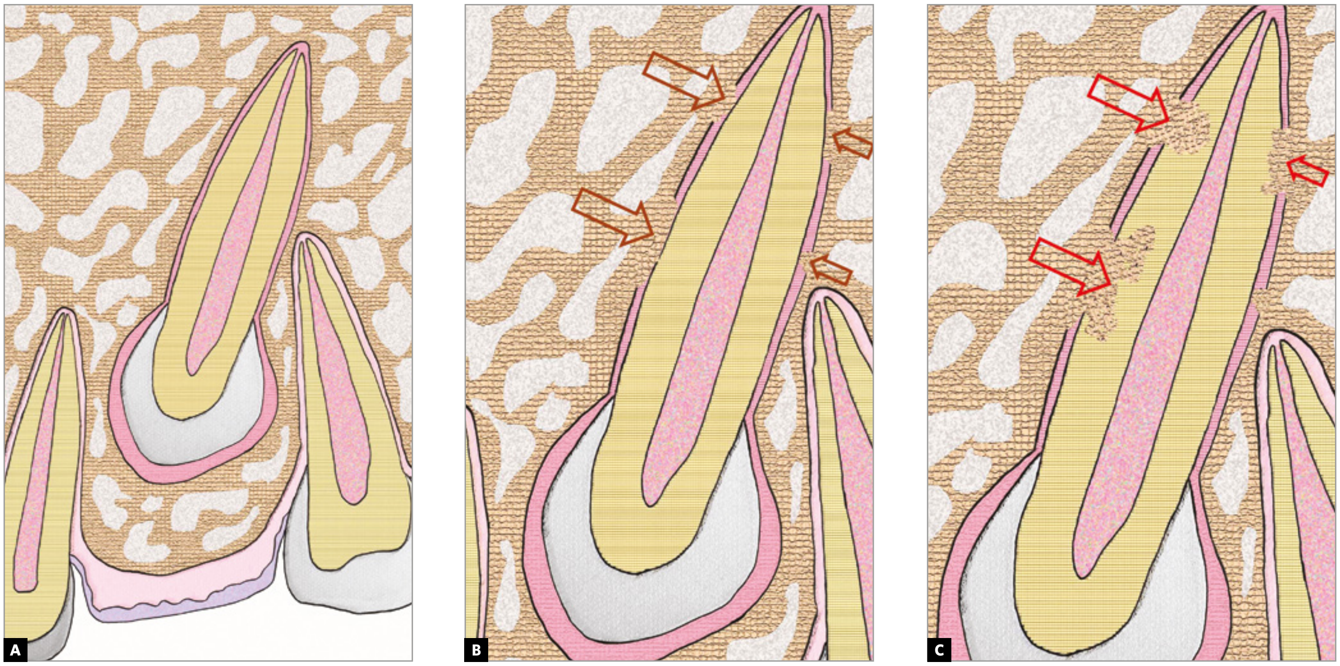

Figure 1 - Schematic representation of alveolodental ankylosis in canine, in **B**, and of incipient replacement resorption, in **C**. In **A**, the pericoronal follicle and continuous periodontal space can be noticed.

The entity that does not allow bone to naturally touch the tooth is the epithelial network, similar to a basket ball basket —with the tooth inside it— known as the Epithelial Rests of Malassez, which have the following physiological function, among others: maintaining the bone distant from the tooth by means of a periodontal space of between 0.2 and 0.4mm, with a mean of 0.25mm. Alveolodental ankylosis represents the union of bone, also the alveolar bone itself, with cement.[1]

In impacted teeth, the only cause is accidental dental trauma, interoperative or of any other nature, such as opening bottles with the teeth, bumping against the teeth with instruments, such as the laryngoscope and many other innocent procedures, such as personal contact during sport and leisure practices, or in fights and accidents. Dental trauma, when the tooth touches bone, promotes destruction of the Epithelial Rests of Malassez.

In impacted teeth, which remain in the bone environment for a longer time after their complete formation, since they remain unerupted and/or without space in the dental arch, excessive atrophy of the periodontal ligament may occur when there is a prolonged period of lack of use.

In teeth that remain unerupted for a longer period than the natural time, without function, the ligament becomes thinner than 0.2 mm, and the epithelial network without stimulus becomes even more delicate. Therefore, the bone that forms and resorbs all the time may trick the Epithelial Rests of Malassez into uniting themselves to the tooth. Initially this occurs at isolated points or isolated trabeculae, and gradually in larger areas, creating interfaces (Figs 1 to 5) of bone-tooth union.

Inevitably, alveolodental ankylosis develops gradually and naturally into replacement root resorption[1]. As from the point at which the bone came into contact with the root surface, their cells will consider the tooth as though it were bone, without distinction. While undergoing constant remodeling, the bone will resorb the tooth and slowly, progressively replace it, to the point where, some months and years later, there will be no more signs of a root at the site. This process is called replacement tooth resorption[1] (Figs. 1 to 5).

Alveolodental ankylosis and replacement tooth resorption are sequential phases in one and the same biological process, but we must not use the terms as synonyms. In replacement tooth resorption, loss of the tooth inevitably occurs in a slow and programmable manner.

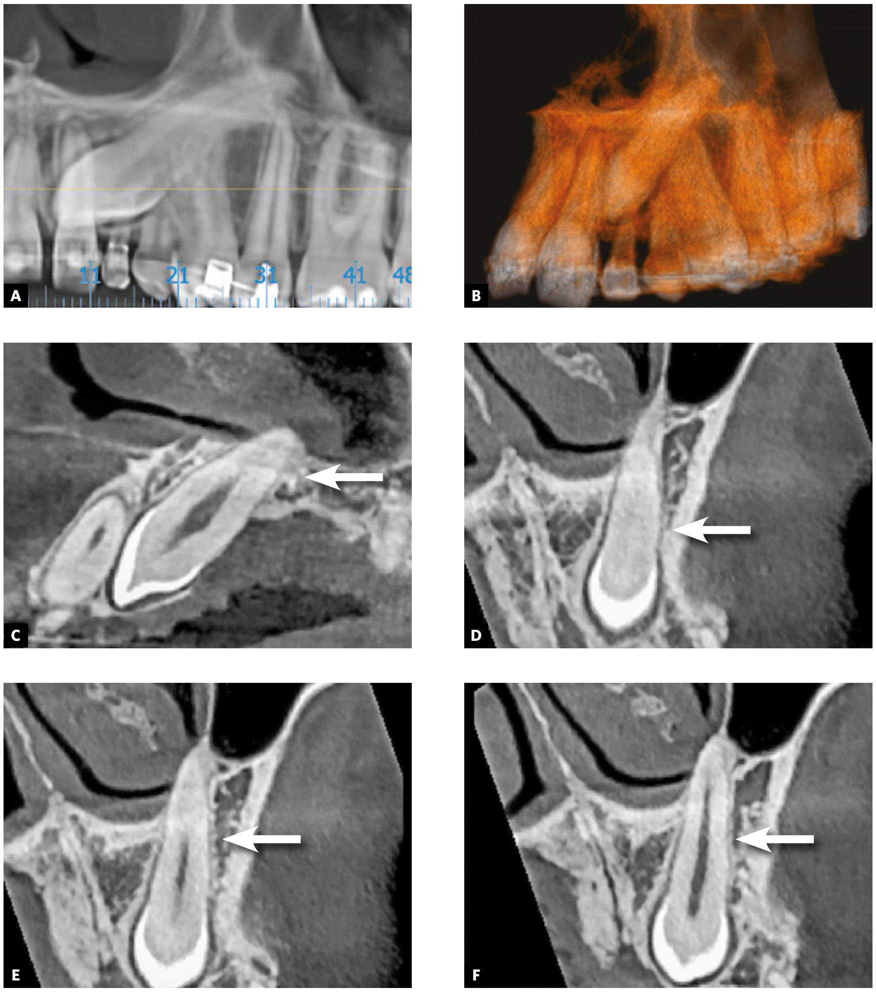

Figure 2 - Alveolodental ankylosis in maxillary impacted left canine. First detectable tomographic signs are loss of continuity of periodontal space and lamina dura in points or segments, as in **D** to **F**, on distal surface (arrows), compared with periodontal space on palatal surface of root, in **C** (**A** = Panoramic reconstruction; **B** = 3D reconstruction; **C** = Sagittal reconstruction; **D**, **E** **F** = Coronal reconstructions).

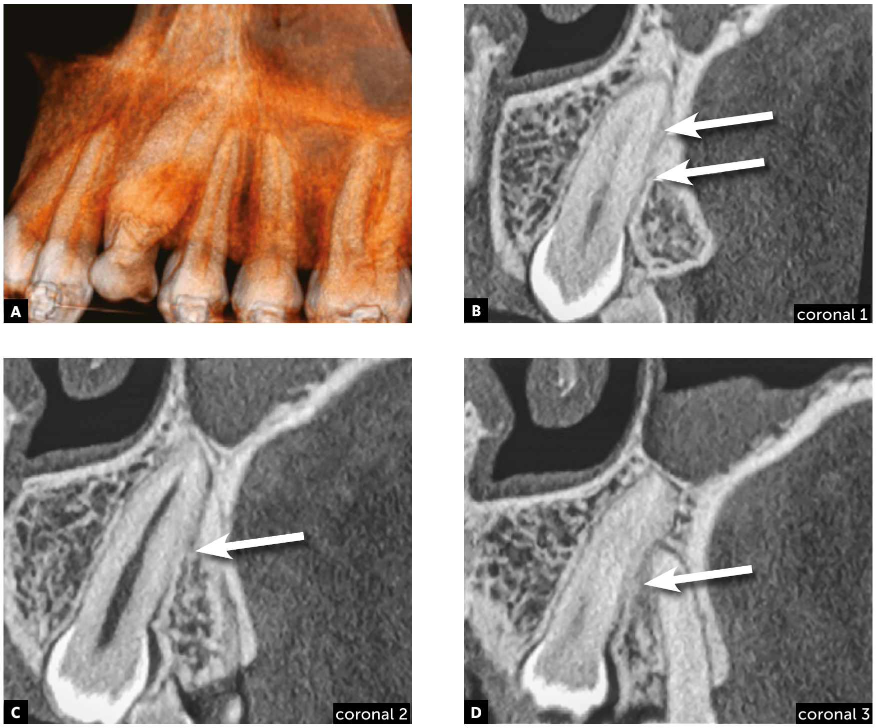

Figure 3 - Alveolodental ankylosis in another maxillary impacted left canine. There is loss of continuity of periodontal space and lamina dura in segments on distal surface (arrows), compared with mesial surface of root. Superficial irregularities in root contour are outstanding, indicating incipient replacement resorption (**A** = 3D reconstruction; **B**, **C** and **D** = Coronal reconstructions).

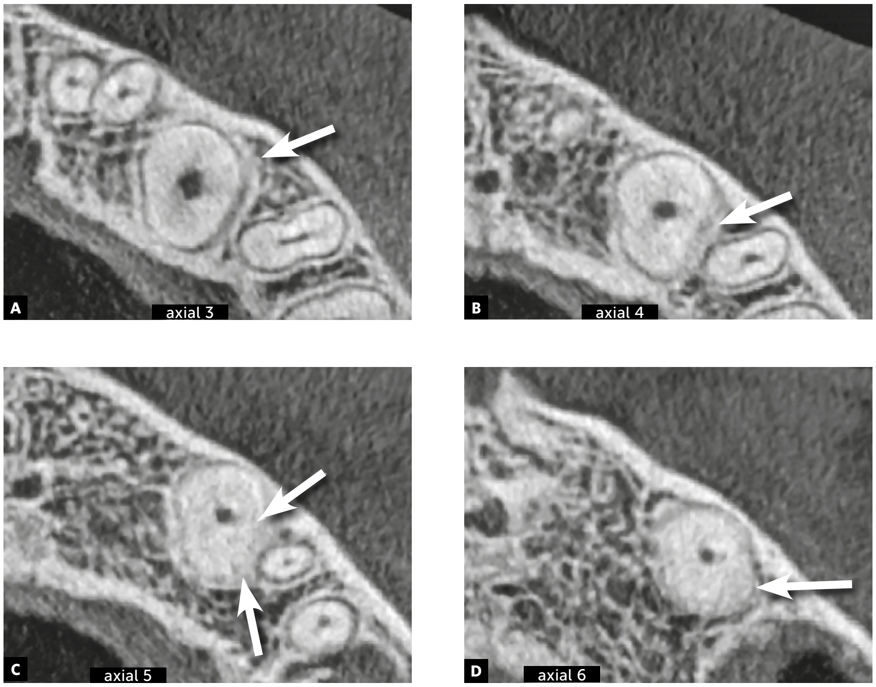

Figure 4 - Alveolodental ankylosis in the same maxillary impacted left canine shown in Fig 2, now in axial reconstructions. There is loss of continuity of periodontal space and lamina dura in segments on distal surface (arrows). Superficial irregularities in root contour are outstanding, indicating incipient replacement resorption.

TOMOGRAPHIC SIGNS OF ALVEOLODENTAL ANKYLOSIS IN IMPACTED CANINES

Due to variations in the position of unerupted teeth, with angulations and superimposition of images in radiographs, the safe diagnosis of alveolodental ankylosis and replacement resorption must be made on tomographic images. In tomographic images, the normal teeth exhibit a uniform and identifiable root surface. The lamina dura is shown as a radiopaque, hyperdense, well defined line, corresponding to the alveolar cortical bone. Between the tooth and lamina dura, a regular, uniform, well defined hypodense line is observed, which corresponds to the space of the periodontal ligament (Figs 1 to 5).

Seeking the continuous hypodense line of the periodontal space must be part of a meticulous analysis of the radicular and alveolar bone structures. The presence of lines and hypodense points in the periodontal space may correspond to bony trabeculae crossing it. The absence of periodontal space between the bone and root in small or larger segments in the tomographic sections indicates that there is alveolodental ankylosis.

Some months or years in the situation of unerupted teeth may indicate the presence of atrophy due to lack of use of the periodontal ligament, with narrowing of the periodontal space, with increasing risk of alveolodental ankylosis and subsequent replacement resorption. The continuous deposition of bone may touch on the cement and determine alveolodental ankylosis.

In the tomographic images, the section and planes (axial, sagittal and coronal) are varied and allow a multiplicity of angles of observation, providing assurance for a precise diagnosis (Figs 2 to 5). The diagnosis of ankylosis and replacement resorption leads to loss of the tooth and generates most important clinical decision-making. Whether or not these details are described in the imagiologic exam report, it is always convenient and necessary for the clinician to check the data that was described by the imagiologist, and when in doubt, promote an exchange of information and experience with this professional.

In teeth in which ankylosis has developed into replacement resorption, the root surface loses its continuity, with bridges, lines or radiolucent spaces, and loses its radiopaque homogeneity or root hyperdensity at the site (Figs 2 to 5). The regularity of the line of the lamina dura is interrupted and mixed with these radicular areas, now equally irregular, as a result of interlocking with bone tissue.

All these imagiological aspects are subtle, but sufficient for making a safe diagnosis. Even if the process of replace-

Figure 5 - Alveolodental ankylosis in another maxillary impacted left canine, in coronal reconstructions. There is loss of continuity of periodontal space and lamina dura in segments on mesial surface (arrows). Superficial irregularities in root contour are outstanding, indicating incipient replacement resorption.

ment resorption were a little more advanced, it would be clearly perceived in the axial, sagittal and coronal segments with respect to the pulp space, which would help to confirm that the process began in the external part of the tooth.

FINAL CONSIDERATIONS

Impacted teeth atrophy the structures due to lack of use, and the periodontal space diminishes to an extent beyond the range of 0.2 to 0.4 mm, considered normal. This reduction places the tooth at risk because the bone may penetrate into the diminished epithelial network of the Rests of Malassez, originating the alveolodental ankylosis, followed by replacement resorption. Ankylosis represents one of the three causes of a canine failing to erupt in its place in the dental arch. Diagnosing alveolodental ankylosis in radiographs is extremely difficult, due to the distortions and superimpositions they present, but in tomography, the images are presented in various sections and planes (axial, sagittal and coronal). Therefore, they allow multiplicities of angles of observation, providing assurance for making a precise diagnosis. The precise and assured diagnosis of alveolodental ankylosis, and the most incipient form of replacement resorption resulting from it, requires the use of tomographic images.

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Nature and severity of dental malocclusion in children suffering from transfusion-dependent β-thalassemia major

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Objective: To evaluate the prevalence and severity of malocclusion in children suffering from β-thalassemia and to assess orthodontic treatment need using Grainger's Treatment Priority Index (TPI) and index of orthodontic treatment need (IOTN)-dental health component (DHC).

Methods: A cross-sectional study was conducted on 200 transfusion-dependent children diagnosed with homozygous β-thalassemia and 200 healthy school children aged 11-17 years. The TPI and IOTN-DHC data was recorded for both groups. Total TPI score for each subject was calculated and graded according to malocclusion severity estimate (MSE). Independent sample *t*-test was used to compare mean TPI scores, overjet and overbite between thalassemic and healthy children. Chi-square test was used to compare the frequency of IOTN-DHC grades, Angle's classification, and MSE grades between thalassemic and healthy children.

Results: The most prevalent malocclusion was Class I in normal children (67.5%) and Class II in thalassemic children (59%). The mean overjet and overbite were significantly (p<0.001) greater in thalassemic children than in healthy children. Severe tooth displacements were 3.5 times greater in thalassemic children, compared to controls. A greater proportion of thalassemic children were in IOTN grades 3 and 4, compared to the controls (p<0.001). MSE grades 4 and 5 were significantly (p<0.001) more prevalent in thalassemic children, compared to the controls.

Conclusion: There is a high prevalence of Angle's Class II malocclusion in thalassemic children. Majority of these children are categorized in higher grades of IOTN-DHC and TPI-MSE, showing a great severity of malocclusion and high orthodontic treatment needs.

Keywords: Thalassemia. Beta-thalassemia. Index of orthodontic treatment need. Malocclusion.

*** Access www.scielo.br/dpjo to read the full article.**

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Attractiveness of different esthetic orthodontic wires

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Objective: The aim of this study was to evaluate the attractiveness of different types of esthetic orthodontic wires by laypeople and dentists.

Methods: Five different types of orthodontic wires were evaluated: three esthetic wires (Teflon-coated, epoxy resin-coated and rhodium-coated wires), and two metallic wires (stainless steel and NiTi), as control. Monocrystalline ceramic brackets were installed in the maxillary arch of a patient presenting good dental alignment. The five evaluated wires were attached to the orthodontic appliance with an esthetic silicone elastic and photographed. The photographs were evaluated by 163 individuals, 110 dentists and 53 laypeople. The data were statistically evaluated by two-way ANOVA and one-way ANOVA, followed by Tukey tests.

Results: There was a statistically significant difference in the attractiveness among the wires evaluated; the most esthetic was the rhodium-coated wire, followed by the epoxy resin-coated wire and, finally, the Teflon-coated wire, with no significant difference from the stainless steel and NiTi control archwires. There was no significant difference between the groups of evaluators.

Conclusion: The most attractive was the rhodium-coated wire, followed by the epoxy resin-coated wire and, finally, the least attractive wire was the Teflon-coated wire, without statistically significant difference to the stainless steel and NiTi wires, used as control.

Keywords: Orthodontic wires. Esthetics. Orthodontics.

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

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INTRODUCTION

Esthetics is the main reason that leads most patients to seek orthodontic treatment.[1-4] The esthetic changes in smile and face achieved through orthodontic treatment have been much approached and conveyed by the media, such as television and internet. The popularization of Orthodontics has generated, in the last years, a significant increase in the number of adult patients seeking for orthodontic treatment.[3,5-7] Most of these adult patients and also part of the young patients who intend to start orthodontic treatment have a preference for discreet appliances[8] and aligners.[9] This finding shows a current tendency to seek esthetics even during orthodontic treatment, either for social reasons, due to professional requirements or simply for avoiding the "metallic smile".[8,10,11]

The major manufacturers of orthodontic appliances began to worry about the esthetics in the mid-1970s. For the manufacture of esthetic orthodontic accessories, the metal that was used in its bases was initially replaced by plastic polymers, which have acceptable clinical properties, even having a much lower stiffness than steel. Subsequently the industry began to use polycrystalline ceramic, acrylic polymers and monocrystalline ceramic, known as sapphire, which is currently the material that provides greater esthetics in orthodontic brackets.[5,7,8]

To obtain esthetic orthodontic wires, a different problem emerged, compared to orthodontic accessories: the orthodontic wire should keep the metallic mechanical properties. The solution to this problem has been used from the 1970s to the present day, either by painting or coating with esthetic materials the conventional metallic archwires of the most varied alloys, such as stainless steel, titanium-molybdenum and NiTi. The first types of coating to be used were Teflon and epoxy resin.[7,8,12-14]

In an attempt to improve the esthetics of orthodontic wires, some manufacturers have developed the silicone-reinforced nylon-based wires (Optiflex, Ormco, Orange, CA, USA and Optis T, TP Orthodontics, Westville, IN, USA). These wires had an exceptional esthetic, however, they did not have good clinical properties. The manufacturers themselves recommended the use of these wires only on special occasions and for short periods of time. Due to clinical inefficiency, these wires were withdrawn from the market.[14] Recently, a technique used in the manufacture of jewelry has been used to make esthetic orthodontic wires, the rhodium bath.[13,15]

In recent years, esthetic brackets and wires have been widely studied, tested and compared in terms of their coefficient of friction,[16] surface roughness,[17,18] mechanical properties[17] and esthetic stability during treatment.[12,18,19] Their advantages and disadvantages have already been described in numerous studies in the literature.[7,12-14,17] Recently, Pinzan-Vercelino et al.[21] performed a cross-sectional study to evaluate laypersons' esthetic perceptions of metal archwires with and without esthetic coating and found that the epoxy resin wire was the most esthetic. But no study compared the attractiveness of several types of esthetic wires evaluated by both laypeople and dentists.

In this context, the present study aimed at evaluating the attractiveness of the different types of esthetic orthodontic wires by laypeople and dentists.

MATERIAL AND METHODS

In this study, five types of 0.016-in orthodontic wires were inserted into a single esthetic orthodontic appliance at different times and photographed in the smile.

Three esthetic wires were evaluated and two metallic wires were used as controls, as follows:

1. Epoxy resin-coated wire (Ever White NITI, American Orthodontics, Sheboygan, Wisconsin, USA).
2. Teflon-coated wire (Spectra, Dentsply GAC, Islandia, New York, USA).
3. Rhodium-coated wire (Sentalloy High Aesthetic, Dentsply GAC, Islandia, New York, USA).
4. NiTi wire (Flexy-NiTi Thermal, Orthometric, Marília/SP, Brasil).
5. Stainless steel wire (Morelli, Sorocaba/SP, Brasil).

In the orthodontic clinic of one of the authors, a female patient with great smile esthetics, good teeth alignment and leveling and normal overjet and overbite was selected. The patient signed a free and informed consent form accepting the participation and permitting the use of the photographs for research and academic purposes.

Monocrystalline ceramic brackets (Inspire Ice, Ormco, Orange, California, USA) were bonded from the right to the left second maxillary premolars. No appliance was bonded in the mandibular arch.

After appliance installation, each wire was inserted and attached to the brackets with silicone ligatures (SiLi-Tie Clear, Dentsply GAC, Iceland, New York, USA). Photographs were taken on artificial light without flash, with a D3200 camera with Nikkor 18/140-DX lens (Nikon LTDA, Minato, Tokyo, Japan), in frontal norm, with the patient in posed smile. The camera was attached to a tripod in front of the dental chair and all photographs were taken in the same position when the chair's backrest was in the most possible vertical position. All images were standardized using Adobe Photoshop software (CC 2016 version, Adobe Systems, San Jose, California, USA), with 300 dpi and with the same zoom (Fig. 1).

The five images (one for each evaluated wire) were used to compose a digital album, using a Google form (Fig. 2), and were evaluated by the raters. The images were presented in a random order, one underneath the other, for evaluation.

The study participants evaluated each wire individually and blindly, and rated from 1 to 10, based on the attractiveness — 1 being the least attractive and 10 being the most attractive wire. The evaluators could look and examine each of the images and compare them as they wanted for 10 minutes in total.

The link to evaluate the attractiveness of the different esthetic orthodontic wires was sent by e-mail and by WhatsApp message to laypeople and dentists, selected from the *Centro Universitário Ingá Uningá* (Brazil) university's database of former students. Inclusion criteria were: Dentists graduated for at least 5 years; laypeople graduated in another area than Dentistry, also for at least 5 years; age from 20 to 40 years. The dentists' specialty was not considered as a criterion.

About 150 messages and e-mails were sent for each group of evaluators, 300 in total, from which 163 individuals answered, resulting in a response rate of 54.3%. The response rate was 73.3% for dentists and 35.3% for

Figure 1 - Photographs of the evaluated wires: **A**) Ever White NiTi (epoxy resin), **B**) Spectra (Teflon), **C**) Sentalloy High Aesthetic (rhodium), **D**) Flexy NiTi Thermal, **E**) stainless steel.

laypeople. The laypeople responded less to the messages than the dentists, perhaps because they were less interested in the subject of the questionnaire.

The total number of evaluators was 163 individuals, 110 dentists (49 males, 61 females) and 53 laypeople (22 males, 31 females). The mean age was 26.78 for the whole sample, 25.31 for the laypeople and 28.72 years for the dentists.

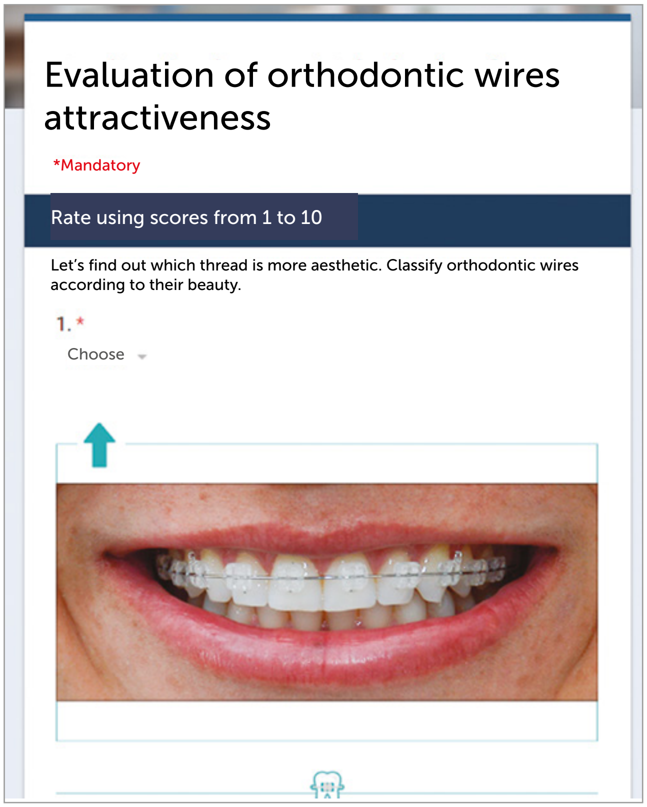

Figure 2 - Screen capture of the Google forms site, where raters evaluated the wires.

STATISTICAL ANALYSIS

The two-way analysis of variance test was performed considering the types of wire and evaluators. Since there was statistically difference in the types of wire, the one-way ANOVA and Tukey tests were performed.

Descriptive statistics were also performed for each evaluated wire and each group of raters.

The tests were performed with Statistica software (Statistica for Windows version 7.0, Statsoft, Tulsa, Oklahoma, USA). Results were considered significant for $p < 0.05$.

RESULTS

The results of the two-way analysis of variance showed statistically significant difference in the interaction and among the different types of evaluated wires, and no significant difference between the evaluators, dentists or laypeople (Table 1).

The rhodium wire showed to be the most attractive with a significant difference for all the other wires, followed by the epoxy resin-coated wire, which also showed significant differences to the other wires and, finally, the Teflon-coated wire, which presented similar attractiveness to the control stainless steel and NiTi wires (Table 2).

Table 3 shows the descriptive statistics of each evaluated wire and each group of raters.

Table 1 - Results of the evaluation of the type of wire and evaluators (two-way analysis of variance).

Type of variation	DF	F	P
Interaction	4	4.229	**0.002***
Type of wire	4	28.312	**0.000***
Type of evaluator	1	2.930	0.087
Intercept	1	4889.689	**0.000***
Error	968		

* Statistically significant for p<0.05. DF = degree of freedom, F = Variance.

Table 2 - Results of the comparison of the attractiveness among the wires (one-way ANOVA and Tukey tests) (n=163).

Variable	Epoxy resin Mean (SD)	Teflon Mean (SD)	Rhodium Mean (SD)	Stainless steel Mean (SD)	NiTi Mean (SD)	p
Attractiveness	6.11 (2.35)^{A}	4.90 (2.38)^{B}	7.42 (2.22)^{C}	5.28 (2.45)^{B}	4.76 (2.21)^{B}	0.000*

* Statistically significant for p<0.05. Different letters in a row indicate the presence of a statistically significant difference.

Table 3 - Means and standard deviations of the attractiveness of each wire evaluated for each group of raters.

WIRES	DENTISTS (n=110)		LAYPEOPLE (n=53)	
	Mean	SD	Mean	SD
Stainless steel	5.04	2.17	5.76	2.75
NiTi	4.50	2.05	5.30	2.46
Epoxy resin	6.10	2.16	6.13	2.66
Rhodium	7.54	2.01	7.16	2.62
Teflon	4.91	2.39	4.90	2.40

DISCUSSION

The objective of this work was to evaluate the attractiveness of the different types of esthetic orthodontic wires. In order to reduce the interference in the evaluators perception, monocrystalline ceramic accessories and silicone esthetic ligatures were used, since these materials were the most esthetic of their categories.[8,21] Besides, a patient with a great occlusion and smile esthetics, good teeth alignment and leveling and normal overbite and overjet was selected for orthodontic appliance bonding, in order to not interfere in the evaluation of the wire esthetics.

The rate of wire attractiveness did not present statistically significant differences between the evaluators (Table 1). This way, it can be assumed that in the evaluation of the attractiveness of orthodontic wires, a specialist's view did not differ from the view of a layperson.

The Teflon-coated wire and the stainless steel and NiTi wires presented similar attractiveness and were the least attractive evaluated wires (Table 2). The NiTi and stainless steel wires are metallic and uncoated, so they were considered as control for a reference parameter in the evaluation of the other wires that have different types of coating. The Teflon-coated wire was expected to be more attractive than the conventional metallic wires, and although it was whitish in color and marketed as esthetic, it did not differ from the metallic non-esthetic wires. It was one of the first wires sold and marketed as esthetic[14] and maybe this is the reason for the worst esthetics when compared to the epoxy resin and rhodium-coated wires, since these wires were developed later.

The epoxy resin-coated wire showed higher attractiveness than the NiTi, Teflon-coated and stainless steel wires, and lower attractiveness than the rhodium-coated wire (Table 2). For being considered esthetic, this result was expected, compared to the conventional metallic wires. Pinzan-Vercelino et al.[21] found in their study that the epoxy resin wire was the most attractive. However, in their study, the wires were evaluated only for 30 seconds each. In the present study, the evaluators had 10 minutes to evaluate all the wires, so they were able to compare the wires together. Probably when compared, the white coating appeared less attractive, justifying the differences with the Pinzan-Vercelino's study.[21]

The white coating of the epoxy resin appears to be more attractive than the Teflon yellowish coating and the conventional metallic wires. However, the epoxy resin wires, when in contact with the oral environment resemble to those of Teflon, and could undergo corrosion, drastic alterations in color, besides peeling in some parts, due to masticatory and friction forces, allowing the metal to be revealed, which causes discomfort to the patient and is unesthetic.[12-14]

The rhodium-coated wire showed the highest esthetic attractiveness among all the evaluated wires, followed by the epoxy resin-coated wire, with a statistically significant but numerically small difference (Table 2). The interesting about this result is that the most esthetic wire is not necessarily the whitest, since the rhodium bath gives a silver color, with a very clear shade, to the orthodontic wire, and may better mimic the shade of the teeth than the white color. This result is understandable since rhodium-coated wire has been developed more recently, using a more modern technique, applied in jewelry production.[13,15] In addition to the fact that rhodium-coated wire has presented the greatest attractiveness, it also presents considerable clinical advantages, being the esthetic wire that presents less color alteration and less corrosion of the esthetic coatings available in the market.[22,23]

Esthetic brackets and wires should not only be attractive, but also efficient in orthodontic movement. It is important that the accessories and wires meet the patient's esthetic expectations with clinical performance expected by the professional.[13] The wire with the best clinical performance in previous studies[13,22,23] was also considered the most attractive in the present study.

However, despite being the best evaluated wire regarding attractiveness, the scores given to the rhodium-coated wire in the present study (mean score of 7.42) are far from excellent, which shows that there is still a need for improvement. The companies can still work on new technologies to improve the esthetic wires, also seeking the best mechanical properties for orthodontic movement.

CONCLUSION

The most attractive wire was the rhodium-coated, followed by the epoxy resin-coated wire. The Teflon-coated wire was the least attractive, without significant difference from the control metallic wires.

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Influence of the growth pattern on cortical bone thickness and mini-implant stability

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Introduction: Controversial reports suggest a relationship between growth pattern and cortical alveolar bone thickness, and its effect in the use of mini-implants.

Objective: The main purpose of this study was to assess the influence of the growth pattern on the cortical alveolar bone thickness and on the stability and success rate of mini-implants.

Methods: Fifty-six mini-implants were inserted in the buccal region of the maxilla of 30 patients. These patients were allocated into two groups, based on their growth pattern (horizontal group [HG] and vertical group [VG]). Cortical thickness was measured using Cone Beam Computed Tomography. Stability of mini-implants, soft tissue in the insertion site, sensitivity during loading and plaque around the mini-implants were evaluated once a month. Intergroup comparisons were performed using *t* tests, Mann-Whitney tests, and Fisher exact tests. Correlations were evaluated with Pearson's correlation coefficient.

Results: The cortical bone thickness was significantly greater in the HG at the maxillary labial anterior region and at the mandibular buccal posterior and labial anterior regions. There was a significant negative correlation between Frankfort-mandibular plane angle (FMA) and the labial cortical thickness of the maxilla, and with the labial and lingual cortical bone thicknesses of the mandible. No significant intergroup difference was found for mini-implant mobility and success rate. No associated factor influenced stability of the mini-implants.

Conclusions: Growth pattern affects the alveolar bone cortical thickness in specific areas of the maxilla and mandible, with horizontal patients presenting greater cortical bone thickness. However, this fact may have no influence on the stability and success rate of mini-implants in the maxillary buccal posterior region.

Keywords: Orthodontics. Skeletal anchorage. Stability.

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

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INTRODUCTION

The use of mini-implants as anchorage has become a common routine due to its high predictability and practicality.[1,2] Stability of these anchorage devices is related to several factors, such as: site of insertion,[1] oral hygiene,[3] bone quality[4] and mostly the primary stability and load intensity.[5]

Cortical bone thickness is considered a determinant factor for primary stability of mini-implants. It is suggested that greater thickness of the alveolar cortical bone is associated with greater chances of primary stability and, consequently, better success rate.[4-6] In addition, associations between cortical bone thickness and vertical growth pattern have been evidenced, and the majority of the studies show that subjects with vertical growth pattern present thinner cortical bone, when compared with subjects with normal or horizontal growth.[7-11]

These associations could lead to the speculation that the vertical growth pattern could have some influence on the stability and success rate of mini-implants. However, only few studies have evaluated this direct association and the findings are controversial.[1,2,12]

Miyawaki el al.[12] reported that a higher mandibular plane angle is associated with greater failure of mini-implants. Contrarily, other studies[1,2] reported that there is no correlation between the mandibular plane angle and mini-implants success rate. Recent evidence supports the assumption that high-angle patients present narrower inter-radicular cortical bone thickness, when compared to low-angle patients, and this fact may play a role in mini-implants success.[10] Therefore, more studies are needed to confirm this association.

Based on this controversy and because cortical bone thickness could depend on the growth pattern, and it is considered an important factor related to mini-implant stability, it should be more deeply studied. For this reason, the primary objective of this study was to evaluate the influence of the vertical growth pattern on the alveolar bone cortical thickness and secondarily, assess the factors related to stability and success rate of orthodontic mini-implants.

MATERIALS AND METHODS

This study was approved by the Ethics in Research Committee of *Universidade de São Paulo, Faculdade de Odontologia de Bauru* (protocol #069/2009). A minimum sample size of 14 participants per group was necessary to provide 80% of test power, at a significance level of 0.05, to detect an intergroup difference of 0.5 mm in the alveolar bone cortical thickness, with a previously reported standard deviation of 0.45.[13]

The sample comprised 30 patients divided into two groups, according to their growth pattern, based on the Frankfort mandibular plane angle (FMA): FMA values smaller than the sample mean (24.35°) indicated horizontal growth pattern, and FMA values greater than 24.35° showed vertical growth pattern.[14] Therefore, the horizontal group (HG) comprised 15 patients that overall had 26 mini-implants (MI) and the vertical group (VG) consisted of 15 patients that overall had 30 MI.

The inclusion criteria consisted on: Class I and Class II malocclusion patients, presence of complete permanent dentition, need of at least one premolar extraction in the maxilla, and cases in which skeletal anchorage was required for anterior retraction in order to prevent any anchorage loss, such as severe Class I biprotrusion and severe Class II cases.

The exclusion criteria involved patients with mini-implants used for other biomechanics need, and the presence of any local or systemic condition that could influence stability of the mini-implants, as active periodontal disease, smoking and diabetes.

A total of 56 self-drilling mini-implants were evaluated. Thirty-eight mini-implants (1.5-mm diameter, 7-mm length) were inserted by one orthodontist (SEB) following the surgical technique that uses a coaxial radiographic positioner associated with a three-dimensional radiographic-surgical guide.[15] The other 18 mini-implants (1.6-mm diameter, 8-mm length) were inserted by another orthodontist (CCM) following the guide-free technique, based on tooth crown references.[16] Both operators were previously calibrated. All MI were inserted into the buccal, posterior maxillary region (38 between second premolars and first molars, 3 between first molars and second molars, and 15 between first premolars and second premolars). Immediate loading (100-250 g) was applied to all mini-implants using elastic chains. Information regarding the insertion techniques, site of insertion, and mini-implant characteristics used in the study are shown in Table 1.

Lateral cephalograms were evaluated to determine the vertical growth pattern (FMA). The cephalometric tracings and landmark identifications were performed on acetate paper by one investigator (CCM) and then digitized with Numonics Accugrid XNT digitizer (Houston Instruments, Austin, TX). These data were then stored in a computer and analyzed with Dentofacial Planner (version 7.0; Dentofacial Software, Toronto, Ontario, Canada).

Cone Beam Computed Tomography (CBCT) images were obtained using the 3D i-CAT cone beam system (Imaging Sciences International, Hatfield, PA) using a protocol of 120 kV, 36.12 mA, 8 cm field of view and voxel size of 0.25 mm. CBCT images were analyzed using an i-CAT Viewer software (XoranCat-Xoran Technologies, Ann Arbor, MI). The CBCT scans were obtained during the alignment and leveling phase and before mini-implant insertions. The reference chosen to standardize the axial and sagittal plane was the bispinal line, coinciding with the vertical and horizontal planes, respectively (Figs 1A and B). The reference used to standardize the coronal plane was a line between the buccal bone crests of the maxillary first molars[17] (Fig 1C).

After obtaining the maxillary and mandibular standardized axial sections,[17] two axial slices were selected passing 3.0 mm and 6.0 mm (Fig 2A, 2B); 4.0 mm and 8.0 mm (Fig 2C, 2D) apical to the cement-enamel junction, for the maxilla and the mandible, respectively.[17]

Measurements of the buccal and lingual cortical bone thickness were performed once on the CBCT scans, by an adaptation of the method advocated by Lee et al.[18] Initially, the interradicular distance was measured for each tooth. This distance was measured parallel to the arch contour, connecting the mean portion of each root, and defined as the smallest distance

Table 1 - Information regarding the insertion techniques, site of insertion, and mini-implant characteristics used in the study.

Operator	Insertion technique	Sample		Site of insertion	Mini-implant characteristics
		n	%		
SEB	Three-dimensional radiographic-surgical guide[15]	38	64.86	All – between second premolars and first molars	1.5-mm diameter, 7-mm length
CCM	Guide-free technique[16]	18	32.14	(n=3) – between first molars and second molars (n=15) – between first premolars and second premolars	1.6-mm diameter, 8-mm length

Figure 1 - Bispinal reference line, to standardize the sagittal and axial sections (**A** and **B**). Reference line between the buccal bone crests of maxillary first molars (**C**).

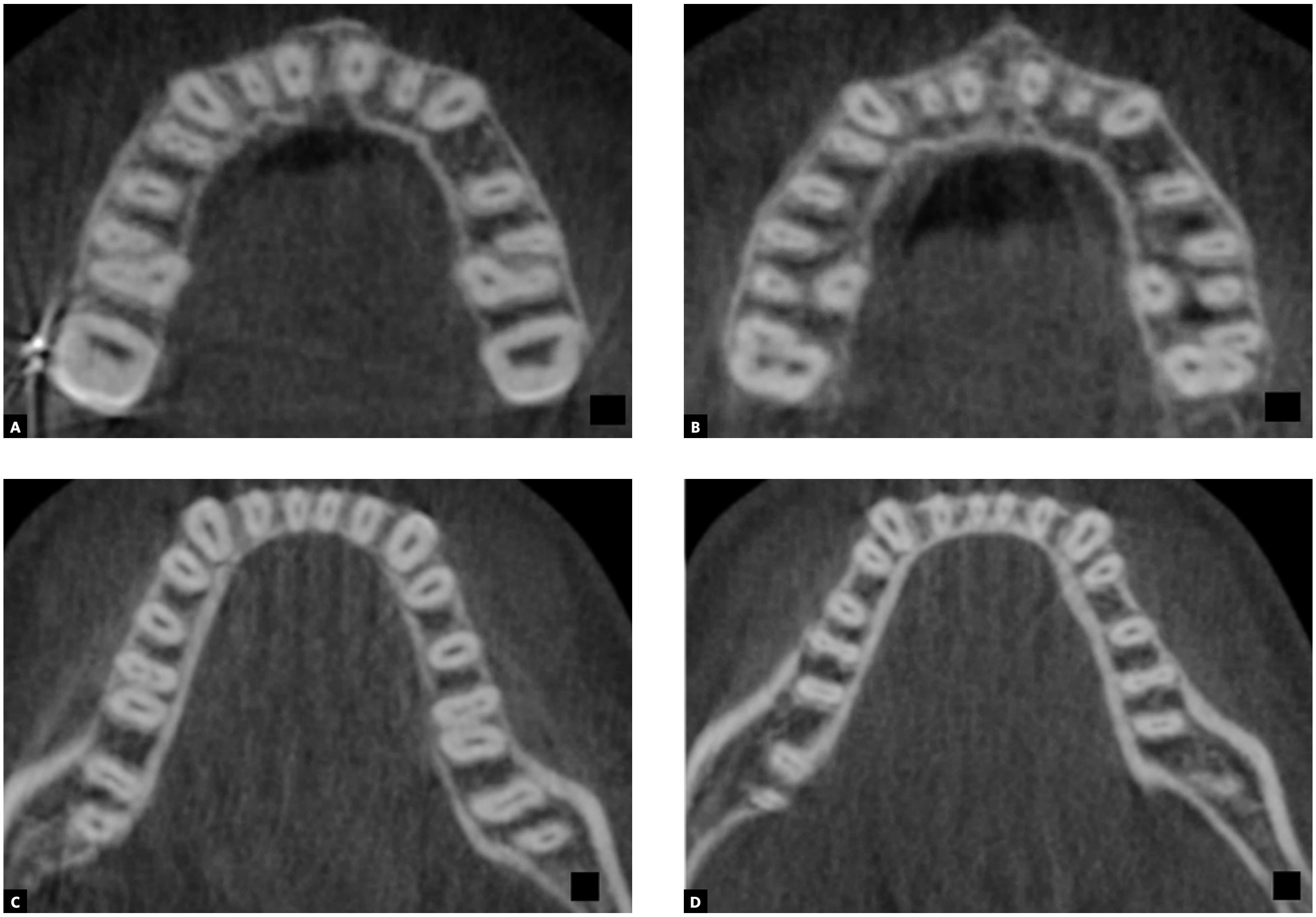

Figure 2 - Axial sections of the maxilla at 3.0 and 6.0 mm apical to the cemento-enamel junction of the right maxillary first molar, respectively (A and B). Axial sections of the mandible at 4.0 mm and 8.0 mm apical to the cemento-enamel junction of the right mandibular first molar, respectively (C and D).

between the radicular surface of the adjacent teeth (Fig 3A). These measurements served as a guide for the subsequent measurements.[18] Thickness of the alveolar cortical bone was measured, for each tooth, from its outermost portion, perpendicular to the arch form, to its most inner portion, in the center of the interradicular spaces on the buccal and lingual sides (Fig 3B).

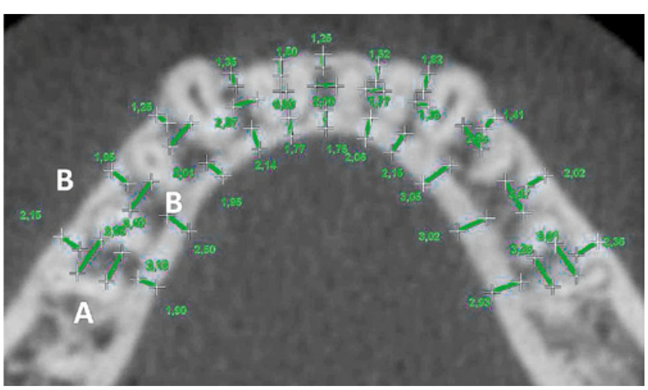

Figure 3 - A) Interradicular distance (mesiodistal dimension). B) Thickness of the buccal and lingual cortical bone in the center of the interradicular septum.

The cortical bone thickness measurements were grouped and the averages of the following regions were calculated for each patient and used in the statistical analyses:

» Maxillary buccal posterior region thickness (MxBP).
» Maxillary labial anterior region thickness (MxLA).
» Maxillary palatal posterior region thickness (MxPP).
» Maxillary palatal anterior region thickness (MxPA).
» Mandibular buccal posterior region thickness (MdBP).
» Mandibular labial anterior region thickness (MdLA).
» Mandibular lingual posterior region thickness (MdLP).
» Mandibular lingual anterior region thickness (MdLgA).

Mini-implant stability was assessed by monthly measurements from the time of insertion (primary stability) until its removal. The horizontal amount of mobility was linearly measured (mm). The mean observation period was 9.62 and 1.67 months, for the success and failure groups, respectively. This measurement was performed with the aid of an adjustable telescopic rod (ATR).[19] The ATR was capable of connecting with the mini-implant head and was associated with an orthodontic tension gauge (Correx series 040-712-00, Dentaurum Orthodontics) which applied a force of 400g.[19] Thus, using reference points, the ATR length was adjusted according to the distance between the mini-implant head and the chosen point. Then, distances could be measured, before and after force application, with a digital caliper (Mitutoyo 500-144B, Mitutoyo, Japan). After the force was applied, if the distance measured by the caliper was similar before and after force application, the mini-implant was considered stable. This method was described in detail and validated in a previous study.[19] The mean of monthly measurements was used for statistical analysis. The success rate was defined as the number of mini-implants that remained clinically stable, to ensure the orthodontic load during the overall observation period, divided by the total number of evaluated mini-implants.

The factors that could interfere with mini-implant stability were clinically evaluated. Three insertion sites (IS) were considered: attached gingiva; mucogingival line; and alveolar mucosa. The sensitivity degree (SE) was monthly evaluated, at the same time point of mobility assessment, during force application, and classified as: 0, when the patient reported no discomfort; 1, when slight discomfort was reported; 2, when bearable pain was reported; and 3, when unbearable pain was reported. Peri-implant biofilm was evaluated with the modified plaque index (MPI) for dental implants. This index uses a score of 0 when there is no detectable plaque; 1 when plaque is recognized onto a probe; 2 when it is visible to the unaided eye; and 3 when there is abundance of soft matter. To verify the technique and/or operator influence, individual associations between techniques with success and failure of these anchorage devices, were evaluated.

ERROR STUDY

Fourteen lateral cephalograms and CBCTs were randomly selected and remeasured by the same examiner (CCM), after a 30-day interval. Random errors were calculated according to Dahlberg's formula and systematic errors, with dependent *t*-tests, at $p<0.05$.

STATISTICAL ANALYSES

Normal distribution was evaluated with Kolmogorov–Smirnov tests. Comparability of the groups regarding sex was evaluated with Chi-square; age and FMA, with *t*-tests. Intergroup cortical bone thickness comparisons and its correlation with FMA were performed with *t*-tests and Pearson's correlation coefficient, respectively. Intergroup comparisons regarding mobility of the mini-implants and the success rate were performed with Mann-Whitney and Fisher exact tests. Modified plaque index, observation period, and insertion technique/operator were compared between groups with Mann-Whitney and Chi-square tests. To further investigate the factors that could interfere with mini-implants stability, all 56 mini-implants were divided into two groups based on "success" or "failure" condition. Then the following variables were compared between these groups: cortical bone thickness at the insertion site (*t*-test); soft tissue at the insertion site (Chi-square test); modified plaque index, sensitivity during loading, and observation period (Mann-Whitney test); and insertion technique/operator (Fisher's exact test). All statistical tests were performed with Statistica software (version 7.0, StatSoft Inc., Tulsa, OK, USA). Results were considered significant at $p<0.05$.

RESULTS

The random errors ranged from 0.07mm (MxLA) to 0.16mm (MdLA) and was 0.57° for the FMA. There were no significant systematic errors.

The groups were comparable regarding sex ratio and age, but the HG presented a significantly smaller FMA than the VG (Table 2).

The HG showed significantly greater cortical thickness of alveolar bone at the maxillary labial anterior region, mandibular buccal posterior region and labial anterior region (Table 2).

The cortical thickness of alveolar bone at the maxillary labial anterior region, mandibular labial and lingual anterior regions showed significant negative correlations with the FMA (Table 3).

Mobility and success rate of mini-implants, modified plaque index, observation period and insertion technique/operator distribution were similar between the horizontal and vertical groups (Table 2).

Table 2 - Intergroup comparisons regarding sex, age, FMA, cortical thickness of alveolar bone, mobility, success rate of mini-implants, modified plaque index, observation period and insertion technique/operator variables.

Variables	Horizontal Group (HG) n= 15 patients (26 mini-implants)		Vertical Group (VG) n= 15 patients (30 mini-implants)		P
Sex	n	%	n	%	
Male	6	40	7	46.67	0.71[¥]
Female	9	60	8	53.33	
	Mean	SD	Mean	SD	
Age	25.12	9.48	21.10	8.96	0.24[€]
FMA	19.79	3.61	28.92	3.14	**0.00[€]***
Cortical thickness of alveolar bone	Mean	SD	Mean	SD	
Maxillary buccal posterior region (MxBP)	1.19	0.14	1.19	0.23	0.99[€]
Maxillary labial anterior region (MxLA)	1.32	0.13	1.17	0.20	**0.02[€]***
Maxillary palatal posterior region (MxPP)	1.59	0.22	1.47	0.29	0.21[€]
Maxillary palatal anterior region (MxPA)	1.47	0.19	1.34	0.36	0.23[€]
Mandibular buccal posterior region (MdBP)	1.73	0.22	1.51	0.26	**0.02[€]***
Mandibular labial anterior region (MdLA)	1.24	0.16	1.03	0.20	**0.00[€]***
Mandibular lingual posterior region (MdLP)	2.33	0.63	2.28	0.34	0.80[€]
Mandibular lingual anterior region (MdLgA)	2.01	0.54	1.74	0.37	0.12[€]
	Mean	SD	Mean	SD	
Mobility	0.04	0.18	0.09	0.23	0.73[$]
Success rate	n	%	n	%	
Success	24	92.31	26	86.67	0.67[£]
Failure	2	7.69	4	13.33	
	Mean	SD	Mean	SD	
Modified plaque index	1.38	0.75	1.69	0.66	0.11[$]
Observation period	8.35	2.87	9.13	3.46	0.07[$]
Insertion technique/operator	n	%	n	%	
SEB	20	76.92	18	60	0.18[¥]
CCM	6	23.08	12	40	

[¥]Chi-square test, [€]t-test, [$]Mann-Whitney test, [£]Fisher's exact test. * Statistically significant at $p<0.05$.

Table 3 - Results of the Pearson correlation between the vertical growth pattern (FMA) and thicknesses of the alveolar cortical bone.

	Thickness variables x FMA	Pearson's correlation coefficient	P
FMA	Maxillary buccal posterior region	-0.16	0.40
	Maxillary labial anterior region	-0.39	**0.03***
	Maxillary palatal posterior region	-0.31	0.09
	Maxillary palatal anterior region	-0.17	0.38
	Mandibular buccal posterior region	-0.35	0.06
	Mandibular labial anterior region	-0.49	**0.01***
	Mandibular lingual posterior region	-0.02	0.92
	Mandibular lingual anterior region	-0.38	**0.04***

*Statistically significant at $p<0.05$.

Table 4 - Analysis of factors associated with mini-implant failures.

Variables	Success n= 50 mini-implants (89.29%)		Failure n= 6 mini-implants (10.71%)		
Cortical thickness of alveolar bone at the insertion site	Mean	SD	Mean	SD	P
	1.21	0.28	1.17	0.31	0.76[€]
Insertion site soft tissue	n	%	n	%	
Attached gingiva	26	89.66	3	10.34	
Mucogingival line	13	86.67	2	13.33	0.91[¥]
Alveolar mucosa	11	91.67	1	8.33	
	Mean	SD	Mean	SD	
Modified plaque index	1.49	0.71	2.00	0.63	0.17[$]
Sensitivity	0.00	0.00	2.58	0.49	**0.00[$]***
Observation period	9.62	2.13	1.67	0.52	**0.00[$]***
Technique/operator	n	%	n	%	
SEB	34	89.47	4	10.53	1.00[£]
CCM	16	88.89	2	11.11	

[€] t-test, [¥]Chi-square test, [$] Mann-Whitney test, [£] Fisher's exact test, *Statistically significant at $p<0.05$.

Failed mini-implants showed significantly greater sensitivity during loading and smaller observation period than succeeded mini-implants (Table 4).

DISCUSSION

Due to controversial reports[1,2,10,12] on the association between vertical growth pattern and stability of mini-implants, this study intended to clarify these points. It could be argued that the number of evaluated mini-implants was small. However, previous studies evaluating load performance or success rate of mini-implants used similar sample sizes.[20,21] Although sample size calculation for the present study was based only in the assessment of the influence of growth pattern on cortical bone thickness,[13] the number of mini-implants used to evaluate stability seems reasonable.[13,21]

The HG showed greater cortical bone thickness at the maxillary labial anterior region, mandibular buccal posterior and labial anterior regions (Table 2). It could be thought that these results support the concept that subjects with horizontal growth have greater cortical bone thickness.[7-11,13] However, this could not be generalized to all regions of the maxilla and the mandible, because some of them did not show significant intergroup differences. Specifically in the region where the MI (posterior maxillary buccal) were installed, there was no difference in cortical thickness, contrary to other studies.[7,9-11] In these studies, although there were significant differences between the subjects with horizontal and vertical growth patterns, they were minimal, and could possibly have no clinical significance.

The significant negative correlation found between maxillary and mandibular labial anterior regions with the FMA confirms the results of the intergroup comparisons (Tables 2 and 3). The smaller the FMA, the greater will be the cortical bone thickness at these regions. Nevertheless, the other variable (mandibular buccal posterior region) that showed significant intergroup difference was not significantly correlated with FMA. There was also a significant correlation with the mandibular lingual anterior region (Table 3). Although significant correlations were present, they were not sufficiently strong. Based on these results, we could expect the same success rate of mini-implants in the posterior regions of the maxilla and mandible, independently of the growth pattern. However, the correlations found should be considered when mini-implants are planned to be inserted in the anterior region.

Primary stability of mini-implants is related to thickness of the alveolar cortical bone[4-6,22,23]. Cortical bone thickness should be of at least 1 mm for a mini-implant to be successful[4]. Both groups in this study had thickness greater than 1 mm (Table 2). Thus, it was adequate in both groups, resulting in similar degree of mini-implants mobility (Table 2).

The success rates of the orthodontic mini-implants were not significantly different in patients with HG or VG (Table 2), supporting previous reports[1]. Miyawaki et al.[12] reported success rates for patients with high mandibular plane angle of 72.7%, and 100% in patients with small mandibular plane angle, which were significantly different. Contrary to the present study, these authors used mini-implants with various diameters, ranging from 1.0 to 2.3 mm and also had several uncontrolled variables that could have influenced their results.[12] Moon et al.[2] also examined the relationship between success rate and growth pattern. Even though they suggested that the FMA might be an important factor when success rate is evaluated, no statistically significant differences in the success rate were shown between the low, average and high angle groups. It seems that more important than the growth pattern is the amount of cortical bone thickness.

In the current study, mini-implants were considered successful if did not have any degree of mobility. Several studies suggest that the absence of attached gingiva in the MI insertion site might interfere with its stability.[1,24-26] Our results demonstrated that the soft tissue characteristics at the insertion site did not significantly influence the mini-implants stability, as previously reported.[19]

The modified plaque index showed no significant differences between success and failure groups, however, the failure group showed a tendency to have smaller quality of hygiene (Table 4). Studies state the idea that the better the hygiene, the greater the mini-implant success rate.[4,12,20] Perhaps our findings were different because the patients were monthly oriented to maintain optimal hygiene in the MI region.

During the monthly mini-implant assessments, it was noticed that the devices without mobility did not have sensitivity, but the degree of sensitivity significantly increased as the mini-implants lost their stability (Table 4). This sensitivity was probably due to compression of the surrounding soft tissues, caused by mini-implants with a high degree of mobility — since, generally, there is no spontaneous pain.[19] It is reasonable to state that pain sensitivity during mini-implant load is not normal, and this finding could be indicative of mini-implant mobility, resulting in an unfavorable prognosis.[27] This was the case of the great majority of the failed mini-implants of the present study. When sensitivity is felt during loading, it is suggested to remove the mini-implant, in order to prevent further bone loss and facilitate the reinsertion procedure in an adjacent location.[27] Mini-implants that failed were evaluated only for 1.67 months, and the successful mini-implants, for 9.62 months. The failed mini-implant period was similar to other studies.[2,19,24]

In this study, pain sensitivity was evaluated using an ordinal scale. A precise quantification of pain is extremely difficult to obtain and mainly subjective, therefore, it could be argued that a visual analogic scale would be more adequate and practical.[1,28] However, the ordinal scale was also capable to provide reliable results as previously reported.[19] Both methods of evaluation are consistent.[29]

Various techniques, as well as different operators involved in mini-implant insertion, has been reported in the majority of the studies. However, they did not evaluate the influence of these factors on the stability of orthodontic mini-implants.[1,2,4,12,20,24] Kyung et al.[30] stated that the ability of the operator influences the stability of the MI. However, this can be overridden when the systems are properly calibrated and follow precise insertion techniques,[2,16,19] as in the present study.

Considering the overall results of this study, the growth pattern did not influence the stability or success rate of mini-implants inserted at the maxillary buccal posterior region, specifically. More studies are necessary to evaluate if the growth pattern influences the stability and success rate of mini-implants in other specific and commonly used maxillary and mandibular regions. When planning the use of mini-implants, the specific anatomical region and characteristics of each patient should be always considered.

Even though this study followed a strict methodology, some limitations such as sample size and participation of different operators should be cited. Nonetheless, previous studies[20,21] presented similar sample sizes, and the operator influences might have been suppressed with proper calibration and precise technique.[2,19] Although both examiners underwent a rigorous clinical calibration before performing the plaque index assessment, reliability of this evaluation was only clinically assessed, and not statistically evaluated.

CONCLUSIONS

The primary objective of this study was to evaluate the influence of the vertical growth pattern on the alveolar bone cortical thickness and, secondarily, assess the factors related to the stability and success rate of orthodontic mini-implants.

Based on this specific sample, it can be concluded that growth pattern has an influence on the alveolar bone cortical thickness in specific areas of the maxilla and mandible, but this fact may have no influence in the stability and success rate of mini-implants in the maxillary buccal posterior region. Some specific conclusions:

» Subjects with horizontal growth showed greater cortical thickness of the alveolar bone in some specific regions: at the maxillary labial anterior region, and at mandibular buccal posterior and labial anterior regions.

» There was a negative correlation between the maxillary labial anterior region, and the mandibular labial and lingual anterior regions with the FMA.

» Stability and success rate of mini-implants, placed in the maxillary posterior buccal region, were similar between horizontal and vertical subjects.

» Failed mini-implants showed greater sensitivity during loading when compared to successful mini-implants. Thus, sensitivity during application of force could be an indicative of probable loss of the mini-implant.

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Evaluation of flexural strength and antibacterial effect of orthodontic acrylic resins containing *Galla chinensis* extract

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Objective: To evaluate different concentrations of *Galla chinensis* extract (GCE) added to poly(methyl methacrylate) (PMMA), which is widely used for fabrication of removable orthodontic appliances, regarding the effectiveness of this herbal extract on antimicrobial effect and flexural strength of PMMA.

Methods: Acrylic resin samples containing 0.4%, 0.8% and 1.6% GCE were prepared. Flexural strength was investigated via three-point flexural strength test for the 15 acrylic resin blocks of each concentration. Disk diffusion test was used to evaluate antibacterial effects of incorporating the same concentrations of GCE into acrylic resin. All these three groups were compared with the control group, with no added GCE, regarding flexural strength and antibacterial properties.

Results: Comparison of flexural strength between the three study groups and the control group showed significant differences between the groups (P=0.018). However, there was no significant difference between the groups containing GCE. There were significant differences in antimicrobial activity between the four groups (P=0.026).

Conclusion: Within the limitations of this study, it is suggested that incorporation of GCE into PMMA would be beneficial for antimicrobial activity and flexural strength of PMMA, but further studies on other physical properties and antimicrobial effects on other bacterial strain would be beneficial prior to clinical investigations.

Keywords: Acrylic resins. Antibacterial. Flexural strength. Natural cariogenic agent.

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INTRODUCTION

Acrylic orthodontic appliances can create great biofilm accumulation on dental surfaces and retentive sites of acrylic baseplate, making it a challenge for patients to maintain adequate oral hygiene especially in bonded appliances. Orthodontic appliances can increase the levels of mutans streptococci (MS) in saliva and dental biofilm during active removable orthodontic treatment. Therefore, dental caries commonly occur in areas adjacent to the irregular orthodontic appliance surfaces.[1,2] Batoni et al.[3] evaluated the effect of removable orthodontic appliances on oral colonization by mutans streptococci in children, and showed that the use of removable acrylic appliances may lead to the creation of new retentive areas and surfaces, which favors the local adherence and growth of MS. Although acrylic resins (AR) are extensively used for fabricating removable orthodontic appliances, including retainers, functional appliances and even bonded orthodontic appliances, accumulation of plaque is one of the major drawbacks.[4-6] Their surface porosities have potential for retention of food, attribute the increase activities of cariogenic microorganisms in the oral cavity.[7] It is absolutely necessary to develop strategies in order to effectively prevent enamel demineralization during application of acrylic appliances as the mechanotherapies during orthodontic treatments. Use of various antibacterial materials in the fabrication of orthodontic appliances and adhesive resins is a new area for investigation in orthodontics.[8,9] New antibacterial agents might be effective in preventing demineralization of enamel through inhibition of colonization and proliferation of cariogenic bacteria, since they are the primary etiologic agents for the development of white spot lesions.[7,10,11]

Novel medicines derived from natural products help investigators to discover new materials with anticariogenic properties.[12] *Galla chinensis* extracts (GCE), a traditional Chinese medicine, is an effective anticariogenic agent, which inhibits the growth and metabolism of cariogenic bacteria.[13-15] Demineralization/remineralization balance of the enamel might be favorable in the presence of GCE.[16] Furthermore, recent studies have shown that GCE inhibits the proliferation and production of acids by cariogenic bacteria, including *Streptococcus mutans* and *Lactobacillus rhamnosus*.[17] In 2008, a study on the multi-species biofilm models showed higher pH levels, lower counts of cariogenic bacteria and less compact biofilms in flow cells with *Galla chinensis* extracts.[18] In addition as a positive character, another study did not show any change in the bond strength of adhesive cements containing GCE.[9] Apart from bacterial activity, the mechanical properties of acrylic resins are equally important; in this context, flexural strength (Fs) is one of the important physical properties that should be evaluated, especially in acrylic appliances. A standard minimum limit has been defined for the flexural strength of acrylic resin types by ISO 20795-1 (2008) for dental base polymers. The flexural strengths of polymerized materials should not be <50 MPa.[19] Therefore, researchers strongly recommended that the effects of additives or modifiers on the mechanical properties of acrylic materials be evaluated to avoid detrimental effects that might decrease their strength to values lower than the standard value. This study was undertaken to evaluate the effect of incorporation of different concentrations of *Galla chinensis* as a phytochemical antibacterial component into poly(methyl methacrylate) (PMMA) on the antibacterial properties without deteriorating the physical properties of this material, by investigating the flexural strength of the material with different concentrations of GCE.

MATERIAL AND METHODS

Preparation of GCE-containing polyacrylic discs

For preparation of all the discs with the same size, a mold was designed, measuring 9 mm in diameter and 1mm in thickness, based on Neo-Sensitabs Tablets (Rosco Diagnostica, Denmark). The GCE powder was added to the liquid of PMMA in proposed fractions, to achieve the following mass fraction of GCE in PMMA mixtures: 0% (control group), 0.4%, 0.8% and 1.6%. To prepare the concentrations mentioned above, 0.032 g, 0.064 g and 0.128 g of GCE were added to each mL of acrylic monomer, respectively. Five samples were prepared for each fraction of GCE impregnation.

Preparation of blood agar (tryptone soy agar with 5% blood)

This culture medium was used as a primary environment for the culture and purification of bacteria. Forty grams of medium powder were dissolved in 1 liter of distilled water. Then the medium was put in the autoclave at a 121°C temperature and 15 psi pressure, for 15 minutes. Then the medium was put at room temperature to cool down. At this time, 5% of defibrinated blood was added to the culture medium under wholly sterile conditions and covered, to prevent medium from outside contamination.

Preparation of the Muller-Hinton agar medium

This medium was used for antibiogram testing. Thirty-eight grams of medium powder were solved in one liter of distilled water and then sterilized by autoclave. In sterile conditions, the medium was poured into sterile plates. The thickness of the environment was 4mm (about 30mL per plate).

Diffusion test

Disk diffusion technique was applied to evaluate the antibacterial effect. *Streptococcus mutans* suspension was inoculated on four plates with at least 20mL of Mueller-Hinton agar (MHA) with 5% sheep blood. Five discs were loaded on each plate. The plates were incubated at 37°C with 5% CO_2. A digital caliper was used to measure the inhibition halo diameters after 24h of incubation. The measurements mentioned above were repeated three times and the mean value was subjected to statistical analysis.

Three-point flexural strength test

PMMA acrylic resin block samples for each different fraction of GCE were prepared as follows. The dimension of the constructed block for 3-point flexural test was 30×5×2 mm. The test was carried out in the four study groups, each containing 15 specimens, with different concentrations of the GCE. Acrylic resin powder containing 0%, 0.04%, 0.8% and 1.6% GCE was mixed with monomer at 25°C; all the procedural steps were carried out by one operator. The mixture was transferred into a silicon mold in its doughy stage during polymerization. After completion of the settling of acrylic specimens, favorable dimensions were achieved by a grinding procedure in the turnery. Before carrying out the flexural strength tests, the prepared specimens were immersed in 37°C distilled water for two weeks, to simulate the oral environment. A universal testing machine (Zwick Z020 Germany) was used for the 3-point flexural strength test. The surface area of the acrylic resin block was determined, and the load at fracture (N) was recorded. The pre-load force was 0.5 N, followed by a gradual increase at a rate of 0.5 mm/min. The load (N) at fracture was recorded for each sample according to the formula below:

$\mathfrak{v} = F \times L \times 3 / 2 \times b \times h^2$

Where $\mathfrak{v}$= flexural strength, F= the maximum force (N), L = the distance between the supporting arms of the machine (mm), b = the specimen width (mm) measured immediately before storage in water, and h = the specimen height (mm) measured immediately before storage in water. As mentioned before, the values for L, b and h were 30 mm, 5 mm and 2 mm, respectively. An auto-polymerizing acrylic resin (Acropars, Self-cured, Iran) was used in this study. The method sequence is briefly presented in the flowchart (Fig 1).

SBS and antimicrobial activity data were described using median, interquartile range (IQR), means and standard deviations (±SD). The non-parametric Kruskal-Wallis H statistical test and *post-hoc* Dunn test were used to compare the groups. SPSS 22.0 (IBM) was employed for data analysis. Statistical significance was set at $p<0.05$.

Ethical considerations were confirmed by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1397.804).

RESULTS

Table 1 presents the comparisons of flexural strengths, indicating significant differences between the control group and the study groups (P=0.018). However, there were no significant differences between groups containing GCE. According to Table 2, there were significant differences in antimicrobial activities between the study groups and the control group (P=0.026).The antimicrobial activity of the acrylic resins containing different percentage of GCE against *Streptococcus mutans* increased after 24 hours. However, no significant trend was observed between the study groups.

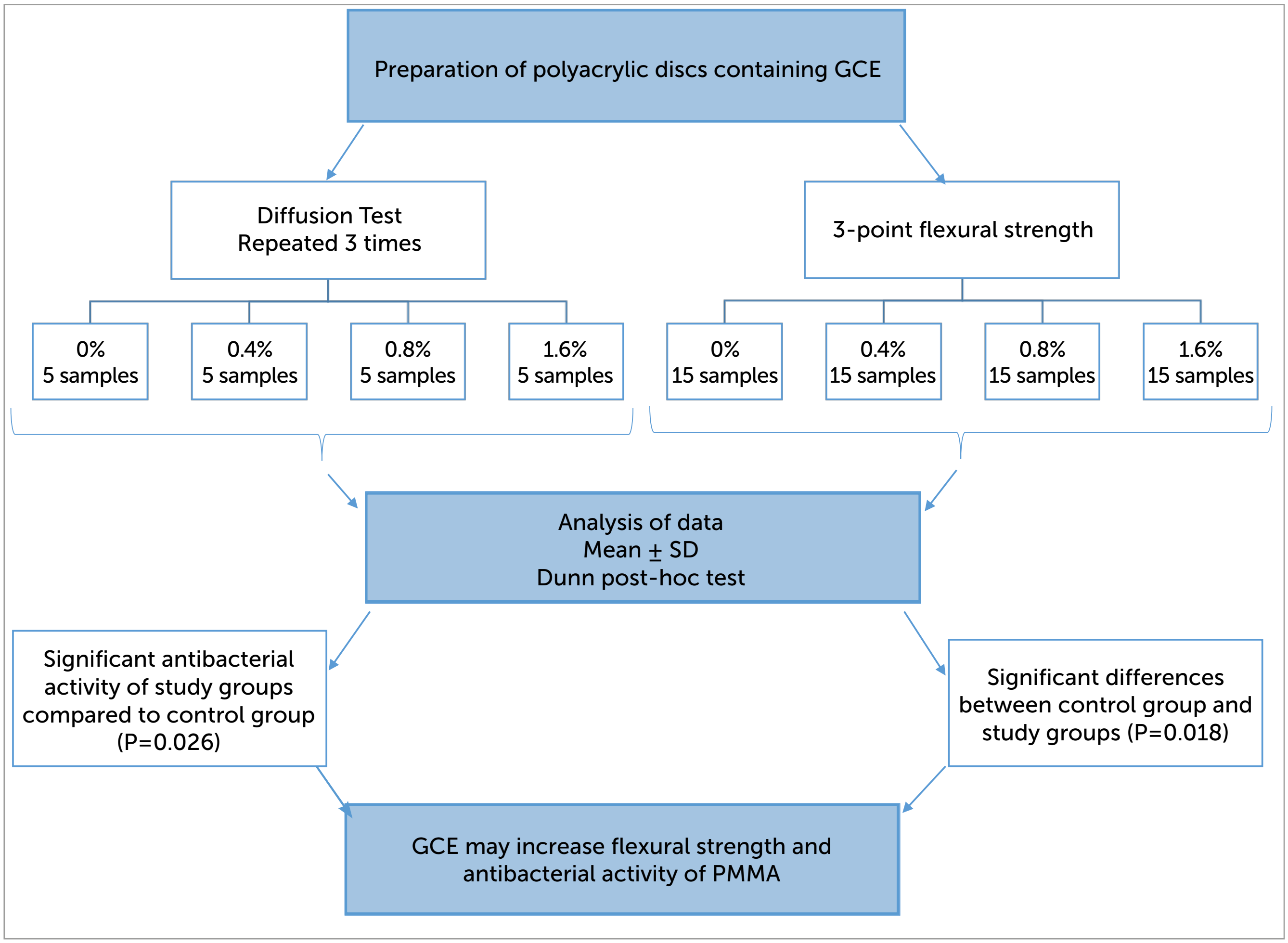

Figure 1 - Illustration of methods and materials.

Table 1 - Comparisons of flexural strengths.

Group	mean±SD	Median	IQR*	Dunn post-hoc	p-value** between groups
1 (control)	62.95±7.32	63.80 ᴬ	11.25		0.018
2 (0.4% GCE)	72.95±7.46	72.10 ᴮ	11.25	p=0.007	
3 (0.8% GCE)	72.36±11.33	76.70 ᴮ	21.25	p=0.006	
4 (1.6% GCE)	69.51±9.88	72.85 ᴮ	18.00	p=0.047	

* inter-quartile range. ** Kruskal-Wallis H test. Median values with at least a common superscript letter were not statistically different (Dunn post-hoc test).

Table 2 - Antimicrobial activities between groups.

Group	Mean ± SD	Median	IQR*	p-value**
1 (control)	0.0±0.0	0.0 ᴬ	0	< 0.001
2 (0.4% GCE)	11.00±1	11.00 ᴮ	6.25	
3 (0.8% GCE)	13.66±0.57	14.00 ᴮᶜ	4.50	
4 (1.6% GCE)	15.66±0.57	16.00 ᶜ	4.50	

* inter-quartile range. ** Kruskal-Wallis H test. Median values with at least a common superscript letter were not statistically different (Dunn post-hoc test).

DISCUSSION

This study was undertaken to investigate the effect of GCE on the flexural strength and antibacterial activity of self-cured polymethyl methacrylate resin (Acropars). The results of this study indicated that incorporation of GCE improved the mechanical and antibacterial activity of PMMA (Tables 1 and 2). Microbial plaque can adhere to the surface of acrylic resin appliances at a wider adhesion area, compared to natural teeth;[20] mechanical methods proved ineffective in removing microorganisms completely.[21,22] Many researchers have made attempts to develop effective and harmless techniques to incorporate self-sterilizing agents into acrylic resins.[23] In this context, incorporation of GCE into the matrix of polymeric materials as an antimicrobial agent has attracted much attention in recent years.[13-15] Based on the present results, incorporation of GCE at all the three concentrations resulted in an increase in antibacterial activity, compared to the control group, in accordance with previous studies.[14,15] In addition, the results showed that the acrylic resin containing GCE had a strong antibacterial effect on *S. mutans*. Further clinical experiments would be useful, especially for different bacterial and fungal components. Apart from the inhibition of enamel demineralization effect observed, in a previous study GCE promoted remineralization of incipient enamel lesions and inhibited metabolism of oral bacteria, suggesting that it might be a potential and promising anticariogenic agent.[17] Based on FS test, the present findings are different from previous studies, such as a study by Shibata et al.[24] and Sodagar et al.,[25] indicating that incorporation of silver nanoparticles (Ag NPs) into acrylic resins would decrease flexural strength, since it serves as impurities, affecting the internal structure of PMMA.[23,26,27] The study by She[28] showed that incorporation of Ag Nps into denture base resins resulted in the growth inhibition of *Streptococcus mutans*, with no significant effect on the mechanical properties of the denture base resin. The results of this study, for the first time, showed the positive effect of GCE on the mechanical properties of acrylic resins. Although further studies are necessary, the results could be justified as follows. Acrylic resins commonly consist of methacrylates, especially PMMA, with this chemical formula: ($C_5O_2H_8$), polyethyl methacrylate and additional copolymers.[4-6] *Galla chinensis* is also rich in gallotannins ($C_5H_{10}N_2O_3$), with nearly 20% of gallic acid ($C_6H_2(OH)_3COOH$) and 7% of methyl gallate.[29] Gallotannins consist of a central glucose core ($C_6H_{12}O_6$), which is surrounded by several gallic acid (GA) units, and further GA units can be attached through bonding of additional galloyl residues.[16] In addition, inorganic ions could in part be responsible for the clinical effects of natural medicines. In the present study, nitrogen ions of the glutamine part were found to produce strong covalent bonds.[30] Carbon–nitrogen is a covalent bond which is one of the well-known bonds between carbon and nitrogen atoms. Given that nitrogen has three electron capacities and carbon has four electrons, these two atoms can create 1–3 covalent links at a time. In addition, since GCE contains a significant amount of polyphenols, the hydroxyl and carboxyl groups of polyphenols might form several hydrogen bonds with bulky acidic and basic amino-acid side chains in the band region of PMMA. In summary, the chemical interaction between the two substrates increased the flexural strength of the block. An increase in flexural strength might indicate that *Galla chinensis* extract can intercalate the resin chains and strengthen the intermolecular interactions. Since this research was limited to one type of acrylic resin, further studies are recommended for evaluation of the effects of different concentrations in other types of acrylic resin. It should be pointed out that GCE might affect the flexural strength of some types of acrylic resin and therefore the advantages of their antimicrobial properties should be considered *versus* the possible effect on flexural strength or some other physical and mechanical properties. Another limitation of our study was using Agar diffusion test, which was used to evaluate the overall antimicrobial properties of this substance, due to its simplicity and low cost. However, for further evaluation and dilution determination, other minimum inhibitory concentration (MIC) tests should be performed.

CONCLUSION

Under the limitations of this study, the results suggested that *Galla chinensis* extract might be used as a newly introduced natural cross-linker to stabilize acrylic resins, which improves resistance to flexural strength and bacterial activity. Chemical interaction between GCE and PMMA was the responsible for increasing the flexural strength of the block.

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Invasive cervical resorption of central incisor during orthodontic treatment

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Introduction: Invasive cervical resorption (ICR) is a relatively rare type of ERR (External Root Resorption), in which a localized resorption begins in the cervical area of the tooth, below the epithelial junction and above the ridge crest.

Objective: Describe the clinical case of an 11-year-old boy with no dental trauma history, presenting moderate crowding and ectopic eruption of the maxillary right central incisor. He had been undergoing orthodontic treatment elsewhere, and his family was dissatisfied with the results.

Description: A new treatment was indicated, which included rapid maxillary expansion followed by extraction of four premolars. During routine panoramic evaluation, a radiolucid image was detected and a periapical radiograph was requested. At this point, an ICR of the maxillary right central incisor was found. The treatment was cautiously finalized and despite the use of light forces, central incisor was severally compromised by ICR and was therefore extracted.

Conclusion: This clinical example discusses the importance of routine radiographs for the early diagnoses of ICR.

Keywords: Root resorption. Maxillary expansion. Tooth movement. Ectopic tooth eruption.

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

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INTRODUCTION

During orthodontic treatment, several side effects might occur. One of the most challenging problems related to tooth movement consists of external root resorption (ERR).[1] Invasive cervical resorption (ICR) is a relatively rare type of ERR, in which a localized resorption begins in the cervical area of the tooth, below the epithelial junction and above the ridge crest.[2,3]

The damage to the tooth structure resulting from the ICR varies widely, and the tooth may become progressively weak. In severe and/or late diagnosed cases, extraction of the tooth is the remaining alternative.[3] Since the occurrence of ICR is clinically asymptomatic, periodic radiographic examination is an important tool for its early diagnoses and treatment.[4]

Despite the unknown etiologic factors involved in the process of ICR, its occurrence has been related to intracoronal bleaching, trauma and orthodontic treatment.[5-7] The relationship between orthodontic treatment and ERR has been widely discussed, but scientific literature still lacks elucidation about the exact mechanism by which the orthodontic forces might cause ICR.[7,8]

The aim of this article is to present a rare clinical example, describing the case of an 11-year-old male patient with a Class I, moderate crowding and ectopic eruption of the maxillary right central incisor, later diagnosed with ICR. This clinical example also discusses the possible relationship between orthodontic tooth movement and ICR, treatment options and the importance of routine radiographic exams during orthodontic therapy.

DIAGNOSIS AND ETIOLOGY

The patient, an 11-year-old boy sought treatment at a private orthodontic clinic since his family was dissatisfied with the orthodontic treatment he was undergoing. The patient was in good general health and reported no accidental dental trauma.

Intraoral photographs showed a Class I malocclusion, moderate crowding in the maxillary and mandibular arches. The maxillary right central incisor was in infraocclusion and the maxillary right lateral incisor had severe palatal root torque (Fig 1). The model discrepancy was - 4.0 mm at the mandibular arch and - 5.0 mm at maxillary arch. The panoramic radiograph showed absence of the maxillary left third molar, and the lateral radiograph (Fig 2) with cephalometric measurements indicated well positioned incisors, maxilla and mandible, and a well-balanced vertical skeletal pattern (Table 1). Maxillary incisors periapical radiograph revealed apical root rounding. The patient reported duration of 3 years and 5 months of the previous treatment (Fig 2).

TREATMENT OBJECTIVES

The treatment goal for this case was to gain space on maxillary and mandibular arches to promote leveling, alignment and ideal Class I canine and molar relationship. At the same time, it was aimed to promote cautious movements to maxillary right central incisor, which already presented a slight ERR on initial radiographs.

TREATMENT ALTERNATIVES

Since patient presented moderate crowding on both arches, maxillary and mandibular incisors flaring could be another alternative for this case. However, this option was ruled out for two main reasons. First, lower incisors buccal movement was a periodontal risk considering the initial contour of the roots in the lower incisors (Fig 1), suggesting the lack of bone in this area. Lastly, incisors flaring could jeopardize patient facial profile, which was within normal limits. Thus, it was decided to gain space using RME and/or extracting four premolars.

TREATMENT PROGRESS

Before starting the new treatment, it was waited four months for spontaneous recovery before bonding fixed appliance (Fig 1). After this period, the patient returned with adequate oral hygiene and the resumed a new orthodontic treatment was resumed.

Due to the maxillary anterior crowding, the primary approach was to create extra space before using orthodontic forces, to align and level the maxillary central incisors. Thus, RME was performed with a Hyrax appliance and a slight midline diastema was obtained (Fig 3). This appliance was used for retention for five months. After this period, as the amount of space gained was insufficient, four premolars were extracted.

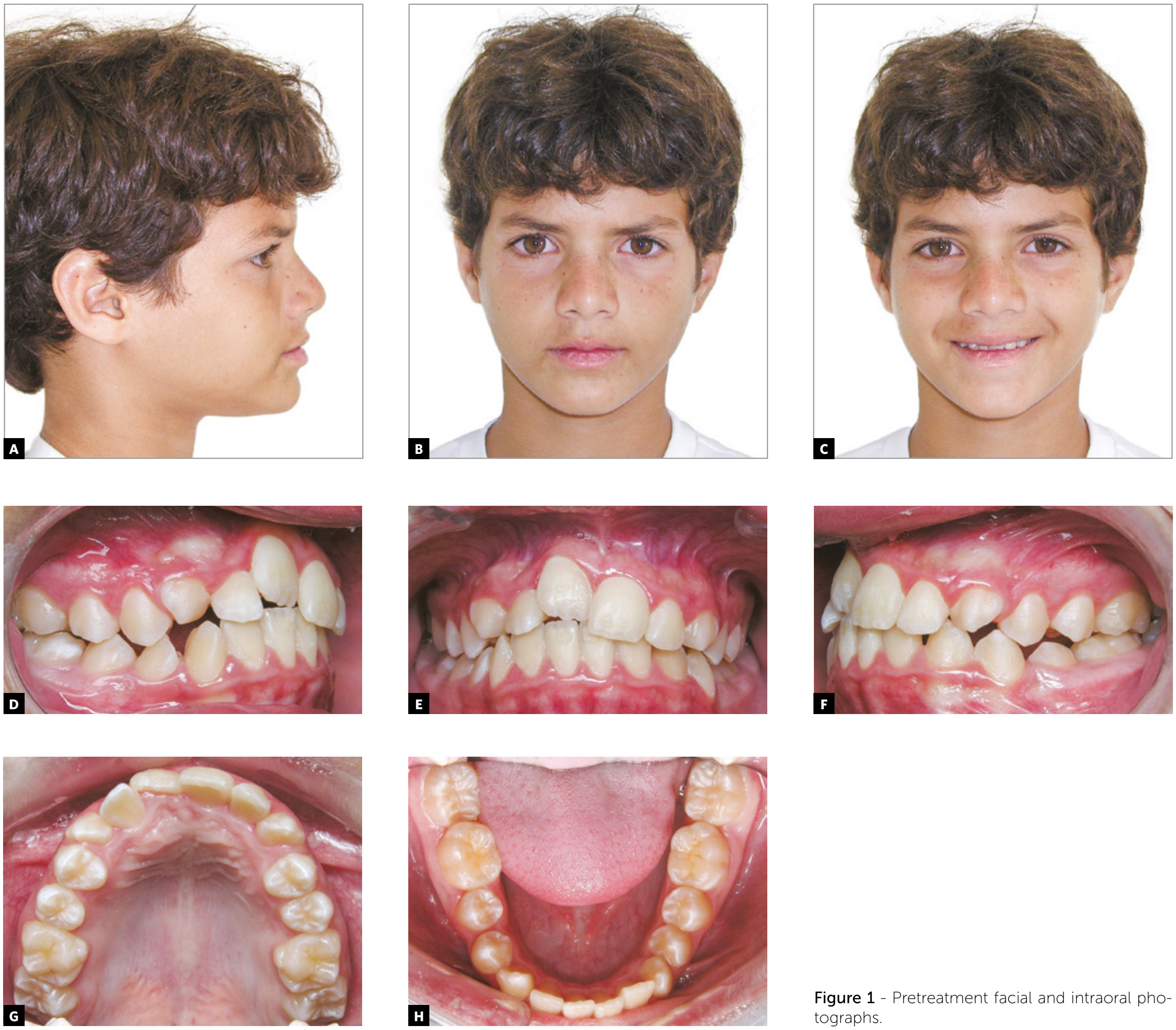

Figure 1 - Pretreatment facial and intraoral photographs.

Table 1 - Cephalometric measurements (norm indicates values as per Brazilian norms).

Measurements	Norm	Pre-treatment	Post-treatment
SNA	82°	84°	82°
SNB	80	82°	79°
ANB	2°	2°	1°
SN.GoGn	32°	33°	33°
IMPA	90°	92°	90°
Interincisal angle	131°	126°	130°
Upper lip - S line	0mm	0mm	-1mm
Lower lip - S line	0mm	0mm	-1mm

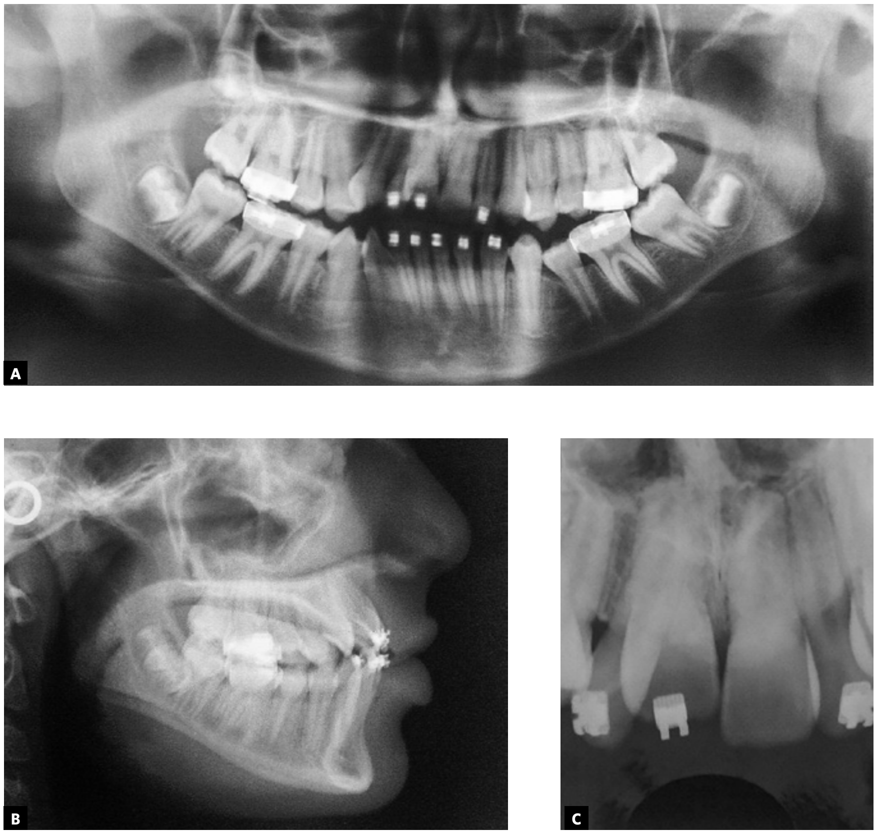

Figure 2 - Initial panoramic, lateral, and periapical radiographs.

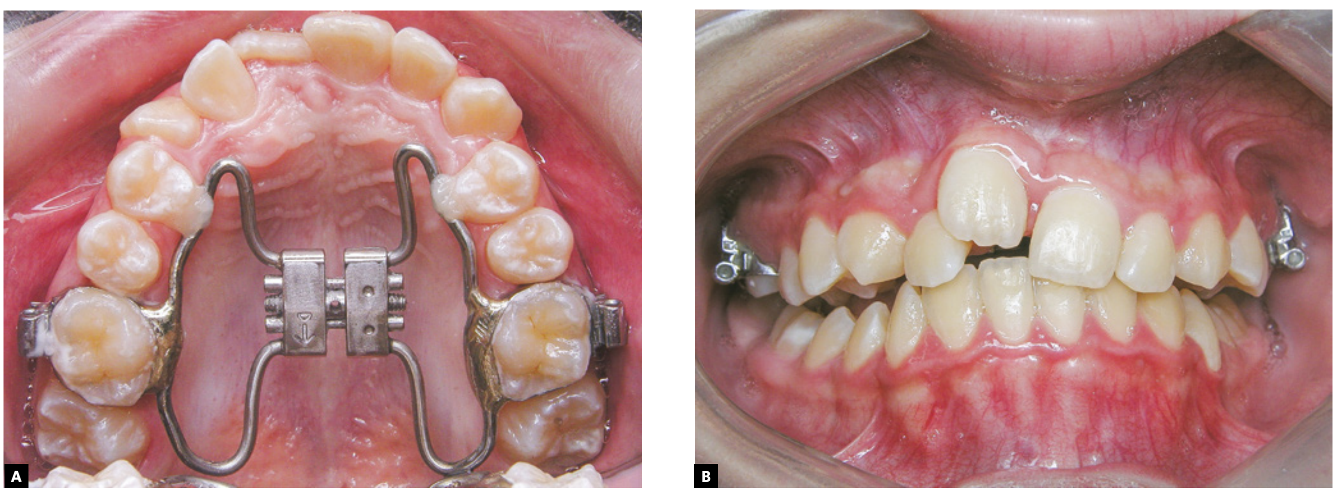

Figure 3 - Intraoral photographs before (A) and after (B) RME, showing evidence of the midline diastema after RME.

In order to avoid round-tripping incisor movements, a segmented approach with 0.017 x 0.025-in stainless steel T-loops were used to retract canines (Fig 4). When adequate space was obtained, the remaining brackets were placed, except on the maxillary right central incisor. Sliding mechanics was used to open space for the maxillary right central incisor before using any orthodontic forces on this tooth. After 14 months of treatment, adequate space was obtained to position the maxillary right central incisor, and then a 0.019 x 0.025-in stainless steel (SS) wire was placed to anchor the maxillary teeth. While this approach anchored the maxillary arch, light orthodontic forces with 0.012-in NiTi wire was used to extrude the right central incisor. At the same time, a button was bonded at the palatal side to derotate this tooth (Fig 5). After three months, the heavy wire was kept in place and the 0.012-in NiTi archwire was replaced by a 0.016-in NiTi archwire (Fig 6). Four months later, ideal vertical positioning was accomplished and a 0.018-in SS archwire was placed in the maxillary arch (Fig 6). Routine panoramic and periapical radiographs were requested (Fig 7).

Radiographic images showed slight apical ERR in the maxillary incisors and a severe asymptomatic ICR in the maxillary right central incisor. Clinically, the tooth exhibited pink discoloration on the cervical region at the palatal surface, thus the patient was referred to endodontic and periodontic specialists for evaluation. The ICR was classified as a Class 4 type, since the lesion had extended beyond the coronal third of the tooth root and tooth extraction was indicated. Since the patient wasn't old enough to perform the tooth implant, the multidisciplinary team (periodontist, endodontist, prosthodontist and orthodontist) decided to keep the tooth in order to maintain alveolar bone levels, until patient reached a suitable age to perform the extraction and insertion of an osseointegrated implant, avoiding the need for a bone graft surgery. Endodontic treatment was not considered, since literature considers it's outcome unsatisfactory when applied to Class 4 resorptions.[2] For this purpose, patient was monitored by the multidisciplinary team since the maxillary right central incisor had the crown structure weakened and would need restorative procedures, if necessary.

Figure 4 - Canine retraction using the segmented arch approach.

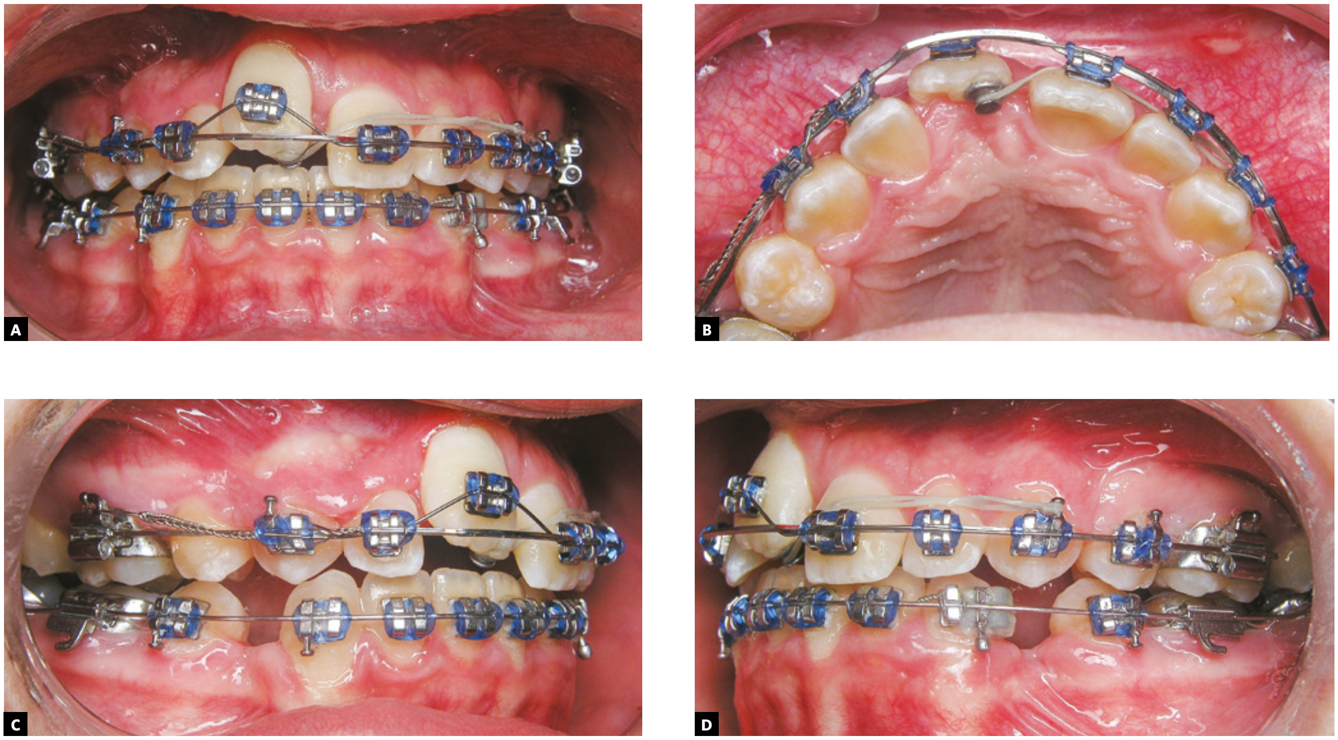

Figure 5 - Orthodontic mechanics to correct maxillary right central incisor vertical position and rotation.

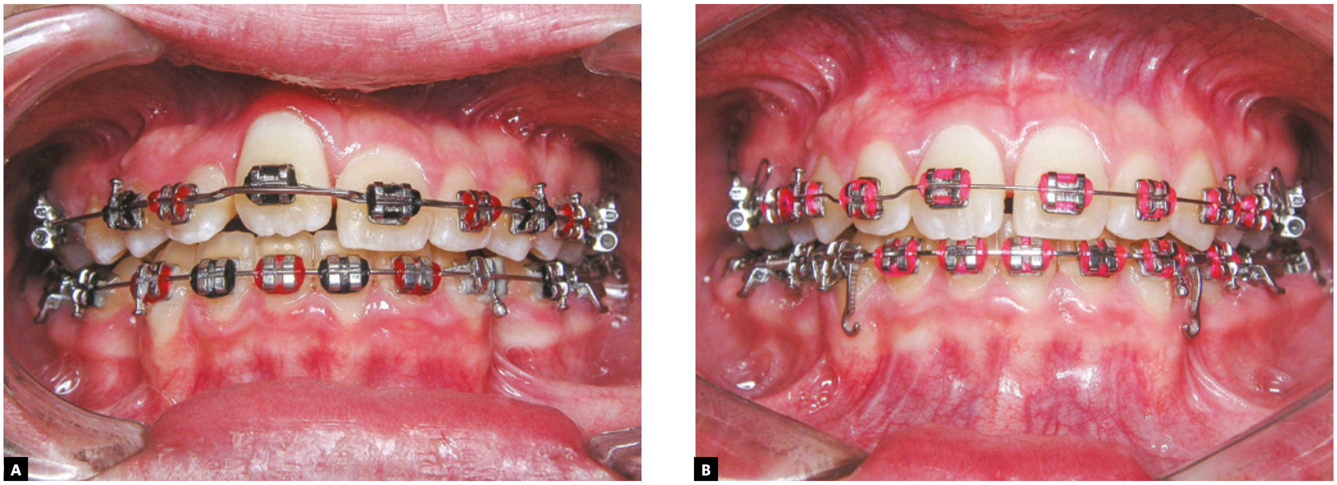

Figure 6 - Progress of vertical and axial movement of the maxillary right central incisor after 2 months (A) and 4 months (B) of the incisor bonding.

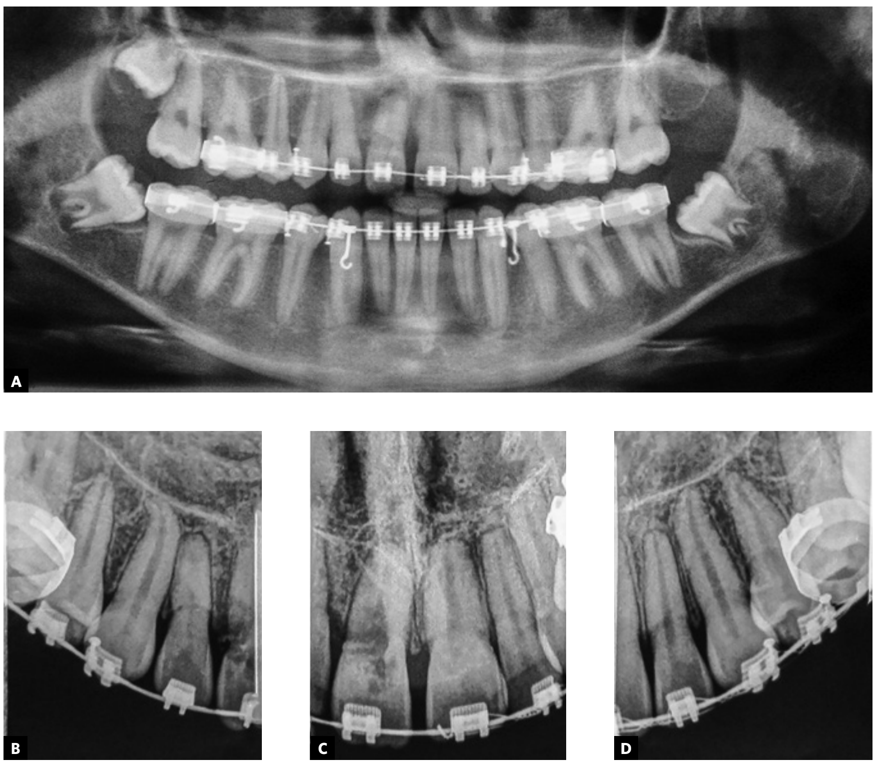

Figure 7 - Routine panoramic and periapical radiographs requested after 17 months of treatment. ICR of the maxillary right central incisor was diagnosed.

RESULTS

The overall treatment duration was 3 years and 9 months. The posttreatment photographs show satisfactory occlusion, Angle Class I molar and canine relationship, coincident dental midlines, ideal overjet and overbite. Bonded maxillary and mandibular 3x3 retainers were installed after treatment (Fig 8). Figure 9 shows final lateral radiograph and Cone Beam Computerized Tomography (CBCT) image, showing the compromised structure of maxillary incisor. Table 1 reveals the final treatment cephalometric measurements.

Six years posttreatment, when the patient was 21 years old, the maxillary right central incisor was extracted and the osseointegrated implant was inserted. At that point, the tooth crown had broke and had been restored with a temporary prosthesis. Figures 10 and 11 show photographs and panoramic radiograph six years after the end of the treatment. Despite of the relapse of mandibular midline shift, there was acceptable stability of the final results.

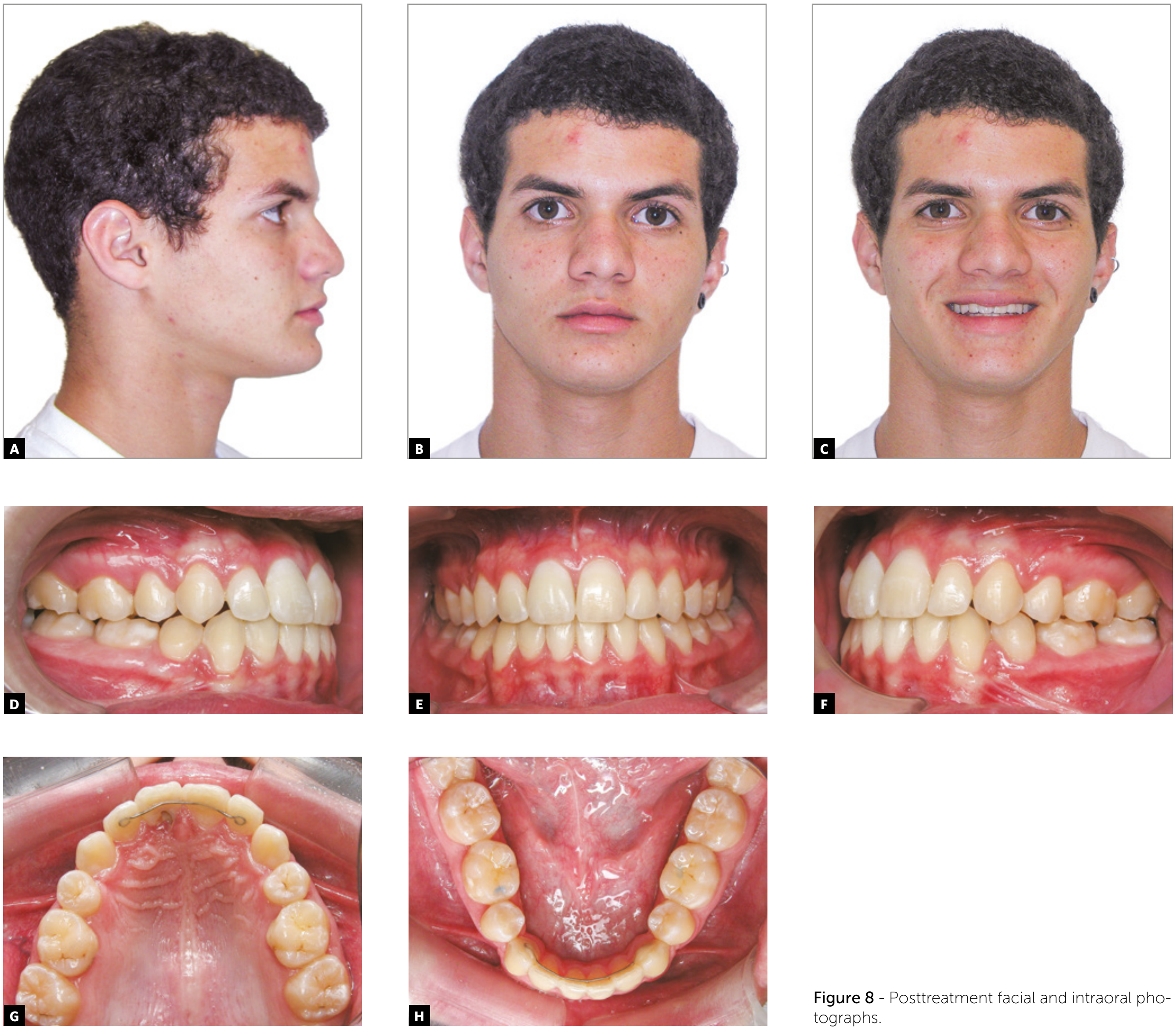

Figure 8 - Posttreatment facial and intraoral photographs.

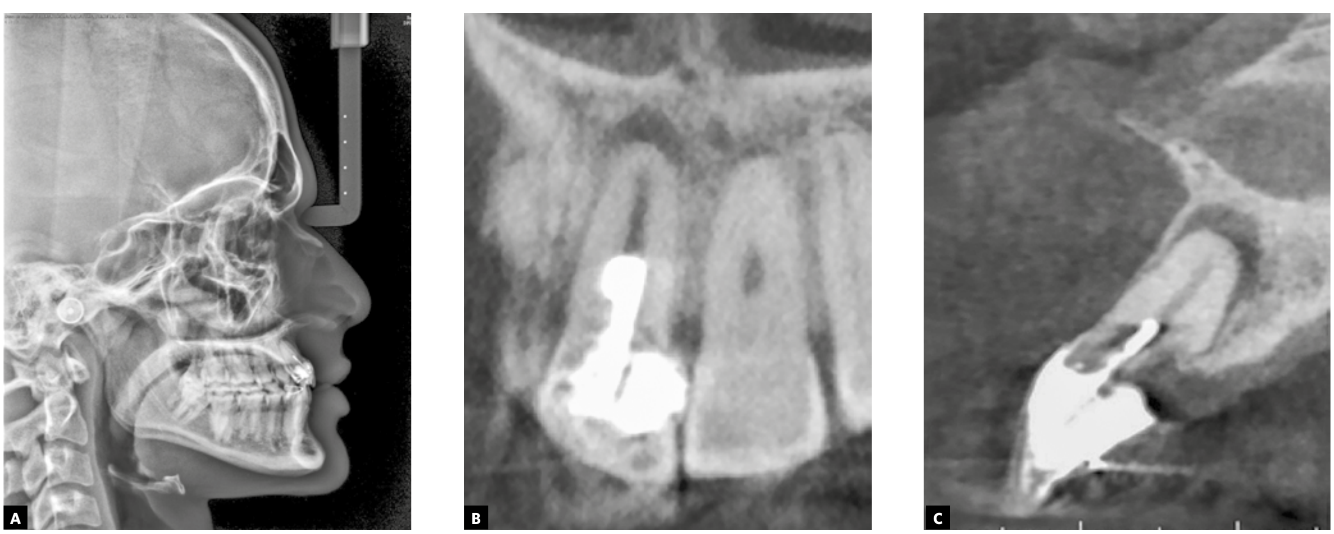

Figure 9 - Final lateral radiograph and Cone Beam Computerized Tomograph image of maxillary central incisors on coronal and sagittal views.

Figure 10 - Follow-up intraoral and facial photographs taken 6 years posttreatment and 2 years after implant placement.

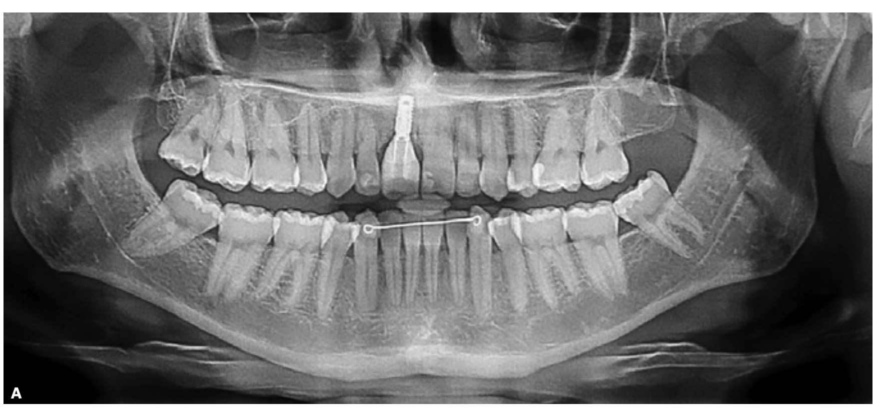

Figure 11 - Six years post-treatment panoramic radiograph showing the implant and bone conditions of the maxillary central incisor region.

DISCUSSION

ICR is an important orthodontic therapy complication. Despite its rare occurrence, the damage to the affected tooth might require removal of the affected tissue, restoration of the defect with filling material, and, in cases in which the tooth structure is severely affected, tooth extraction might be required. The feature that makes this case unique is that the asymptomatic ICR affected a permanent upper central incisor during orthodontic treatment, which was eventually extracted. This unwanted side effect is extremely important to highlight the role of routine radiograph exams during orthodontic treatment.

The affected tooth showed a clinical aspect of trauma, but the patient and his family reported no trauma history. According to the family, the right central incisor had delayed eruption during mixed dentition, when the patient started the previous treatment. Literature has pointed out orthodontic treatment as being the most common risk factor for ICR,[9] and there is a higher percentage of cases when the two risk factors — orthodontic treatment and occurrence of trauma — were found in combination. However, this event may be underestimated, since patients might not be able to recall trauma to their teeth.[10]

According to Heithersay,[2] ICR can be classified in four different levels (from Class 1 to 4), according to its extent. The treatment and prognosis of this pathology varies with the degree of the resorptive process. Usually Classes 1, 2 and 3 allow removal of the resorptive tissue and restoration of the defect.[11] A multidisciplinary approach might be necessary if the resorption involves the root canal system and demands endodontic treatment; or if the lesion is located too far in the apical direction, and requires orthodontic forced eruption to expose the resorption area to allow the filling procedure.[12] The Class 4 ICR is a large invasive resorption that reaches beyond the coronal third of the root, and its occurrence demands extraction of the tooth.[3] In the presented case, the tooth exhibited a pink discoloration on the cervical region at the palatal surface, and the periapical radiography revealed coronal radiolucency that extended deeply into the root on apical direction (Fig 8).

This case was conducted with the aim of preventing unnecessary tooth movement, such as round tripping of the incisors, and to avoid unwanted forces during aligning and leveling stages. The maxillary anterior teeth, especially the maxillary right central incisor, were bonded only after adequate space was gained. This approach consisted of RME and subsequent extraction of four premolars. Additionally, light forces were used to extrude the right central incisor. Since controlled mechanics were used and the right central incisor was carefully positioned, the possibility of this orthodontic treatment being associated with the primary etiology of this ICR was not considered. However, it was not possible to make the same statement about the orthodontic mechanics used in the previous treatment. It is unclear whether the previous orthodontic treatment could be an iatrogenic factor and a possible cause of the ICR in this tooth.

Another important precaution taken during the treatment planning was that after discontinuation of the first treatment, four months were waited for recovery, before resuming the new treatment. This clinic conduct was based on previous studies,[13-15] as several authors have addressed the recovery of dental and periodontal tissues after force application, based on animal research. In addition, Katzhendler and Steigman[16] highlighted the increased risk of ERR during the retreatment of a previously moved tooth. Although most studies have investigated the apical ERR, this might have played a role in this other type of ERR that affected the cervical area of the tooth — that is, the ICR.

As the radiographic image of the ICR looks like an Internal Root Resorption (IRR), it's important to clarify the differential diagnoses of the two pathologies. The ICR is a type of external inflammatory resorption that begins on the cervical area of the tooth; thus, the diagnose is frequently done using radiographs and during clinical examination. The IRR is a pulp disease that causes the resorption of the tooth structure, starting from the root canal. It is also usually asymptomatic and recognized through routine radiographs. Several authors[17-19] have emphasized the difficulty in distinguishing IRR and ICR, especially when the ICR is not accessible by probing and, on radiographic examination, it is projected over the root canal. In order to guide clinicians on radiographic differentiation of the ICR and IRR, Gartner et al.[20] described IRR as smooth and symmetrically distributed lesions, and ICR as asymmetrical and with borders that are poorly defined. Thus, the clinical examination performed by the endodontic and periodontic specialists was imperative to diagnosis definition.

There is no doubt about the importance of the initial radiographic screening before beginning the orthodontic treatment. For the treatment planning, it is necessary to accurately assess the relationships of the teeth to the jaws, and the jaws to the rest of the facial skeleton. Although the British Orthodontic Society recommendations[21] for monitoring treatment involves the use of radiographs only to assess unerupted teeth, iatrogenic factors, and at the end of active tooth movement; the use of routine radiographs was essential for the diagnosis of ICR in this case, especially because of its asymptomatic nature. ERR of maxillary incisors is considered an important issue, as demonstrated by the mechanics applied in the current clinical case. However, periapical radiographs of maxillary central incisors could have been taken earlier than 17 months of treatment. Thus, it might have been possible to save this tooth.

CONCLUSION

ICR is a possible complication that might occur during orthodontic treatment and few authors have reported such problem. This clinical example highlights two important aspects regarding this issue: the importance of routine follow-up radiographs during treatment, to allow early diagnosis of this asymptomatic problem; and the treatment difficulties related to ICR, such as the need for tooth extraction.

Since orthodontic treatment has been listed as a possible risk factor to ICR, this article brings important concepts regarding this issue, in order to assist the clinician in dealing with this unwanted situation.

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Evaluation of stability of three different mini-implants, based on thread shape factor and numerical analysis of stress around mini-implants with different insertion angle, with relation to *en-masse* retraction force

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Objectives: Assess the stability of three different mini-implants, based on thread shape factor (TSF), and evaluate stresses at the mini-implant site and surrounding cortical bone on application of retraction force, at two different insertion angles.

Methods: Mini-implants of three different diameters (M1 - Orthoimplant, 1.8mm), (M2 - Tomas, 1.6mm) and (M3 - Vector TAS, 1.4mm) and length of 8mm were used. Using scanning electronic microscopy, the mean thread depth, pitch and relationship between the two (TSF) were calculated. The mini-implants were loaded into a synthetic bone block and the pull-out strength was tested. One way ANOVA and Tukey *post-hoc* tests were used to compare the pull-out strength of mini-implants. P values < 0.05 were considered statistically significant. Finite element models (FEM) were constructed with insertion angulation at 90° and 60°, with retraction force of 150 g. The results were analyzed using ANSYS software.

Results: Statistically significant difference was found among all the three mini-implants for thread depth and pitch (<0.001). Statistically significant higher pull-out force value was seen for Orthoimplant. The stress distribution level in mini-implant and surrounding bone was observed to be smaller for Orthoimplant.

Conclusion: Orthoimplant mini-implants have more favorable geometric characteristics among the three types, and less stress with 90°angulation.

Keywords: Thread shape factor. Primary stability. FEM.

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INTRODUCTION

The need for orthodontic treatment modalities that maximize anchorage control and minimize patient compliance has led to the development of mini-implant-assisted orthodontics.[1] Temporary anchorage devices (TADs) in the form of mini-implants are used as a skeletal anchorage and their utilization has become a reliable and acceptable method.[2]

Primary stability of mini-implant is due to the mechanical interlock between the bone and mini-implant, and it depends on many factors, including bone quality, mini-implant site and insertion angle, and design of mini-implants, such as diameter, thread form, pitch, thread size, mini-implant material,[3-5] and the recently introduced thread shape factor (TSF)[2]. TSF is calculated as the geometrical relationship between the mean thread depth and the pitch (D/P) and is expressed as a percentage.[2]

Bone remodeling processes at the bone/screw interface are correlated with the structural response of the bony tissue to the TADs and then to the stress/strain field, developing within themselves and the surrounding bone.[6] Studies of stress allow optimization of the shape and geometric parameters. A key to the success or failure of mini-implant is the manner in which stresses are transferred to the surrounding bone.[7]

The proper insertion angle is important for cortical anchorage, patient safety (root damage), and biomechanical control. It also provides increased surface contact area between the mini-implant and the bone.[8]

Measurement of the stresses *in vivo* is virtually impossible. The finite element method (FEM) is thus a valid technique used to analyze structural stress.[9] In order to understand better how a viscous-elastic material, such as the bone (cortical and cancellous layer), reacts to the insertion of rigid material like titanium, and which kind of stress can be generated by a specific thread design, FEM analysis can be utilized to serve this purpose.[2]

However, the literature lacks information on the combination of ideal geometric design characteristics, i.e., TSF and optimal insertion angle during *en-masse* retraction. To address that, this study was conducted to evaluate the effect of TSF of 3 different mini-implants, and their various insertion angle combinations, on the pull-out strength and stresses at the mini-implant site and surrounding bone during *en-masse* retraction, using a FEM study.

MATERIAL AND METHODS

Detailed geometry of all three mini-implants was studied through scanning electron microscope (SEM), to measure the TSF.

Pull-out test was carried out to determine the primary stability.

FEM was done to evaluate stress distribution at the mini-implant site and in the surrounding cortical bone, with the application of retraction force at two different insertion angles (60° and 90°).

Material

The three mini-implants used in the study were as follows:

1) ORTHOImplant (3M Unitek, Monrovia, CA, USA): 1.8-mm diameter and 8-mm length (M1).

2) TOMAS (Dentaurum): 1.6-mm diameter and 8-mm length (M2).

3) VECTOR TAS (Ormco): 1.4-mm diameter and 8-mm length (M3).

According to the manufacturer's description, these mini-implants are available in the above mentioned diameter with three different lengths. All mini-implants are made of Ti-6Al-4V alloy.

For the pull-out test, double layer artificial bone block (Sawbones, Pacific Research Laboratories Inc, Vashon, Washington;) was used. The block is composed by a polyurethane foam, measuring 120 x 170 x 41 mm thick, having a 1.1-mm top layer with a 40-pcf density, and a 39-mm base layer with a 10-pcf density (Table 1).[10]

Methods

Scanning electron microscopy

Each mini-implant was examined using a scanning electron microscope (Tescan Vega3, Czech Republic), operating at 30.00 kV, which was performed at Sanray laboratories Pvt Ltd (Hyderabad, India). Images of each mini-implant were captured with VEGA 3.0 software, and obtained at 27× and 33× magnifications (Figs 1 and 2). The pitch and thread depth was measured using team measurement tool of Biovis Materials VA4.59 software.

Pull-out test

Pull-out strength tests were performed at the same laboratory on bone blocks constructed featuring a superficial layer with biomechanical characteristics (elas-

Table 1 - Material properties of artificial bone materials (poisson ratio = 0.3).

	Strength and modulus (MPA)					
	Compressive		Tensile		Shear	
Density pcf (g/cc)	Strength	Modulus	Strength	Modulus	Strength	Modulus
10 (0.16)	22	58	2.1	86	1.6	19
40 (0.64)	31	759	19	1000	11	130

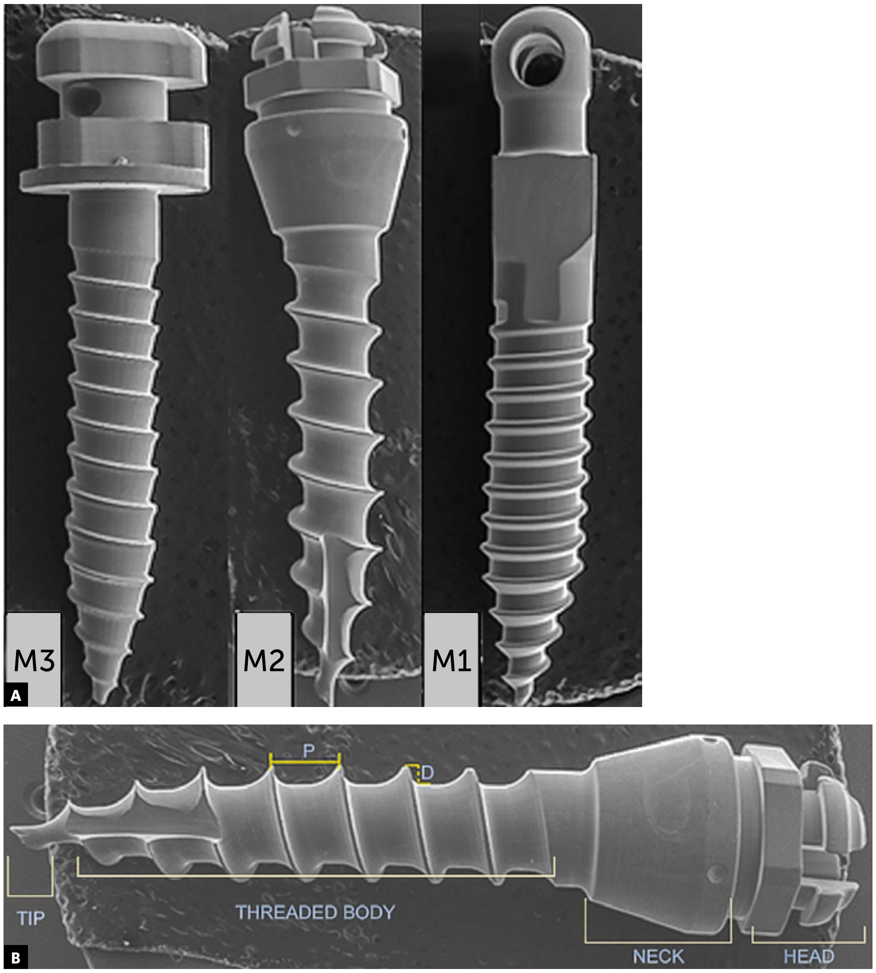

Figure 1 - A) M1, M2, M3: SEM images of mini-implants at magnification x27. B) Illustrating parts of mini-implant (D is thread depth and P is pitch).

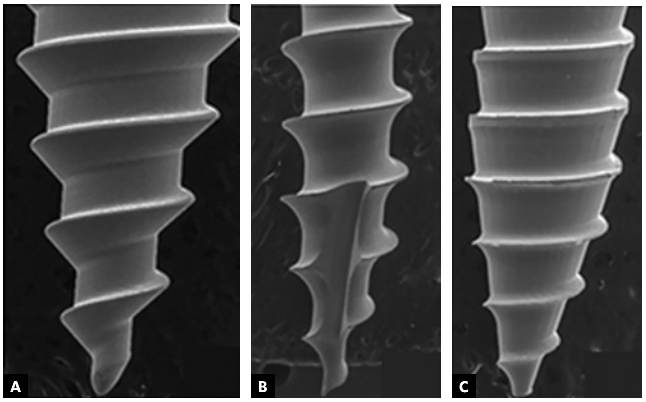

Figure 2: SEM images of mini-implants at magnification x 33.

ticity, hardness and density) similar to the cortical bone and a deeper layer with characteristics mimicking the trabecular bone. Computed tomography study by Migliorati et al.[13] reported a mean cortical thickness of 1.10mm on the buccal side of the maxilla. So a bone block with 1.1-mm cortical thickness was used in the present study.

This bone block was divided into small blocks measuring 1.5cm x 2.5cm, so that it could fit accurately in between the metal plates of the testing machine. The geometric center was marked on each bone block and the mini-implants were inserted at these points, to a thread depth of 6mm. The pull-out test was carried out by a universal testing machine Shimadzu AGS-X featuring 5 kN load. The mini-implant was loaded with a traction speed of 2mm/minute and the pull-out strength was measured as the peak force recorded by the built-in machine software (Trapezium v. 1.4.5). The method was repeated for each mini-implant.

Finite element method

For creating a finite element model, a 3D CAD model was constructed from a CT scan of the craniofacial complex of a 15-years-old female patient. CT scan images of the maxillary bone were taken by Siemens Somatom Definition 64 (120kVp; 290 mAs) in axial direction. Sequential CT images were taken at 0.5 mm intervals to reproduce finer and detailed aspects of the geometry. A total of 625 images were stacked over one another and converted to a finite element meshed model by the software MIMIC (version 18.0). Tetrahydron elements were used to mesh the skull and teeth. Archwire, brackets, crimpable hooks and NiTi closed coil spring were modeled by the software ANSYS Design Modeler (version 19; ANSYS Inc., Integrated Design Analysis Consultants, INDIA Pvt Ltd) with beam elements. The total number of elements in the geometry was 864,650 and the total number of nodes created was 247,119 (Fig 3). Nodes and elements defined for each model of mini-implants (M1, M2 and M3) for 90º and 60º angulations, respectively, is presented in Table 3.

Only one side of the maxilla was generated, as results on the other side are expected to be the same. To simulate the extraction space, maxillary first premolar was removed from the model. Geometric model of brackets, mini-implants, archwire with crimpable hook and nickel-titanium closed coil spring were constructed using reverse engineering technique. Brackets models were constructed using stainless steel MBT prescription of slot size 0.022 x 0.028-in. Stainless steel archwire of 0.019 x 0.025-in dimension and a nickel-titanium closed coil spring was fabricated and attached from crimpable hook to the mini-implant head, generating retraction force of 150g (Fig 3).The mini-implants were inserted at angulations of 60° and 90° to the buccal surface of alveolus. Three FEM models were generated, in which all the parameters were kept the same, except the insertion angulation of the mini-implant. Material properties assigned to the FEM were tabulated in Table 2.[9]

Statistical analysis

Descriptive statistics included calculation of mean and standard deviation for TSF and pull-out tests of three different mini-implants. Shapiro-Wilk's normality test was used to verify the equality of variance. One-way ANOVA and Tukey *post-hoc* tests were used to compare the TSF and pull-out strength of the mini-implants, within as well as between the groups. The level of significance was $p<0.05$. Data were analyzed using SPSS software v. 23.0.

Table 2 - Material property data representation (10).

Material	Elastic modulus E (GPa)	Poisson's ratio
Tooth	20.7	0.30
Compact bone	14.7	0.30
Cancellous bone	1.5	0.30
Titanium mini-implant	114	0.34
Bracket and wire	179	0.30
Nickel-titanium	36	0.33

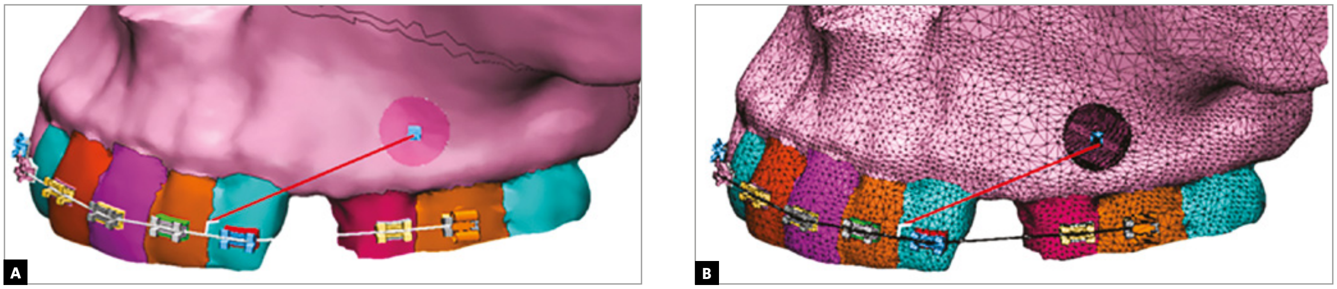

Figure 3: Three-dimensional geometric model of half maxilla with brackets, mini-implant, archwire with crimpable hook and NiTi closed coil spring.

Table 3 - Nodes and elements defined for each model.

	Angulation			
	90°		60°	
Mini-implants	Nodes	Elements	Nodes	Elements
M1	357,580	1,529,563	357,737	1,529,610
M2	357,822	1,531,187	357,714	1,531,233
M3	357,103	1,527,129	357,214	1,527,246

RESULTS

SEM and pull-out test

Since the Shapiro-Wilk's normality test confirmed the equality of variance, one-way ANOVA was used for the between-group comparisons. The mean thread depth, pitch and TSF of M1 was found to be 0.088mm, 0.426mm and 20.667%, respectively; for M2, it was 0.217mm, 0.849mm and 25.483%, respectively; and for M3, it was 0.097mm, 0.507mm and 19.100% respectively. ANOVA showed statistically significant difference for thread depth and pitch for all the three mini-implants, and statistically insignificant for TSF (Table 4). *Post-hoc* Tukey test showed: statistically significant difference for thread depth between M1 and M2, and M2 and M3; not significant difference between M1 and M3; and statistically significant difference between all the groups for the pitch of the mini-implants (Table 5).

The mean values of M1, M2 and M3 for the pull-out test were 0.181kN; 0.142kN and 0.138kN, respectively. Differences were statistically significant (Table 4).

Finite element method

The results showed changes in terms of von Mises stress and principal stresses. The magnitude of stresses developed in reaction to applied retraction force is mentioned in Table 6 and the pattern of stress distribution is described below.

Mini-implant

For M1 at 90° insertion angle, maximum stress was observed on the head of the mini-implant at the point of attachment with the retraction spring and at the junction of the head and transmucosal collar (neck). The stresses gradually decreased from first thread until fourth thread. Minimum levels of stress remained constant throughout the length of the mini-implant (Fig 4, M1).

At 60° insertion angle, a small portion of maximum stress was observed at the junction of the head and neck. The stresses gradually decreased from first thread until fourth thread. Minimum levels of stress remained constant throughout the length of the mini-implant. The maximum von Mises stresses at 90° and 60° insertion angle were 23.72 MPa and 29.01 MPa, respectively (Fig 5, M1).

For M2 at 90° insertion angle, maximum stress was observed in the first and second threads. Stresses decreased towards the neck and below the third thread. The stresses gradually decreased from fourth and fifth thread. The stresses remained minimal from fifth thread to the tip of the mini-implant (Fig 4, M2).

Table 4 - Comparisons of mean depth, pitch, TSF and peak load among all three groups, by analysis of variance.

Parameter	Orthoimplant (M1)		Tomas (M2)		Vector TAS (M3)		
	Mean	SD	Mean	SD	Mean	SD	ANOVA p value
Depth (mm)	0.088	0.019	0.217	0.046	0.097	0.027	<0.001*
Pitch (mm)	0.088	0.049	0.849	0.024	0.507	0.010	
TSF (%)	20.667	4.894	25.483	4.967	19.100	5.277	0.107
Peak load (kN)	0.181	0.018	0.142	0.030	0.138	0.025	0.017*

* $p < 0.05$.

Table 5 - Multiple comparisons between groups by Tukey *post-hoc* test.

Parameter	M1-M2		M1-M3		M2-M3	
	Mean difference	p value	Mean difference	p value	Mean difference	p value
Depth (mm)	-0.130	<0.001*	-0.010	0.871	0.120	<0.001*
Pitch (mm)	-0.423	<0.001*	-0.080	0.002*	0.343	<0.001*
TSF (%)	-4.817	0.255	1.567	0.854	6.383	0.105
Peak load (kN)	0.039	0.040*	0.043	0.024*	0.004	0.962

* $p < 0.05$.

Table 6 - Magnitude of stresses developed under same load and different mini-implant angulations.

Mini-implant	Mini-implant				Cortical bone			
	Insertion angle							
	90 degree		60 degree		90 degree		60 degree	
	Maximum (MPa	Minimum (MPa)	Maximum (MPa	Minimum (MPa)	Maximum (MPa	Minimum (MPa)	Maximum (MPa	Minimum (MPa)
M1	23.72	0.1056	28.01	0.062	2.4184	0.078	2.9524	0.077
M2	80.03	0.1382	107.06	0.014	6.7626	0.134	5.4152	0.115
M3	17.01	0.0625	14.89	0.008	3.8516	0.081	3.6095	0.071

At 60° insertion angle, maximum stresses were observed at the larger portion of first and second threads, and a smaller portion of third thread and neck of the mini-implant. Stresses were decreased to a small portion of fourth thread, and the stresses reached minimum levels and remained constant at the head and a larger portion of neck and from fifth thread to the tip of the mini-implant. The maximum von Mises stresses at 90° and 60° insertion angle were 80.03 MPa and 107.06 MPa, respectively (Fig 5, M2).

For M3 at 90° insertion angle, maximum stress was observed at the first and second threads and a small portion of the head, at the point of attachment of retraction spring. The stresses gradually reduced at the neck and a small portion of third and fourth threads, and from there the stresses reached minimum level and remained constant throughout the length of the mini-implant (Fig 4, M3).

At 60° insertion angle, maximum stresses were observed at the junction of head and neck. The stresses reduced from the threaded body and at the small portion of third thread. The stresses reached a minimum level and remained constant throughout the length of the mini-implant. The maximum von Mises stresses at 90° and 60° insertion angle were 17.01 MPa and 14.89 MPa, respectively (Fig 5, M3).

Cortical bone

For M1 at the 90° and 60° insertion angle, the pattern of stress distribution was the same, where maximum stresses were observed at the mesial, distal and apical to the mini-implant. Stresses uniformly decreased in the form of concentric circles as it is moved away from the mini-implant and reached closer to the upper small portion of the lower crest of the cortical bone (Figs 6 and 7, M1).

For M2 and M3 at the 90° insertion angle, the pattern of stress distribution was similar to what was observed for the M1. At 60° insertion angle, the stresses at M2 and M3 were close to M1, with a main difference that the stresses reached the broader area of lower crest of the cortical bone (Figs 6 and 7, M2-M3).

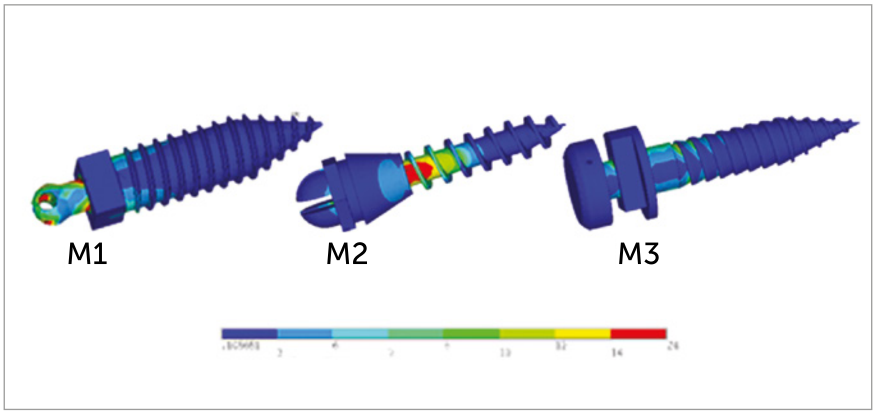

Figure 4 - M1, M2, M3: Pattern of stress distribution along mini-implant length at 90° insertion angulation.

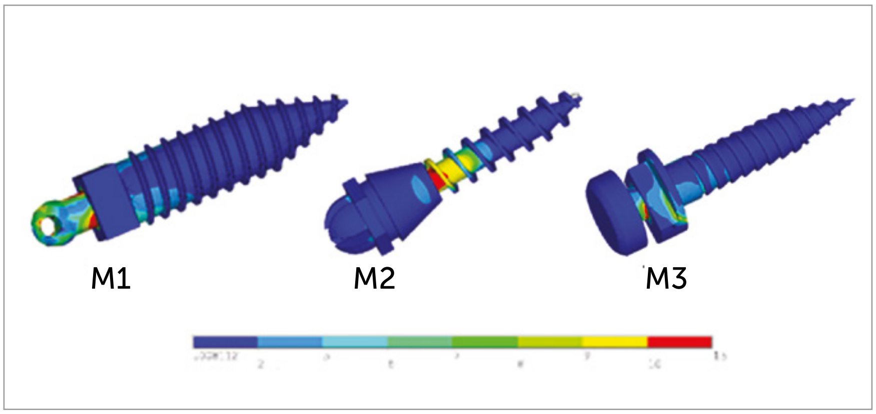

Figure 5 - M1, M2, M3: Pattern of stress distribution along mini-implant length at 60° insertion angulation.

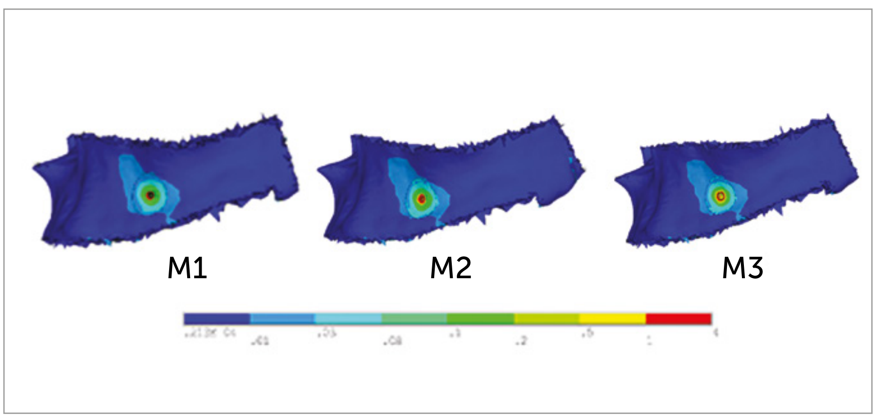

Figure 6 - M1, M2, M3: Pattern of stress distribution in cortical bone at 90° insertion angulation.

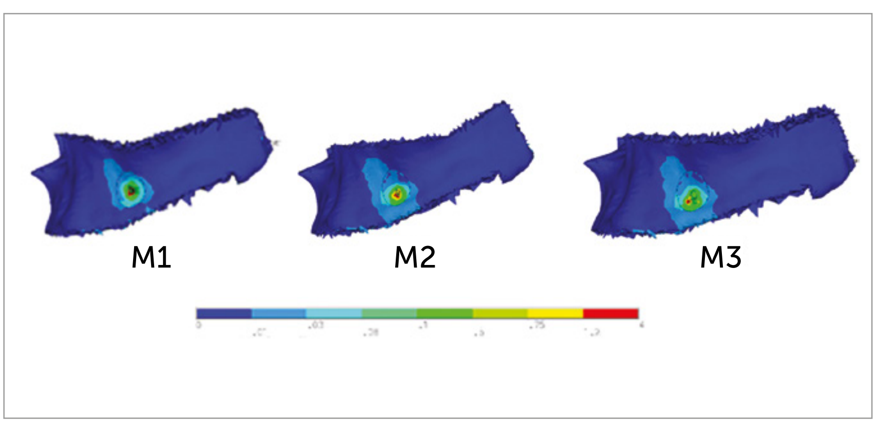

Figure 7 - M1, M2, M3: Pattern of stress distribution in cortical bone at 60° insertion angulation.

DISCUSSION

SEM and pull-out test

The fundamental parameter for primary retention of TADs is the pull-out strength, which is linked to bone related factors[11-12] and mini-implant design factors like diameter, pitch, thread depth and TSF.[2,13] The TSF and relative pull-out strength values in the current study were: 20.6%, 0.181kN for M1; 25.4%, 0.142 kN for M2; and 19.1 %; 0.138kN for M3.

The results of this study showed no correlation between TSF and pull-out strength. Previous literature has shown contradicting conclusions. Radwan et al[5] concluded that decreased TSF led to increased pull-out forces and thus, to higher primary stability; however, Migliorati et al[2,13] reported that a larger TSF provided higher primary stability.

The results in the current study showed a non-significant difference in TSF and significant difference in pull-out force between the three groups. M1 had the highest value of pull-out force, followed by M2 and, finally, M3 (Table 4). The results of the current study indicate that different geometric design parameters like pitch, thread depth and diameter of mini-implant, apart from TSF, influenced the mechanical stability of the mini-implant.

The results of the current study showed no definitive correlation between the pitch and pull-out values, as shown in Table 4. Brinley et al[14] reported that a decrease in pitch led to increase in pull-out force and therefore higher primary stability. In contrast, Migliorati et al[2] reported that there was a positive correlation between pitch and pull-out force when mini-implants of less than 1mm pitch were inserted in cortical thickness of 2.2mm. The reason for increased primary stability in that study could be due to more thread engagement in cortex in mini-implants with < 1mm pitch when cortical bone was 1.0 - 2.0mm in width.

The current study showed no definitive correlation between the thread depth and pull-out values, as shown in Table 4. Chang et al[4] concluded that pull-out resistance decreased abruptly as the thread depth increased from 0.32 to 0.40 mm. In the present study, the thread depth is within 0.32mm for all the three mini-implants. Mini-implants used in this study have three different diameters (1.8mm, M1; 1.6mm, M2; and 1.4mm, M3). The results of this study showed a definitive correlation between diameter and pull-out force (Table 4).

The greater the diameter of the mini-implant, the greater the bone compression is, leading to an increased primary stability.[15] Results of this study were in agreement with results reported in previous studies[16,17,18] Walter et al[18] stated that mini- implants with <1.2 mm in diameter should be avoided to prevent failure. Studies on fracture resistance have related the relationship between diameter and strength; they considered that a 0.1 mm increase in core diameter should give greater fracture resistance.[19] OrthoImplant implants can safely resist the high levels of orthodontic forces used for *en-masse* teeth retraction and molar uprighting.

FEM study

The insertion angle of mini-implant varies most often according to clinical preference. Therefore, it is necessary to compare the efficacy in terms of stress induced in the metal and bone among mini-implants of various design and insertion angle with orthodontic loading.[20]

Stress analysis on the mini-implant and cortical bone

In the present study, it was observed that for a given load, i.e. 150g, the stress values on mini-implant and in surrounding bone were higher for M2 with 60° and 90° insertion angle, followed by M1 and M3, respectively (Table 6). M2 mini-implant, which has a greater thread depth and smaller taper design, showed higher stresses when compared to the other two mini-implants. The results of the present study are in agreement with Chang et al,[4] who concluded that mini-implant with greater thread depth, smaller taper and short taper length generated higher stresses on the bone and thread elements in lateral loading condition.

The stress levels in the mini-implant increased with reduction in the insertion angle for M2 and M1. The results are in agreement with studies by Woodall et al,[21] and Lee et al,[22] who concluded that placing mini-implant at 90° insertion angle increases the biomechanical stability of mini-implant. The authors also stated that oblique/acute angulations potentially creates longer lever arms, making the threads not completely engaged into the bone, creating increased stress and displacement around the mini-implant, negatively contributing to the primary stability.[15,23] In the present study, the stress levels in M3 increased with an increase in the insertion angle, and the reason could be the reduced diameter of the mini-implant.

For M2 mini-implant, high stresses were distributed on the uppermost threads at the neck of the mini-implant near the margin of bone, with both insertion angulations. High stresses were observed on the head of mini-implant at the point of attachment of the retraction spring, with respect to M1 and M3 with both insertion angulations. This pattern of stress distribution on mini- implant (M1 and M3) was in agreement with studies conducted by Ammar et al[24] and Gracco at al.[6] Benedict et al[25] and Ammar et al[24] in their studies suggested that 2–3mm of the implant's endo-osseous length is most critical in terms of stress response under tangential loading, and the results of the present study were in agreement with that. Mini-implants manufacturers should expect more failures at top three threads.

However, the stress values in the current study were below the yield stress of titanium (692 Mpa),[26] thus indicating that all mini-screws have sufficient strength to resist forces during orthodontic loading.

Highest amount of principal stress in the bone were seen with the M2 mini-implant and the least amount of principal stress were seen for the M1 type. The results were in agreement with previous studies[27-28] that concluded that mini-implants with smaller pitch showed less stress within the bone. In the present study, M1 and M3 had smaller pitch when compared to M2, so smaller amount of stresses was observed with M1 and M3 mini-implants.

The maximum principal stress in bone for both insertion angles indicated that the stress decreased from 60° to 90° for M1, but this decrease in stress distribution was observed to be marginal. These findings were in agreement with previous studies,[8,29] which reported that when the mini-implant insertion angle was increased from 60° to 90°, the stress in the surrounding bone decreased. However, for M2 and M3 there was a marginal increase in stress distribution from 60° to 90° insertion angle. The maximum stress value of 6.7626 MPa was seen with 150-g load and at 90° insertion angulation. As this value is way smaller compared to the 133 MPa yield stress of cortical bone, it can be inferred that no significant adverse changes will be seen in cortical bone.

CONCLUSION

» Within the limitation of this study involving the finite element analyses and mechanical testing of different mini-implants, the result demonstrated that Ortho-implant type with a larger diameter, smaller pitch and shorter taper length have better primary stability, and also have low stresses within the mini-implants and surrounding bone amongst the three groups.

» The favorable insertion angulation found was 90°, as it provides better primary stability and low stresses in the mini-implant and surrounding bone under orthodontic loading.

» Further research is required for optimization of thread-parameters and its validation on living bone tissue.

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Conception or design of the study: SS, RR, AKT. Data acquisition, analysis or interpretation: SS, RR, AKT, AH, SLB, AF. Writing the article: SS, RR. Critical revision of the article: SS, RR, AKT, AH, SLB, AF. Final approval of the article: SS, RR, AKT, AH, SLB, AF. Obtained funding: RR. Overall responsibility: SS.

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Association between hypodontia of permanent maxillary lateral incisors and other dental anomalies

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Introduction: Tooth agenesis is often associated with other tooth anomalies, such as microdontia, delayed eruption and ectopic eruption. Moreover, they may be found all in the same individual, as certain genetic mutations may have a variable phenotypic expression. Treatment of cases of hypodontia of anterior teeth should not involve only opening or closing space for prosthetic rehabilitation. Individuals with hypodontia of permanent maxillary lateral incisors may have teeth with a mesiodistal width smaller than that of patients with a normal dentition, and which may need reshaping to achieve an esthetic and functional occlusion. **Objective:** This clinical case report discusses the association of hypodontia of permanent maxillary lateral incisors with other tooth anomalies and their treatment alternatives.

Keywords: Hypodontia. Anodontia. Tooth agenesis. Tooth abnormalities.

INTRODUCTION

Tooth agenesis, one of the most common tooth anomalies, is the absence of teeth due to a failure in their development.[1]

Several factors may affect the normal development of tissues and lead to changes and defects in tooth shape and size. The causes of tooth anomalies may be congenital, developmental or acquired.[2]

Tooth agenesis is classified according to the number of missing teeth. Hypodontia is the term used to describe the absence of one to five teeth; oligodontia, the absence of six or more teeth; and anodontia, the absence of all teeth.[3]

These terms may be confusing to clinical dentists when talking to each other or to their patients. Several times tooth agenesis is used to indicate congeni-

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

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tally missing teeth. However, the term congenitally missing is inadequate to describe this clinical entity, as tooth development is completed after birth.[4] Hypodontia is etymologically more adequate to classify agenesis when only one tooth is missing, whereas oligodontia and anodontia are more appropriate to describe severe forms of tooth agenesis.[5]

Tooth agenesis is rare in primary dentition. Hypodontia of a primary tooth is associated with hypodontia of its permanent successor. The presence of a primary tooth does not necessarily mean that its permanent successor will also be present. However, hypodontia of a primary tooth is followed by hypodontia of its permanent successor. This association is explained by the histology of odontogenesis: the permanent tooth develops from the tooth bud attached to the dental papilla of the primary tooth under formation. Therefore, the absence of the dental papilla of the primary tooth means that the tooth bud of the permanent successor is missing too.

Tooth agenesis is an anomaly that may be associated with several syndromes, such as Down syndrome, ectodermal dysplasia, Axenfeld-Rieger syndrome, radiotherapy and hypophosphatasia.[2] Genetic inheritance is the main etiologic factor of tooth agenesis. However, this entity has a multifactorial character associated with genetic characteristics, endocrine dysfunctions, viral problems, trauma and congenital deformities, which are mentioned as the main causes of agenesis in the literature.

The prevalence of agenesis of permanent teeth in non-syndromic individuals is higher among Europeans (4.6% men; 5.5% women) and Australians (5.5 men; 7.6% women) and lower among American white people (3.2% men; (4.6% women).[6] The prevalence of agenesis of permanent maxillary lateral incisors ranges from 6% to 8% in different ethnic groups, and molecular genetics has identified shared genetic mutations in families with tooth agenesis.[7] Moreover, individuals with agenesis of permanent maxillary lateral incisors or other teeth often also have other tooth anomalies. That is, the same genetic mutation may have a variable phenotypical expression.[8]

Permanent maxillary lateral incisors are the teeth with the second most frequently affected with hypodontia. Treatment alternatives for this type of tooth anomaly are: space closure by mesialization of permanent canine, placement of a resin-bonded prosthesis, placement of osseointegrated implants, or autogenous tooth transplantation.[7,9-11]

The absence of permanent teeth may, for example, generate problems in the articulation of dental arches, a predisposing factor to malocclusion, and may lead to important changes in the stomatological system. Moreover, it is associated with great esthetic discomfort, which is the main complaint of patients with agenesis of maxillary lateral incisors.

However, treatment approaches in cases of hypodontia of permanent maxillary lateral incisors should not be based only on whether to open or close space for prosthetic rehabilitation. An accurate diagnosis and multidisciplinary planning should define the best treatment option. The mesiodistal width of the other teeth is smaller in patients with hypodontia of maxillary lateral incisors.[12] The other teeth often require reshaping so that their mesiodistal diameter is appropriate for an esthetic and functional dental occlusion. Moreover, an ideal occlusion is dependent on the presence of a well-proportioned anatomy of both maxillary and mandibular teeth, so that dental alignment is ideal when associated with the closure of the space resulting from hypodontia.[13]

This study discusses the association of hypodontia of permanent maxillary lateral incisors with other tooth anomalies, and describes treatment alternatives to treat the absence of maxillary lateral incisors. A brief review of the literature is followed by the description of the clinical case of a patient with hypodontia and microdontia of permanent maxillary lateral incisors.

CASE REPORT

A white 14-year and 2-month-old boy presented with a chief complaint of diastema of anterior maxillary teeth, missing tooth #12, microdontia of tooth #22 and delayed eruption of tooth #53. Clinical examination revealed that tooth #13 had erupted at the site of the missing tooth #12, and that the eruption of tooth #53 was delayed and distal to tooth #13. The patient had microdontia of tooth #22, and tooth #85 had not erupted yet (Figs 1, 2). He had a Class I skeletal pattern (ANB = 4°), a mesocephalic pattern, a balanced vertical growth pattern (SN.GoGn = 32°, y-axis = 52°, FMA = 21°), a well-positioned maxilla and a retrog-

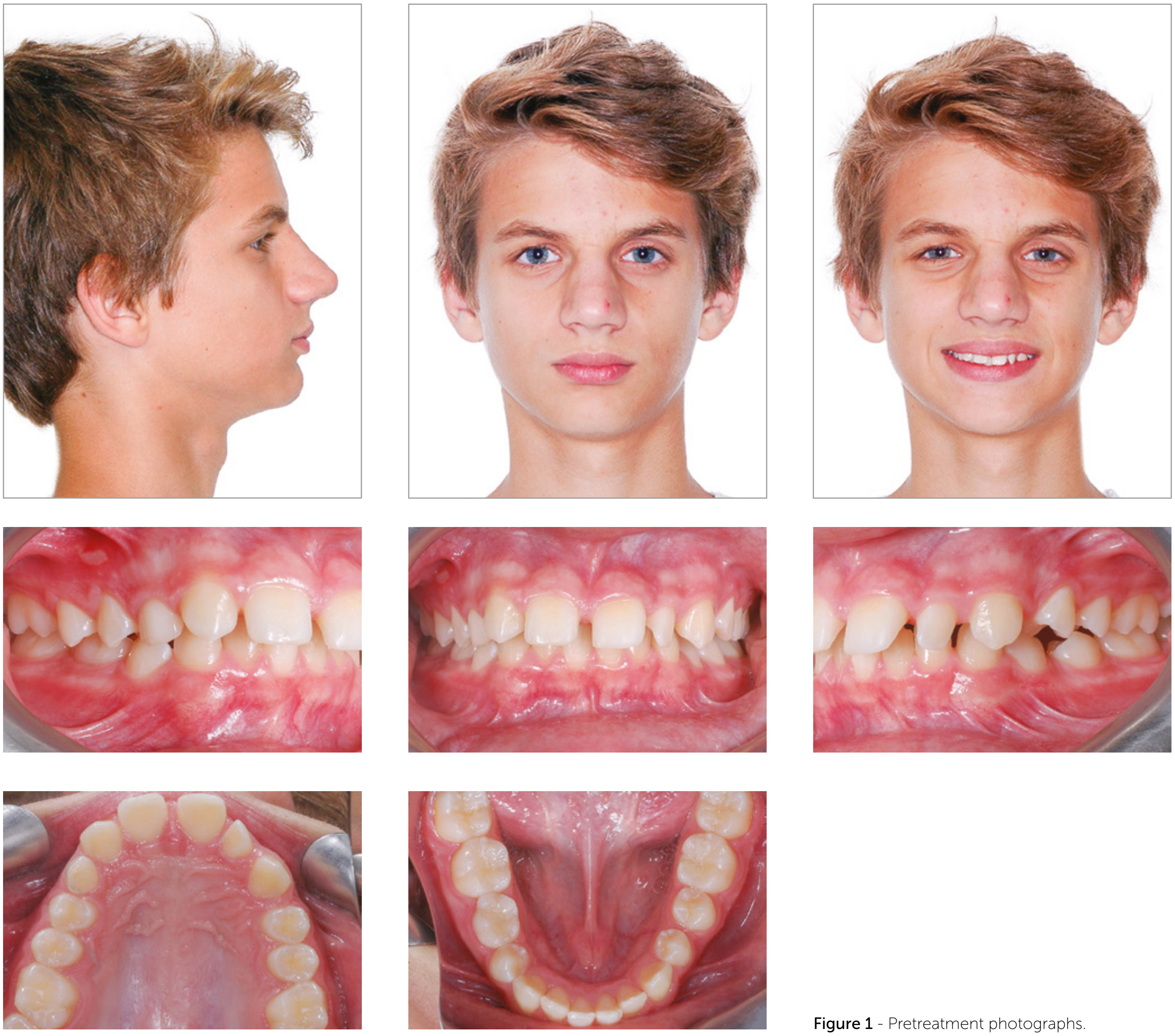

Figure 1 - Pretreatment photographs.

Figure 2 - Pretreatment panoramic radiograph.

nathic mandible (SNA = 81° and SNB = 77°). He also had an edge-to-edge molar relationship, which tended to an Angle Class II occlusion, and positive space discrepancy in the maxillary arch (6.5 mm). Overbite and overjet were increased (4.67 mm and 8 mm), maxillary dental midline was deviated 3.5 mm to the right, and there were diastemas between maxillary anterior teeth. Maxillary incisors were proclined (1.NA = 35°, 1-NA = 5 mm) and mandibular incisors were slightly crowded and proclined (1.NB = 27°, 1-NB = 6mm) (Table 1, Fig 3). He had a straight profile and an upper lip short to the S-line (Steiner), a right mentolabial angle and an obtuse nasolabial angle. The analysis of function revealed atypical phonation and deglutition, as well as tongue thrust.

Treatment objectives were leveling and alignment of dental arches, adequate overbite and overjet, coinciding dental and facial midlines, molar and canine Class I relationship, reshaping of tooth #22 and space opening for implant at the site of the missing tooth #12.

TREATMENT AND ORTHODONTIC MECHANICS

Multidisciplinary planning included opening space for the replacement of missing tooth #12 and reshaping of #22. The patient's guardians were informed that this treatment strategy would require a longer time, because the use of asymmetric mechanics would be necessary. Moreover, the treatment would require total patient compliance with the use of intermaxillary elastics to achieve an adequate dental occlusion. They were also informed that an osseointegrated implant would have to be placed when the patient reached adulthood, and that the long-term stability of soft and hard tissues around the implant, as well as esthetic results, were unpredictable.[9]

The final width of tooth #22, affected by microdontia, was calculated using the simplified method described by German et al,[13] which defines that the mesiodistal widths of anterior teeth are correlated to each other and may be easily estimated according to the mesiodistal diameter of mandibular incisors. Tooth size was then used to build the orthodontic setup with plaster models to plan treatment mechanics and to check the viability of achieving the final estimated mesiodistal width. Tooth #22, affected by microdontia, had a mesiodistal width of 5.45 mm. The orthodontic setup included a 1-mm increase for tooth #22. This way a molar and canine Class I occlusion and adequate overbite and overjet might be achieved (Fig 4).

After the placement of the fixed appliance, a sequence of preformed nickel-titanium archwires were used for leveling and alignment. The space at the site of missing tooth #12 was obtained using open NiTi coil springs. Class II intermaxillary elastics in the

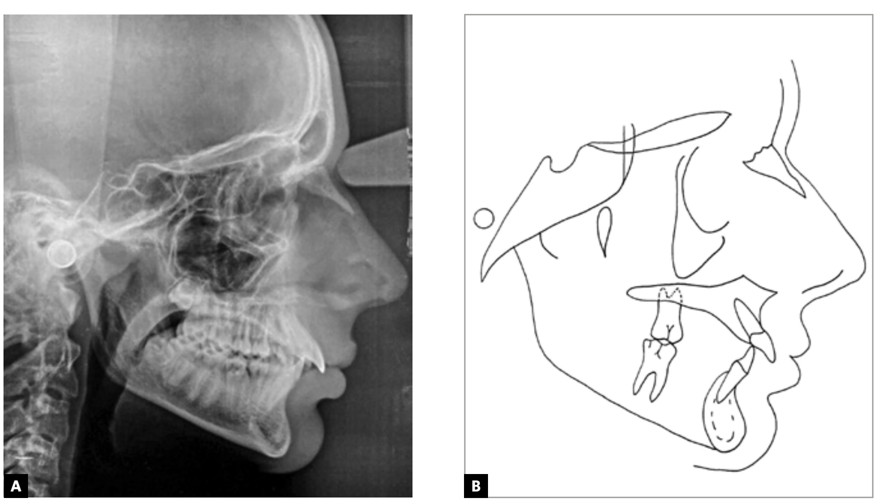

Figure 3 - Pretreatment cephalometric radiograph (**A**) and cephalometric tracing (**B**).

Figure 4 - Orthodontic setup using plaster models.

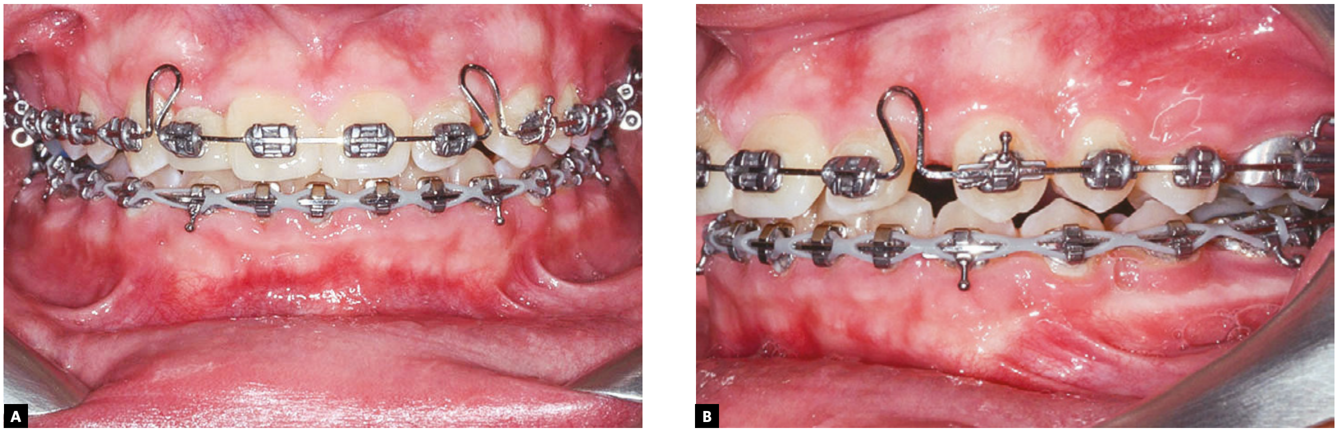

Figure 5 - Frontal intraoral photo (A) and left lateral intraoral photo (B) during maxillary incisor retraction.

right side and Class III in the left side were used after the correction of maxillary dental midline deviation. After the space was opened, a prefabricated provisional was attached to a 0.019 x 0.025-in rectangular stainless steel archwire with Bull retraction loops. Retraction to close diastemas and maintain the space distal to tooth #22 was controlled, so that the tooth could be reshaped later (Fig 5).

For retention after the fixed appliance was removed, a lingual canine-to-canine 0.7-mm stainless steel arch was bonded to the mandibular teeth, and a removable wraparound retainer was used for the maxillary teeth. The patient received instructions to use the removable retainer full time for six months and only overnight after that.[14] A provisional for the missing tooth #12 was placed in the mouth using a Maryland bridge and removed only when the osseointegrated implant was placed.

RESULTS

All the treatment objectives were achieved: molar and canine Class I relationship; maintenance of lip position and profile; adequate overbite and overjet; midline correction; space for the implant; and an adequate mesiodistal diameter for tooth #22 (Fig 6).

The profile became more concave, but its satisfactory esthetic appearance was preserved. Roots were parallel at the end of the treatment, and the anteroposterior relationship between maxilla and mandible improved (ANB = 1°). Mandibular growth was satisfactory, and the balanced pattern of facial growth was preserved (SN.GoGn = 27°, y-axis = 54°, FMA = 18.5°) (Table 1, Figs 7 and 8). Superimpositions showed that the patient maintained his balanced facial and mandibular growth, and that the maxillary incisors were retroclined as a result of the orthodontic mechanics used for retraction (Fig 9).

Interradicular distance at the apices of teeth #11 and #13 for the placement of an implant in the space of missing tooth #12 was 6.72 mm. Olsen and Kokich[15] found that the adequate interradicular distance between maxillary canine and central incisor to place an implant is at least 5.7 mm, whereas intercoronal space should be 6.3 mm (Fig 10).

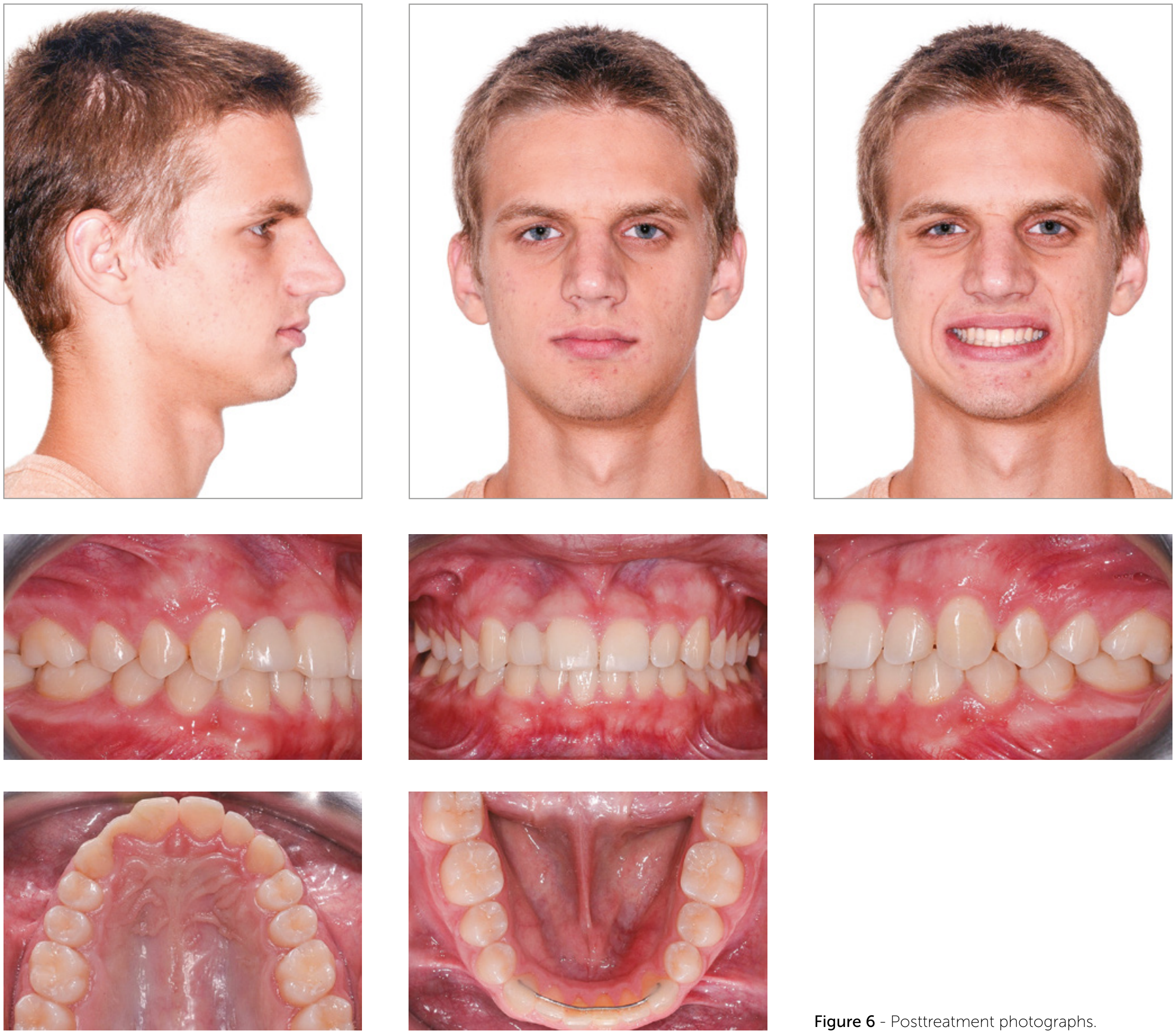

Figure 6 - Posttreatment photographs.

Figure 7 - Posttreatment panoramic radiograph.

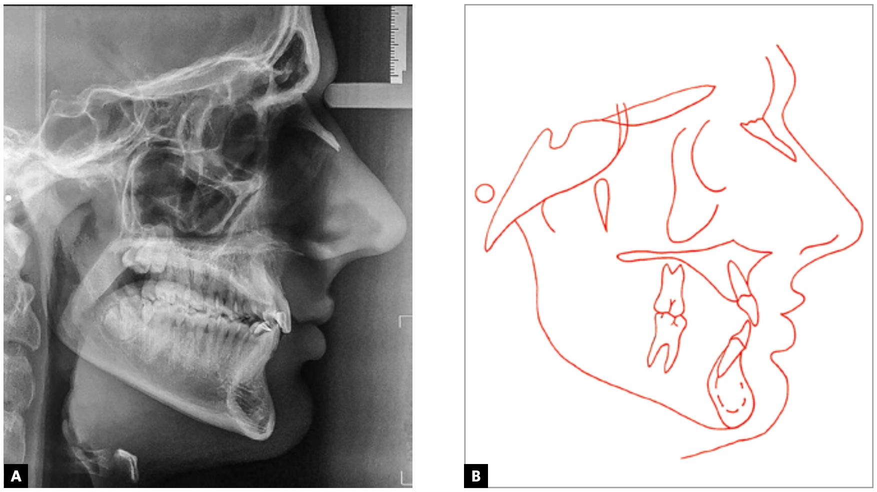

Figure 8 - Posttreatment cephalometric radiograph (A) and cephalometric tracing (B).

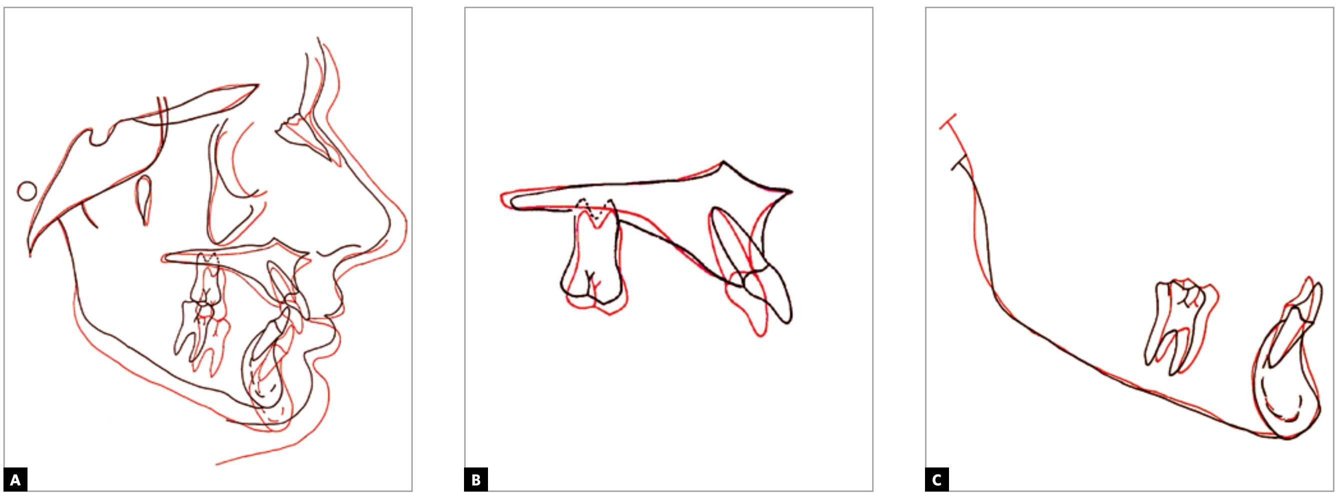

Figure 9 - Total (A) and partial (B, C) superimpositions of cephalometric tracings pretreatment (black) and posttreatment (red).

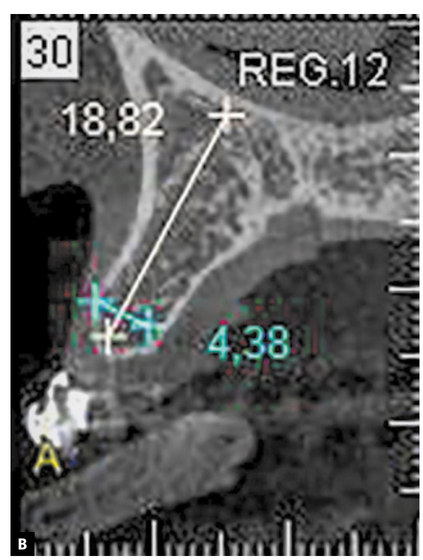

Figure 10 - Cone-beam CT slices. Panoramic view shows interradicular distance between teeth #13 and #11 (A). Sagittal view shows anteroposterior and vertical bone thicknesses in region of missing tooth #12 (B).

Table 1 - Cephalometric values before (A) and after (B) treatment.

	Measurement		Normal	A	B	Dif. A/B
Skeletal pattern	SNA	(Steiner)	82°	81°	80°	1
	SNB	(Steiner)	80°	77°	79°	2
	ANB	(Steiner)	2°	4°	1°	3
	Wits	(Jacobson)	♀ 0 ± 2mm ♂ 1 ± 2mm	5mm	0mm	5
	Angle of Convexity	(Downs)	0°	4°	-6°	10
	Eixo Y	(Downs)	59°	52°	54°	2
	Facial Angle	(Downs)	87°	80°	90°	10
	SN.GoGn	(Steiner)	32°	32°	27°	5
	FMA	(Tweed)	25°	21°	18.5°	2.5
Dental pattern	IMPA	(Tweed)	90°	96.5°	96°	0.5
	$\underline{1}$.NA (degrees)	(Steiner)	22°	35°	28°	7
	$\underline{1}$-NA (mm)	(Steiner)	4mm	5mm	4mm	1
	$\bar{1}$.NB (degrees)	(Steiner)	25°	27°	23°	4°
	$\bar{1}$-NB (mm)	(Steiner)	4mm	6mm	4mm	2
	$\frac{1}{1}$ - Interincisal Angle	(Downs)	130°	114°	128°	14
	$\bar{1}$ - APg	(Ricketts)	1mm	0mm	0mm	0
Profile	Upper lip-S line	(Steiner)	0	-1mm	-6mm	5
	Lower lip-S line	(Steiner)	0	0mm	-5mm	5

DISCUSSION

Studies in molecular genetics have found mutations in the MSX1, PAX9 and AXIN2 genes in families with multiple cases of tooth agenesis.[15,16] The transmission or familial inheritance of these genetic mutations may be the result of dominant, recessive or X-linked recessive disorders. Some homeobox genes, such as MSX1, MSX2, PAZ 9 and TGFA, have an important role in the development of dentition and in craniofacial morphogenesis.[7] Moreover, hypodontia of permanent maxillary lateral incisors or other teeth are often associated with other tooth anomalies in the same patient: microdontia, delayed eruption, ectopic eruption, and others. This indicates that different tooth anomalies in the same individual at any one time may be distinct expressions of the same genetic mutation.[16] In the clinical case described here, the patient had an anomaly of number and shape: hypodontia of tooth #12 and microdontia of tooth #22.

In this clinical case, tooth #23 erupted normally, but tooth #13 erupted in the site of missing tooth #12. Canines are the teeth that have the longest path of eruption: about 22 mm until they reach their final occlusal position. This distance is a risk factor for deviations during their eruption.[16] Canine eruption may be explained by the *Guidance Theory*, which indicates that permanent lateral incisors are eruption guides for canines. If incisors have any shape anomaly or are missing, canines may erupt ectopically or become impacted.[18]

Orthodontic patients with hypodontia of lateral incisors are a challenge for a satisfactory orthodontic treatment completion, because ideal intercuspation at the end of the treatment is dependent on the relationship of crown sizes between maxillary and mandibular teeth. In such cases, satisfactory final intercuspation is difficult, as hypodontia of lateral incisors is often associated with a reduced mesiodistal width of other teeth.[19] Consequently, drilling or interproximal augmentation of the crowns of adjacent teeth may be necessary in individuals with hypodontia of maxillary lateral incisors.[20]

In this case report, tooth proportions were corrected in the anterior segment, where the main problem was. Several methods may be used as a reference for orthodontists when defining the ideal size of a tooth crown. A study conducted by Black[21] was one of the first to measure teeth, and the tables of tooth sizes in that study are still used today.

The golden proportion has also been suggested for the calculation of ideal tooth size. However, the application of the golden proportion for dental rehabilitations has been refuted in several studies that found patients and dentists were unhappy with the smiles achieved when using this technique. Such dissatisfaction is a result mainly of cases of narrow lateral incisors, in which teeth that measure 3 to 4 mm less than ideal are classified as less appealing by laypeople and specialists.[21,22]

In the case report presented here, a simplified version of the method described by German et al.[13] was used to adapt the mesiodistal width of tooth #22 to the width of the prosthesis for missing tooth #12. This protocol ensures a simplified communication with the prosthesis technician by means of calculations based on the correlation between the mesiodistal widths of the crowns of anterior teeth. The results of these calculations should not be analyzed as absolute values, but, rather, as a reference for the orthodontist during planning with setups using either plaster or virtual models.[13] The calculation of the proportions of the ideal size of teeth should take into consideration also the vertical dimension of the crowns. Câmara[23] reported that it is common to use the following measurements as a reference for the crowns of maxillary permanent central incisors: width = 8 to 9 mm; height = 10 to 11 mm. These values may be used as initial parameters for predictions. However, more important than the use of isolated measurements are the mean proportions between coronal height and width, which may range from 70% to 80%.[24]

The growth of the nose and in the region of the pogonion, added to the counterclockwise rotation of the mandible, were the main contributions to the increase of the patient's profile concavity. The growth of the nose bone is completed at about 10 years of age. After that, nose growth is limited to the nasal cartilage and soft tissues, which undergo accelerated growth in adolescence. In this phase, the nose becomes more prominent, especially in boys (Fig 9).[25]

The idea that incisor retraction alone flattens facial profile is not a consensus in the literature, except in cases of extraction of the four premolars when incisors are retracted.[26] Even when planning does not include extractions, the reduction of overjet by incisor retraction may result in lip retrusion. Lip position is closely associated with the degree of mandibular incisor inclination: when mandibular incisors are proclined, they may limit the degree of overjet and, consequently, the degree of incisor and lip retraction. Therefore, in this clinical case, the side effect of mandibular incisor proclination due to Class II intermaxillary elastic mechanics contributed to a reduction of overjet and, consequently, to a lower degree of incisor and lip retraction and the preservation of facial profile harmony.

The clinical association between mandibular incisor proclination and gingival recession has not been definitely explained, and few studies have reported on long-term effects of mandibular incisor proclination on the periodontium.[27] A marked proclination of mandibular incisors may be achieved without the risk of gingival recession.[28] The gingival characteristics of the anteroinferior segment of the patient in this clinical study ensured the safety of mandibular incisor proclination, resulting in about 2 mm of the attached gingiva and good plaque control.[29] Whether to close or open space for the replacement of a missing tooth has always been a dilemma for a clinical dentist, but, according to Zachrisson et al.[9], space closure for lateral incisors by means of canine migration leads to better long-term results. This author also added that it is not possible to predict the degree of complications that affect hard and soft tissues around the osseointegrated implant-supported crowns, which may compromise esthetics mainly.[9]

However, in the case described here, the alternative of rehabilitation using an adhesive prosthesis would require drilling adjacent teeth to receive the prosthesis. Space closure by means of mesial migration of posterior teeth toward tooth #13 would result in a longer treatment time and higher costs because of the need to use temporary anchorage or to apply techniques that require total patient cooperation.

The ideal age for the surgery for implant placement for missing tooth #12 should be assessed frequently by the dentist to define whether bone maturity is satisfactory for the procedure. In most cases, girls at the age of 16 years and boys at 21 may already undergo surgery for implant placement.[30]

CONCLUSIONS

» Hypodontia of permanent maxillary lateral incisors may be associated with other forms of tooth anomalies. This entity is transmitted by familial heritance in a dominant, recessive or X-linked recessive manner.

» Two treatment options are recommended for cases of agenesis of maxillary lateral incisors: space closure and mesial movement of canines to the position of the missing incisors, or the opening or preservation of spaces for prosthetic rehabilitation of the missing lateral incisors using implants. A multidisciplinary approach should be adopted to correct mesiodistal widths of anterior teeth, to achieve a satisfactory esthetic and functional outcome.

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Conception or design of the study: DJSS, JAMM. Data acquisition, analysis or interpretation: DJSS, JAMM. Writing the article: DJSS, JAMM. Critical revision of the article: DJSS, JAMM. Final approval of the article: DJSS, JAMM. Overall responsibility: DJSS.

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Orthodontic treatment of periodontal patients: challenges and solutions, from planning to retention

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Introduction: There is an increasing number of adult patients with sequelae of periodontal diseases seeking orthodontic treatment to improve their occlusion and quality of life. However, it is important to highlight that the patient who has vertical bone loss has unique needs, arising from the frequent related pathological migrations. Therefore, it requires an individualized orthodontic treatment in terms of anchorage, biomechanics, and multidisciplinary planning, which raises doubts in the hierarchy of priorities and organization of the treatment plan.

Objectives: It was proposed a stratified hierarchy of the needs of orthodontic-periodontal treatment in six levels, which were illustrated with examples of clinical cases in which biomechanical planning and a multidisciplinary approach made it possible to obtain a balanced occlusion, aesthetic improvement and stabilization of the results.

Conclusion: Orthodontic treatment of periodontal patients with a multidisciplinary approach is increasingly frequent and should be planned individually, considering bone losses suffered by each patient. Respecting some limitations, it is possible to improve the level of bone insertion, smile aesthetics and masticatory function, to facilitate oral hygiene through the orthodontic treatment of adult patients with little bone support. It is also important to highlight that there are unique aspects in the orthodontic retention in these cases.

Keywords: Adult periodontitis. Orthodontics. Anchorage.

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» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

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

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INTRODUCTION

With an increasing number of adult patients seeking orthodontic treatment, it is now common to treat patients who need correction of functional and esthetic sequelae of periodontal disease.[1] In fact, periodontal treatment as a single therapy is not always able to correct and control the damage produced by periodontal disease and a consequent pathological occlusion, depending on the degree of tissue impairment. In these cases, orthodontic tooth movement is an important step when planning the global treatment of the patient,[2] since one of the most important factors for periodontal balance is the physiological stimulation received by the tissues during function.[3,4]

Thus, recovery of the integrity and continuity of the dental arch, as well as balanced tooth positioning, is an essential step for the successful treatment of a patient with periodontitis and pathological migration of teeth.[4] The first step in treating these patients is always the elimination of active periodontal disease.[1,3-15] However, even after complete removal of the disease, the patient with pathological migration should not be considered completely treated.

Patients with periodontitis often have several sequelae, such as: 1) inadequate angulation; 2) excessive buccal projection; 3) extrusion of one or more incisors; and 4) development of single or multiple diastemas in anterior teeth, with progressive spacing of incisors, often fan-shaped.[1,3,4,14] This spacing is the most evident sign of pathological change in tooth positioning, occurs in a progressive manner and the most affected teeth are the maxillary incisors.[3,4] Concomitantly, periodontal patients have traumatic occlusion, which can contribute to the development of destructive periodontal disease, since secondary occlusal trauma may further deteriorate the supporting tissues.[4,5]

This occurs because it is extremely important that masticatory forces are transmitted in the axial direction of teeth, allowing the application of intense forces with less tension on the periodontal ligament.

When there are pathological changes in tooth positioning,[1,3,4,13] masticatory forces start to occur in inclined planes, which causes dental hypermobility and thickening of the periodontal ligament. This is a secondary occlusal trauma caused by the reduced capacity of the periodontium to withstand normal occlusal loads,[5,16] which contributes to the progression of pathological migration of teeth, even in the absence of active periodontal disease.[2,4,5] This type of trauma does not cause periodontal pocket or gingivitis, nor does it increase the gingival fluid.[16] However, it is essential to eliminate it to extinguish the inflammatory process and allow spontaneous regeneration of the periodontal ligament.[17] In summary, secondary occlusal trauma is an aggravating factor for periodontal problems and should be eliminated by orthodontic correction.[11]

In cases of pathological migration and extrusion, the intrusion movement is recommended to realign the teeth, improve the clinical crown length and marginal bone levels.[8,14,18] A study that analyzed histological sections of animal tissues suggests that orthodontic intrusion may allow the formation of new healthy periodontal insertion tissue.[8] In fact, there is evidence that the combination of orthodontic intrusion with periodontal therapy has a noticeable effect on incisors that suffered pathological migration caused by periodontitis.[1,10,13,18] This combination can achieve several benefits: stabilization or recovery of alveolar bone height; correction of dental positions; stabilization of new positions by splints; and significant improvement in facial profiles.[1,14,18]

TREATMENT PLANNING – THE PYRAMID OF ORTHODONTIC-PERIODONTAL PLANNING

In these interdisciplinary cases, orthodontic therapy should be focused on eliminating or reducing the severity of periodontitis sequelae. However, planning of orthodontic-periodontal treatment usually raises doubts among orthodontists, since it involves a conflict of priorities between the specialties involved. To create a way to stratify and prioritize the planning and treatment needs of a patient with vertical bone loss, the "Pyramid of Esthetics Needs of Smile"[19] was used as reference, which stratifies the esthetic needs in the search for an ideal smile into four levels.

Similarly, a Pyramid of Orthodontic-Periodontal Planning was designed (Fig. 1), stratified into six stages of the sequence of individualized planning of the patient with periodontitis. The ascending order of levels in the pyramid does not determine its importance;[19] it is based on the sequence used by most orthodontic-periodontal studies.[2-4,6-9,10-12,14,18,20-23]

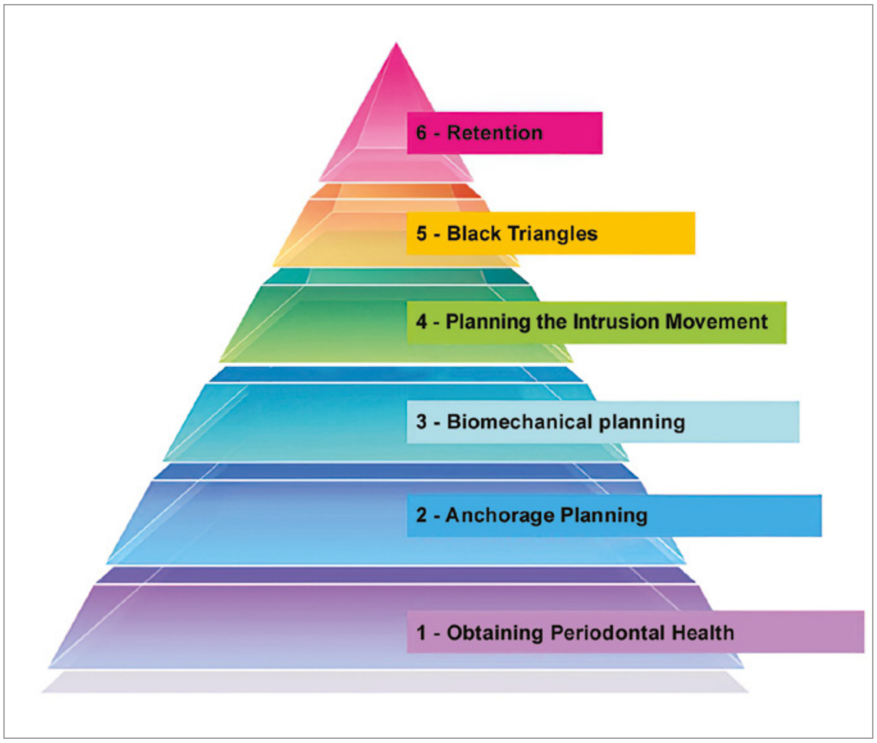


Figure 1 - Pyramid of Orthodontic-Periodontal Planning.

THE SIX STAGES IN THE SEQUENCE OF ORTHODONTIC-PERIODONTAL PLANNING

1) The base of the pyramid – Level 1: obtaining periodontal health. The accumulation of dental biofilm is the most important factor in the initiation, progression and recurrence of periodontal disease.[5] Longitudinal studies by Re et al.[6] (12 years) and Boyd et al.[7] demonstrated that orthodontic therapy is indicated for the treatment of occlusal sequelae in patients with controlled severe periodontitis. After controlling the periodontal disease, teeth with insertion loss may be submitted to movement. Orthodontic treatment can even improve bone support and the prognosis of stabilizing periodontal results in the long term.[1,2,4,6] However, the periodontium only responds favorably to orthodontic movement if it is healthy. Therefore, the first step in treating a patient with bone loss is to check whether periodontitis has been properly controlled by a periodontist.[3-15,20] Orthodontic movement can only be initiated after obtaining control of inflammation and dental biofilm, with excellent cooperation from the patient regarding oral hygiene techniques. This stage can last from 3 to 9 months, depending on the severity of the problem.[6,7,11]

Intensive periodontal treatment involves instructions for oral hygiene, removal of biofilm retentive factors, and scaling and root planing, which may include flap surgery and/or antibiotic prescription.[13,18] Before the onset of orthodontic treatment, periodontal disease must be controlled. In principle, in the initial treatment stage, only teeth with very severe conditions that preclude the control of inflammation[10,12,13,20] should be extracted. If a tooth has a prognosis of extraction due to marked insertion loss, yet it presents inflammation under control, it can be maintained during orthodontic treatment, since it facilitates anchorage and provides greater comfort to the patient.[10,11,20]

In addition to the periodontal disease control, it is also essential to maintain the results obtained by periodic control by the periodontist, at intervals of 1 to 4 months. This time interval depends on the quality of biofilm control obtained by the patient. These periodontal maintenance consultations are essential for the periodontist to evaluate and control sites that may have recurrence of the inflammatory process, to maintain periodontal health[7-9,11,21] and also to reinforce the hygiene instructions.

The appliances used in the orthodontic treatment of these patients should not favor the accumulation of dental biofilm. The use of metal ligatures or self-ligating brackets and careful removal of excess resin around the brackets are recommended.[22]

In the initial planning, in this first stage, all biomechanical and anchorage needs inherent to the case are not always identified. It is common to observe that, after reestablishment of periodontal health, the problems at the pyramid base are eliminated, and the demands of higher levels become more important.

2) Level 2 – anchorage planning: The planning of movement anchorage is critical in patients with controlled periodontitis. It is difficult to obtain adequate anchorage for orthodontic movement in patients with partial edentulism and reduced alveolar bone support.[23] As in most cases, there is a need for intrusion and retraction of the extruded and projected incisors, with diastemas and changes in angulation.[1,3,4,15] It is mandatory to analyze if the posterior teeth of the patient have enough periodontal insertion to allow them to anchor the movement. It should also be considered that there is an increase in the extrusive component of posterior teeth with bone loss, which represents an additional component that must be considered in anchorage planning.[8,22-25] As previously described, the anchorage must be reevaluated after achieving periodontal health, so that the condition of posterior teeth is accurately diagnosed.

When the posterior teeth are healthy and did not suffer significant insertion losses, they can be used for anchorage control in vertical and anteroposterior directions,[8,24,25] by the use of high-pull headgear[8] or other devices that reduce extrusion and mesial displacement of posterior teeth, such as the rigid transpalatal bar,[8,24] the Nance button[25] or a Bite Block[25]. However, if several posterior teeth are absent or have an unfavorable prognosis, it should be reassessed whether there is indication of extraction of the affected teeth after periodontal health is achieved.

In this case, in the absence of posterior teeth, before starting orthodontic treatment, dental implants with provisional crowns must be placed to provide anchorage. If it is not possible to use the posterior teeth as anchorage units, but there is also no indication for their extraction, absolute anchorage can be used with the aid of temporary anchoring devices (TADs).[24] The use of absolute anchorage with TADs is highly applicable in these cases, since it provides greater safety for movement and has become a clinical reality.[21,23] Using molars with insertion loss greater than 4mm as anchorage units may compromise their viability in the oral cavity.[23]

It is important to highlight that, in cases of severe bone loss in the anterior or posterior segments, the use of intermaxillary elastics with Class II or III direction promotes greater extrusion of these teeth, which can harm the occlusion, besides having a deleterious effect in the increase of vertical dimension.[24] Therefore, the use of elastics should be carefully considered; it is recommended to use extra-alveolar mini-implants for sagittal corrections whenever possible. In cases in which elastics are essential, the entire posterior extent of arches must be used to reduce the extrusive component and follow the patient in intervals shorter than four weeks.[11]

3) Level 3 – biomechanical planning: The greatest limitation in the treatment of patients with controlled periodontitis is the reduction in vertical height of the alveolar bone, which alters the biomechanics of movement.[26,27] With bone loss, the crown-root relationship is altered: the lower the bone height, the more the fulcrum of movement moves to the root apex.[7,15,18,26] Therefore, many problems in planning the force system to be applied must be analyzed. Some important points are the following:

a) The force magnitude must be reduced proportionally to the amount of alveolar bone height of teeth to be moved.[15,18] In the initial stage of orthodontic treatment for adults with no loss or minimal vertical bone loss, a force of 20-30g per tooth is recommended. Thereafter, the force can be increased to 30-50g (tilt movement) and 50-80g (body movement), depending on the degree of marginal bone loss and the quality of remaining alveolar bone.[28] According to Melsen et al.,[8] the ideal intrusion force in teeth with bone loss is between 5 and 10g per tooth.

b) With the change in positioning of the Center of Resistance (CRes), which becomes more apical as the alveolar bone height is reduced, there is a change in the moment/force ratio (M/F).[15,26] Therefore, it is suggested to bond the orthodontic accessories as cervically as possible, provided it does not interfere with hygiene procedures. In addition, the most frequent occurrence of uncontrolled inclination movements and the greatest difficulty in achieving body movements should be highlighted.[15,26]

It is agreed that the mean perpendicular distance from the CRes to the line of action of forces that will be applied to the brackets is approximately 10 mm[29,30] in teeth with a healthy periodontium. The application of force to the bracket 10 mm distant from the CRes of a tooth causes a moment resulting from the force and the tooth tilts, rotating around its center of rotation (CRot), whose location is usually slightly above the CRes, being altered depending on the relationship between the force action line and the CRes.[31] Therefore, when there is alveolar bone loss, the CRes is apically displaced proportionally to the amount of bone height present, thus becoming proportionally more distant than the conventional 10 mm in relation to the bracket. Therefore, the moment (the rotation that occurred) will be greater.[15,26]

This type of movement, in which the crown moves in the direction of force and the apex moves in opposite direction to a lesser extent, is called uncontrolled inclination.[31] Clinically, this movement occurs in patients with intact periodontium, during the retraction stage in the continuous archwire mechanics, when there is a gap at the wire/bracket interface.[31] With the apical displacement of the CRes, this inclination becomes frequent even with the force application by thicker archwires. For this reason, the use of continuous archwires to perform intrusion and retraction movements and the use of thin, round archwires for alignment and leveling should be avoided in the treatment of periodontal patients. To obtain body movements, in these cases, the use of lever arms and segmented mechanics directed to the CRes of teeth to be moved is an important resource.[24]

The movement of continuous alignment and leveling with flexible round archwires will produce a greater tendency of projection of incisors with loss of alveolar bone height, which can be increased in the presence of a marked Spee curve. In these cases, the "relative" leveling achieved by the extrusion of posterior teeth and projection of anterior teeth[32] will result in a greater uncontrolled inclination in the anterior region and greater posterior extrusion,[24] depending on the magnitude of bone loss that occurred in that region, which leads to an uncontrolled force system and undesirable effects. For these reasons, it should be avoided.

c) There is a greater risk of tissue damage if a greater amount of displacement is performed.[27] With the apical displacement of the CRes, the uncontrolled inclination becomes more frequent and generates higher pressures in the periodontium than the controlled inclination.[27] In addition, the force will be dissipated in a smaller area of periodontium. This combination will greatly alter the dental angulations and generate unnecessary movements of the root apices, concentrating a lot of pressure in the apical region.[18,33]

With this overload of force in the apical region, the risk of resorption increases.[11,14,34] This information must be considered together with the root anatomy and trauma history[30] for planning more extensive movements, in which the risk of root resorption is greater. Shen et al.,[14] in studies on patients with bone loss due to periodontal reasons, demonstrated that there is higher rate of external root resorption in lower and upper incisors, due to intrusion and retraction movement, usually performed on these teeth for correction of pathological migrations. The authors observed that the alveolar bone loss further concentrated the forces in the apical region of these teeth, which was confirmed by the finite tooth study by Choi et al.[15] Therefore, it is essential to use light forces and adequate biomechanics in the treatment of patients with controlled periodontitis.

Similarly, the treatment must be as short and simple as possible: it is necessary to evaluate which orthodontic movements will benefit the periodontium, if conventional orthodontic objectives are applicable to each case or if there is an individual physiological limit.

d) The extrusion movement has been advocated as an effective method for: handling of one- and two-wall infrabony defects; reducing the probing depth of periodontal pockets; increasing the area of attached adhered gingiva; bone development for implant placement; and the position of the gingival margin, being considered a beneficial movement in the planning of periodontal repair.[35,36]

4) Level 4 – planning the intrusion movement

The orthodontic intrusion of teeth extruded by pathological migration is frequent in patients with vertical bone loss.[14] Some biomechanical protocols can be proposed for intrusion and retraction of over-projected incisors due to severe loss of periodontal insertion. Ideally, the retraction forces should be directed, combined with an intrusive component, as close as possible to the center of resistance of the teeth affected by the loss of periodontal insertion. Thus, the movement becomes more effective and the results will be obtained more quickly, with low force intensity. A minimum force intensity, compatible with the intrusion movement in teeth with compromised insertion, should be used, with a maximum of 10 g per tooth.[8] It is essential to measure the force at each orthodontic maintenance consultation, which must be performed at intervals of six weeks, to allow for a longer period of tissue repair.[8]

To achieve intrusion in teeth with a marked tendency to uncontrolled inclination (due to loss of insertion), the force must be directed to the CRes of the tooth[8,9,10,13,15,18,21] or group of teeth that should be moved. Thus, in the case of intrusion of anterior lower dental blocks, the CRes of the movement unit should be located[29] and its apical alteration should be estimated according to the amount of bone loss.[15] In case of individual tooth movements, this must be done for each tooth.[15,24,29,31]

The orthodontic intrusion can displace the supragingival plaque to the subgingival region and result in the formation of infrabony periodontal pockets.[5] However, in the absence of biofilm due to excellent oral hygiene, orthodontic intrusion associated with adequate periodontal treatment has improved the health of the reduced periodontium,[20,21] increasing the level of periodontal insertion,[18,37] especially in anterior teeth.[18] Therefore, the possibility of strict scaling and root planing in the patient should be analyzed with the periodontist, to eliminate the presence of dental biofilm and granulation inflammatory tissue, ten days[7] before the onset of active orthodontic movement. There is evidence that this procedure (which may be surgical or not) can improve the likelihood of increased periodontal insertion. When an exposed area of the root cementum is moved towards the bone, local proliferation of cells of the periodontal ligament can occur.[7-9,21]

If this procedure is not indicated, strict control of the patient's hygiene should be maintained during the intrusion movement, with monthly consultations for periodontal control.

5) Level 5 – black triangles and gingival recessions

Periodontitis can cause loss of interdental papillae, also called “black triangles” or black spaces.[38] Besides resulting in images without esthetic harmony[19] and causing phonetic changes, such losses contribute to the retention of food debris, affecting the health of periodontal tissues.[38] Very often, after the closure of diastemas resulting from the pathological migration of incisors, tooth alignment is completed with the presence of one or more black triangles, due to deficient bone crest height. The distance between the bone crest and the base of the contact point is the main indicator of the complete presence or absence of interdental papillae, even though it is affected by other factors, such as coronal morphology and root distance and divergence.[39]

Reconstruction of the interdental papilla is a challenging and unpredictable problem;[31] however, the predictability in these cases has been increased by multidisciplinary treatment. This fact must be shared with the patient to assist in decision making regarding the best treatment protocol. Depending on the dental proportions and gingival conditions, orthodontics can act in the repositioning of teeth and closing the diastemas, creating a contact point and reducing the distance between the contact point and the alveolar bone crest by the intrusion movement, and by proximal stripping and space closure.[38] Other options such as filling with hyaluronic acid,[41] reshaping with composite resins[31] or subepithelial connective tissue graft[42] should be considered in combination or as an alternative to orthodontic options.

During orthodontic movement, a progression of preexisting gingival recessions may occur; therefore, root coverage should be performed after orthodontic treatment.[43] However, in patients with thin gingival biotype or who require expansion or projection movements, it may be necessary to perform a mucogingival graft before orthodontic treatment.[44]

However, it should be noted that such movements should be avoided in patients with a history of alveolar bone loss.[44]

6) <u>Level 6 – retention</u>

During the retention period, periodontal and orthodontic supervision should be maintained. The interval of consultations can vary for each individual, according to the risk of periodontitis recurrence.[22] After completion of orthodontic treatment, teeth with insertion loss usually have mobility, and the maintenance of their positions should be considered with caution.

Due to the presence of mobility, many professionals question whether the new positions will be stable, even if they are ideal for maintaining periodontal health after removal of all secondary trauma.[11] Basically, two primary factors are involved in the balance that determines the final position of the tooth.[45] These are: 1) the pressure caused by the tongue, lips and cheeks in their rest positions; and 2) forces produced by the metabolic activity in the periodontal ligament. When the periodontium is intact, the unbalanced forces of the lips and tongue are normally compensated by the periodontal ligament. However, when the periodontium is compromised, these forces are no longer counterbalanced, and the teeth begin the migration process. Therefore, since bone loss persists after tooth movement, definitive retention of these teeth must be performed, to preserve their stability in new positions.[11]

If the patient has a clenching or bruxism habit, it is recommended to make an acrylic interocclusal plate to protect the teeth and periodontium from excessive occlusal forces. Definitive retentions in these cases are also at greater risk of fractures and should be reinforced.

There is evidence that periodontal disease cannot be cured, but it can be controlled.[13,18] Therefore, patients with periodontitis must be monitored and controlled throughout their lives by a periodontist.[8,11,13,20,21,24] However, when these patients are also submitted to orthodontic treatment, it is essential to maintain follow-up consultations. Periodontal recurrence can further reduce bone insertion levels and generate additional tooth loss.[43]

With such changes, the occlusal balance is altered and should be reestablished. Occlusal adjustments, prosthetic rehabilitation, modifications or extensions of retainers may be necessary, and interocclusal stabilization plates may be indicated. Instability in the periodontal condition can generate occlusal instability,[45] thus annual or semiannual orthodontic follow-up becomes essential throughout the patient's life.

CASE REPORTS

The priorities of orthodontic treatment of a patient with insertion loss are:

• Try to correct or reduce bone defects.

• Improve the esthetic aspect, with benefit to the patient's self-esteem.

• Correct the tooth positioning to facilitate biofilm control by the patient and periodontist.

• Establish a balanced occlusion, with adequate cusp-fossa contacts, without interference or occlusal trauma.

• Obtain the six keys of occlusion, whenever feasible.[1,8-11]

The biological limits must be considered in these cases,[1,11] and it is often not possible to achieve the ideal occlusion. However, achieving occlusal balance and eliminating interference should always be considered the main objective, since the repair of connective attachment will only be possible after the elimination of occlusal trauma.[17]

It is also important to consider that, in cases of inadequate oral hygiene, smoking, unsatisfactory response to periodontal treatment and uncompensated diabetes mellitus, the treatment may be contraindicated.[40] Likewise, in cases of advanced bone loss, presence of furcation lesions, intense dental mobility, teeth with thin bone and gingival tissue and root prominence, there is greater risk of recurrence of periodontal disease[40] and periodontal follow-up during and after orthodontic treatment should be performed at closer intervals.

There is a considerable risk of relapse of periodontal disease, mainly due to the difficult cleaning resulting from the presence of the appliance and orthodontic accessories.[40] In case of recurrence, the orthodontic therapy must be stopped immediately: passive archwires should be placed and orthodontic forces must be removed, but the appliance does not need to be removed, so that the orthodontist's work is not lost.

Periodontal treatment should be started and prioritized and, as soon as the patient returns to health, the orthodontic treatment should be activated again.[40]

Case 1 – Patient with Class II malocclusion with increased overjet, marked curve of Spee and pathological migration of incisors

The patient was a young adult (25 years old) presenting Class II division 1 malocclusion, deep overbite, overjet of 7.2 mm, marked lower curve of Spee and pathological migration of the upper incisors, which showed excessive projection, extrusion and diastemas (Fig 2). Chronic periodontal disease also caused significant insertion loss and mobility in the maxillary and mandibular incisors. Significant bone loss was detected at the following sites: 32 (M), 31 (MD), 41 (MD), 42 (MD), 46 (D), 36 (D and bifurcation), 12 (MD), 11 (MD), 21 (MD), 22 (MD), 23 (M), 16 (D), 17 (M), 18 (M) and 27 (M). Marked pneumatization of the maxillary sinus was observed in the mesial aspect of tooth 27, which was mesially inclined (Fig. 3). The periodontal diagnosis identified a variation of 4 to 9 mm in the probing depths and presence of gingival recession in the labial and lingual surfaces of lower incisors, particularly in tooth 31.

The chief complaint of the patient was the projection and spacing of maxillary incisors. Facial photographs (Fig. 4) showed a convex facial profile, with incompetent lip sealing and satisfactory chin, with slight deviation to the right. The cephalogram confirmed the extrusion and interposition of maxillary incisors between the lips, marked projection of the maxillary and mandibular incisors, skeletal Class II and brachycephalic pattern (Fig. 5, Tab. 1).

As a first step, intensive periodontal treatment was conducted until the disease was controlled and the patient acquired the ability to maintain excellent oral hygiene. After six months of periodontal treatment, the patient was ready to start orthodontic treatment and continued to be supervised quarterly by the periodontist throughout the treatment.

The first orthodontic strategy proposed was to use a modified palatal arch to intrude and retract the upper incisors with indirect anchorage on mini-implants. However, the patient did not accept the use of mini-implants for indirect reinforcement of molar anchorage. Therefore, the alternative was to use a high-pull headgear (HPH) to maintain anchorage and correct the Class II malocclusion. This anchorage option can only be considered after obtaining periodontal health and assessing, with the periodontist, the viability of molars to receive the required load magnitude.

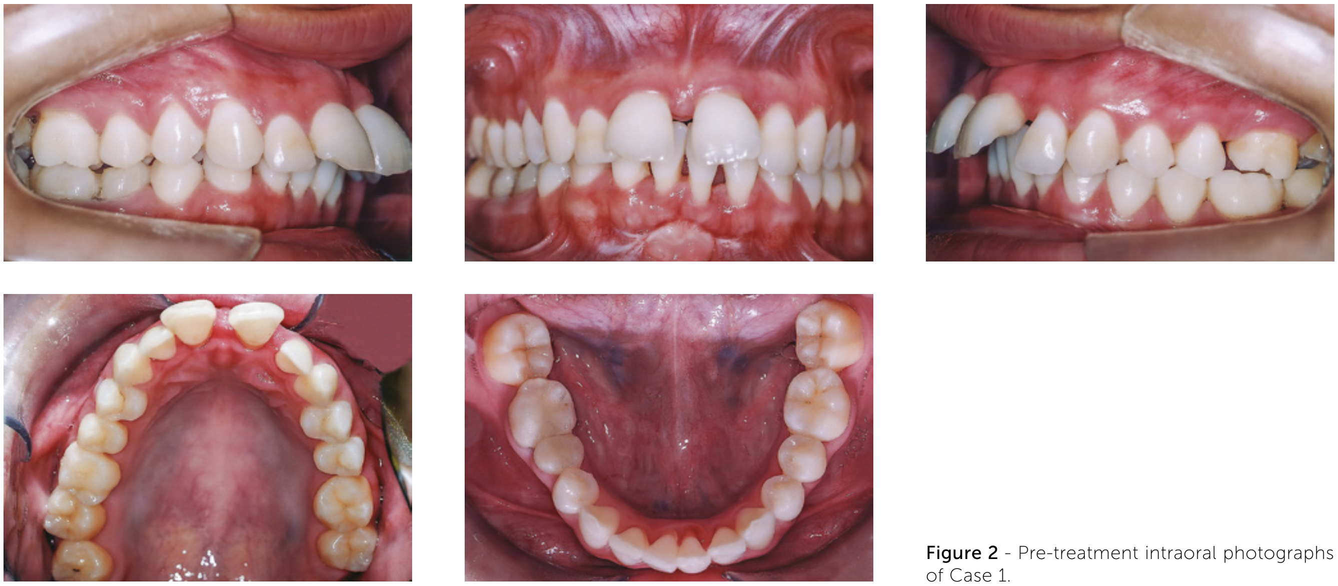


Figure 2 - Pre-treatment intraoral photographs of Case 1.

Figure 3 - Pre-treatment radiographs of Case 1.

Figure 4 - Pre-treatment facial photographs of Case 1.

Table 1 - Cephalometric measurements of Case 1.

Measurements	Pretreatment	Post-treatment	Retention
SNA	86.8°	87.2°	87.2°
SNB	81.9°	83.1°	83.2°
ANB	5.7°	4.1°	3.9°
1.NA	41.4°	23.8°	23.5°
1-NA	10.5 mm	6.0 mm	6.2 mm
1.NB	36.3°	30.1°	30.0°
1-NB	7.2 mm	5.5 mm	5.5 mm
IMPA	107.3°	100.9°	101.2°
Interincisal angle	93.2°	119.0°	118.6°
FMA	18.3°	19.5°	19.2°
SN.Go-Me	25.8°	26.7°	26.2°
PLO (Go-Gn.Ocl)	21.4°	14.9°	15.2°
LAFH (ANS-Me)	69.7 mm	70.0 mm	70.1 mm

A diagnostic set-up was performed to assess the viability of the proposed treatment plan (Fig. 6). The set-up showed that acceptable overjet and overbite could be obtained if:

- tooth 18 was extracted;
- tooth 16 was distalized by 4.0 mm;
- teeth 26, 36 and 46 were kept in position, without anchorage loss;
- the lower incisors underwent 2.5 mm of intrusion and 1.0 mm of retraction; and the upper incisors, 2.5 mm of intrusion and 5.0 mm of retraction.

Specific biomechanical planning was necessary to meet the requirements of the amount of movement and the force magnitude used, considering the level of bone insertion of incisors. The set-up demonstrated that, even after intrusion and retraction of upper incisors, there would still be an overjet of 2.5 mm, with black triangles present in the regions between 13-23 and 33-43, especially between 11 and 21. To finalize the reduction of overjet, proximal stripping was required in regions between 13-23 (3.0 mm) and between 33-43 (1.8 mm). The intercanine and intermolar distances remained unchanged, and the midlines were coincident.

Modified palatal arch

Due to pathological migrations, biomechanical planning for periodontal cases often involves the intrusion and retraction of maxillary incisors with vertical alveolar bone loss — i.e., teeth with a center of resistance positioned more apically, according to the magnitude of bone loss. This phenomenon increases the tendency of uncontrolled inclination,[15,18] which impairs the intrusion and retraction in these cases.

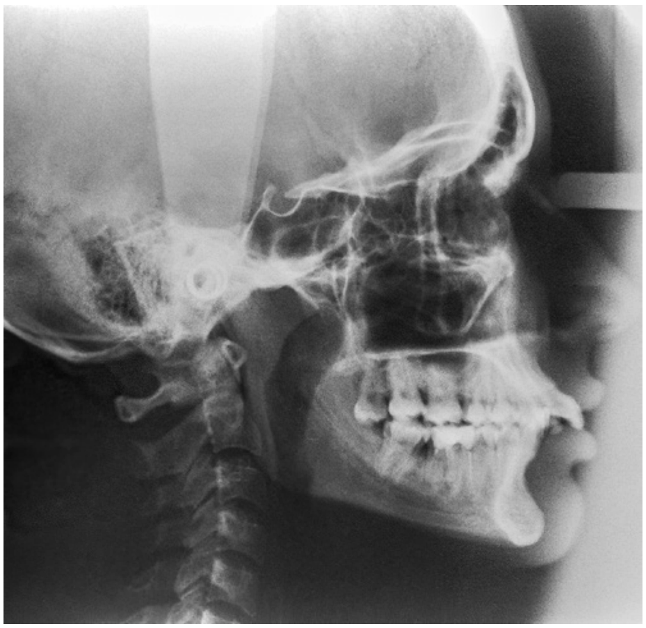


Figure 5 - Pre-treatment lateral cephalogram of Case 1.

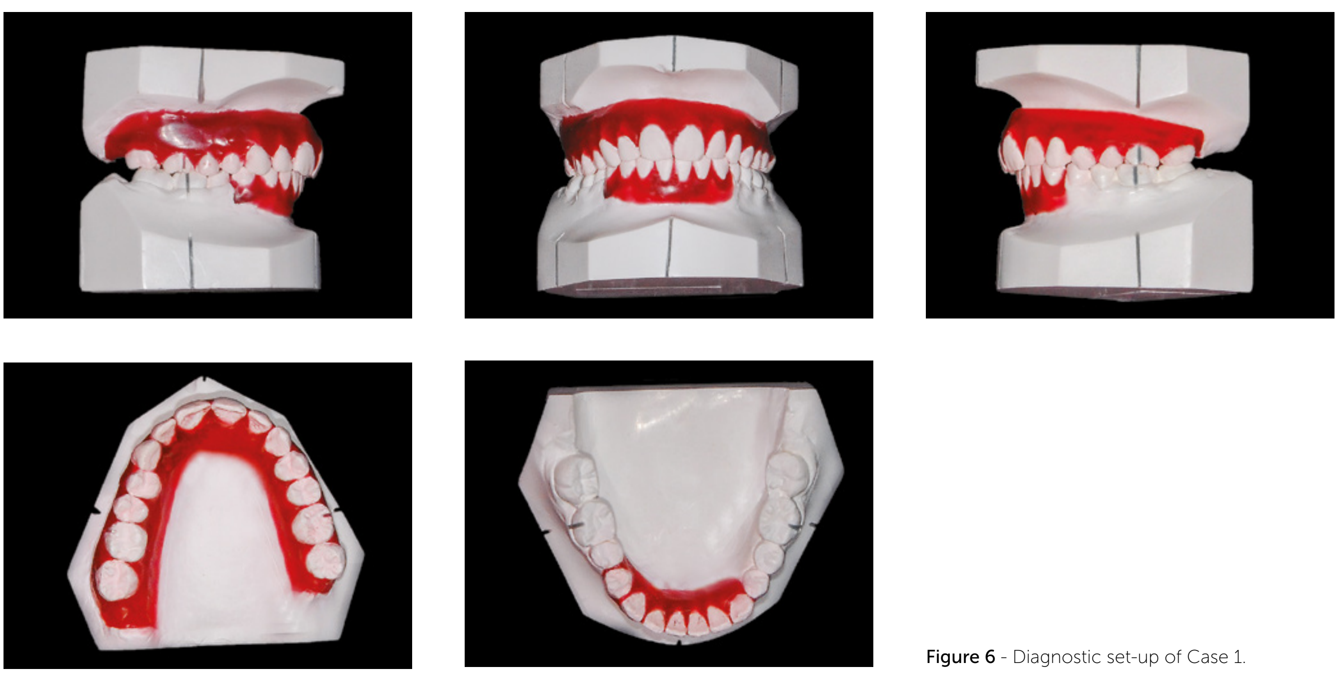


Figure 6 - Diagnostic set-up of Case 1.

To help the orthodontist to adapt the biomechanics of each orthodontic-periodontal case that requires retraction and intrusion, a modified palatal arch was developed, which allows simultaneous accomplishment of both movements. The design of this arch depends on: number of teeth to be moved; anchorage availability; and amount and direction of movement required. When this arch is used as an aid, the maxillary incisors can be retracted with controlled inclination without the use of orthodontic wires, since the applied force is directed to the center of resistance of each tooth. The direction of retraction can be modified, favoring the movements of intrusion, retraction or retroclination, by the differential positioning of brackets bonded on the palatal surface and connectors soldered to the palatal arch to which NiTi springs will be connected.

In cases with bone loss and pathological migration of incisors (with extrusion, projection and diastemas[18]), palatal brackets should be bonded as cervically as possible, to reduce the tendency of retroclination inherent to the movement, increased by the presence of bone loss.[15]

The magnitude of bone loss of maxillary incisors must be previously assessed on the periapical and cephalometric radiographs to determine the approximate position of the CRes of each tooth that will be moved, according to the amount of remaining bone. The system must be designed so that the force applied by the NiTi springs is as close as possible to the CRes. It is important to highlight that, as the alveolar bone migrates apically, the center of resistance of the tooth also changes, and its distance from the alveolar crest (analyzed on the periapical radiograph) decreases. This distance in teeth with a healthy periodontium is approximately 5.5 mm in relation to the bone crest, and is reduced to 1.6 mm in teeth with bone loss of 8 mm.[19]

When planning the movement, it must be considered that the change in CRes also makes the incisors more prone to inclination than to body retraction, when traditional orthodontic mechanics with continuous archwires are used.[2] This also occurs when the palatal arch mechanics is applied. Therefore, it is important to bond the palatal brackets as cervically as possible, and that the direction of springs balances the horizontal vector with the amount of remaining bone in teeth to be moved. It is essential to use light forces, not exceeding 10g/tooth, which can be reduced according to the amount of bone loss diagnosed in the moved teeth. The force can be controlled by changing the length of NiTi springs, and not by the position in which they will be connected to the palatal arch, which must be planned according to the biomechanics of movement.

The accomplishment of this treatment protocol also depends on the control of vertical dimension, by the preparation of anchorage to obtain an effective intrusion of incisors. In the clinical Case 1, the anchorage was obtained with passive thick segmented archwires between the canines and the second upper molars, associated with the use of high-pull HPH with light forces for more than 15 hours/day. This modality was selected according to the periodontal condition of the maxillary premolars and molars. In cases of posterior teeth with very deteriorated periodontal conditions or patients who are not willing to cooperate with the use of HPH, direct or indirect anchorage with TADs can be used. Direct anchorage secures the palatal arch to the mini-implants placed on the palate.

Treatment performed in Case 1

Initially, tooth 18 was extracted to allow distalization. The treatment started with the use of high-pull HPH for at least 15 hours/day, with a force of 150g/side. A standard-edgewise 0.022 x 0.028-in appliance was bonded only to teeth 23-28 and 13-17; and a 0.017 x 0.025-in passive segmented archwire was used to complete the anchorage system. The intrusion was planned with a modified palatal arch placed in the same period, cemented in teeth 17 and 28.

This palatal arch had compressed nickel-titanium (NiTi) springs tied to standard edgewise brackets, which were bonded as cervically as possible to the palatal surface of upper incisors (Fig. 7) to direct the force as close as possible to the center of resistance of incisors, to perform the intrusion and retraction simultaneously. Ten days before the onset of intrusion with the modified palatal arch, periodontal surgery was performed with scaling and root planing.[13] After surgery, orthodontic intrusion became a more reliable therapeutic treatment, which improved the esthetics, periodontal health and bone levels of intruded teeth.[13]

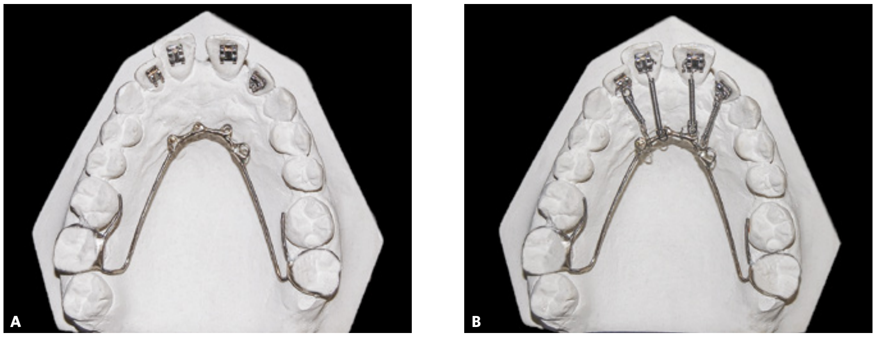


Figure 7 - A) Modified palatal arch. B) Palatal arch with activation.

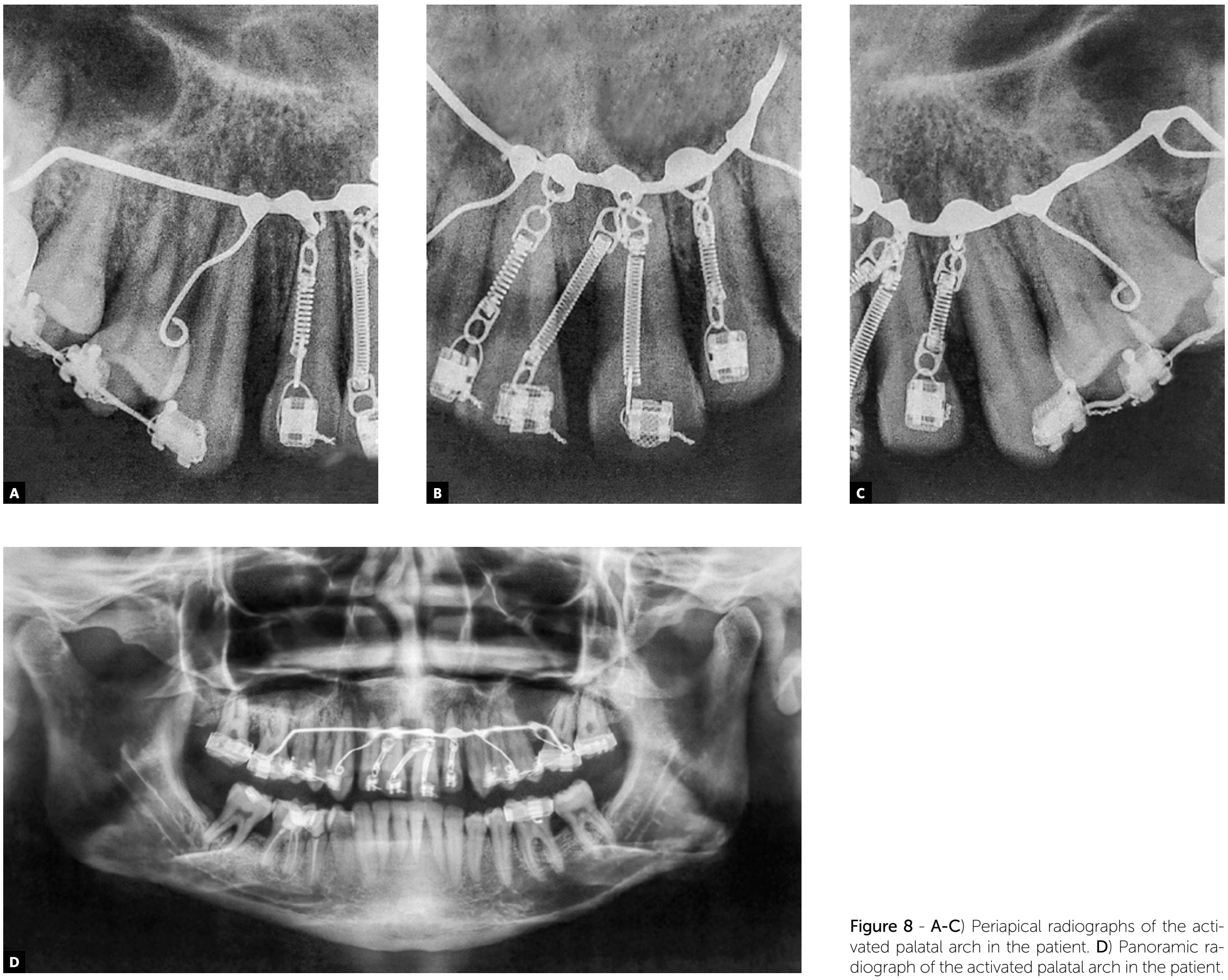


Figure 8 - A-C) Periapical radiographs of the activated palatal arch in the patient. D) Panoramic radiograph of the activated palatal arch in the patient.

The retraction and intrusion of these teeth were initiated with a 12-mm NiTi compressed spring tied to each of the four incisors, with the line of force action passing close to the center of resistance, displaced apically, due to the bone loss of these teeth (Fig. 8), which generated a force of 10g/tooth. During this period, orthodontic maintenance was performed at every six weeks, and the springs were progressively replaced by smaller springs, until reaching the 5-mm spring, maintaining the same force of 10g per tooth. The intrusion and retraction of anterior teeth with this system were performed for eight months. The interincisal angle gradually decreased after the first two months of retraction. The spaces were closed, while the posterior occlusal relationship was maintained (Fig. 9). At that moment, it was possible to observe the black triangles and plan the proximal stripping after joint evaluation with the periodontist: the incisors showed a subtle improvement in the clinical insertion levels (with reduction of probing depth), absence of inflammation and bleeding sites, and mobility compatible with the movement performed.

Subsequently, the palatal brackets were removed, and a standard Edgewise 0.022 x 0.028-in appliance was bonded to both arches. The HPH was maintained to achieve the Class I molar relationship. The initial 0.012-in stainless steel wire was used in the upper arch. For uprighting of the third mandibular molars, a cantilever was made with 0.017 x 0.025-in beta titanium wire on the 0.019 x 0.025-in stainless steel passive base archwire.[8]

When there is a need to level the curve of Spee in patients with vertical bone loss, the intrusion of lower incisors should be planned considering the tendency of increased buccal projection of these teeth, due to the change in the CRes and the need for reduced strength. Therefore, continuous archwire mechanics[2] should be avoided. Whenever the minimum projection is desired, it is recommended to use the three-piece intrusion mechanics, recommended by Burstone,[46] fitting the beta titanium cantilevers (0.017 x 0.025-in) in the region compatible with the distal surface of 33 and 43 in the passive base archwire (stainless steel 0.019 x 0.025-in).[46] The force magnitude can be controlled by checking the force applied by the cantilevers on the base archwire, to use a force compatible with the level of bone loss in the incisors.

In this case, a magnitude of 5mg per tooth was calculated (20mg/side, which was measured and maintained with each activation). Then, the alignment and leveling of the lower arch was started with a 0.014 x 0.025-in nickel-titanium continuous archwire. Sequentially, thicker rectangular stainless steel wires were used to level the mandibular and maxillary arches, and the crossbite was corrected with symmetrical and coordinated archwires.

To correct the black spaces and normalize the remaining overjet, proximal stripping of 13-23 (3.4 mm) and 33-43 (2.0 mm) was necessary. A 0.019 x 0.025-in stainless steel retraction archwire with T-shaped spring was used to avoid the uncontrolled inclination of incisors during space closure as much as possible. The treatment was ended with ideal coordinated 0.019 x 0.025-in archwires.

After 19 months of treatment, a stable occlusion was obtained. Root parallelism was confirmed on the panoramic radiograph, and all appliances were removed. During orthodontic treatment, periodontal control was performed by a periodontist at every three months. The retention was made with 0.018-in stainless steel wire, bonded from 3-3 in the maxillary and mandibular arches, splinting the anterior teeth.

Posttreatment facial photographs showed that there was a reduction in the protrusion of incisors, and a well-balanced face was obtained, due to the upper lip retraction (Fig. 10). The cephalometric analysis (Fig. 11, Tab. 1) showed a small increase in the FMA angle, reduction of ANB from 5.7° to 4.1° and intrusion and retraction of maxillary anterior teeth. The mandibular incisors were intruded and lingually inclined, and the interincisal angle was reduced to the normal pattern (Fig. 12). The cephalometric superimposition confirmed that there was bodily retraction, retroclination and intrusion of 3.2 mm of the maxillary anterior teeth (Fig. 13). The maxillary posterior teeth were distalized with minimal extrusion (almost null), due to the vertical control of the HPH. Thus, the lower facial height was maintained at an adequate proportion, without chin retrusion, which resulted in a harmonious facial result (Fig. 10).

The treatment results were within acceptable limits, and the patient was satisfied. Periapical and pan-

Figure 9 - Extraoral photographs after eight months of intrusion.

Figure 10 - Posttreatment facial photographs of Case 1.

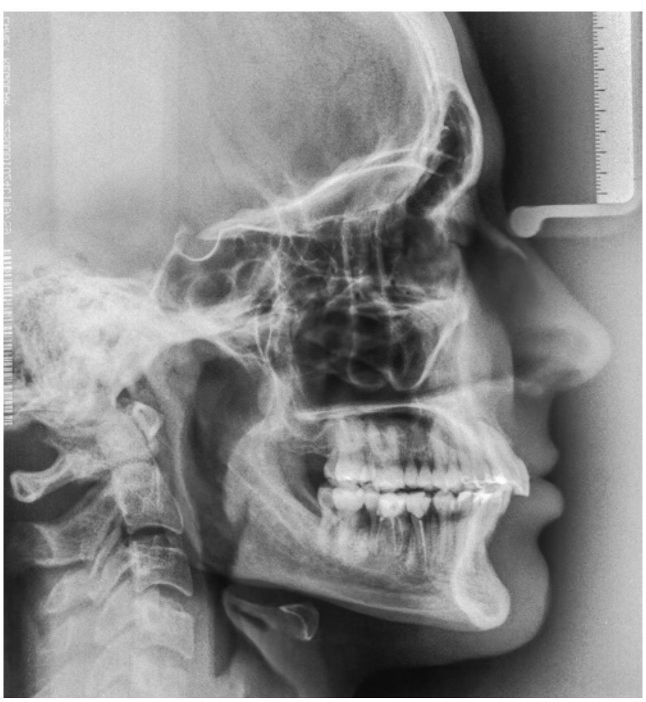


Figure 11 - Posttreatment lateral cephalogram of Case 1.

Figure 12 - Posttreatment intraoral photographs of Case 1.

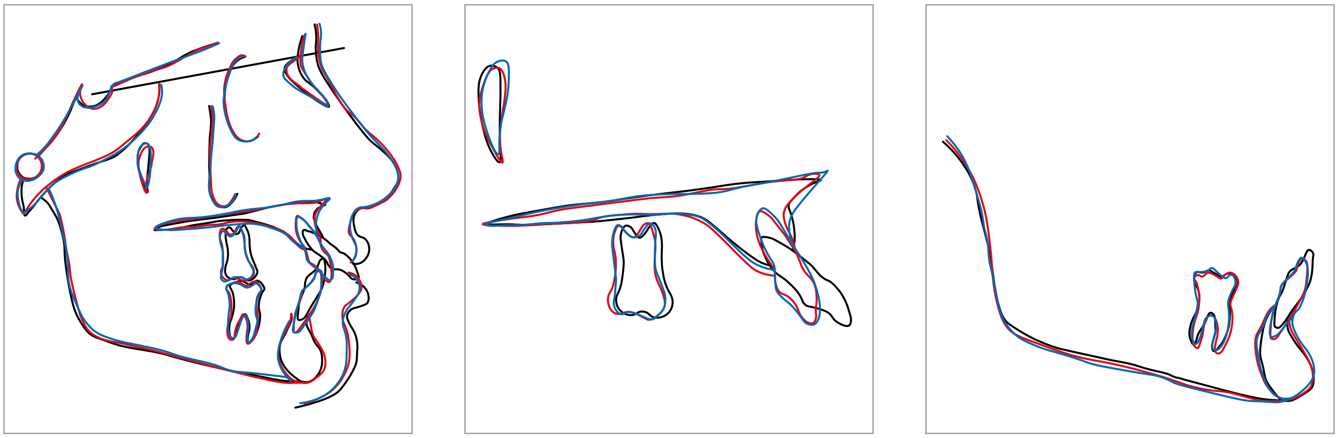


Figure 13 - Cephalometric superimpositions of Case 1.

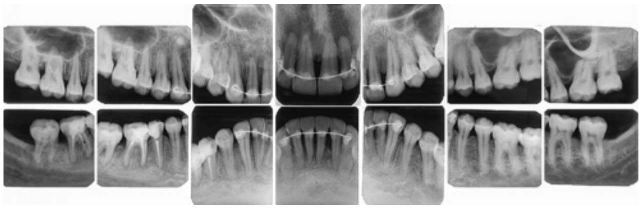


Figure 14 - Posttreatment radiographs of Case 1.

Figure 15 - Intraoral retention photographs of Case 1.

Figure 16 - Extraoral retention photographs of Case 1.

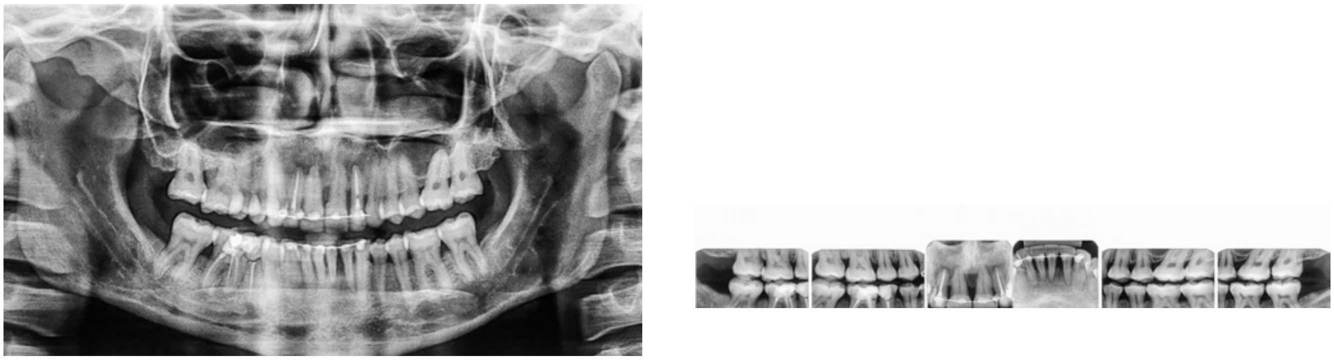


Figure 17 - Retention radiographs of Case 1.

Figure 18 - Retention lateral cephalogram of Case 1.

oramic radiographs (Fig. 14) showed good root parallelism and no noticeable root resorption. The radiographs showed reduction in the dimensions of the angular infrabony defects in the regions of maxillary and mandibular molars and in the maxillary incisors.

During active orthodontic treatment, probing depths and bone levels in the anterior segment, radiographically assessed, were maintained at the levels reached after initial periodontal treatment. The occlusal stability of this case was maintained with semiannual periodontal consultations and semiannual maintenance of the fixed retainers, and can be observed 24 months after treatment completion, both from a clinical (Fig. 15 and 16) and radiographic (Fig. 17 and 18, Tab. 1) standpoint.

Case 2 – Pathological migration of upper incisors and Class II

The patient was an elderly woman (62 years old), with Class II division 1 malocclusion, deep overbite, overjet of 6.8 mm, moderate lower curve of Spee. She also presented pathological migration of maxillary incisors (projected, extruded and with diastemas), especially in tooth 11 (Fig. 19).

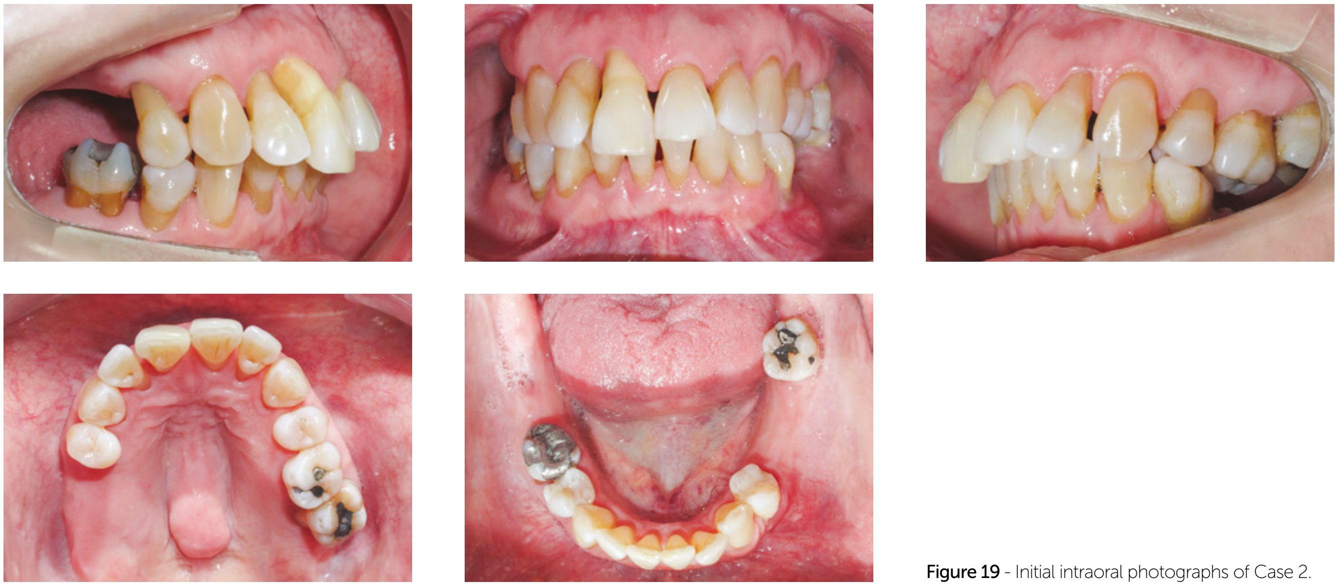


Figure 19 - Initial intraoral photographs of Case 2.

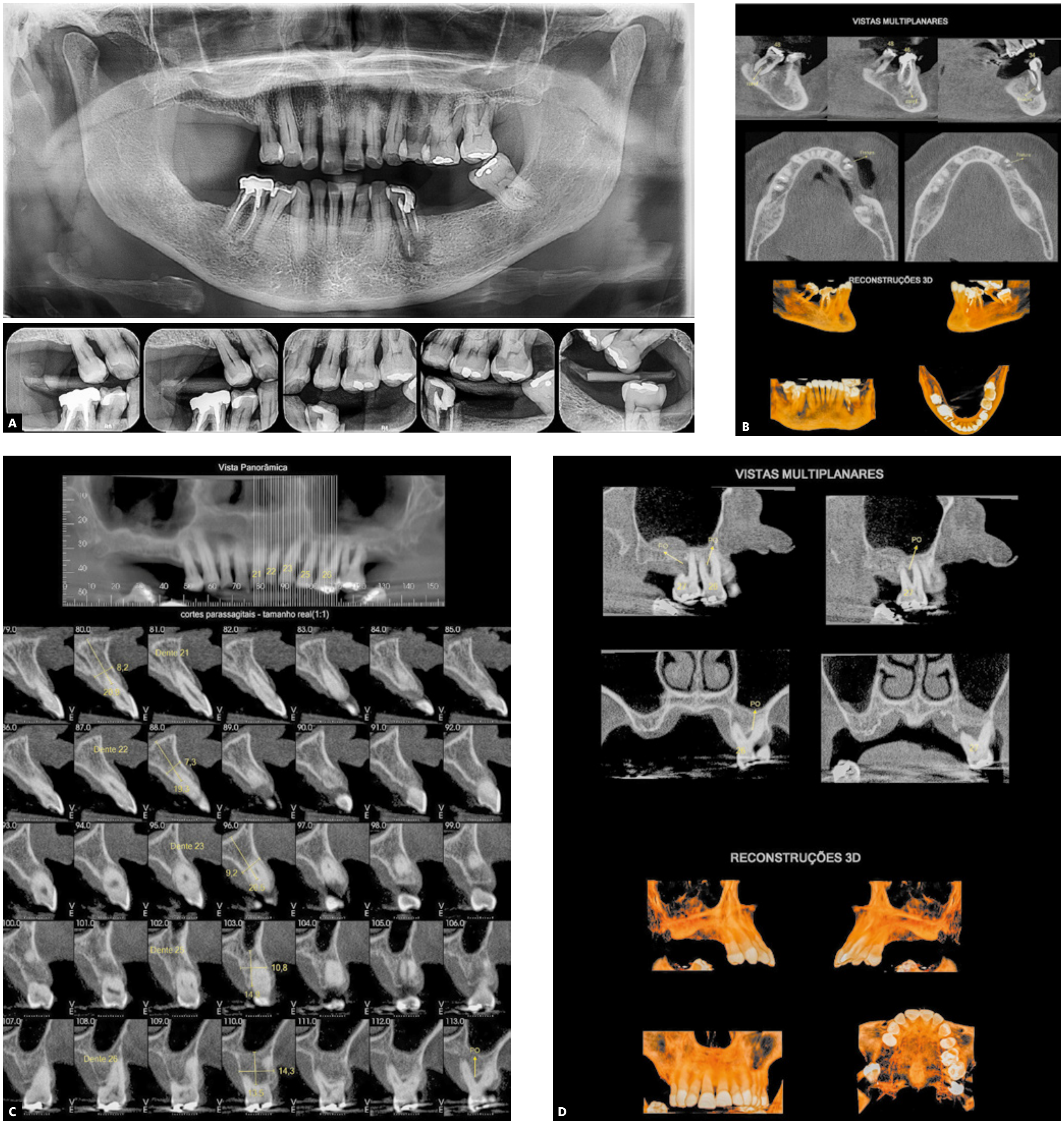


Figure 20 - **A**) Initial radiographs of Case 2. **B-D**) Initial tomographic sections of areas of interest of Case 2.

Chronic periodontitis caused significant insertion loss and mobility in the maxillary and mandibular incisors, in addition to extraction of teeth 16, 17, 47, 35 and 36. Significant insertion loss was detected in the following areas: 34 (M), 33 (MD), 32 (MD), 31 (MD), 41 (MD), 42 (MD), 43 (M), 48 (M and bifurcation), 15 (MD), 13 (M), 12 (MD), 11 (MD), 21 (MD), 22 (MD), 23 (M), 26 (D and furcation) and 27 (MD and furcation with large extension). In addition, tooth 34 was fractured and tooth 46 had bone rarefaction in the healing phase (Fig. 20). The periodontal diagnosis detected probing depths of 3-9 mm and the presence of gingival recessions on the buccal and lingual surfaces of all present teeth, most significantly in teeth 11 and 12.

The cephalogram confirmed the extrusion of maxillart incisors, marked projection of the maxillary and mandibular incisors, skeletal Class II and dolichocephalic pattern (Fig. 21, Tab. 2).

The chief complaints of the patient were extrusion of tooth 11, interincisal diastemas and missing teeth. The facial photographs (Fig. 22) presented a convex facial profile, with incompetent lip sealing and satisfactory chin, with slight deviation to the right.

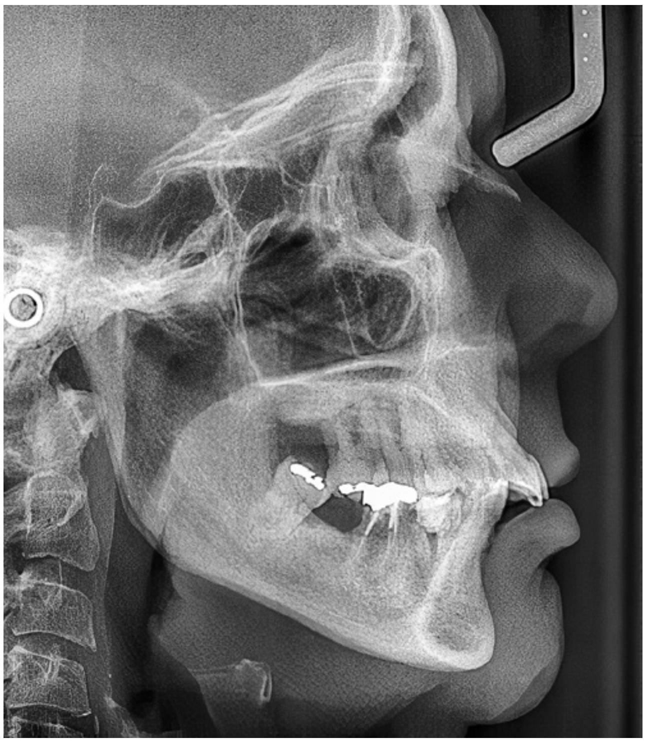


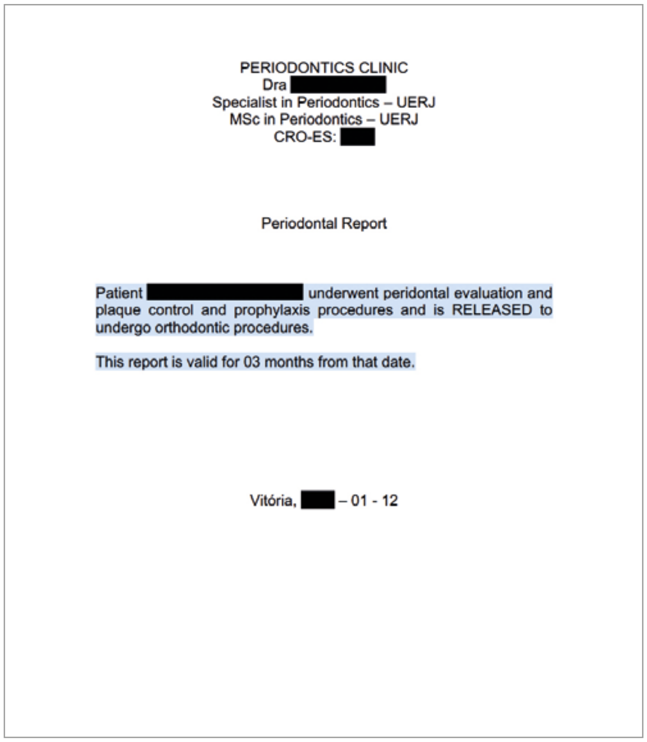
Figure 21 - Initial lateral cephalogram of Case 2.

As a first step, intensive periodontal treatment was performed until the disease was controlled and the patient acquired the ability to maintain good oral hygiene, which was supervised monthly by the periodontist throughout the treatment. Subsequently, due to the significant improvement in periodontal indices and in oral hygiene, the consultations became quarterly. It is important to note that the frequency of periodontal consultations can be changed, according to the compliance with hygiene and tissue response of the patient throughout the orthodontic treatment. It is recommended to request a report from the periodontist confirming the release for orthodontic movement, as well as its validity (Fig. 23).

Orthodontic planning in this case also used the modified palatal arch with direct anchorage on TADs to intrude and retract the maxillary incisors. The palatal arch was made to be fixed to four mini-screws (Fig. 24). We opted for the use of TADs because of the impossibility of using the posterior maxillary teeth as anchorage, due to marked insertion loss and absence of tooth 16.

Due to the marked loss of insertion, it was decided to extract teeth 35 and 27. Dental implants were planned in the regions of 16, 34 and 35. Since the implant placement for tooth 16 required bone grafting, it was not initially considered as an anchorage option. The implant of tooth 16 was later used as

Figure 22 - Initial extraoral photographs of Case 2.



PERIODONTICS CLINIC
Dra [redacted]
Specialist in Periodontics – UERJ
MSc in Periodontics – UERJ
CRO-ES: [redacted]

Periodontal Report

Patient [redacted] underwent peridontal evaluation and plaque control and prophylaxis procedures and is RELEASED to undergo orthodontic procedures.

This report is valid for 03 months from that date.

Vitória, [redacted] – 01 - 12

Figure 23 - Example of a periodontal report.

anchorage for Class II correction, combined with an extra-alveolar mini-implant on the left side. However, due to the patient's age and extensive bone loss, this treatment had significant biological limitations. After correcting the pathological migration of maxillary incisors, additional retraction was necessary, whose planning was performed in combination with the periodontist.

The interincisal black spaces, already present between the four incisors, would be increased after correcting the extrusion of tooth 11. To avoid this, proximal stripping between 11-21 (0.3 mm) and between 11-12 and 21-22 (0.2 mm) was planned. The feasibility of additional retraction of incisors would be reevaluated after the correction of migrations, conditioned to the biological response of these teeth. The remaining black spaces could be closed with direct composite resin restorations. However, reshaping with resin should be limited due to the contraindication of creating biofilm retention sites.

Figure 24 - Modified palatal arch with direct anchorage in TADs.

Figure 25 - Modified palatal arch in activation, in Case 2.

Therefore, the patient was advised that black spaces would be reduced, but they might not be completely solved. The treatment limitations should be clarified at the planning stage, to prevent the patient from creating unrealistic expectations about the results, since biological limitations in the treatment of periodontal patients are frequent.

The retraction and intrusion were initiated with a 12-mm compressed NiTi spring tied to the four maxillary incisors. The line of action of the applied force was close to the center of resistance of incisors (apically displaced due to bone loss) and generated a force of 10 g/tooth in teeth 21, and 22 and force of 5 g/tooth in teeth 11 and 12. As the occlusal contact of tooth 21 generated a fremitus, a posterior occlusal stop was made to de-occlude this tooth, eliminating the secondary occlusal trauma. At first, only the intrusion of teeth 21 and 22 was initiated (Fig. 25).

When teeth 21 and 22 were leveled with teeth 11 and 12, the intrusion movement became simultaneous in the four incisors. Orthodontic maintenance consultations were performed at every six weeks. The springs were progressively reduced until reaching the 5-mm spring, maintaining the same force intensity.

The intrusion and anterior retraction were performed for six months. Then, the spaces were closed, maintaining the occlusal relationship of posterior teeth. Since tooth 27 showed relapse of periodontal inflammation (with worsening of insertion loss on the mesial and distal surfaces), it was indicated for extraction. At that time, the lingual brackets were removed, and fixed 0.022 x 0.028-in Roth prescription orthodontic brackets were bonded to both arches.

At this stage, the implant in the region of tooth 16 was placed in Class I relationship, after checking the quality of bone grafting performed at the site. Implants in regions of teeth 35 and 36 had been previously placed. Together with the periodontist, a consensus was reached that Class II correction would be feasible only on the right side, since additional retraction of the incisors would be possible; however, the movement of tooth 26 was contraindicated.

Therefore, due to the biological limitation present, a Class I relationship was established on the right side and Class II was maintained on the left side. Proximal stripping was performed to minimize the black triangles, keeping the coincident midlines. In the laterality guides, a group function was established on the left side and canine guidance on the right side. The stripping spaces were closed with a 0.019 x 0.025-in stainless steel retraction archwire, with a T-shaped spring, to control the inclination of incisors. The treatment was completed with ideal coordinated 0.019 x 0.025-in archwires.

Figure 26 - Final intraoral photographs of Case 2.

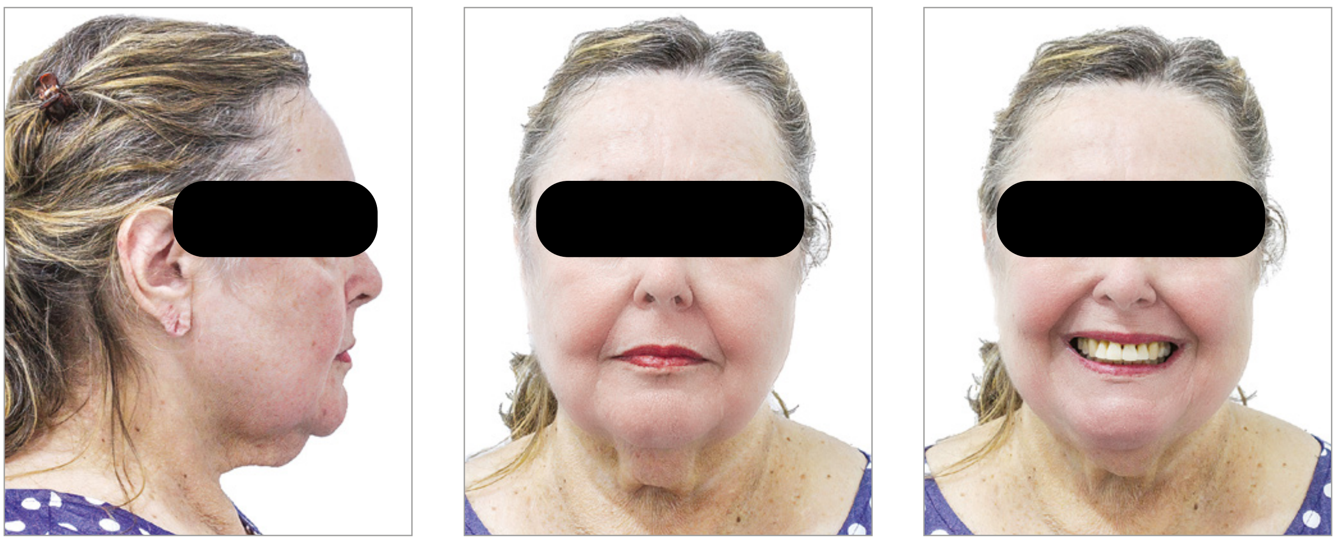


Figure 27 - Final extraoral photographs of Case 2.

Table 2 - Cephalometric measurements of Case 2.

Measurements	Pretreatment	Post-treatment
SNA	83.9°	84.1°
SNB	78.1°	80.0°
ANB	5.8°	4.1°
1.NA	30.3°	25.9°
1-NA	6.4 mm	4.5 mm
1.NB	31.6°	30.2°
1-NB	6.1 mm	6.3 mm
IMPA	95.8°	95.0°
Interincisal angle	113.4°	118.9°
FMA	29.7°	26.6°
SN.Go-Me	36.9°	35.4°
PLO (Go-Gn.Ocl)	21.8°	18.1°
LAFH (ANS-Me)	71.7mm	70.3mm

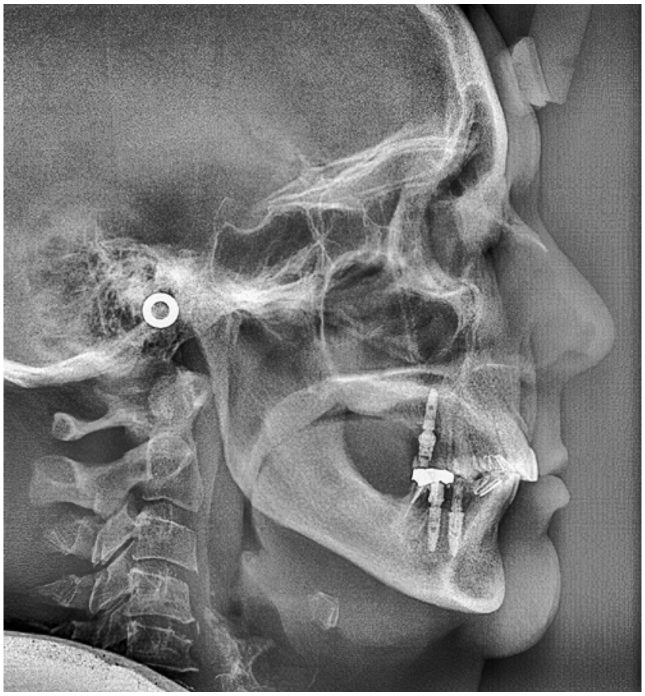


Figure 28 - Final lateral cephalogram of Case 2.

After 24 months of treatment, a stable occlusion was obtained. Root parallelism was confirmed on the panoramic radiograph, and the appliances were removed. The patient chose not to reshape the remaining black triangles with composite resins, as they were not visible in the smile and because she did not want to impair her hygiene. During the treatment period, periodontal control was performed by a periodontist at every three months. The retention was made with 0.018-in stainless steel wire, bonded on 3-3 in the maxillary and mandibular arches, splinting the anterior teeth.

The posttreatment intraoral photographs showed leveling of incisors, reduction of extrusion and protrusion, achieving adequate overbite and overjet and rehabilitation of edentulous areas (Fig. 26). The face was well balanced, due to the intrusion and retraction of incisors, with consequent upper lip retraction and obtaining passive lip sealing (Fig. 27).

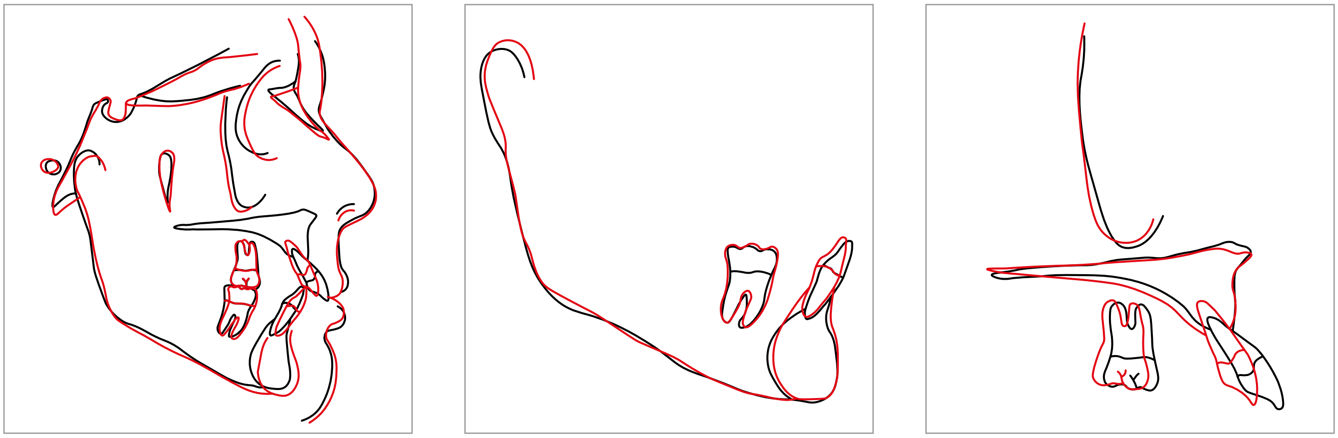


Figure 29 - Cephalometric superimposition of Case 2.

Figure 30 - Final radiographs of Case 2.

Figure 31 - Intraoral photographs of the retention phase of Case 2.

Figure 32 - Extraoral photographs of the retention phase of Case 2.

The cephalometric analysis (Fig. 28, Tab. 2) showed a small increase in the FMA angle, reduction in ANB (from 5.7° to 4.1°), intrusion and retraction of maxillary incisors. Analysis of the cephalometric superimposition confirmed that there was bodily retraction and retroclination of upper incisors, and an intrusion of 3.8 mm from the apex of tooth 11 (Fig. 29). The treatment results were clinically acceptable, and the patient was satisfied.

The periapical and panoramic radiographs (Fig. 30) showed good root parallelism, absence of root resorption and reduction of angular infrabony defects in the regions of maxillary and mandibular molars and maxillary incisors. The stability of the case was maintained with periodontal consultations at every four months, with orthodontic maintenance of the fixed retention bars, and can be verified 12 months after treatment completion (Figs 31 and 32).

Case 3 – atypical pathological migration of mandibular incisors

The patient was an adult (50 years old), with Class I malocclusion, anterior crossbite, negative protrusion of -2.3 mm, bilateral posterior crossbite and diastemas between the maxillary and mandibular incisors. Significant pathological migration in incisors generated 5.6 mm of diastema in the mandibular arch and 2.9 mm in the maxillary arch. The mandibular arch still had a marked curve of Spee and the maxillary arch presented a reverse curve of Spee (Fig. 33). The patient also had nocturnal bruxism, with significant occlusal wear, especially in the canines.

Chronic periodontal disease also caused insertion loss, mobility in all incisors and loss of teeth 14, 17, 36, 45 and 46. Significant bone loss was detected in the following areas: 31 (MD), 41 (MD), 34 (D), 35 (MD), 37 (M), 47 (M), 11 (MD), 12 (D), 13 (M), 15 (M), 21 (M),

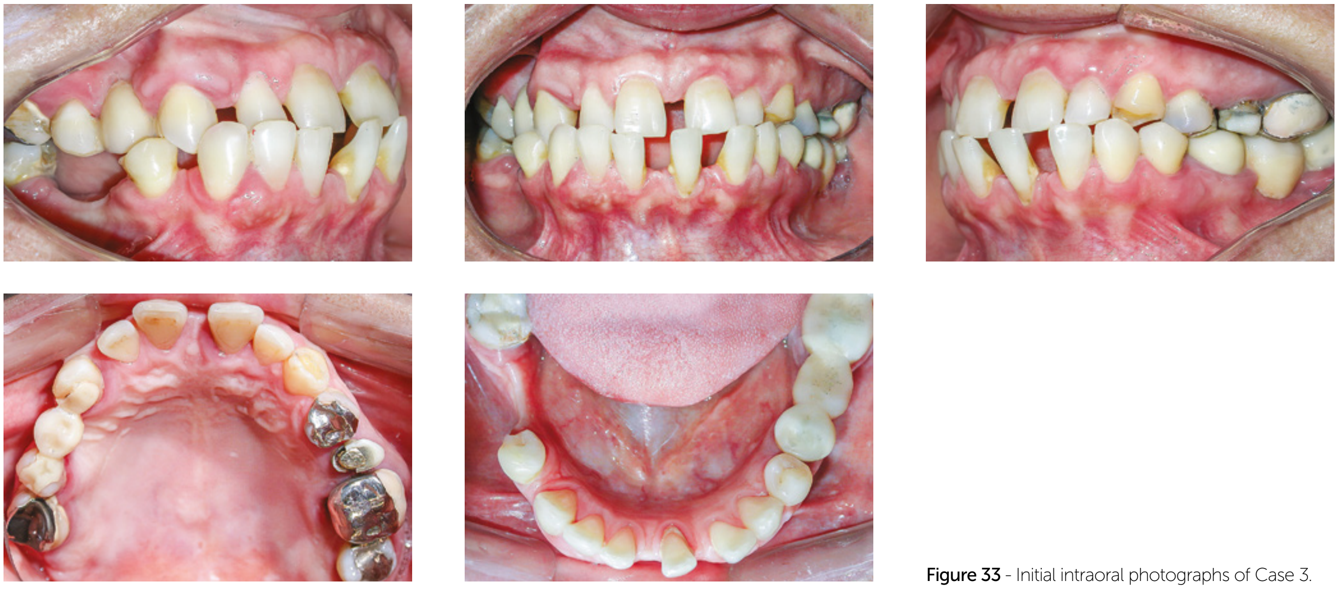


Figure 33 - Initial intraoral photographs of Case 3.

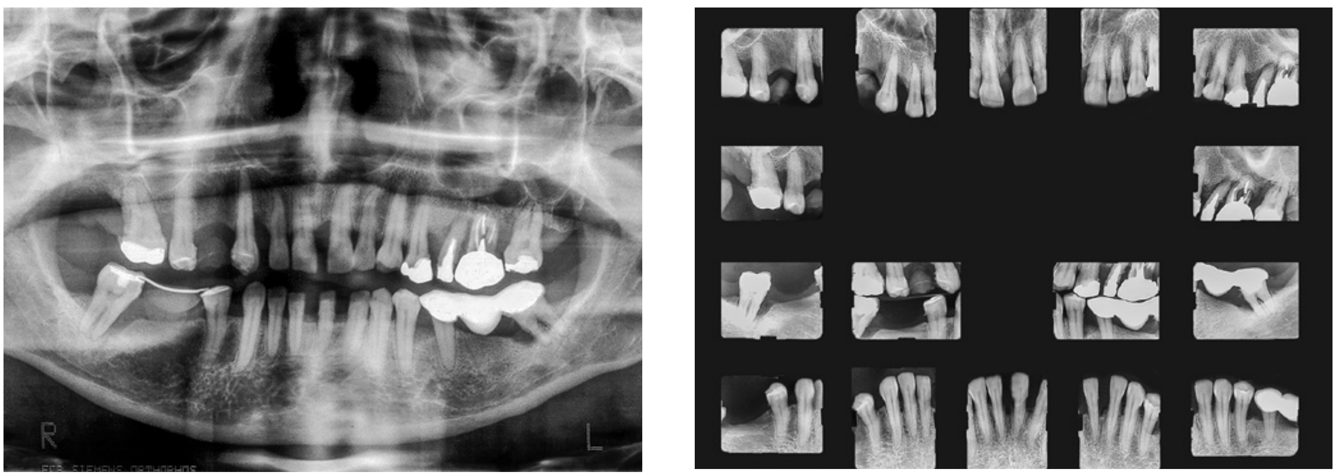


Figure 34 - Initial radiographs of Case 3.

Figure 35 - Initial extraoral photographs of Case 3.

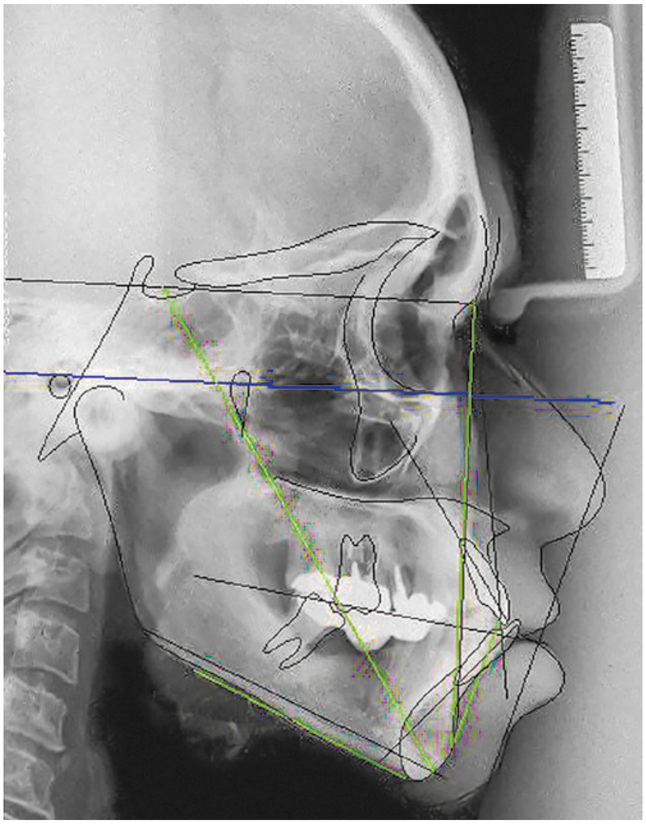


Figure 36 - Initial lateral cephalogram of Case 3.

24 (D), 25 (MD), 26 (MD) and 27 (M) (Fig. 34). The probing depths varied from 4 to 10 mm. Gingival recessions were observed on the labial and lingual surfaces of lower incisors, particularly in tooth 31.

The chief complaints of the patient were negative overjet, missing teeth and lower and upper interincisal diastemas. In facial photographs (Fig. 35), a convex facial profile was observed, with competent lips and satisfactory chin. The cephalogram confirmed the marked projection and protraction of the mandibular incisors, skeletal Class II and brachycephalic pattern (Fig. 36, Tab. 3).

As a first step, intensive periodontal treatment was performed until periodontitis was controlled and the patient acquired the ability to maintain good oral hygiene. The initial planning was to perform periodontal control on a quarterly basis; however, during the intrusion of mandibular incisors, the frequency of these consultations became monthly, due to the large accumulation of calculus in this region, due to the patient's difficulty with oral hygiene. During the intrusion movement, this control is even more important, due to the risk of displacing supragingival biofilm to the subgingival region, worsening the formation of infrabony periodontal pockets.[5] In some cases, periodontal consultations may be monthly until completion of the intrusion movement, so that it is possible to maintain and even improve the health of the reduced periodontium.[20,21]

The diagnostic set-up showed that the correction of overjet required intrusion of 3.6 mm of the mandibular incisors. Since these teeth had vertical alveolar bone loss, the three-piece intrusion mechanics of Burstone[46] associated with dental implants was planned, which were immediately placed to provide adequate anchorage for the cantilevers of this technique.

Since it was planned to place dental implants in the regions of teeth 14, 25, 26, 36, 46 and 47, and to extract the tooth 37 (condemned by the periodontist), the diagnostic set-up was used to create a guide to the surgical positioning of implants using addition silicone. To make this guide, it is necessary to make retentions in the initial study model of the patient (Fig. 37A) and then duplicate it with guides for the set-up preparation (Fig. 37B). After completing the set-up, the crowns of future implants are positioned on the model and then the silicone guide is made, which can be transferred to the patient's initial study model (Fig. 37C, D and E).

A standard Edgewise 0.022 x 0.028-in appliance was bonded to the maxillary and mandibular dental arches. The initial alignment and leveling was performed with multiloop 0.012-in stainless steel archwire with tieback, to avoid the projection of incisors. Immediately after the initial alignment, the intrusion mechanics was started, with a passive 0.019 x 0.025-in stainless steel base archwire in the region of mandibular incisors with a projection of 3 mm to the distal surface of canines. This planning allowed the line of force action to pass as close as possible to the center of resistance of the mandibular incisors block (displaced distally to the canines, due to bone loss).[45] The cantilevers were made from 0.017 x 0.025-in beta titanium archwire, activated at every five weeks, applying an intrusion force of 20 mg per side (5mg on each tooth) for six months.

During the six months of intrusion, the patient attended monthly consultations with the periodon-

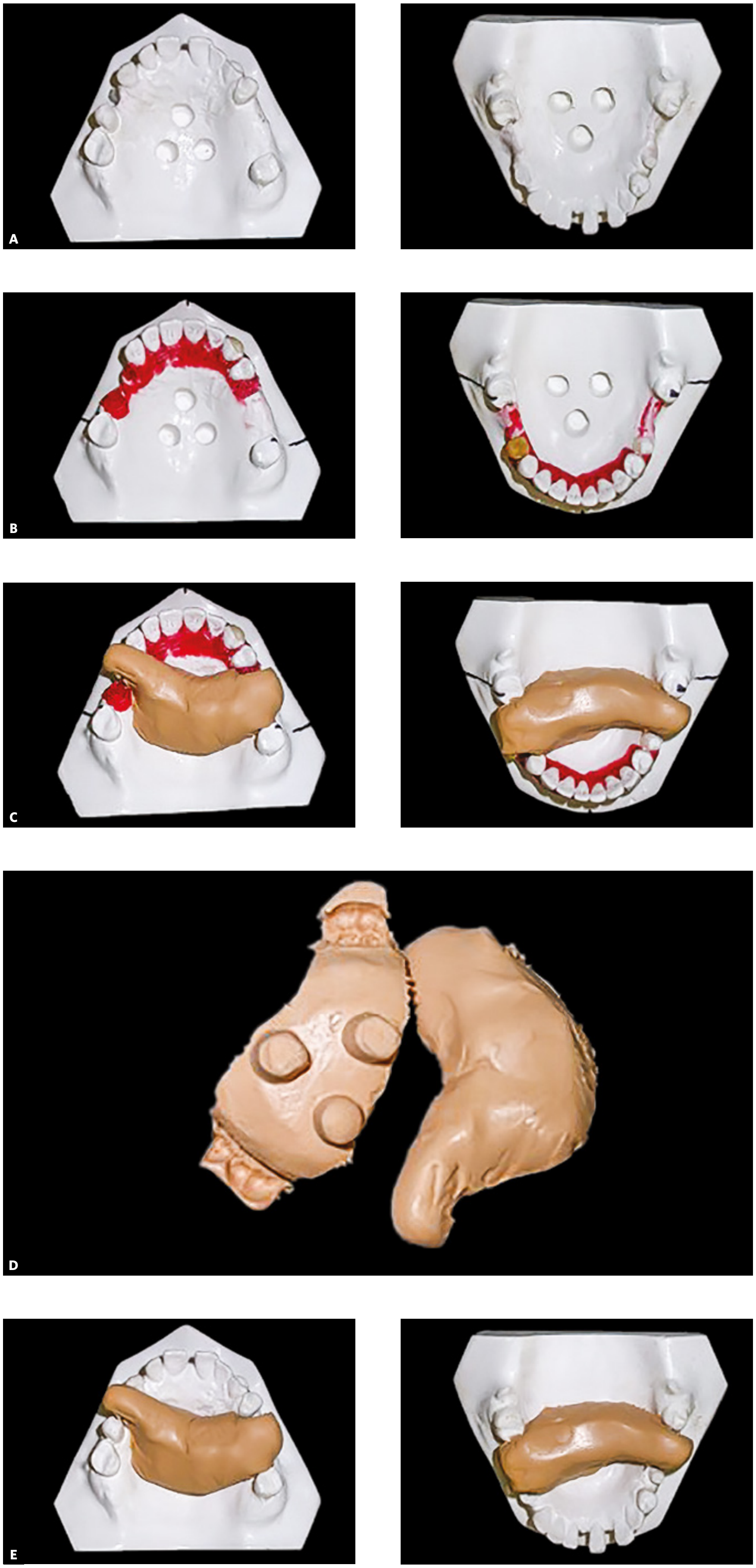


Figure 37 - A) Retentions made in the initial model of the patient. B) *Set*-up made in the duplicated model with retentions. C-E) Making and transferring the silicone guides.

tist for scaling and root planing, due to poor hygiene in the region (Fig. 38). In fact, during the intrusion movement, monthly periodontal control can be indicated.[40] After completion of intrusion, consultations with the periodontist became quarterly and a 0.016-in lower multiloop stainless steel archwire with tieback was used to align and level the teeth. A sequence of progressively thicker archwires was used to obtain proper alignment and leveling, until the use of a 0.019 x 0.025-in stainless steel archwire with T-spring to close the maxillary and mandibular spaces.

After the spaces were closed, it was decided to maintain the remaining black triangles in the mandibular arch, to avoid proximal stripping on the incisors, due to the unfavorable anatomy, and to minimize their movement. The patient chose not to reshape the region with composite resins. The treatment was completed with ideal coordinated 0.019 x 0.025-in stainless steel archwires.

After 30 months of treatment, a stable occlusion was obtained. Root parallelism was confirmed on the panoramic radiograph, and the appliances were removed. The orthodontic retainer splinted the anterior teeth with 0.020-in stainless steel wire bonded on 4-4 in the mandibular arch and 0.018-in stainless steel wire bonded on 3-3 in the maxillary arch.

Figure 38 - Deficient hygiene during the intrusion movement.

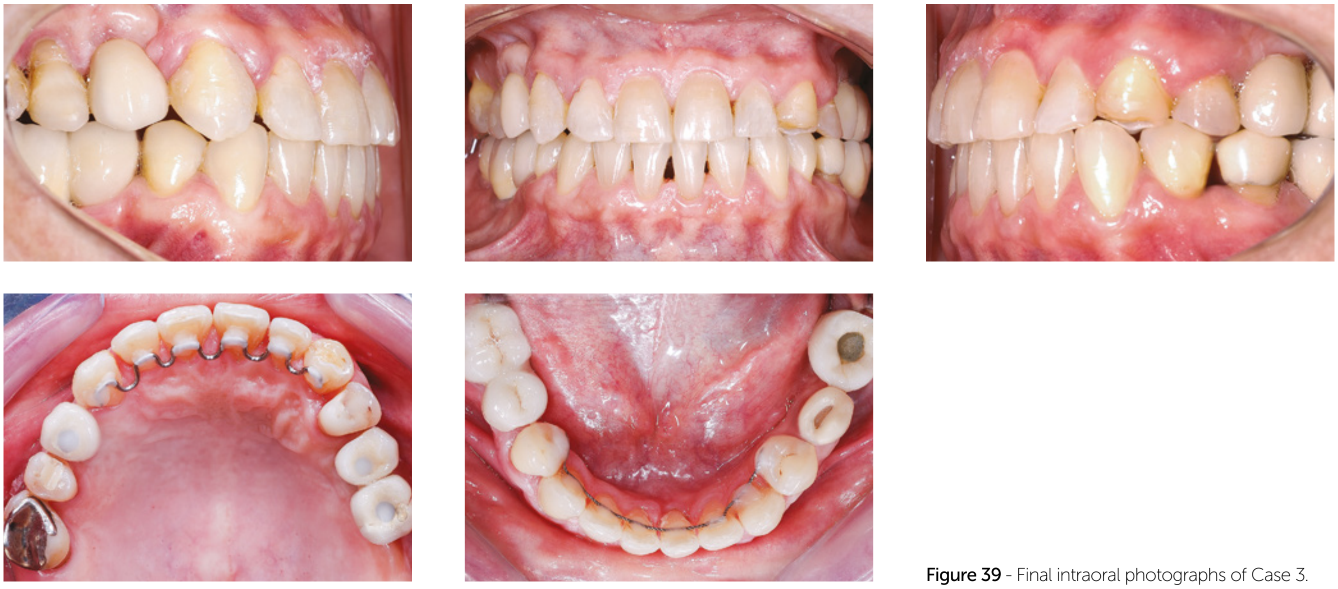


Figure 39 - Final intraoral photographs of Case 3.

Figure 40 - Final extraoral photographs of Case 3.

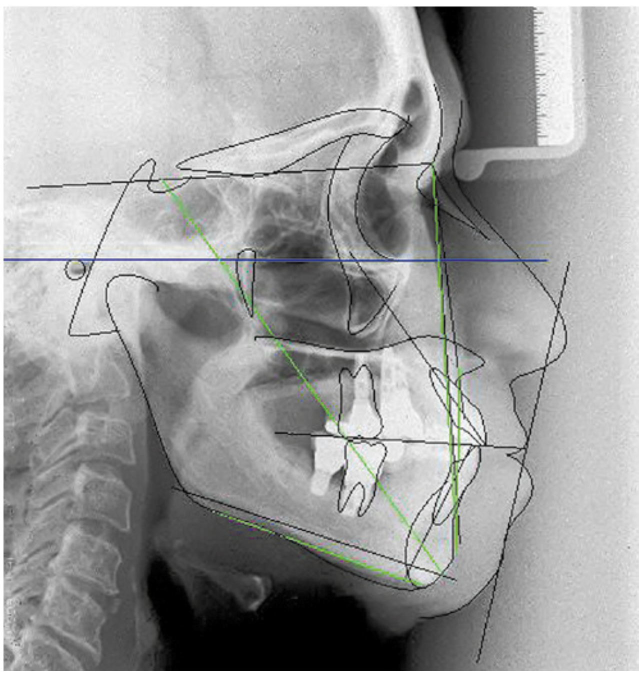


Figure 41 - Final lateral cephalogram of Case 3.

A bite plate was installed to distribute the forces equally in the posterior region and protect the anterior region, leaving it without contact. The posttreatment intraoral photographs show the leveling of maxillary and mandibular incisors, and the closure of diastemas, as well as reduction of extrusion and protrusion of mandibular incisors, obtaining adequate overbite and overjet, and the prosthetic rehabilitation of edentulous areas (Fig. 39).

Posttreatment facial photographs showed reduced incisor protrusion, and a youthful and well-balanced face, due to lip retraction (Fig. 40). The cephalometric analysis (Tab. 3, Fig. 41) showed a small increase in the FMA angle, reduction in ANB (from 5.7° to 4.1°), intrusion and retraction of maxillary incisors.

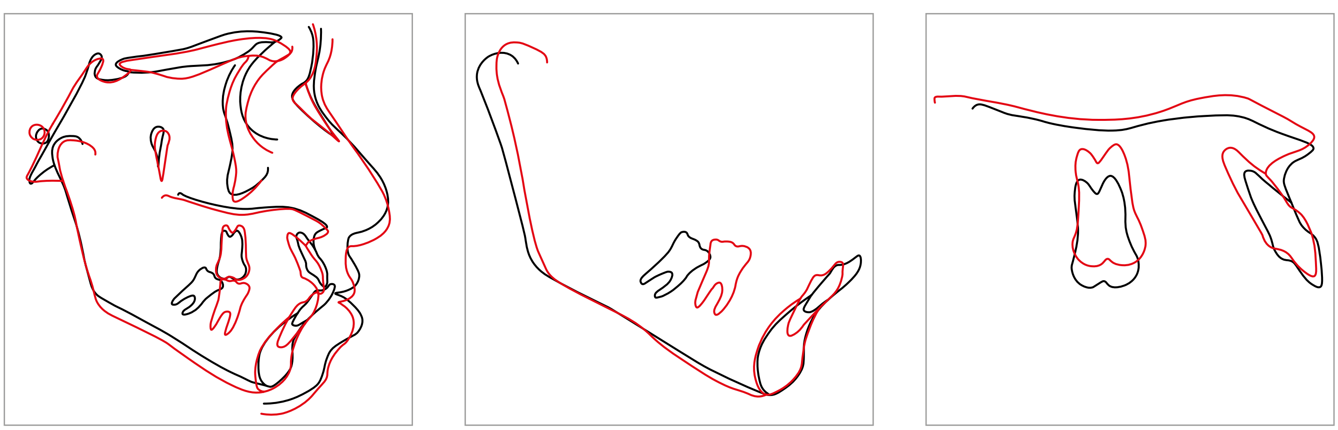


Figure 42 - Cephalometric superimposition of Case 3.

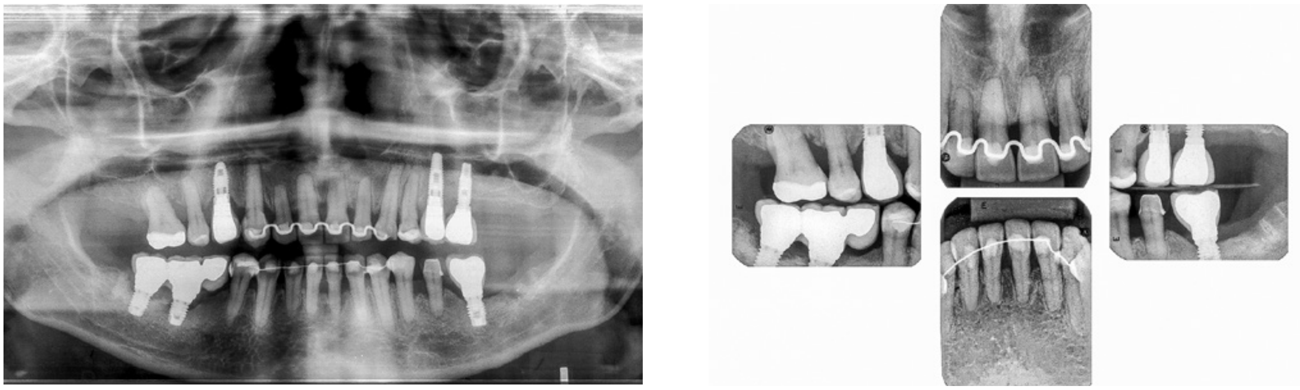


Figure 43 - Final radiographs of Case 3.

Figure 44 - Intraoral retention photographs of Case 3.

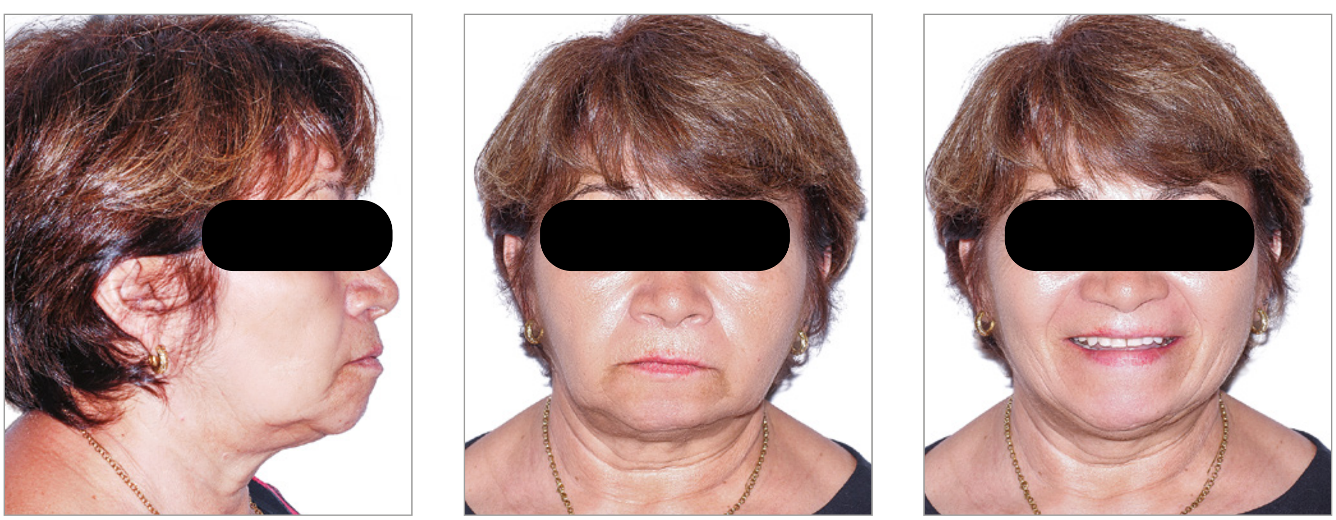


Figure 45 - Extraoral retention photographs of Case 3.

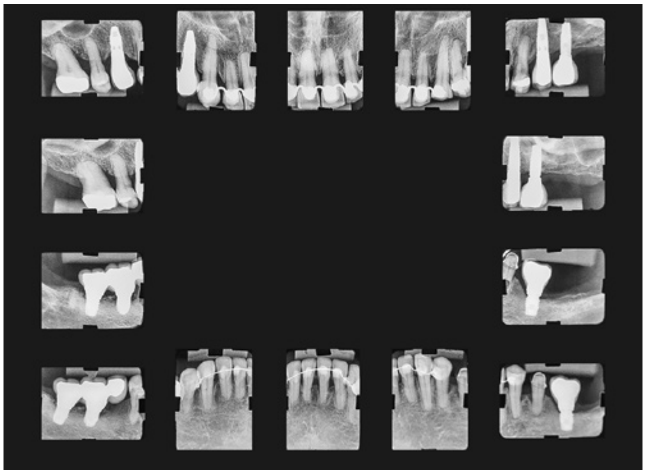


Figure 46 - Retention radiographs of Case 3.

Table 3 - Cephalometric measurements of Case 3.

Measurements	Pretreatment	Post-treatment
SNA	83.6°	82.2°
SNB	77.9°	80.1°
ANB	6.7°	2.1°
1.NA	25.5°	28.8°
1-NA	1.9 mm	4.7 mm
1.NB	42.9°	30.0°
1-NB	13.2 mm	5.6 mm
IMPA	108.4°	96.5°
Interincisal angle	104.5°	118.5°
FMA	22.2°	19.5°
SN.Go-Me	23.6°	22.7°
PLO (Go-Gn-Ocl)	17.9°	20.5°
LAFH (ANS-Me)	65.2 mm	66.1 mm

The mandibular incisors were intruded and lingually inclined, with improvement in the interincisal angle, which was reduced to normal values. The cephalometric superimposition confirmed the bodily retraction, retroclination and intrusion of 3.2 mm of the mandibular incisor apices (Fig. 42).

The treatment results were within acceptable limits, and the patient was satisfied. Periapical and panoramic radiographs (Fig. 43) showed good root parallelism and mild root resorption in the maxillary and mandibular incisors. The radiographs showed reduction in the dimensions of angular infrabony defects in the regions of maxillary and mandibular incisors.

During the active orthodontic treatment, probing depths and bone levels in the anterior region (radiographically assessed) were maintained at the levels reached after initial periodontal treatment. The stability of this case was maintained with semiannual periodontal consultations and orthodontic maintenance of retainers and the bite plate, which can be clinically (Fig. 44 and 45) and radiographically (Fig. 46) observed 30 months after treatment completion.

Case 4 – Alveolar bone loss in maxillary incisors in biprotrusive patient

The patient was an elderly man (68 years), with Class I malocclusion, biprotrusive incisors, overjet of 4.2 mm, diastemas between the maxillary central incisors and moderate anterior lower crowding (-5.1 mm). Pathological migration generated

Figure 47 - Initial intraoral photographs of Case 4.

Figure 48 - Initial radiographs of Case 4.

Figure 49 - Initial extraoral photographs of Case 4.

Figure 50 - Initial lateral cephalogram of Case 4.

significant protrusion in the maxillary incisors and 2.3 mm of upper midline diastema. The mandibular arch had a marked curve of Spee and the maxillary arch had a reverse curve of Spee (Fig. 47).

Chronic periodontitis caused mobility and significant insertion loss in the maxillary incisors at the following sites: 11 (MD), 12 (M), 21 (MD), 22 (M). The periodontal diagnosis showed that the probing depths varied from 4 to 7 mm and that gingival recession was observed on the labial surfaces of maxillary central incisors and mandibular canines. Tooth 36, which had a bulky metallic pin, was condemned due to the presence of root fracture (Fig. 48). The patient also had daytime tooth clenching (centric bruxism).

The chief complaints of the patient were the midline diastema and the difficulty in lip sealing. Facial photographs (Fig. 49) showed a convex facial profile, with competent lips and a satisfactory chin. The cephalogram confirmed biprotrusion of incisors, skeletal Class I and a brachycephalic pattern (Fig. 50, Tab. 4).

As a first step, intensive periodontal treatment was performed until the disease was controlled and the patient was trained to maintain excellent oral hygiene. Periodontal control was performed quarterly throughout the treatment and the patient cooperated with a good standard of hygiene.

After this step, tooth 36 was replaced by a dental implant with a provisional crown. Then, a 0.022 x 0.028-in Roth prescription fixed orthodontic appliance was bonded to both arches. The space to dissolve the anterior lower crowding was obtained by proximal stripping, performed since insertion of the first archwire, to avoid further projection of the mandibular incisors. Alignment was performed with 0.012-in braided stainless steel archwires with tied omegas and a step up fold in the incisors region, to avoid the use of continuous leveling. The alignment evolved with 0.014-in, 0.016-in and 0.018-in braided stainless steel archwires, always with tied omegas and the step up in the incisors region.

After alignment, the intrusion was planned using three-piece intrusion mechanics of Burstone[46] in the mandibular arch, to correct the marked curve of Spee and provide sufficient overjet to enable the retraction of maxillary teeth (to subsequently correct the protrusion). The mandibular molars did not present vertical bone loss and thus were considered an adequate anchorage for the use of cantilevers in this mechanics.

The intrusion mechanics was initiated by placing the 0.019 x 0.025-in passive stainless steel base archwire in the region of mandibular incisors, with a projection that coincided with the distal surface of canines, so that the line of force action passed as close as possible to the center of resistance of the mandibular incisors block. Since there was no bone loss in the mandibular incisors, it was not necessary to make a entension beyond the distal of canines.[45] The 0.017 x 0.025-in beta titanium wire cantilevers were activated at every five weeks and applied an intrusion force of 40 mg per side (10 mg on each tooth) for five months. After completion of intrusion, a 0.017 x 0.025-in lower braided steel archwire with tied omegas was used to finalize the alignment and leveling. In the maxillary arch, alignment and leveling were performed concomitantly and also used progressively thicker braided and steel wires with tied omegas.

The retraction of maxillary incisors was performed with a 0.019 x 0.025-in stainless steel retraction archwire with a T-spring and a bend accentuating the Gable effect on the T-spring to prevent the extrusion of incisors during retraction (Fig. 51).

This closed the midline diastema and also the spaces of proximal stripping of 0.2 mm/surface on all anterior teeth, between the mesial aspects of teeth 14 and 24. Since there was a need to correct the excessive protrusion of maxillary incisors and the upper reverse curve of Spee, it would be possible to consider the retraction with continuous wires; however, the presence of marked alveolar bone loss always contraindicates this type of mechanics. Due to the apical migration of the CRes, if retraction with continuous archwires was used, there would be uncontrolled inclination from the apex of incisors to the buccal side, the malocclusion would not be corrected and this might generate side effects, such as root resorption. Due to the proximal stripping made, after the spaces were closed, there were no remaining black triangles. The treatment was completed with ideal 0.019 x 0.025-in coordinated archwires.

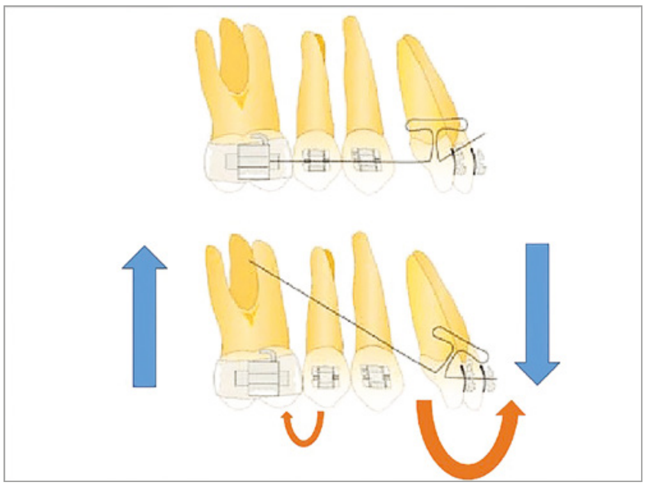


Figure 51 - Illustration of the T-shaped spring and bend, accentuating the Gable effect on the T-spring, to prevent the extrusion of incisors during retraction.

After 22 months of treatment, a stable occlusion was obtained. Root parallelism was confirmed on the panoramic radiograph, and the devices were removed. The 0.018-in stainless steel wire retainer was bonded on 3-3 to the mandibular arch, complemented by a removable rigid acetate plate for daytime use, which also aided in clenching control, as a reminder for the patient. Due to centric bruxism, a nighttime bite plate was also installed, which equally distributed the forces in the posterior region and protected the anterior region, leaving it without contact. The posttreatment intraoral photographs showed that the leveling of incisors, closure of the diastema, rehabilitation of the edentulous area and correction of biprotrusion, overbite and overjet were achieved (Fig. 52).

The posttreatment facial photographs showed that the reduction of protrusion of incisors contributed positively both to the reduction in chin tension and to improve the lip seal and the smile esthetics, with good exposure of maxillary incisors (Fig. 53). The cephalometric analysis (Tab. 4, Fig. 54) showed a small increase in the FMA angle, reduction in the ANB (from 5.7° to 4.1°), intrusion and retraction of maxillary incisors.

Figure 52 - Final intraoral photographs of Case 4.

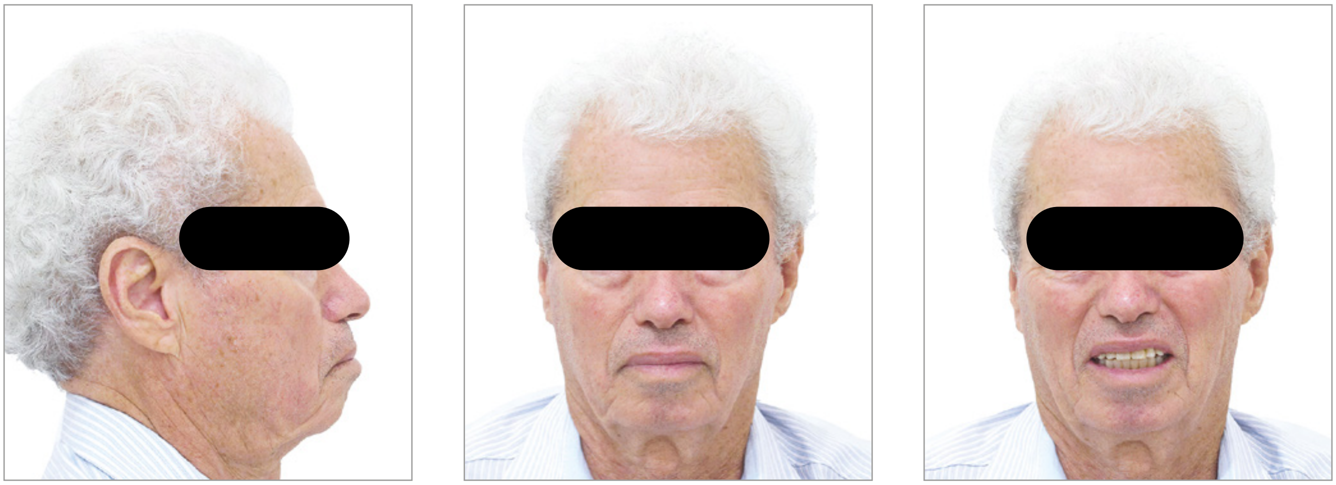


Figure 53 - Final extraoral photographs of Case 4.

Table 4 - Cephalometric measurements of Case 4.

Measurements	Pretreatment	Post-treatment
SNA	85.0°	85.9°
SNB	82.9°	83.9°
ANB	2.1°	2.0°
1.NA	39.2°	29.8°
1-NA	11.2 mm	7.4 mm
1.NB	40.7°	36.0°
1-NB	10.2 mm	8.8 mm
IMPA	108.4°	103.5°
Interincisal angle	107.7°	100.5°
FMA	19.8°	20.5°
SN.Go-Me	30.1°	29.8°
PLO (Go-Gn-Ocl)	18.0°	15.5°
LAFH (ANS-Me)	69.3 mm	69.1 mm

Figure 54 - Final lateral cephalogram of Case 4.

The mandibular incisors were intruded and lingually inclined, with improvement in the interincisal angle, which was reduced to normal values. The cephalometric superimposition confirmed that there was bodily retraction and retroclination of the maxillary and mandibular incisors, and also that there was no extrusion of posterior teeth, used as anchorage (Fig. 55).

The treatment results were within acceptable limits, and the patient was satisfied. Periapical and panoramic radiographs (Fig. 56) showed good root parallelism and absence of noticeable root resorption. The radiographs showed a significant reduction in the dimensions of the angular infrabony defects in the maxillary incisors region. During active orthodontic treatment, the probing depths and bone levels in the anterior segment, radiographically assessed, were maintained at the levels reached after initial periodontal treatment.

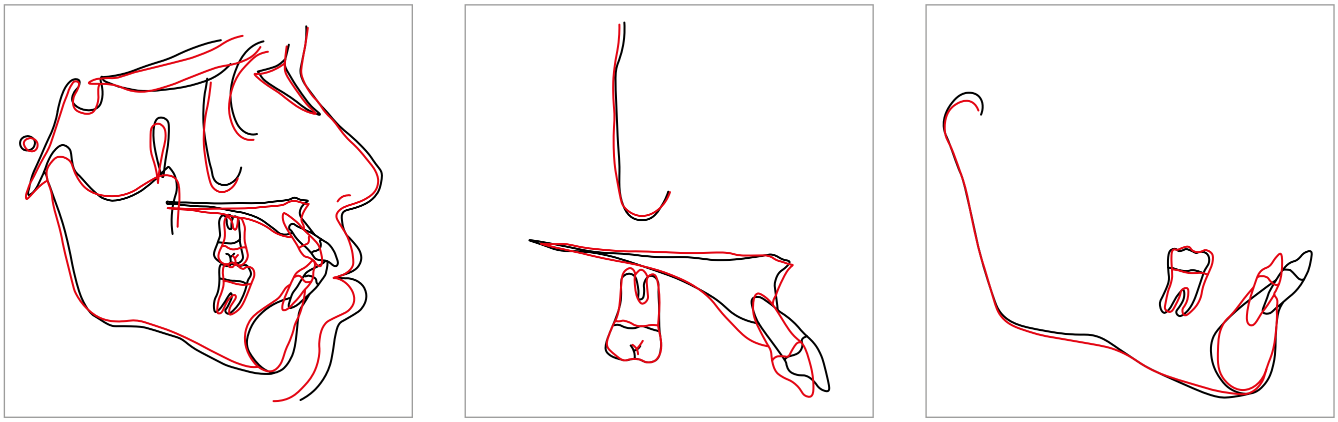


Figure 55 - Cephalometric superimposition of Case 4.

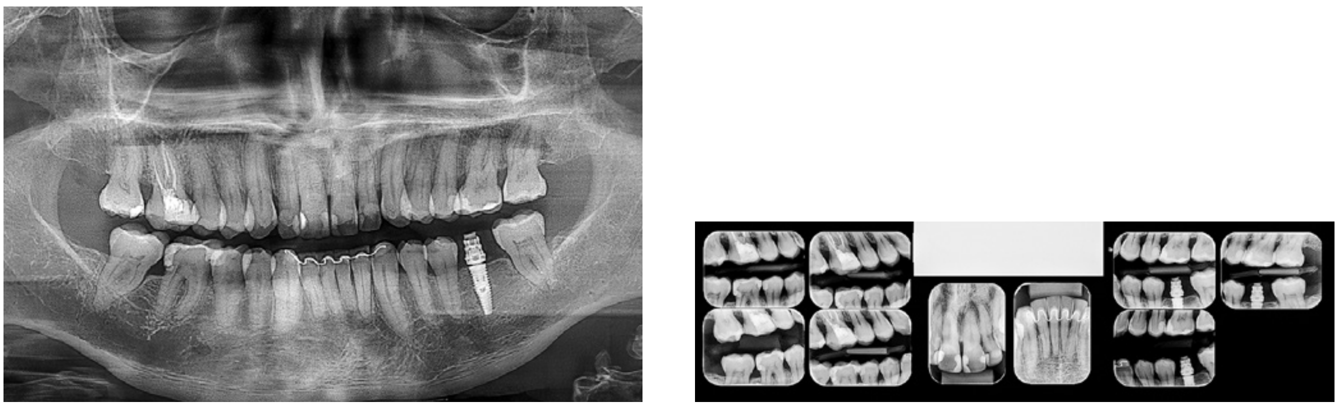


Figure 56 - Final radiographs of Case 4.

During the retention control of this patient, there was a great need for speech therapy, due to the atypical tongue posture during rest and speech. It is important to note that, in patients with loss of periodontal support, speech-language disorders can be critical to the stability of treatment and should always be evaluated. The joint performance of Speech Therapy and Periodontics provides these patients with the benefit of interaction between shape and function, since the maladjustments of the static and dynamic structures generate compensations in the performance of oral functions,[47] which should then be normalized after orthodontic correction. Orthodontic treatment will reestablish a stable position of bones and teeth, to achieve the balance of these structures, while speech therapy directly meets the functional demands resulting from this structural imbalance, interfering with the dynamic structures, thus restoring the functions of the stomatognathic system[47,48] and contributing to the stability, since it will adapt the active and passive functions affected by periodontal disease, which should be adjusted to the new positions achieved after orthodontic treatment. In this patient, speech therapy was performed for eight months, until the articulation of phonemes and the tongue posture at rest were readjusted to the new occlusal arrangement, without generating undesirable forces on the dental structures.

CONCLUSION

Orthodontic treatment in patients with vertical alveolar bone loss and history of periodontal disease should be planned according to the individual characteristics of each patient, such as: insertion level of teeth that need to be moved; patient's oral hygiene; control obtained from periodontal disease; numbers of missing and/or compromised teeth; and types of pathological migrations present.

However, regardless of the particularities of each case, the sequence of six steps described in the Pyramid of Orthodontic-Periodontal Planning should be used to guide the planning and accomplishment of interdisciplinary treatment focused on malocclusions and the needs of patients with a history of periodontitis.

As described in the presented cases, the levels of the pyramid must be staged and individualized for each patient:

1) Achievement of periodontal health: this should always be the first step. However, the duration of this treatment, the need for periodontal surgery or not, and the frequency of periodontal maintenance depend on each case and will be defined by the periodontist. It should be noted that the frequency of periodontal maintenance can be changed during orthodontic treatment, especially during intrusion movements. Ideally, the periodontist should send a report indicating the date of the next follow-up appointment, so that the treatment may be safely conducted, dividing the responsibilities.

2) Anchorage planning: anchorage is critical in the movement of teeth with insertion loss. It should be checked whether the bone levels of posterior teeth allow their use as anchorage units or not. If not, the use of direct or indirect anchorage with TADs may be indicated. If there is severe bone loss in posterior teeth, the tendency to extrusion and anchorage loss will increase.

3) Biomechanical planning: with the loss of alveolar insertion, there is apical displacement of the CRes, which induces an increase in the tendency of uncontrolled inclinations in the accomplishment of orthodontic movements. Therefore, orthodontic forces must be reduced, proportionally to the severity of bone loss.

4) Planning the intrusion movement: this is a very frequent movement in these patients due to pathological migrations. However, it must be planned so that the force falls close to the CRes of the tooth or group of teeth to be moved.

5) Black triangles: they are also frequent in these patients, due to vertical alveolar bone loss. Usually, they become even more apparent after intrusion movements. The possibilities and limitations of correction must be presented and discussed with the patient during planning.

6) Retention: due to bone loss, the stability of results is critical. To maintain long-term results, it is essential to splint the anterior teeth with fixed retainers (sometimes even premolars), identify whether there is a need to install interocclusal plates (in cases of possible parafunctions), speech therapy treatment and follow-up, and maintain routine periodontal and orthodontic consultations.

The realignment of teeth associated with the correction of traumatic occlusion facilitates the patient's oral hygiene and increases the chances of maintaining the health of the supporting periodontium, even if reduced. It is widely demonstrated by the literature that patients with periodontitis must be monitored and controlled by the periodontist for life. However, after orthodontic-periodontal treatment, regular control by the orthodontist also becomes essential to maintain the occlusion of this patient, since changes in the periodontal health condition may occur, with possible additional bone and dental losses. Therefore, the orthodontist will contribute to the periodontist to maintain the patients' periodontal and occlusal balance, despite the countless potential changes that may occur.

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- GUIDELINES FOR DPJO CASE REPORTS

— Case reports are published on a regular basis in the DPJO. In order to standardize the clinical cases presented the authors should follow the protocol described below unless, for a very particular reason, the items below cannot be followed. The authors should try to be objective in their report, which will be judge by the uniqueness of the case, quality of the records and knowledge contributed to the clinicians.

Abstract

— The abstract should be structured following a one or two sentences description of a brief introduction and aim of the manuscript, treatment objectives, results and conclusion.

Introduction

— This section should be brief. The author must introduce the reader to the problem that is illustrated by the case report. This section should consist of one to three paragraphs, and it should begin with a general description of the problem to be illustrated, have a brief description of the literature and should end with a sentence that leads the reader into the purpose of the report.

Diagnosis and etiology

— The author should describe the dental and skeletal diagnosis. It is important to focus on the uniqueness or abnormality of the case and not on the normal findings. Anamnesis information, etiology of the malloclusion and any other information that would interfere with the treatment plan should be described. Preteatment radiographs and complete records are needed (models should be used if the intraoral radiographs can't portrait the clinical case and authors may be asked to submit pictures of the dental casts at the discretion of the editor). The author should refer to specific cephalometric measurements if necessary, and refer the reader to radiographs and photographs.

Treatment objectives

— The list of problems itemized in the diagnosis and etiology section should match a list of specific treatment objectives to solve each of these problems. The treatment objectives should include references to the maxilla, mandible, maxillary dentition, mandibular dentition, occlusion, and facial esthetics. The objectives should include goals for those.

Treatment alternatives

— The author must refer to all possible and reasonable treatment plans and describe the advantages and disadvantages of each alternative. The alternative chosen should be also described.

Treatment progress

— The author must describe the treatment for the patient thoroughly. Types of appliances, prescription, length of treatment, interaction with other aspects of dentistry, and special decisions that were made during treatment should be included.

Treatment results

— In this section the author should describe the results of orthodontic treatment. Final records must be presented in the same manner initial records were presented. In growing patients, total and partial superimposition are needed (Björk's method is suggested), while only a total superimposition for non-growing patients. It is important that the objectives and aim of the clinical case presentation are supported by the results. Conventional cephalometric measurements should be used, along with any specific measurement as long as they pertain to the objective of the clinical cases. It is suggested that the cephalometrics taken per each phase should not exceed 15 measurements

Discussion

— This section must discuss the uniqueness of this case report unique, how they relate to the decisions made by the author, and finally, how the treatment relates to the published literature on the topic. The discussion must contain references to the literature. The discussion should focus on the points that made the case report or the treatment of the patient unique. Each point is discussed in a separate paragraph with reference to the patient's treatment and the appropriate literature.

Summary and conclusions

— The author should write one paragraph that summarizes what was learned from this specific case

References

— The format for this section is the same as that found in scientific articles of the DPJO

1. Registration of clinical trials

Clinical trials are among the best evidence for clinical decision making. To be considered a clinical trial a research project must involve patients and be prospective. Such patients must be subjected to clinical or drug intervention with the purpose of comparing cause and effect between the groups under study and, potentially, the intervention should somehow exert an impact on the health of those involved.

According to the World Health Organization (WHO), clinical trials and randomized controlled clinical trials should be reported and registered in advance.

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results, since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and 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 existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of 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 the best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, registered clinical trials will be forwarded to those recommended by WHO.

WHO proposes that as a minimum requirement the following information be registered for each trial. A unique identification number, date of trial registration, secondary identities, sources of funding and material support, the main sponsor, other sponsors, contact for public queries, contact for scientific queries, public title of the study, scientific title, countries of recruitment, health problems studied, interventions, inclusion and exclusion criteria, study type, date of the first volunteer recruitment, sample size goal, recruitment status and primary and secondary result measurements.

Currently, the Network of Collaborating Registers is organized in three categories:

» Primary Registers: Comply with the minimum requirements and contribute to the portal;

» Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;

» Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

3. Dental Press Journal of Orthodontics - Statement and Notice

DENTAL PRESS JOURNAL OF ORTHODONTICS endorses the policies for clinical trial registration enforced by the World Health Organization - WHO (http://www.who.int/ictrp/en/) and the International Committee of Medical Journal Editors - ICMJE (# http://www.wame.org/wamestmt.htm#trialreg and http://www.icmje.org/clin_trialup.htm), recognizing the importance of these initiatives for the registration and international dissemination of information on international clinical trials on an open access basis. Thus, following the guidelines laid down by BIREME / PAHO / WHO for indexing journals in LILACS and SciELO, DENTAL PRESS JOURNAL OF ORTHODONTICS will only accept for publication articles on clinical research that have received an identification number from one of the Clinical Trial Registers, validated according to the criteria established by WHO and ICMJE, whose addresses are available at the ICMJE website http://www.icmje.org/about-icmje/faqs/clinical-trials-registration/. The identification number must be informed at the end of the abstract.

Consequently, authors are hereby recommended to register their clinical trials prior to trial implementation.

Yours sincerely,

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Nature and severity of dental malocclusion in children suffering from transfusion-dependent β-thalassemia major

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DOI: *https://doi.org/10.1590/2177-6709.25.6.26.e1-9.onl*

Objective: To evaluate the prevalence and severity of malocclusion in children suffering from β-thalassemia and to assess orthodontic treatment need using Grainger's Treatment Priority Index (TPI) and index of orthodontic treatment need (IOTN)-dental health component (DHC).

Methods: A cross-sectional study was conducted on 200 transfusion-dependent children diagnosed with homozygous β-thalassemia and 200 healthy school children aged 11-17 years. The TPI and IOTN-DHC data was recorded for both groups. Total TPI score for each subject was calculated and graded according to malocclusion severity estimate (MSE). Independent sample *t*-test was used to compare mean TPI scores, overjet and overbite between thalassemic and healthy children. Chi-square test was used to compare the frequency of IOTN-DHC grades, Angle's classification, and MSE grades between thalassemic and healthy children.

Results: The most prevalent malocclusion was Class I in normal children (67.5%) and Class II in thalassemic children (59%). The mean overjet and overbite were significantly ($p<0.001$) greater in thalassemic children than in healthy children. Severe tooth displacements were 3.5 times greater in thalassemic children, compared to controls. A greater proportion of thalassemic children were in IOTN grades 3 and 4, compared to the controls ($p<0.001$). MSE grades 4 and 5 were significantly ($p<0.001$) more prevalent in thalassemic children, compared to the controls.

Conclusion: There is a high prevalence of Angle's Class II malocclusion in thalassemic children. Majority of these children are categorized in higher grades of IOTN-DHC and TPI-MSE, showing a great severity of malocclusion and high orthodontic treatment needs.

Keywords: Thalassemia. Beta-thalassemia. Index of orthodontic treatment need. Malocclusion.

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INTRODUCTION

Thalassemia is one of the commonest types of hemoglobinopathies resulting from decreased synthesis of different types of polypeptide chains constituting normal adult hemoglobin molecule (HbA, $\alpha2\ \beta2$).[1] β -thalassemia is one of the severest forms of this disease, resulting from mutations in the HBB gene on chromosome 11, which ultimately leads to partial or completely nonfunctional formation of β-globin chain. Depending on the severity and type of genetic mutations, β-thalassemias may be divided into β-thalassemia major, intermedia and minor.[2]

With a global prevalence of about 1.5%, the *per annum* incidence of β-thalassemia has been recorded to be 1 in 100,000 worldwide.[3] Children suffering from β-thalassemia major comprise the most affected group and usually need regular blood transfusions. According to one estimate, about 5,000-9,000 transfusion-dependent β-thalassemia children are born every year in Pakistan.[4] According to World Health Organization (WHO), Pakistan has the largest numbers of thalassemia major children in the world, a majority of which do not have access to the proper health facilities.[5]

In a β-thalassemia afflicted child, the diagnostic signs and symptoms start to become eminent within the first two years of life. The common clinical manifestations of β-thalassemia major usually originate from a severe form of chronic anemia associated with cardiac complications and hepatic pathologies.[6,7] A striking abdominal enlargement by the virtue of enlarged spleen and liver is frequently observed.[7] Moreover, extramedullary hematopoiesis and rapid cell turnover with consequential bone marrow expansion is a prominent feature. As a complication of iron overload, stunted growth as well as skeletal deformities with resultant osteoporosis and pathologic fractures are common.[8]

Regarding the pathognomonic orofacial features, the predominant ones include characteristic "Cooley's facies", marked by prominent frontal and parietal bones, saddle nose, protruded zygomas and epicanthic fold.[9] The common dental features include Class II malocclusion, spacing, flaring and protrusions of maxillary anterior teeth and increased overjet.[9,10] Other pathological signs such as dental caries and discolorations and xerostomia are also frequently reported.[11,12]

In order to deal with various dental conditions, a conservative treatment approach is preferred; while for the correction of various orthodontic dentofacial deformities and malocclusion, specialized interventions —such as the use of different orthodontic appliances (fixed , removable, functional, extraoral appliances) and, in advanced cases, surgical approach— is required.[13,14] Considered a "global health burden" this issue has been neglected due to its expensive and long term treatment requirements.[15] Furthermore, there are no comprehensive guidelines given by the Thalassemia International Foundation for management of oral health complications in such patients.[16]

Therefore, it is of paramount importance to assess the prevalence and orthodontic treatment needs in this particular lot of population, so that a generalized opinion may be formulated regarding the severity of malocclusion, burden of disease and required expertise and resources. Hence, the primary objective of this study was to evaluate the prevalence of different malocclusion characteristics in the children suffering from β -thalassemia and to assess the orthodontic treatment needs using Grainger's Treatment Priority Index (TPI)[17] and index of orthodontic treatment need (IOTN) - dental health component (DHC).[18]

MATERIAL AND METHODS

A cross-sectional study was conducted at the department of orthodontics, Bakhtawar Amin Medical and Dental College in collaboration with Sundas Foundation. Ethical approval was obtained from the Institutional Research Board, Bakhtawar Amin Dental College and Hospital, Multan (protocol #309/2020), prior to the data collection.

Sample selection

A total of two-hundred transfusion-dependent children suffering from β-thalassemia major registered with Blood Bank and Hematological Services Charitable Organization were included in the study. A non-probability consecutive sampling technique was employed.

The inclusion criteria comprised of subjects diagnosed with homozygous β-thalassemia, within the age range of 11 to 17 years, receiving regular blood transfusions. Children in mixed dentition period, or those having history of any previous orthodontic treatment or any type of chronic disease or growth retardation were excluded from the study.

For the control group, a sample of 200 healthy school children, matched according to age and gender, were selected from four different schools, using stratified sampling technique, and the TPI and IOTN-DHC data was recorded. The same exclusion criteria were followed for the controls as was for the study group.

Data collection

For the evaluation of TPI and IOTN-DHC, the main investigator was trained and the intraoral examination of all the patients, in cases and control categories, was performed by the same examiner. The data collection form recorded the patient's demographic details, IOTN-DHC grade and various parameters of TPI. The assessment of TPI parameters was carried out as follows:

» Bilateral first molar relationship depicts sagittal relation between the maxillary and mandibular first molars, and is considered normal if the mesiobuccal cusp of maxillary first molar occludes in the buccal groove of mandibular first molar. First molar relationship is defined by a constant in TPI that reflects the severity of malocclusion.

» Overjet was measured as the horizontal distance from the labial surface of the most prominent maxillary central incisor to the labial surface of mandibular central incisor, parallel to the occlusal plane.

» Overbite was measured as the amount of vertical overlap on the mandibular central incisor by the maxillary central incisor, considering the extent of coverage of crown height of mandibular central incisor. A negative overbite depicted no overlap between maxillary and mandibular incisors, and was denoted as open bite. Open bite was measured as the vertical distance between maxillary and mandibular incisors.

» Tooth displacement: was assessed as the number of teeth noticeably rotated or displaced from ideal alignment, and posterior teeth rotated above 45° or anterior teeth displaced greater than 2 mm were given double weightage.

» Crossbite is a buccal or lingual displacement of the posterior teeth, deviating from normal cusp-fossa relationship. During TPI assessment, the number of teeth in buccal or lingual crossbite was assessed and were given respective weightages, as shown in Table 1.

In addition to these parameters, patients were examined for congenitally missing incisors and other intraoral defects. The findings of TPI were recorded and a total TPI score was computed for each subject using the Table 1. The total TPI score for each subject was calculated and graded according to the Malocclusion Severity Estimate (MSE), as given below.

I. Virtually classic normal occlusion: TPI score <1.
II. Minor manifestations of malocclusion and treatment need is slight: TPI score from 1 to 3.99
III. Definite malocclusion, but treatment elective: TPI score from 4 to 6.99
IV. Severe handicap, treatment highly desirable: TPI score from 7 to 9.99
V. Very severe handicap with treatment mandatory: TPI score >10.

Reliability of measurements

The TPI scores and IOTN-DHC for the 30 patients were re-graded after one month to assess intraexaminer reliability. Intraclass correlation coefficients were performed for TPI, which showed a correlation coefficient of 0.89. The Kappa statistics were applied for IOTN-DHC, which showed a high coefficient of reliability (0.957). Thus, both assessments were found to have good intraexaminer reliability.

Statistical analysis

Independent sample *t*-test was used to compare the linear variables —like TPI scores, overjet and overbite— between the cases and controls. Chi-square test was used to compare the frequency of IOTN-DHC grades, Angle's classification and other categorical variables, between cases and controls. A value of $p<0.05$ was taken as statistically significant.

RESULTS

A total of 121 male and 79 female adolescents were included in the study group, while 107 males and 93 females were included in the control group. There was no statistically significant difference ($p=0.189$) in the gender distribution between the two groups. The mean ages of children in the study and control groups were 13.89 ± 1.79 and 14.1 ± 2.07 years, respectively. There was no statistically significant difference ($p=0.258$) in the mean ages of the children belonging to both the groups.

The frequency of children with Angle's Class I malocclusion in thalassemic children was far less than that in normal children (38% *vs.* 67.5%). On the other hand, the prevalence of Angle's Class II malocclusion was 59% in thalassemic children, as compared to 24.5% in normal children. Table 2 compares the prevalence of Angle's malocclusion between the cases and controls.

A greater proportion of thalassemic children were in IOTN grades 3 and 4, as compared to controls ($p<0.001$). These results were highly significant. The distribution of cases and controls in different IOTN grades is given in Figure 1.

Table 1 - Treatment Priority Index[17].

First Molar Relationship (choose the appropriate column)		(6) Distocclusion: 2 sides full Class II	1 side half Class II 1 side full Class II	2 sides half Class II or 1 side full Class II	1 side half Class II	NEUTRAL	(7) Mesiocclusion: 1 side half Class III	2 sides half Class III or 1 side full Class III	1 side half Class III 1 side full Class III	2 sides full Class III	WEIGHT	Type of Syndrome
Incisor Horizontal Relationship in mm												
(1) Upper Overjet	>9	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0		Retrognathism
	9	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4		
	8	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0		
	7	0.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	0.6		
	6	0.4	0.6	1.0	1.7	2.9	1.7	1.0	0.6	0.4		
	5	0.2	0.3	0.4	0.8	1.3	0.8	0.4	0.3	0.2		
NORMAL (Counting 0)												
(2) Lower Overjet	1	0.2	0.3	0.4	0.8	1.3	0.8	0.4	0.3	0.2		Prognathism
	0	0.4	0.6	1.0	1.7	2.9	1.7	1.0	0.6	0.4		
	1	0.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	0.6		
	2	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0		
	3	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4		
	>3	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0		
Incisor Vertical Relationship												
(3) Overbite in relation to crown thirds	>3/3	2.9	3.8	4.8	6.2	8.0	6.2	4.8	3.8	2.9		Overbite
	3/3 to ⅔	1.5	2.0	2.4	3.2	4.1	3.2	2.4	2.0	1.5		
	⅔ to ⅓	0.5	0.7	0.9	1.1	1.5	1.1	0.9	0.7	0.5		
NORMAL (Counting 0)												
(4) Open bite in mm	<2	1.5	2.0	2.4	3.2	4.1	3.2	2.4	2.0	1.5		Open bite
	2 to 4	2.9	3.8	4.8	6.2	8.0	6.2	4.8	3.8	2.9		
	>4	4.9	6.3	7.9	10+	10+	10+	7.9	6.3	4.9		
(10) Teeth displacement	No.											
• Sum of teeth rotated 45º or 2mm displaced • Sum of teeth rotated >45º or >2mm displaced x2 • Total (0,1 without counting)	2	0.1	0.1	0.2	0.3	0.4	0.3	0.2	0.1	0.1		**Distocclusion and/or posterior buccal crossbite** May be: YES: - maxilla - expansion - Brodie syndrome NO: - maxilla - collapse - posterior crossbite
	3	0.2	0.3	0.4	0.7	1.1	0.7	0.4	0.3	0.2		
	4	0.3	0.5	0.9	1.2	1.9	1.2	0.9	0.5	0.3		
	5	0.5	0.8	1.2	1.9	3.0	1.9	1.2	0.8	0.5		
	6	0.7	1.1	1.8	2.8	4.3	2.8	1.8	1.1	0.7		
	7	1.0	1.5	2.4	3.9	5.9	3.9	2.4	1.5	1.0		
	8	1.3	19	3.1	4.9	7.7	4.9	3.1	19	1.3		
	9	1.7	2.5	4.1	6.2	9.7	6.2	4.1	2.5	1.7		
	>9	2.0	3.0	4.9	7.7	10+	7.7	4.9	3.0	2.0		
Constants		5.17	3.95	2.72	1.50	0.27	1.50	2.72	3.95	5.17		

(8) Sum of teeth in posterior crossbite												
Buccal upper posterior teeth	No.	0	1	2	3	4	5	6	7	8	More
	Weight	0	0.1	0.6	1.3	2.2	3.5	5.0	6.9	9.0	10
Lingual upper posterior teeth	No.	0	1	2	3	4	5	6	More		
	Weight	0	0.3	1.0	2.3	4.2	6.5	9.4	10		

Score sum is the Treatment Priority Index (TPI)

There were significant differences ($p<0.001$) in the mean overjet and overbite between the cases and controls (Table 3). Moreover, the prevalence of mild tooth displacements (rotation up to 45 degree or displacement up to 2mm) and severe tooth displacements (rotation >45 degree or displacement >2mm) were 1.8 times and 3.5 times greater in the cases, as compared to the controls, respectively.

According to TPI, majority of thalassemic children had MSE grade 4 and 5 malocclusion, as compared to grade 2 and 3 in controls. Severe forms of malocclusions were significantly ($p<0.001$) more prevalent in thalassemic children, as compared to the controls (Fig. 2). The mean TPI score for thalassemic children was 8.55±4.13, which was significantly higher ($p<0.001$) than that in normal children, which was recorded as 4.09±3.27.

Table 2 - Comparison of Angle's classification between cases and controls.

Angle's classification of molar relationship	Thalassemic children (n=200)	Healthy controls (n=200)	Total	*p* value
Class I	76	135	173	
Class II	118	49	108	<0.001
Class III	6	16	19	

Table 3 - Comparison of different occlusal parameters between cases and the controls.

	Thalassemic children n=200	Healthy controls n=200	Mean difference	*p* value
Overjet (mm)	4.17 ± 2.64	2.90 ± 2.31	1.27	<0.001*
Overbite (mm)	4.18 ± 2.88	3.14 ± 1.91	1.04	<0.001*
Teeth mildly displaced	4.37 ± 3.10	2.49 ± 2.05	1.88	<0.001**
Teeth severely displaced	2.09 ± 2.64	0.59 ± 0.95	1.50	<0.001**
Number of patients with buccal/lingual crossbite	20	8	6%	0.079**

* Independent sample t-test. ** Chi-square test.

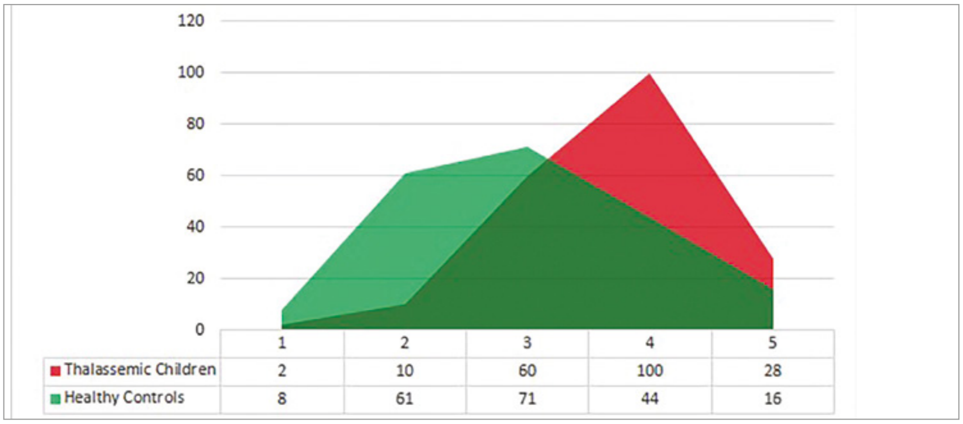

Figure 1 - Distribution of cases and controls into five grades of IOTN-DHC.

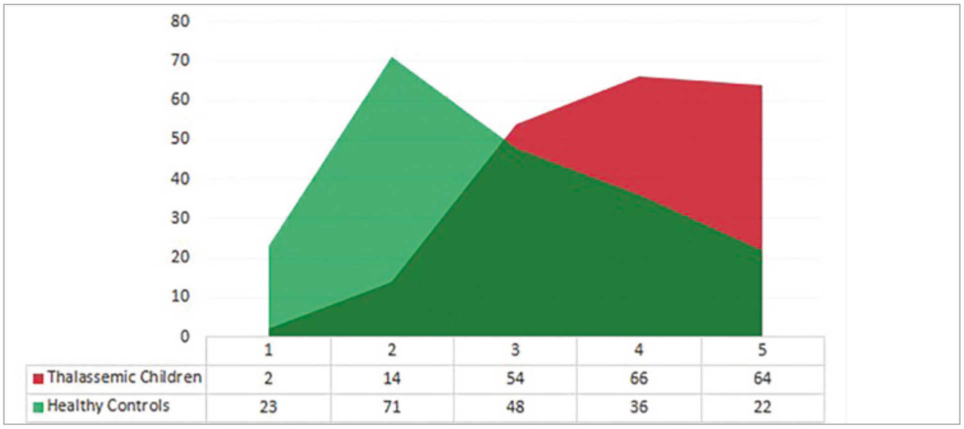

Figure 2 - Distribution of cases and controls into TPI grades of MSE.

DISCUSSION

Patients suffering from β-thalassemia major usually become dependent on regular blood transfusions early in life. However, the dental features become noticeable when the permanent teeth start to erupt and child enters puberty. So, patients aged 11-17 years were included in this study, which also marks the time when orthodontic treatment is usually sought.

There are several indices to evaluate the severity of malocclusion, such as American Board of Orthodontics Discrepancy Index (ABO-DI), Summer's Occlusal Index, and Grainger's TPI. ABO-DI requires cephalometric assessment along with the clinical examination, which makes it impractical to apply for patient when no actual treatment is being provided. On the other hand, occlusal index is relatively complicated and requires more clinical time, as compared to TPI.[19] Thus, we used Grainger's TPI, which is not only reproducible and valid, but has also proven to be a useful tool for epidemiological assessment of malocclusion.[20,21]

In the present study, the subjects with thalassemia were found to have greater prevalence of skeletal Class II, increased overjet and both mild and severe tooth displacements, as compared to the controls. In the extraoral aspect, these children had a tendency towards convex facial profile due to maxillary prognathism and incompetent lips. The typical extraoral and intraoral clinical features of transfusion-dependent children with β-thalassemia are shown in Figures 3 and 4. Enlarged maxillary bone marrow due to extracellular haematopoiesis and lack of oral hygiene awareness may well have contributed to the aforementioned malocclusion. The statistics from the current and previous studies reveal that thalassemic patients consistently have greater prevalence of Angle's Class II malocclusion, reported to be 55% by Gupta et al,[22] and 51% by Shahsevari et al,[23] as compared to 59% in the current study.

Figure 3 - Patient presenting convex facial profile with incompetent lips. Note fractured edge of maxillary right central incisor, which is not an uncommon finding in patients with excessive proclination of maxillary incisors.

The statistics also reveal that around 84% and 65% of the thalassemic patients lie in the IOTN moderate to severe treatment need groups, and MSE handicapping and severely handicapping malocclusion groups, respectively. Thus about two-thirds to three-fourths of transfusion-dependent thalassemic children required definitive orthodontic treatment. Gupta et al[22] used Grainger's TPI and found that 68% of their thalassemic sample had definitive to severely handicapping malocclusion. The current study reports that 29% of healthy children had handicapping to severely handicapping malocclusion. The reported percentage of healthy school children needing definitive orthodontic treatment ranges from 18 to 26 percent in other studies, which is similar to the present findings.[22,24,25]

The similarities between the present results and those of Gupta et al[22] are remarkable. This might be due to similar selection criteria and subcontinental origin of the sample. Majority of the thalassemic patients in the world are located in South Asian countries like India, Pakistan and Bangladesh.[26] According to one estimate, about 10 million individuals in Pakistan suffer from thalassemia minor, while more than 50,000 have thalassemia major.[27,28] Most of these patients are being treated by nongovernmental organizations, which have limited resources. The sample of thalassemic children in the current study was also collected from transfusion centers run by one of such organizations. A single center study reports that the treatment provided at these centers is not optimum, and majority of the thalassemic children are under-transfused.[29] This might explain greater severity of malocclusion in the present sample, as compared to that reported in literature for other population groups.[22,23]

As the dental and orthodontic complications are not life threatening, they are likely to be ignored by the affected individual and the medical specialists. As a conse-

Figure 4 - A typical female patient showing features of skeletal Class II malocclusion due to maxillary prognathism, Class II division 1 malocclusion with proclined incisors and an increased overjet.

quence, these problems tend to worsen over time. A preventive and interceptive orthodontic treatment approach is required in these patients, to reduce the likelihood of trauma, to improve stomatognathic function and the facial appearance.[30] In the present sample, the age at first transfusion ranged from 6 months to 6 years. Hakeem et al[31] have shown that starting transfusions in older age is a protective factor against poor quality of life. Authors recommend that the relationship between the severity of malocclusion in these children and the age of starting transfusions should be assessed on a larger sample.

Effective orthodontic treatment interventions usually comprise of high-pull headgear and functional appliances, to restrict maxillary sagittal and vertical growth, as well as to enhance mandibular growth. As these patients usually have to undergo regular blood transfusions, hence orthognathic surgeries need to be avoided if possible.[32] Thus, early intervention, interceptive treatment and growth modifications are usually the treatment of choice in these patients.[30,32]

The dental and orthodontic treatment modalities may significantly contribute to the generalized well-being and improved quality of life in these patients. Based on the staggering findings of the current study, it is recommended to have continuous orthodontic supervision for transfusion-dependent thalassemic children, similar to those for the patients with craniofacial syndrome and cleft lip and palate.

CONCLUSION

Majority of thalassemic children suffer from Class II malocclusion; in contrast to normal children, who most commonly have Class I malocclusion. The IOTN-DHC grades and TPI-MSE depict that the malocclusion in thalassemic children is much more severe and handicapping. Since the life expectancy of these children has improved over the last few decades, more expertise and resources need to be allocated to cater the orthodontic treatment needs of these children.

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Conception or design of the study: WJ, US, MA. Data acquisition, analysis or interpretation: WJ, US, MA. Writing the article: WJ, US, MA. Critical revision of the article: WJ, US, MA. Final approval of the article: WJ, US, MA. Overall responsibility: WJ, US, MA.

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