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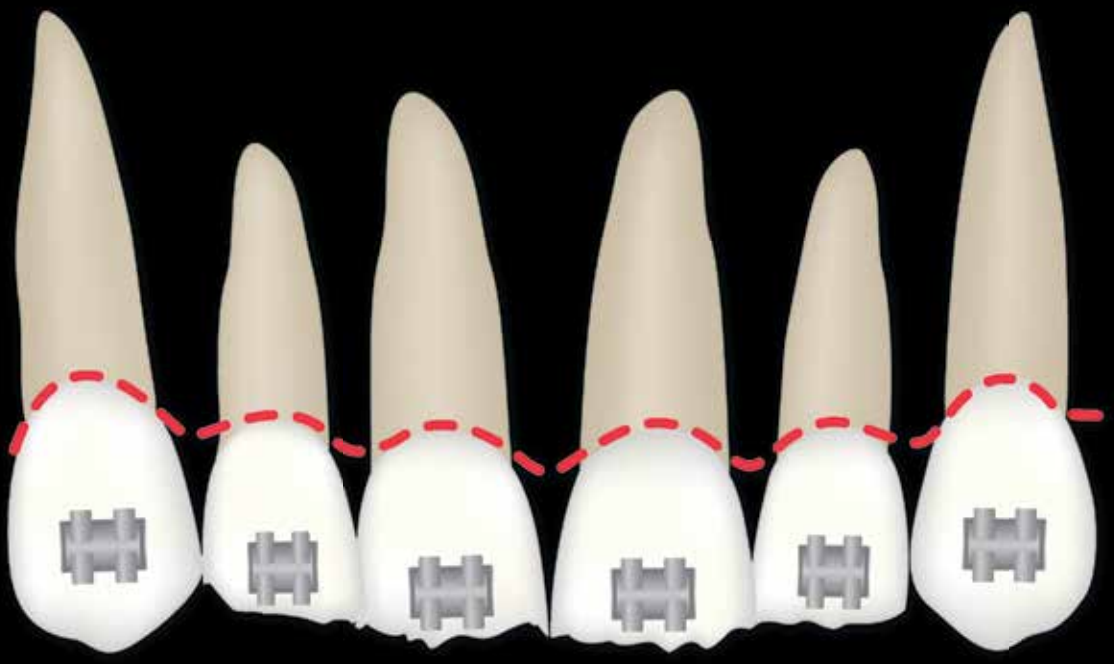

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Contents

Esthetics and human perception

"Beautiful is what pleases unselfishly, without being originated by or remissible to a concept."
Humberto Eco

Esthetics, from Greek *aisthesis*, means perception, sensation. It is a philosophical reflection on beauty. In health sciences, the construction of meanings and values about body esthetics is increasingly present, influencing the identity construction of the individual and the perception that this one has about himself and what he understands as health.

In orthodontics, the patient's seek for perfection is growing steadily in recent years. This increase has led orthodontists to search for new knowledge in other areas of dentistry and also in other health areas. This growing interest is strongly driven by consumption boosted by images generated by the great appeal of the media, where models with "perfect" and "white" smiles are presented to the public. It is clear, and concerning, that this appeal seems to induce the orthodontists to think as "layman", making us forget that we are, in first place, healthcare professionals.

The senses socially used to understand the care with what is considered healthy have been suffering strong influence of esthetic parameters that are apparently outside the field of health sciences. It is unquestionable that the esthetic rehabilitation of the patient is one of the primary objectives of orthodontic treatment; however, it cannot be the only focus. Just like it is impossible to understand the concept of health, and the care it imposes on contemporary urban society, without taking into account fashion, seduction, the spectacle and consumption. However, the appeal of esthetics-based "marketing", in its essence, has led many to think that way and make decisions based solely on the anxiety and pressure of this market, without considering the expectations of the patient.

The fragmentation of our professional view, due to the appeal of the media and the market together, often encourages us to induce the patient to treat problems that he had never realized he had, regarding both the esthetics of the smile and face. Explaining all treatment possibilities, including plausible esthetic improvements, is one of our obligations, but this approach must be made using common sense and without impositions, because understanding that patients think in a diverse, individual and subjective way must be the premise of a cordial, honest and ethical relationship. Otherwise, the feeling is as if we were only dictators of an esthetic need, instead of spectators and connoisseurs of the needs of our patients.

The variability of esthetic perception is related to the educational, cultural and socioeconomic background, besides the emotional formatting of each individual. It is not easy to understand it. In orthodontics, it is not enough just to understand what affects the smile, it is necessary to diagnose what is outside the normal range, so we can establish a treatment plan. Just as in the functional problems we follow protocols which lead us to diagnose anomalies, the esthetic problems also require parameters so we can find the defects.[1] In this context, the scientific research on the criteria used by orthodontists and patients to define a smile or a face as esthetically pleasing could build a solid stairway to understanding the differences between professional's perception and patient's perception. This issue of Dental Press Journal of Orthodontics, composed by articles that evaluate esthetics concepts in orthodontics, pretend to be one of these steps. Let's take it...

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REFERENCES

1. Câmara CA. Aesthetics in Orthodontics: six horizontal smile lines. Dental Press J Orthod. 2010 Jan-Feb;15(1):118-31.

Matheus Melo Pithon[1]

PARAMETERS USED FOR REFERRING PATIENTS FOR ORTHOGNATHIC SURGERY

During the course of decades, orthodontics was based on linear and angular static measurements to define the orthodontic treatment plan. Nowadays, a great deal of attention has been paid to facial analysis. In line with this trend, an interesting article[1] was published, in which the proposal was to verify whether it was necessary or not to refer Class II, division 1 patients for orthognathic surgery, based on observation of the face in lateral view. The conclusions drawn from this study were that the displacement of the soft tissues of the pogonium and point B in the posterior direction and the diminished facial profile angle were decisive factors for orthodontists to indicate these patients for orthognathic surgery. These results suggested that in the presence of cases with limitations it is always important to take a profile photograph of the patient and show it to the patient, so that he/she can evaluate his/her face and together with the orthodontist, define whether or not it would be convenient to undergo surgical treatment.

SELF-ETCHING AGENTS PRODUCE FEWER CHANGES IN ENAMEL COLOR AFTER DEBONDING

When bonding orthodontic accessories, a constant concern is whether this bonding will or will not change the color of the enamel on the conclusion of orthodontic treatment. There are various materials and techniques used for tooth enamel conditioning before bonding orthodontic accessories. In a recent study[2] Egyptian researchers performed an evaluation of whether or not the different methods and materials would alter enamel color after debonding, in addition to verifying the degree of penetration of bonding materials into enamel. The results found showed that self-etching agents presented lower levels of penetration and coloring of enamel after debonding, whereas etching with 37% phosphoric acid for 60 seconds presented the highest level of coloring and infiltration, and showed differences when compared with the same phosphoric acid for a period of 15 seconds. These findings add further advantages to the use of self-etching agents, which are outstanding for their practicality and the possibility of performing bonding in a humid environment.

PATIENTS ARE THE PRINCIPAL RESPONSIBLE FOR THE APPEARANCE OF WHITE STAINS

In spite of the many advancements achieved by orthodontics over the last few years, decalcifications and white stain lesions continue to be frequent problems in orthodontic dental offices. The growing trend to replace banding of teeth by bonding associated with the use of fluoride-releasing bonding materials has certainly reduced the appearance of these lesions, however, there is still a great deal to be done. While giving some thought to this problem, researchers at the Universities of Jordan and Virginia in the USA[3] decided to verify, by means of questions put to patients and their parents, orthodontists and general clinicians, about who would be the responsible for the appearance of white stains, what would be the methods to prevent them, and who should treat them. All the groups evaluated were unanimous that white stain lesions depreciate the orthodontic patient's general appearance,

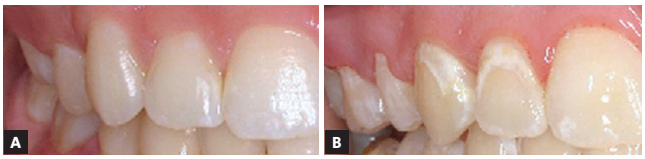

Figure 1 - Intraoral photographs of two patients after orthodontic treatment: **A**) teeth with no white stain lesions, **B**) teeth with white stain lesions (Source: Maxfield et al.[3], 2012).

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and that the patient is the principal responsible for the appearance and prevention of these lesions. These results bring us some relief, but does not exonerate us from our responsibility towards these patients.

EXTRACTION OF MANDIBULAR INCISOR AFFECTS ESTHETICS WHEN SMILING

One of the options widely disseminated in the literature for the treatment of anterior mandibular crowding is the extraction of a mandibular incisor. In spite of being an extensively practiced procedure, a persistent question arises: How acceptable will this treatment method be to the patient? With the intention of elucidating this doubt, Brazilian researchers,[4] using photographs with changes made by means of an image edition software, created images in which the mandibular incisor had been extracted. The results found showed that when there are other options available, the option to extract mandibular incisors should be discarded, due to the esthetic impairment caused and perceived by the evaluated groups.

Figure 2 - Modified images assessment. Image 1: **A**) With four incisors; **B**) without any alteration as regards the width of the three remaining incisors.; **C**) with increase in the three mandibular incisors with the same proportion; **D**) with a mesiodistal increase in the central incisor and no alteration in the lateral incisors; **E**) image with a mesiodistal increase in the lateral incisors and the central without any alteration. Image 2: **E**) image with a mesiodistal increase in the lateral incisors and the central without any alteration; **D**) with a mesiodistal increase in the central incisor and no alteration in the lateral incisors; **C**) with increase in the three mandibular incisors with the same proportion; **B**) without any alteration as regards the width of the three remaining incisors; **A**) with four incisors (Source: Pithon et al.[4], 2012).

TOOTH EXTRACTIONS CHANGE THE LIP VERMILION

Recognized worldwide for her esthetic attributes, Angelina Jolie is outstanding because of her delicate facial lines and full lips. As she is a Hollywood actress her esthetic attributes encourage women all over the world to copy her. In this context, an increasing number of women appear in medical consulting services every day seeking to have lips like those of Angelina Jolie. You may, however, ask, what does orthodontics have to do with lips? It was in an endeavor to explain this relationship that Japanese authors developed a study[5] evaluating the influence of orthodontic treatment with extraction, in cases of bimaxillary protrusion, on lips vermilion. The results showed evidences of the influence of tooth extractions on lip vermilion, which could thereby favor improvements in facial esthetics.

REFERENCES

1. Hodge TM, Boyd PT, Munyombwe T, Littlewood SJ. Orthodontists' perceptions of the need for orthognathic surgery in patients with Class II Division 1 malocclusion based on extraoral examinations. Am J Orthod Dentofacial Orthop. 2012 Jul;142(1):52-9.
2. Zaher AR, Abdalla EM, Abdel Motie MA, Rehman NA, Kassem H, Athanasiou AE. Enamel colour changes after debonding using various bonding systems. J Orthod. 2012 Jun;39(2):82-8.
3. Maxfield BJ, Hamdan AM, Tüfekçi E, Shroff B, Best AM, Lindauer SJ. Development of white spot lesions during orthodontic treatment: perceptions of patients, parents, orthodontists, and general dentists. Am J Orthod Dentofacial Orthop. 2012 Mar;141(3):337-44.
4. Pithon MM, Santos AM, Couto FS, da Silva Coqueiro R, de Freitas LM, de Souza RA, dos Santos RL. Perception of the esthetic impact of mandibular incisor extraction treatment on laypersons, dental professionals, and dental students. Angle Orthod. 2012 Jul;82(4):732-8. Epub 2011 Dec 12.
5. Trisnawaty N, Ioi H, Kitahara T, Suzuki A, Takahashi I. Effects of extraction of four premolars on vermilion height and lip area in patients with bimaxillary protrusion. Eur J Orthod. 2012 May 9. [Epub ahead of print].

Esthetics in Orthodontics: Interest points, reference points and discrepancy points

Carlos Alexandre Câmara[1]

It is fundamental for orthodontists and all professionals related with facial, oral and dental esthetics to know how the individuals observe dentofacial structures. Thus, it will be the purpose of this Orthodontic Insight to present and describe the Interest, Reference and Discrepancy. Points With the knowledge and perception of these points it will be easier for orthodontists to create a convergent canal of communication with their patients.

Keywords: Esthetics. Beauty. Orthodontics.

Esthetics is the rational study of beauty, from the possibility of its definition,to the diversity of emotions and feelings that it raises in man.[1]

This definition, apparently simple, of the meaning of the word Esthetics, which can be found in several dictionaries,[1] hides an extremely broad sense. The study and search of its real meaning in the Western world goes back to the greek philosophers such as Plato, Aristotle and Plotinus. The complexity of the term Esthetics is the result of several philosophical theories that sought a consistent explanation for its meaning. The word Esthetic came to designate the general field of Esthetics, which included all categories for which the artists and thinkers had shown interest, such as Tragic, Sublime, Gracious, Laughable, Humorous etc.; saving the word Beauty for that special type, characterized by harmony, by the sense of measure, by the calm and serene fruition.[2] Esthetic is, then, this kind of reformulation of the entire Philosophy in relation to Beauty. And, considering the complexity of the esthetic field comes the dilemma created by the irrational temptation: Beauty is in the eyes of the beholder or it is intrinsic to the object? Although this question cannot be solved in an easy way, for it is about a philosophical approach that each individual interprets in their own manner, it can and must be assisted on its conception, especially for orthodontists that work with dentofacial esthetics.

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Thus it is important that every professional that deals with orthodontic treatments with esthetical purpose is aware and alert to the parameters that affect the perception of Beauty, the type of beauty that really matters in an orthodontic treatment. Among these parameters there are concepts of esthetic evaluation that are very important for its perception. From these concepts the Interest Points, Reference Points and Discrepancy Points will be presented in this insight. Although the examples presented in this insight are in the sagittal view, the Interest Points, reference and discrepancy are presented in all plans of observation.

INTEREST POINTS

It is fundamental for orthodontists and all professionals that are involved with facial, buccal and dental esthetics to know how people observe a face. By tradition the clinician uses his own experience and empathy to predict what the observer can or must extract from a facial analysis, but he does not always obtain the correct result. The eye-tracking technique provides an experimental proof about how people observe a scene or an image. In the pioneer study performed by Yarbus,[3] in 1967, the author observed that the eye scans the image in quick jumps, moving from a focus of interest to another. These eye movements he denominated saccades and each point where the eye stops and observes "Interest Points". The explanation for this phenomenon is due to the fact that the central part of the retina, the fovea, has high resolution; and the succession of saccades allows the brain to build a total view on the short term memory. It is possible to follow the saccadic eye movements and register the course of the look. However, this process is so quick (the saccades last between 20 to 200 millisecond) that most people do not notice their observation pattern. In approximately one second it is possible to focus in two or three Interest Points, also called points of fixation. The steady look pattern is affected by factors as news, complexity and incongruity. The moments of eye fixation, that occur during the observation of simple pictures, indicate that the Interest Points correspond to the angles of the picture. Other points that also call attention are the point of maximum curvature, unusual details and unpredictable contours.[3]

Figure 1 - Sagittal view with Interest Points (in blue) located in the facial profile line. The Interest Points includes the following characteristics: angles, maximum curvatures (concave and convex) and unpredictable contours.

This acquaintance of the Interest Points created by the visualization of objects leads to the necessity to comprehend which are the Interest Points in a dentofacial esthetical analysis. As said before, the studies that sought an understanding of the main Interest Points show that the eye searches for spots and lines that are within three main characteristics: angles, maximum curvature (concave and convex) and unpredictable contours. The acquaintance of this information allows a facial analysis much more objective and effective. Recognizing the observed areas it is possible to evaluate more accurately the facial regions and characteristics that directly interfere on the dentofacial analysis, assisting and facilitating the comprehension of factors that affect positively and/or negatively for the creation of Beauty. From the Interest Points it can be derived another two concepts that assist and explain better its perception. They are: Reference Points and Discrepancy Points.

Figure 2 - Sagittal view with Interest Points (in blue) and points of anthropometric references (in yellow) located in the facial profile line. Notice that the Interest Points include all Reference Points and some other points (in blue) that call attention from the observer.

REFERENCE POINTS

Reference Points are to locate, guide and limit structures of study units. They allow to see in a different way the studied structures.

When we observe an object we have the tendency to stick to the whole image. That is natural, for an unpretentious look search the information in a global way. However, for those who seek to interpret rigorously, the attention to details is fundamental for a correct evaluation. In these cases the recognition of Reference Points is necessary for the structure to be analyzed accurately and deeply. In an esthetical analysis the determination of Reference Points is the initial step for a correct interpretation of the structure. To determine these points must be the first accomplishment of the analysis. With the Reference Points identified, the study of the object becomes simpler. It is possible to delimit the structure, as well as to perceive its proportions. Reference Points give conditions to observe the limits of the analyzed structures facilitating the study of the object, because with the delimitation of what is been observed it is much easier and objective to analyze its components. Worth remembering that Reference Points used in facial analysis are from craniofacial anthropometry and to facilitate the orientation and assure uniformity on the anthropometric terminology the points are named in Greek or Latin.[4]

DISCREPANCY POINTS

The human cerebral observation and interpretation is capable of evaluating both what pleases us and what displeases us. However, we frequently find difficulty to identify and measure the details that makes an object beautiful or ugly. In another words, although the general perception of beautiful and ugly is easy and inherent to all individuals, the capacity to identify the specific location of the error is not always easy. Therefore, the Discrepancy Points are derivative from Interest Points and facilitate the visualization of flaws. These points are seen every time that a solution of continuity occurs in lines that design and delimit specific structures. While the Reference Points indicate the location of the points that delimit the structures, the Discrepancy Points show the flaws. That is, every time that an unexpected or unwanted interruption occurs on the tracing of a line that represents the picture of

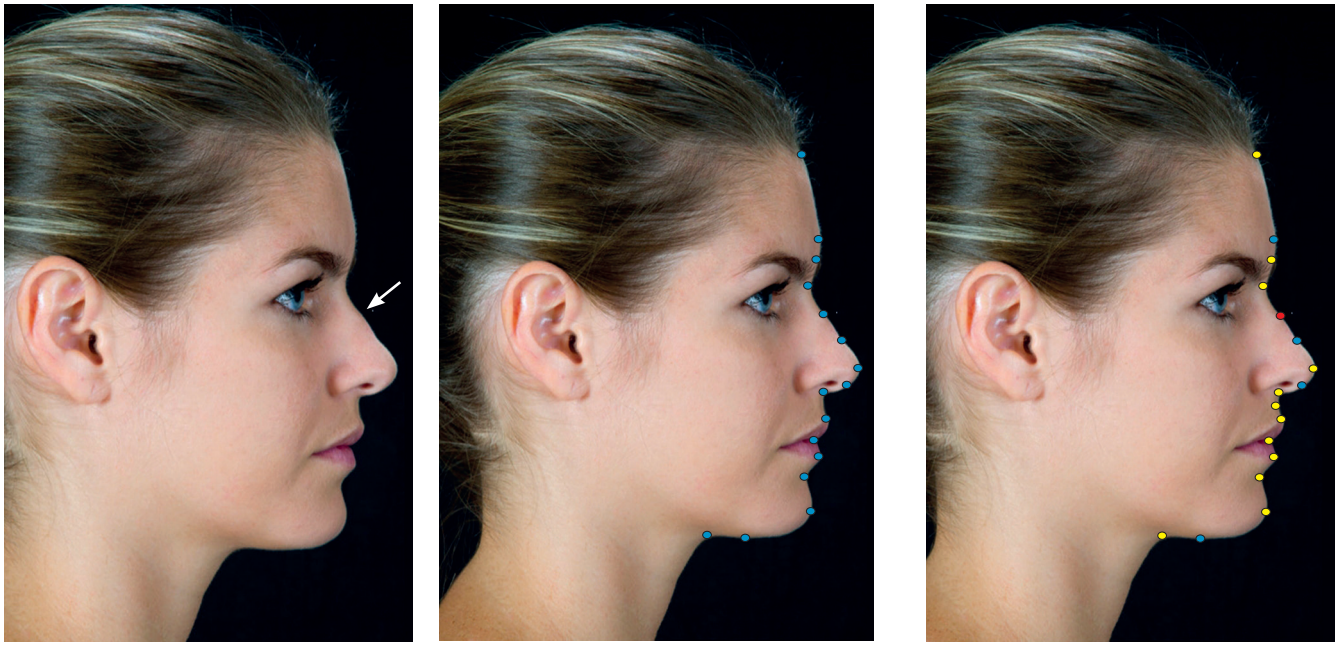

Figure 3 - Sagittal view with Interest Points (in blue), Reference Points (in yellow) and Discrepancy Points (in red). By manipulating the image on the computer a protuberance was added to the nasal dorsum (arrow) of the model, which created a new point of interest, that changed the esthetic perception that we call point of discrepancy.

the analyzed part, breaking or damaging its harmony, this flaw is considered as a Point of Discrepancy. Exaggerated or unexpected inclination of lines and structures can also be considered as Discrepancy Points. This evaluation and determination of the Discrepancy Points facilitate the perception of the problem. It is much easier to notice and quantify the error of a specific flaw when we identify these points. The attention given to Discrepancy Points leads the observer to a more careful analysis of the studied structure and eases the comprehension of specific needs. It is important to remember that Discrepancy Points have an intrinsic relation to Reference Points and it is necessary to have a clear idea of these last ones, so that the professional is alert for characteristics of normality. Only then the observer will have conditions to identify what is discrepant or has an unwanted alteration. The observation of Discrepancy Points allows us to comprehend the reason why some evaluations privilege the visualization of determined structures depending on the analyzed view. So, depending on the observation plan (sagittal or frontal) the esthetic evaluation of determined structure can be changed, and this change can be caused by the perception of Discrepancy Points that are found or not in a determined observation plan.

CONCLUSION

The Interest, Reference and Discrepancy Points are points that facilitate the visualization of analysis with esthetic perspective, allowing the professionals involved with esthetic orthodontic treatments to observe more carefully the evaluated structures.

REFERENCES

1. Ferreira, A. B. H. Novo Aurélio: o dicionário da língua portuguesa. Rio de Janeiro. Nova Fronteira. 1999.
2. Suassuna. A. Iniciação à estética. 10º ed. Rio de Janeiro. José Olympio. 2009.
3. Yarbus, A. L. Eye movement and vision. New York. Plenum. 1967.
4. Farkas, L. G. Anthropometry of the head and face in medicine. New York. Elsevier. 1987.

An interview with

Paulo José d'Albuquerque Medeiros

- Graduated from the School of Dentistry, Rio de Janeiro Federal University (UFRJ) – Praia Vermelha, Brazil, 1978.
- Specialist in Oral and Maxillofacial Surgery, UERJ, 1979.
- Residency in Oral and Maxillofacial Surgery, University of Texas-Dallas – USA, 1981-1984.
- MSc and PhD, School of Dentistry, UFRJ – 1991 and 2001.
- Professor at UFRJ and Rio de Janeiro State University (UERJ) since 1979 to date.
- Head Professor, Oral Surgery, School of Dentistry, UERJ, since 1995.
- Author of the following books: "Orthognathic Surgery for Orthodontists" (Ed. Santos), "Retained Tooth Surgery" (Ed. Santos), "Update on Oral and Maxillofacial Surgery and Traumatology" (Ed. Santos).
- In private practice in Rio de Janeiro, Brazil, since 1979.
- Renowned lecturer in Brazil and abroad.

Prof. Paulo José d'Albuquerque Medeiros was born to Paulo Pinho de Medeiros and Conceição Rosário d'Albuquerque Medeiros in the city of Rio de Janeiro, Brazil on March 7, 1957. He has been married for 31 years to Patricia Leo Medeiros and they have two children: Alessandra Leão Medeiros Parente, 30, a law judge, and Leo Bruno Medeiros, 28, economist. He is fond of music and the movies, and is a fine singer. He has developed a refined taste for good wines, his favorite being Chateau Palmer. He is currently reading a pocket book titled "1001 wines to drink before you die". His most daunting challenge in life: "Keeping up the motivation to teach, which is my true calling".

Marco Antonio Almeida

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

AESTHETICS

What is the greatest demand of patients: Esthetics of function? (Antenor Araújo)

Most patients expect improved esthetics. Don't forget that - if the patient's facial esthetics is not compromised - it is quite a challenge for the orthodontist to persuade the patient to agree to ortho-surgical treatment, even if they have some sort of malocclusion.

Which parameters are most important in the analysis of facial esthetics?
(Carlos Estevanell Tavares)

I could cite several variables, but I prefer to highlight the smile, which is our "calling card." I've had several patients who, after correction of vertical maxillary excess, came to be questioned by friends who wanted to know if they were wearing contact lenses (Fig 1). It seems that an unsightly smile can "erase" other interesting facial features. The "buccal corridor", which is sometimes treated by ortho-surgical expansion (Fig 2), and in other situations by simply improving the shape of dental arches through tooth movement, also greatly affects the smile and facial esthetics (Fig 3).

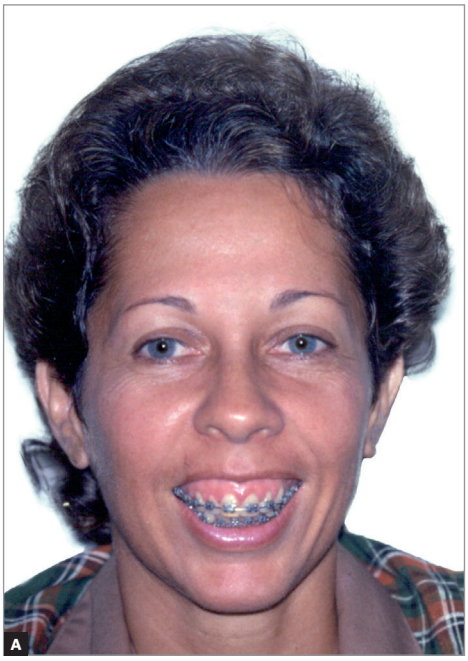

Figure 1 - Class II patient with vertical maxillary excess and anteroposterior mandibular deficiency (**A**). After maxillary repositioning and mandibular advancement. The surgical procedure highlighted the eyes (**B**).

Figure 2 - Before (**A**) and after (**B**) surgically assisted rapid maxillary expansion. "Buccal corridor" shows improvement. Initial occlusion (**C**) and after intervention (**D**).

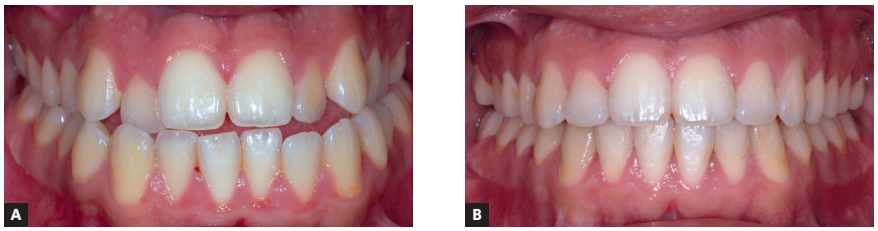

Figure 3 - Class III malocclusion and maxillary constriction before ortho-surgical treatment. Occlusion after osteotomies of maxilla and mandible without segmentation. The upper arch was expanded and its form improved through tooth movement.

Figure 4 - Note nasal base tapering toward the tip. Increased nose harmony after slight base enlargement as a result of maxillary advancement.

What steps do you take in cases of advancement or repositioning orthognathic surgery in the maxilla to avert undesirable effects on facial esthetics? (Carlos Estevanell Tavares)

Nasal esthetics is a major concern of surgeons in planning and performing maxillary orthognathic surgery. Le Fort I osteotomy could cause nasal enlargement due to muscle detachment, but this issue is particularly challenging in the aforesaid movements, i.e., maxillary advancement/repositioning. In rare, select cases enlargement may even be desirable (Fig 4). The vast majority of patients, however, have the base of their nose sutured after maxillary repositioning, which is intended to prevent enlargement. This procedure is called "Nasal plication" (Fig 5).

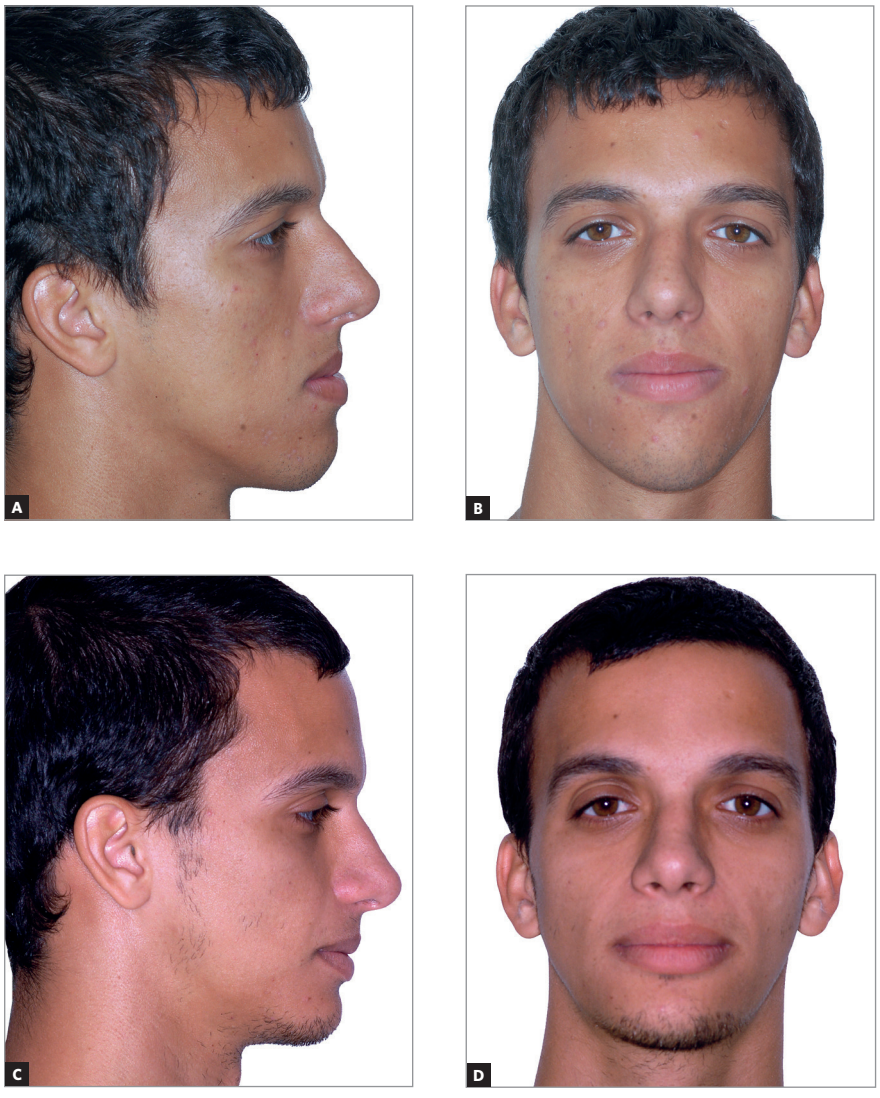

Figure 5 - **A**, **B**) This patient is a good candidate for maxillary advancement combined with maxillary repositioning. **C**, **D**) Good control of nasal base although the movement performed can be considered potentially detrimental to the esthetics of the nose.

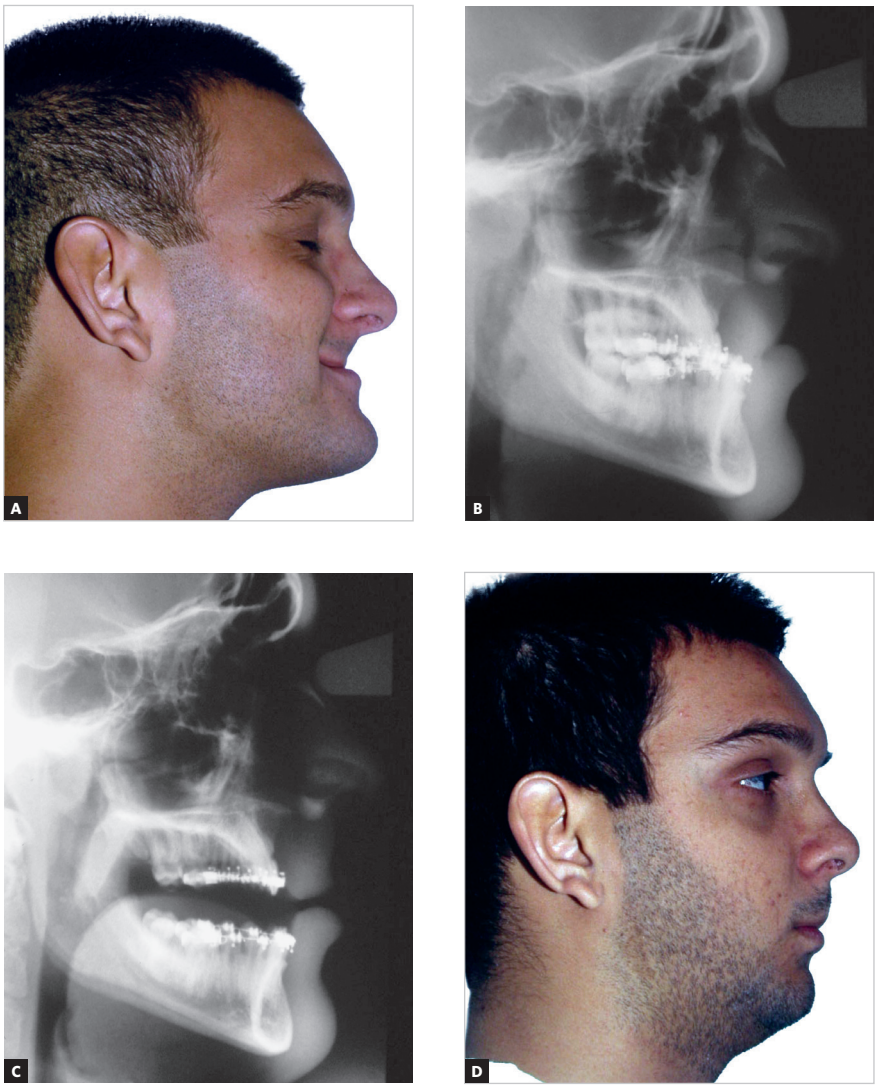

Figure 6 - Patient presented with anteroposterior and vertical maxillary hypoplasia in addition to anteroposterior mandibular excess. Lateral cephalometric radiograph highlighting the discrepancy between maxilla and mandible. Lateral cephalogram with mouth slightly open enabling visualization and quantification of vertical maxillary deficiency in relation to the upper lip. Patient after lowering and maxillary advancement combined with mandibular setback.

How do you address cases of closed mandibular plane and decreased lower face?
(Carlos Estevanell Tavares)

In the past, this condition was mistakenly called "Short Face Syndrome". Although not a true syndrome, its expression tends to recur at different levels. The starting point for treatment is determining how many millimeters the maxilla should be lowered, and whether this lowering will have one single magnitude or different magnitudes, considering the incisal and molar regions. A predictive tracing should indicate whether the mandible is likely to undergo a clockwise rotation only, and require surgery, or whether it will have to undergo advancement or setback osteotomy, depending on the initial malocclusion. The height of the mandibular symphysis in these individuals is usually short. Therefore, performing a genioplasty to increase the vertical dimension may be beneficial (Fig 6). These procedures elongate the face and improve the mandibular plane at the same time.

Figure 7 - Note the unsightly shape of the nasal dorsum (**A**). Improved nasal esthetics as a result of orthognathic surgery (**B**).

Figure 8 - Note unfavorable aspect of submental region (**A**). Note beneficial effect in the submental region after mandibular advancement (**B**).

When do you recommend plastic surgery as a complement to facial esthetics, concurrently with orthognathic surgery? (Carlos Estevanell Tavares)

The plastic surgery procedures more commonly performed as adjuncts to orthognathic surgery are rhinoplasty, submental liposuction and plication of the platysma muscle. As regards indication and timing, one should bear in mind that surgical movement of the maxilla and/or mandible can effect favorable changes in these anatomical regions. There are cases of individuals who wished to undergo rhinoplasty and who gave it up after deciding that the effect of orthognathic surgery on the nose had delivered the desired esthetic outcome (Fig 7). Currently, most maxillofacial surgeons only indicate rhinoplasty when it is combined with isolated osteotomies of the mandible. When the patient is undergoing maxillary osteotomy, rhinoplasty is planned for 6 months after orthognathic surgery, but only if at that time the patient still wishes it. The same applies in the case of mandibular advancement, which in itself produces esthetic effects in the submental region (Fig 8).

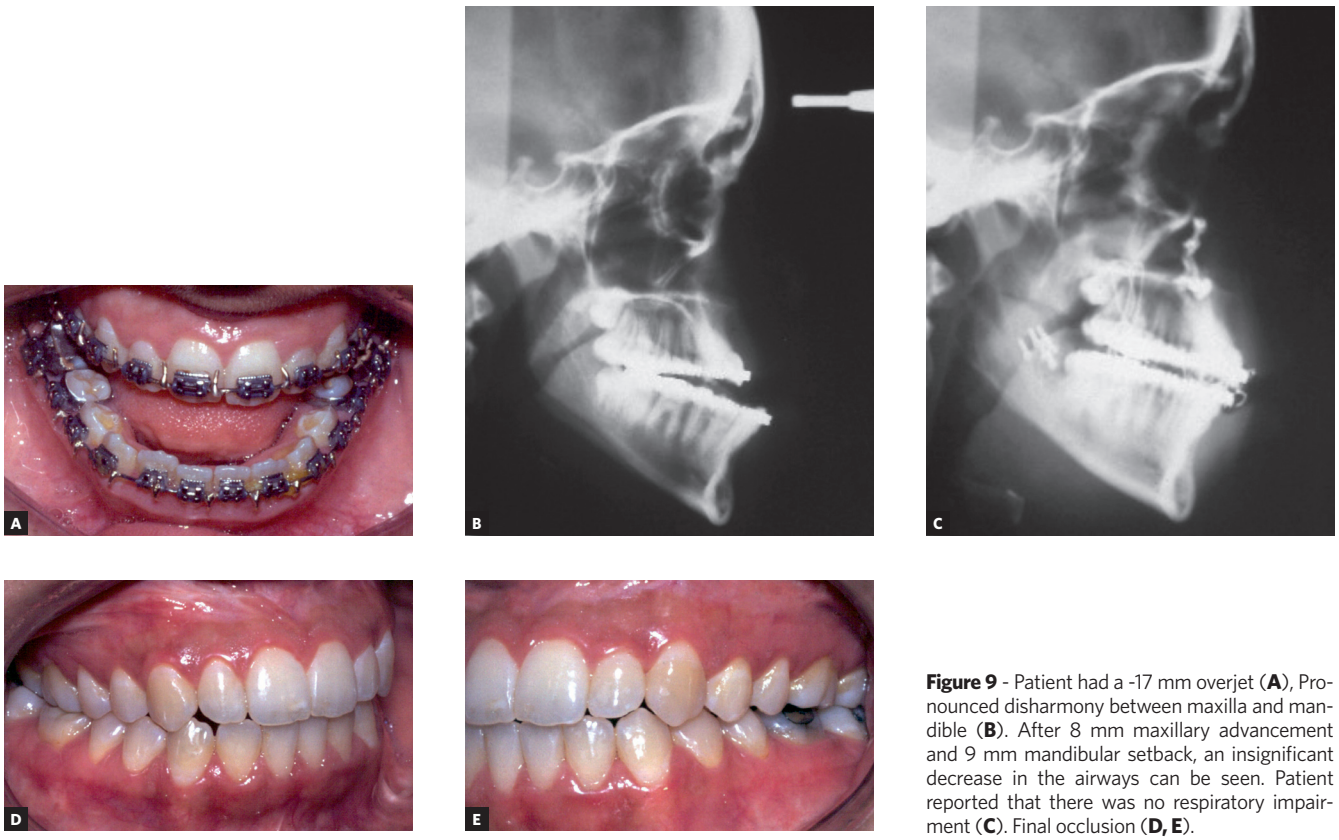

Figure 9 - Patient had a -17 mm overjet (**A**), Pronounced disharmony between maxilla and mandible (**B**). After 8 mm maxillary advancement and 9 mm mandibular setback, an insignificant decrease in the airways can be seen. Patient reported that there was no respiratory impairment (**C**). Final occlusion (**D, E**).

Conversely, in a patient undergoing mandibular setback who presents with excess submental tissue, liposuction and/or plication of the platysma at the time of orthognathic surgery seems to be the best approach.

FUNCTION

Surgical mandibular retrusions can impair the airspace and compromise breathing. Currently, how does surgical planning deal with this issue? (Arno Locks)

Although decreases in airspace have been observed in mandibular setback samples, there are no studies demonstrating functional impairment in these individuals. This may be because mandibular setbacks in excess of 7 mm or 8 mm are extremely rare. In treating severe Class III malocclusions, with overjets in excess of 10 mm, professionals tend to divide movements between the maxillary advancement and mandibular setback movements (Fig 9). Our group published an article in the September/October 2011 issue of this journal which analyzed 17 patients who had undergone isolated mandibular setbacks and other setbacks associated with maxillary advancement.

The average mandibular setback was of about 7 mm, and we noted an average reduction of about 1 mm in oropharynx, and about 3.5 mm in the hypopharynx. Despite these findings, none of the patients in the sample reported impaired breathing after surgery. In over 30 years of practice in orthognathic surgery I cannot recall having had any patients who returned with respiratory complaints after this procedure. I would only be reluctant to indicate mandibular setback for individuals with prior respiratory disorders or obese patients.

What scientific evidence is there regarding a cause-and-effect relationship between orthognathic surgery and snoring or sleep apnea? (Marco Antonio Almeida)

Orthognathic surgery has been used to treat sleep apnea in cases that prove refractory to more conservative, less invasive therapies. The literature reports that maxillary advancement performed simultaneously with mandibular advancement has yielded favorable results in a significant number of patients. There are researchers out there who have been conducting reliable, well-designed research that can attest to this fact, but I've had no experience with these patients.

A patient with no TMD symptoms before treatment starts presenting with TMD signs and symptoms after orthognathic surgery, such as clicking joints, pain in the TMJ region and restricted opening. What are the possible causes of this condition? Are the causes somehow related to orthodontic treatment, orthognathic surgery or attributable to chance? (Weber Ursi)

Joint dysfunction hardly ever occurs after orthognathic surgery. The most frequently occurring symptoms are muscle pain and discomfort, which the literature refers to as Myofascial Pain and Dysfunction Syndrome. This condition tends to be transient and is treated through measures to mitigate the symptoms and increase patient comfort. The rare cases of patients who experienced joint noises, which by the way were not painful, the incident occurred in the first weeks of the postoperative period and resolved spontaneously. This adaptability of patients might be due to the fact that they are young and without prior dysfunction. I don't believe either orthognathic surgery or orthodontics is responsible for the onset of joint dysfunction in this particular population.

TECHNIQUE

What aspects of orthodontic preparation are you most often confronted with, which potentially compromise the outcome and stability of orthognathic surgery? How can these problems be avoided? (Weber Ursi)

Instability of movements during dental orthodontic preparation usually manifests itself in the medium or long term. After surgery the patient is still undergoing orthodontic treatment for about 1 year, after which a retainer tends to maintain the teeth in their correct position. In reassessing patients 10, 20 and even 25 years after ortho-surgical treatment I have noticed that the most significant losses occur in the transverse direction, as is usually the case with surgical relapses. When the patient needs significant transverse gains, either orthopedic or surgically assisted maxillary expansion seems to offer better results.

Do you believe that evaluation by a psychologist experienced with this type of patient in order to detect specific responses regarding acceptance of changes in appearance, actual motivation toward surgery, anxiety level, etc, would go a long way towards averting dissatisfaction with the outcome? Or is it your belief that this sort of detection can always and easily be carried out by the orthodontist and/or surgeon? (Carlos Elias Ferreira de Freitas)

I see no need for ortho-surgical patients to be routinely evaluated by a psychologist. In specific cases I do think such an evaluation would be highly advisable. On occasion, I have obviously had a few unsuccessful cases, and have also encountered difficulties in treating a handful of patients.

Those patients who lack family support, those living in conflict with relatives and making regular use of antidepressants should be more carefully evaluated by a professional psychologist. I strongly believe that patient selection is the key to a successful practice.

To what extent have the new distraction osteogenesis techniques contributed to resolve large mandibular advancements—including mandibular ramus lengthening—causing counterclockwise mandibular rotation? (Arno Locks)

Distraction osteogenesis, unlike what was initially believed, has not replaced conventional orthognathic surgery in conventional cases. Distraction osteogenesis is optimally indicated in the first decade of the patient's life to treat mandibular growth deficiencies. Cases of hemifacial microsomia or retrognathia resulting from TMJ ankylosis have been successfully treated by this method. The discomfort caused by prolonged use of a distractor in addition to difficulty in controlling the distraction vector are some of the disadvantages of distraction osteogenesis vs. orthognathic surgery starting in the second decade of the patient's life.

The conduct advocated by U.S. professor Larry Wolford, who often indicates surgical interventions in the temporomandibular joint concurrent with orthognathic surgery when the patient presents with intra-joint changes, has met with widespread acceptance in Brazil. What is your opinion on the subject?
(Carlos Elias Ferreira de Freitas)

I worked with Dr. Wolford for 2 years during my residency program and I know for a fact that he is a highly judicious professional. I believe this is not a routine approach, and the numerous joint interventions that he performs simultaneously with orthognathic surgery are due to, firstly, the large volume of patients he operates on, and secondly, because he is a reference in the treatment of patients with joint dysfunction. I have limited experience in performing orthognathic surgery in joint TMD patients. The vast majority of patients I treat are young and hardly ever present with joint TMD pain. I see no need to perform concurrent joint intervention. As in the cases of muscle TMD, these patients' dysfunction is treated conservatively before orthognathic surgery and, if necessary, further treatment is provided after surgery.

STABILITY

Some patients, after mandibular advancement surgery for correction of Class II, present with condylar resorption, totally compromising the outcome. What have studies so far contributed on this topic? (Arno Locks)

It is important to differentiate condylar resorption from condylar remodeling. Condylar remodeling is a sort of "wear", albeit minor, which occurs in surgical and non-surgical patients, causing increased overjet over a few years. This can be considered a physiological phenomenon. It has been more often observed in patients who have undergone mandibular advancement, especially in those with the following three sets of features: 1) Small mandibular condyles inclined posteriorly, 2) open mandibular plane and short mandibular ramus, and 3) decreased posterior facial height and increased anterior facial height. Treatment results for these patients may be partially or totally compromised by this phenomenon. Condylar resorption has been widely studied and described, especially by the team of researchers led by Dr. Leonard Kaban, in Boston. In these cases condyles disappear altogether as meaningful retrognathia and open bite develop. There are many idiopathic cases, where patients never underwent orthodontic or ortho-surgical treatment. Among the possible causes of this condition are rheumatoid arthritis, use of corticosteroids, systemic lupus erythematosus, scleroderma, other collagen diseases, and even orthognathic surgery. Healthy patients who are good candidates for orthognathic surgery, but who present with the three sets of features I mentioned earlier should be alerted about the possibility that this phenomenon might occur.

The hierarchy of stability of ortho-surgical cases established by the North Carolina team of researchers is usually cited in scientific papers. Drawing on your extensive experience, how would you assess this hierarchy, and what factors can affect it? (Marco Antonio Almeida)

The two extremes of this "hierarchy" seem quite relevant: Maxillary repositioning is very stable, and maxillary expansion induces a certain medium and long term instability. Research shows that the routine use of rigid internal fixation has taken maxillary lowering off the list of unstable maxillary procedures. The presence of four mini-plates for

stabilization combined with bone grafting appear to give optimum vertical stability to the maxilla. As far as mandibular setback surgery is concerned, contrary to what is stated in the article, I have had excellent stability. I do however use, whenever possible, intraoral vertical osteotomy, which is a technique renowned for its high stability. The literature demonstrates that the optimal stability afforded by sagittal osteotomy in mandibular advancement is not replicated in mandibular setbacks, and the latter was the technique used in the study group. The major hurdle in terms of stability in orthognathic surgery today has to do with mandibular advancement, and this procedure appears in the article as the second most stable. However, when you read the article carefully you can't help but realize that mandibular advancement was performed or discussed only in individuals with normal or short facial height, which does not encompass those patients presenting with the three sets of features I referred to earlier on. I strongly believe that a study conducted in Class II patients with the three sets of characteristics described above will inevitably yield different outcomes.

FUTURE

How do you view the current position held by orthognathic surgery in Brazil? How would you compare it to other countries? (Antenor Araújo)

We owe the inception of orthognathic surgery in Brazil to pioneers, the likes of Mario Graziani, Paulo Pinho de Medeiros, Italo Gandelman, João Jorge de Barros and João Ephraim Wagner, and I can't think of a better start. With the development of "Modern Orthognathic Surgery" — by which is meant a combination of surgery and orthodontics - there was a refinement in surgical techniques that already existed, and are still widely employed to this day, combined with new concepts in diagnosis and treatment planning. When he arrived in Brazil in 1978 after 3 years spent in Dallas, Texas, USA, Dr. Antenor Araújo helped to develop Brazilian orthodontics and enabled a most fruitful exchange with centers of excellence abroad. Today Brazil has established itself in the international scene given the quality of our professionals, which is comparable to that of the best centers in the world. The challenge we face today lies in training high-level professionals to serve 200 million people in a country of continental proportions. It is still not uncommon to see surgeons packing a "doctor's bag" with surgical instruments and traveling to operate on patients a long ways from home. This is obviously not the best care you can provide. I'd hate to have, say an abdomen surgery, today and not have the surgeon around the next day because he has flown off somewhere else to see another patient. Our challenge is to train more and more quality professionals and spread them throughout Brazil. I try to give my humble contribution.

What medium to long-term advances can we expect in the field of Orthognathic Surgery? What will this major surgery be like 20 years from now? (Weber Ursi)

Although there have been refinements in surgical techniques, the main developments have occurred and tend to develop further in surgical materials and in the area of digital technology. Rigid fixation techniques have improved through the development of finer plates and screws, without any noticeable loss in quality. Alloplastic materials are replacing autografts at such a rate that I believe in the near future we will no longer need to remove the patient's own bone for any purpose. Digital diagnostics and planning save time and impart reliability to ortho-surgical treatments. I really look forward to the development of less traumatic bone cutting instruments. Less invasive surgeries? Robotic Surgery? Time will tell.

YOUR SPACE

What were the three most gratifying ortho-surgical cases in your career? (Marco Antonio Almeida)

The first patient I would highlight is a girl now 25. She has a 7-year-old daughter with a severe retrognathia and no mouth opening as a result of temporomandibular joint ankylosis. The patient was operated on to resolve the ankylosis in two different steps, i.e., she received costochondral graft to improve mandibular growth in another intervention, and finally underwent orthognathic surgery. The interventions put in place during the first decade of life are aimed at enabling mobility and stimulating growth. The ortho-surgical

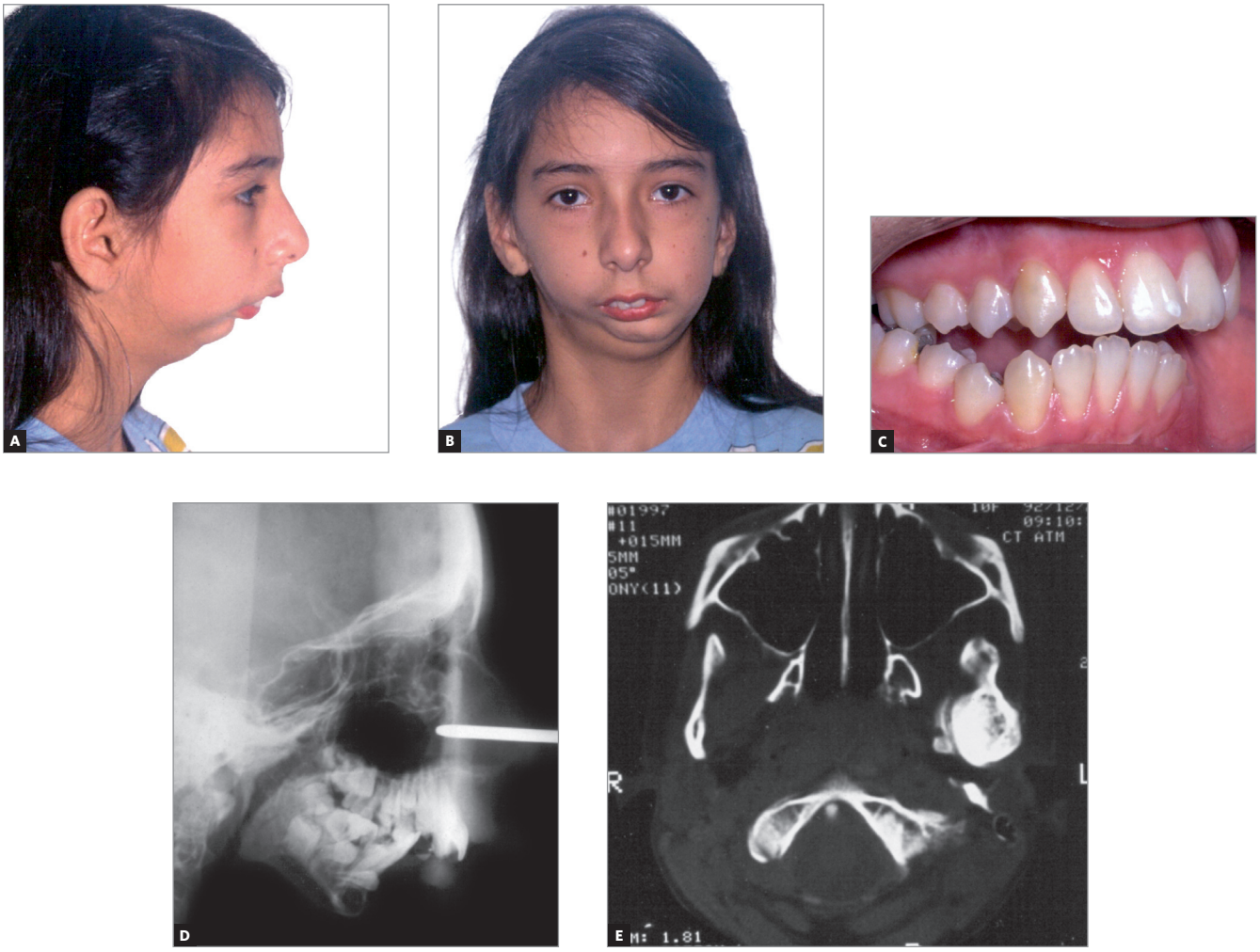

Figure 10 - Seven-year-old patient showing retrognathia with severe mandibular deviation to the left (**A, B**). Marked Class II malocclusion (**C**) and severely underdeveloped mandible (**D**). CT scan showed a major ankylotic block on the left side (**E**).

Figure 11 - After two interventions and 4 years into treatment, there was improvement in oral movements and esthetics (**A, B**). Patient at age 7 and 14 (**C**, **D**).

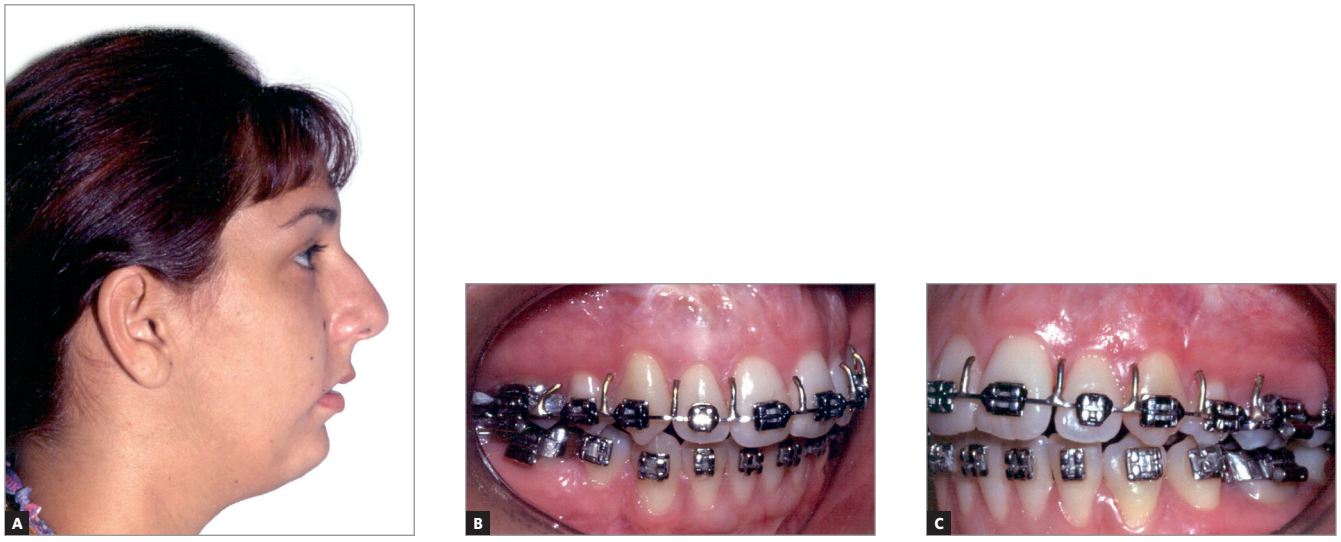

Figure 12 - Patient at age 21 years.

Figure 13 - Note degree of mandibular development about 14 years after interventions.

treatment achieved a better occlusion and satisfactory facial esthetics (Figs 10 to 13).

Shy and withdrawn, the second patient presented for treatment at 20 years of age. According to his mother, he had been bullied for many years because of his unsightly facial appearance. He underwent orthodontic treatment and maxillomandibular osteotomies, and was given psychological support postoperatively. About a year after surgery and orthodontic treatment, he returned, now more talkative, lively and even responding to the jokes and remarks from members of our surgical team (Figs 14, 15, 16).

Figure 14 - Hypoplastic mandible and greatly increased mandibular plane. Note long face and severe lip incompetence (**A**, **B**); patient was extremely shy and hardly ever smiled (**C**).

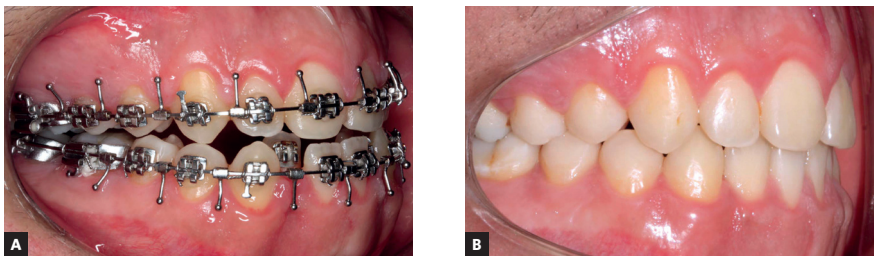

Figure 15 - Preoperative occlusion. Due to difficulties in social adjustment, "Anticipated Benefit" was employed (**A**). Occlusion about 14 months after surgery (**B**).

Figure 16 - 14 months postoperatively. Note improvement in interlabial relationship. Changes in behavior and attitude were remarkable.

The third patient was a young woman aged 23, who exhibited several positive characteristics such as beautiful skin, eyes and hair which, however, were undermined by a complex dentofacial deformity. She presented with maxillary retrusion, maxillary vertical hypoplasia, mandibular prognathism and lateral deviation of the mandible. As a result of the successful functional and esthetic outcome achieved, positive changes occurred in many areas of her life (Figs 17 to 20).

Figure 17 - **A**) The maxilla was retruded, the mandible overly protruded and the nasal dorsum showed an unfavorable contour, **B**) patient had facial asymmetry with marked mandibular deviation; **C**) the maxilla was uneven and also hypoplastic in the vertical direction, which compromised the smile.

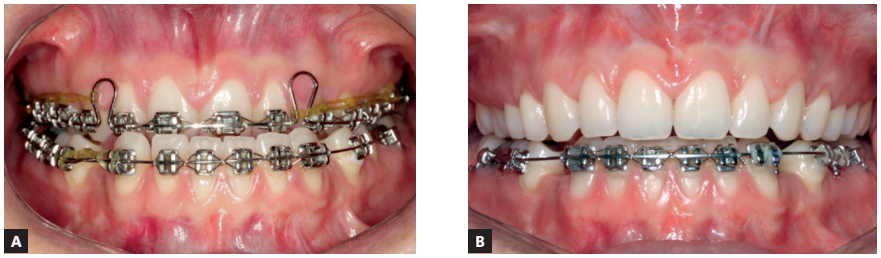

Figure 18 - Preoperative occlusion (**A**) and approximately 8 months after surgery (**B**).

Figure 19 - Patient about 8 months after surgery.

Figure 20 - Changes in frontal view resulting from esthetic treatment (**A, B**). Profile before and after surgery (**C, D**). An improved facial symmetry and smile highlighted other patient features (**E, F**).

REFERENCES

1. Gornic C, Nascimento PP, Melgaço CA, Ruellas ACO, Medeiros PJD, Sant'Anna EF. Análise cefalométrica das vias aéreas superiores de pacientes Classe III submetidos a tratamento ortocirúrgico. Dental Press J Orthod. 2011 Sept-Oct;16(5):82-8.

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Study of face pleasantness using facial analysis in standardized frontal photographs

Imara de Almeida Castro Morosini[1], Ana Paula Lazzari Marques Peron[2], Keila Rodrigues Correia[3], Ricardo Moresca[4]

Objective: The purpose of this research was to check if the numeric facial analysis can determine facial attractiveness.

Method: The sample consisted of frontal and lateral standard facial photographs, in natural head position, of 85 Brazilian Caucasian women, without facial plastic surgery report. The sample mean age was 23 years and 9 months. A group of 5 orthodontists, 5 layman and 5 plastic artists classified the photographs according to their own attractiveness graduation in: pleasant, acceptable and not pleasant. The numeric facial analysis was then performed using a computerized method. Linear, proportional and angular measurements were compared among groups.

Results: According subjective analysis the sample was consisted of 18.8% of pleasant, 70.6% of acceptable and 10.6% of not pleasant. In most measurements there were no differences among groups. Just in three of them significant statistical difference was observed and in two of them the comparison value was within decision limit. All the differences found were related to the lower third of the face and to facial pattern.

Conclusion: On the present research, the numeric facial analysis, by itself, was not capable of detecting facial attractiveness, considering that beauty judgment seems to be very personal.

Keywords: Facial analysis. Attractiveness. Facial esthetics.

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

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INTRODUCTION

Since the beginning of the 20th century, it has been observed in Orthodontics a great concern about esthetics, especially involving concepts of balance and facial proportions.[2,21,27]

Beauty criteria are highly subjective, reflecting cultural peculiarities of a population, the region where they live and a determined period of time.[11] Over the years there were significant changes in facial esthetic standards, so orthodontists must be updated about what the population considers an ideal face.[20]

From the patient's point of view, esthetics is the main motivation for seeking orthodontic treatment.[26,28] For this reason it is recommended that orthodontic treatment is planned starting from a global evaluation of the face, paying attention to esthetic necessities as well as to cephalometric and functional matters.

Through diagnosis, the professional must try to identify the unpleasant facial characteristics which can be improved with the orthodontic treatment, as well as the aspects considered pleasant and must be preserved during treatment. It is important, however, that this evaluation consider the ethnical and personal characteristics of the patient, trying to use the same esthetic evaluation parameters of the patient and the society in which he belongs.

Several studies were developed focusing both numerical and subjective facial analysis,

Aiming to establish reference values for facial measurements and to verify esthetical tendencies of the studied populations.[1,3,4,5,7-11,16,22,23,26]

Some authors evaluated esthetics through clinical exams and measurements directly on the face.[3,8,25] Studies with laser scanning techniques[16] and computerized methods[17,18] were also performed. Other authors chose to use facial photographs to evaluate esthetics,[4,9] considering that photographs allow a more accurate evaluation of measurements and proportions, which would be difficult directly on the face.

Photographs allow the observation of harmonious relation between soft and hard facial tissues, also considering adipose tissue, besides not exposing the patient to radiation and having a very low cost.[9]

This study was developed to evaluate facial attractiveness and facial characteristics of women in a frontal view through standardized photographs, in order to:

1) Characterize the studied sample according to subjective concepts of facial esthetics in esthetically pleasant, esthetically acceptable and esthetically unpleasant, considering frontal and lateral photographs together.
2) Verify agreement level between subjective evaluations conducted by orthodontists, plastic artists and laypeople.
3) Verify the possible differences between means of the variables proposed in the three studied groups, considering only frontal photographs.
4) Verify whether the numerical frontal facial analysis is sensitive to detect facial attractiveness.

MATERIAL AND METHODS

Material

Sample

The present study was part of a series of performed researches with the objective of studying the facial esthetics in women, applying several facial analysis, both numerical and proportional.

Standardized facial photographs from 85 individuals of female gender,Brazilians, Caucasians, living in the city of Curitiba, from 18 to 30 years old, without previous facial plastic surgery were used. The mean age of the sample was of 23 years and 9 months ± 3 years and 2 months. All individuals voluntarily participate in the research and signed a Term of Informed Free Consent, which informed them about the study intentions.

Methods

Photographs

To obtain the photographs (frontal and lateral) individuals were sat and, looking directly to the eyes reflected in the mirror in front of them,[6,14,30] keeping an upright and normal posture, with both arms free along the body.[9] This position corresponds to the "Broca's Natural Head Position".

Behind individuals were placed a white screen to standardize the background, this way the ambiance would not influence photographs evaluation. For true vertical reference it was used a plumbline.[14]

The camera was placed on a Vivitar tripod to stan-

dardize the distance between it and the individual, also avoiding undesirable movements of operator while taking photographs. Configuring the camera, focal length, Shutter Speed and lens aperture were, respectively, 1.70 m, 1/200 and F 29. It was used ring flash as source of light.[5,22,26] To verify correlation between real measurements and measures from the photographs, two reference points were marked in the forehead of 5 individuals distancing 1 cm from each other.[5] After photographs revelation, the marks were measured and the value of 0.4 cm was obtained. It could be concluded in this sample that photographs corresponded to 40% of the real size.

The photographs were printed in the same QLab studio (international Kodak quality standard) in 10 x 15 cm size, color, matte paper.

Method of sample classification

The photographs were presented to 15 examiners divided into 3 groups:

5 specialists in Orthodontics, 5 laymen in Orthodontics and not related to the arts and 5 plastic artists. The mean age of evaluators was 44 years and 8 months ± 10 years and 8 months.

Evaluators were instructed to assign a value ranging from 1 to 9 to each participant using their own esthetics criteria, always considering the two photographs together. Value 1 meant the lowest facial attractiveness and 9 the highest level os facial attractiveness. They were instructed to do all evaluations at the same time.

After results tabulation, it was calculated the means for each one of the 85 individual and they were classified into 3 groups according to the facial attractiveness, being:

» Group 1: Esthetically pleasant (score 1, 2, 3 or 4);
» Group 2: Esthetically acceptable (score 5 or 6);
» Group 3: Esthetically pleasant (score 7, 8 or 9).

Facial analysis

The photometric tracings were performed only in frontal photographs, by the same trained observer, not from the group in charge of subjective evaluations, using a computerized method. For this purpose, it was used the software Radiocef Studio 2®, in which was developed a frontal facial analysis with the Mixcef tool.

The photographs were saved in JPEG format and uploaded directly to the software, with 300 dpi resolution. Aiming a better identification of the points, the software had also a tool for enlarging the image, which was used by the professional when it was needed.

Photometric points

Photometric points used are displayed in Figure 1.

Linear measures

Linear measures are represented in Figures 2, 3 and 4, with its descriptions.

Proportional measures

1) Facial index: Is the proportion between the facial height (N'-Me') and the upper facial width (Zid'-Zie') (Fig 5).

The Facial Index determines the facial type and is calculated this way:

$$\frac{\textit{facial height x 100}}{\textit{upper facial width}}$$

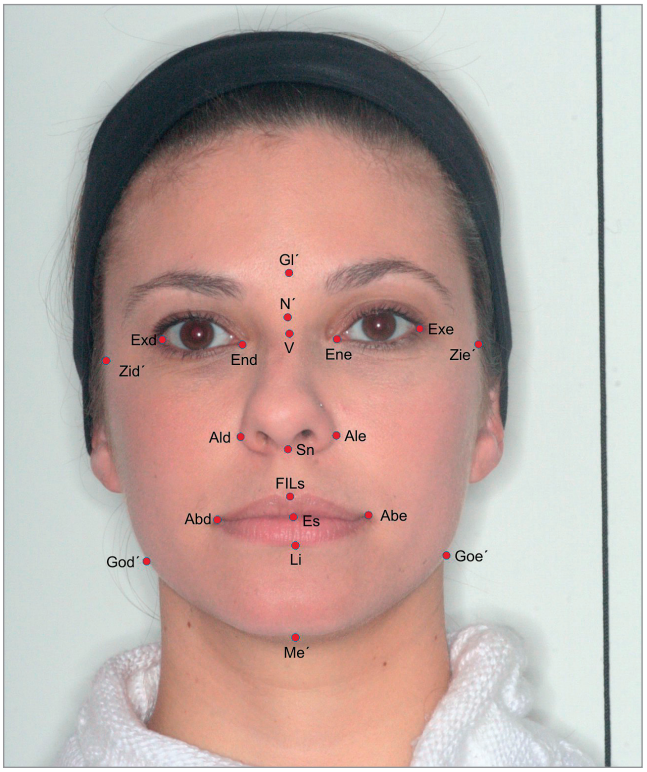

Figure 1 - Photometric Points: Gl' – soft tissue glabella; N' - soft tissue nasion; Exd-right external corner of the eye; Exe – left external corner of the eye; End – right internal corner of the eye; Ene – left internal corner of the eye; V – Point V; Sn – subnasale; Ald – right alar poit; Ale – left alar point; F- lower philtrum; Ls- upper philtrum; Li- lower lip; Abd- right mouth angle; Abe – left mouth corner; Es- stomium; Zid – right zigion; God'- right gonion; Goe'- left gonion; Me'- Menton.

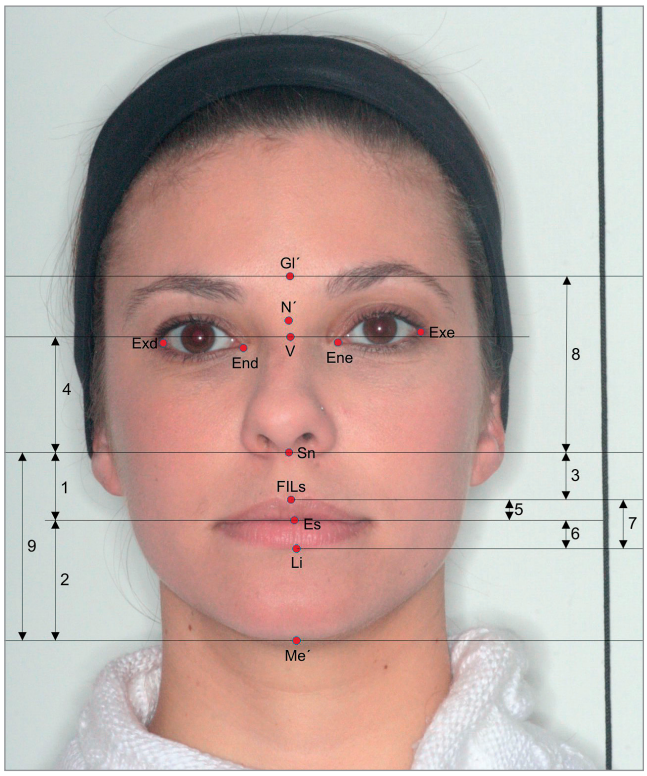

Figure 2 - Linear measurements from 1 to 9: 1) Upper lip length (Sn–Es); 2) Lower lip length (Es-Me'); 3); Philtrum length (Sn-U1); 4) Nose prominence (V- Sn); 5) Vermilion border of the upper lip (Ul-Es); 6) Vermilion border of the lower lip (Es–Ll); 7) Mouth heigth (Ul-Ll); 8) Middle facial height (Gl' to Sn); 9) Lower facial height (Sn to Me').

Figure 3 - Linear measurement 10: Commissure line inclination - difference, in millimeters, from the commissure line to the line joining the external corners of the eyes at Abd point height (a) and at Abe point height (b).

2) Facial Height Proportion: The proportion between Middle facial height (Gl'-Sn) and lower facial height (Sn-Me') (Fig 5).

Angular measures

Angular measurements used are shown in Figures 6 and 7, with their respective descriptions.

For the angle of facial symmetry the midline of the face was defined by the nasion (N') and filter (F).

Statistical Analysis

Comparisons between numerical measurements obtained in the 3 groups (esthetically pleasant, acceptable and unpleasant) were performed using ANOVA and Kruskal-Wallis test, with the software "Primer of Biostatistics" The significance level was of 5% ($p < 0.05$).

To verify concordance level between evaluations of different groups, Kappa index was used and the percentage of reviewers agreeing by the Minitab software, 2007 version (www.minitabbrasil.com.br).

Error of method evaluation

The Error of method analysis was performed by repeating the marking points of the same operator, followed by measurement of factors by Radiocef Studio 2 software and 20 photographs of the sample, randomly selected. The interval between evaluations was of 1 week.

To check the systematic error, data obtained from first and second measurements were submitted to Student's t test and to Wilcoxon test for paired samples, significance level of 5%. To evaluate casual error, the Dahlberg formula was used.

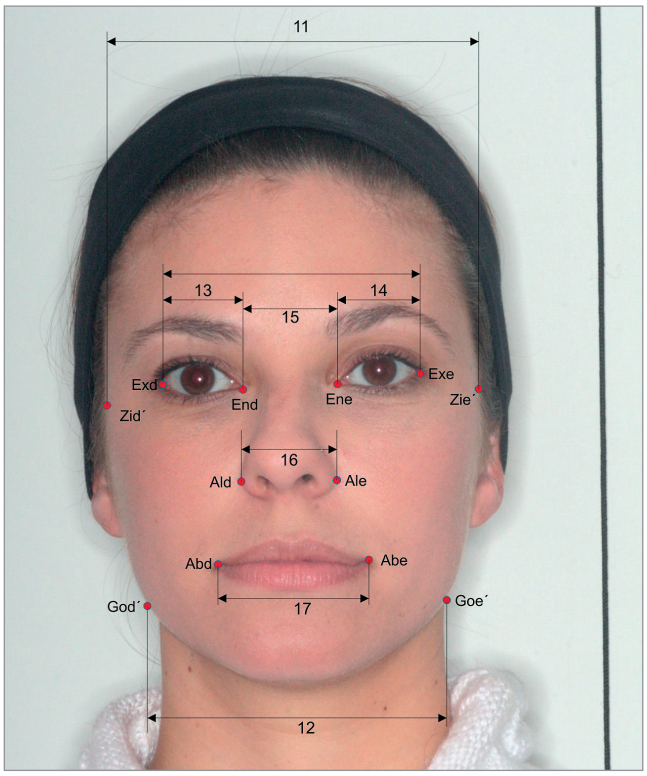

Figure 4 - Linear measures 11 to 17: 11) Upper facial width (Zid' and Zie'); 12) Lower facial width (God' and Goe'); 13) Right eye width (Exd to End); 14) Left eye width (Exe to Ene); 15) intercanthal distance (End to Ene); 16) Nasal width (Ald to Ale); 17) Mouth width (Abd to Abe).

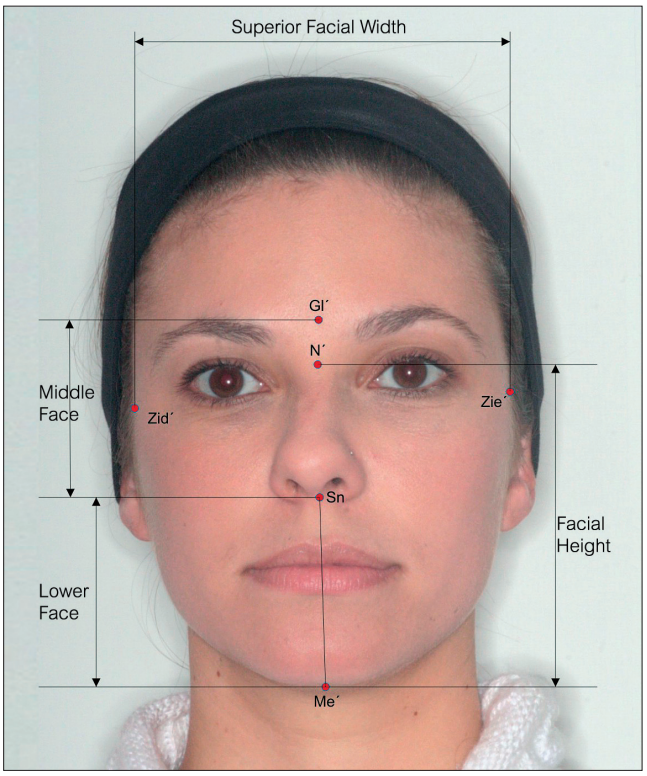

Figure 5 - Proportional measures – Facial Index: Proportion between upper facial height and facial width; Facial Height Proportion: Proportion between middle face height and lower face height.

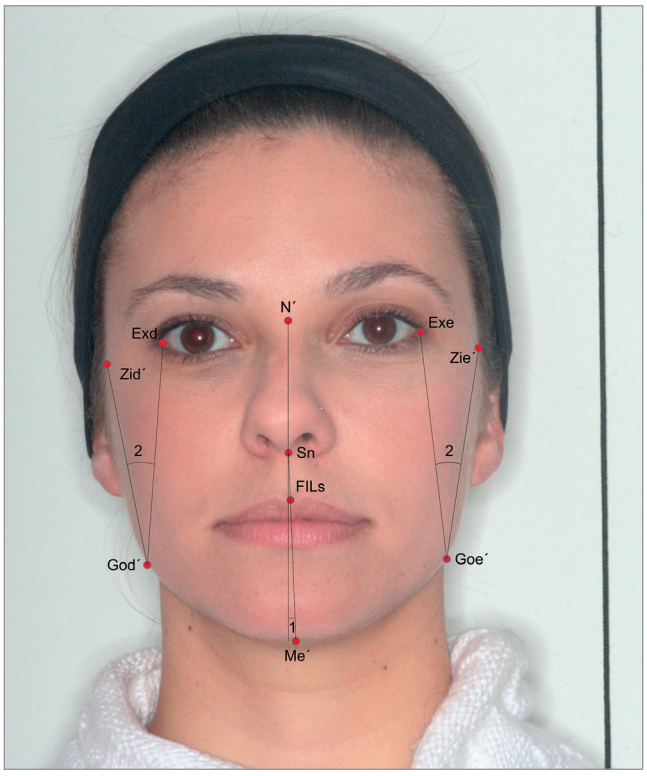

Figure 6 - Angular measures 1 and 2: 1) Facial symmetry angle - angle formed between facial midline (N'-F) and Sn'Me' line 2) Symmetry between left and right side of the face - the difference between left and right angle measurements formed by intersection of Zi'-Go' and Ex-Go' lines

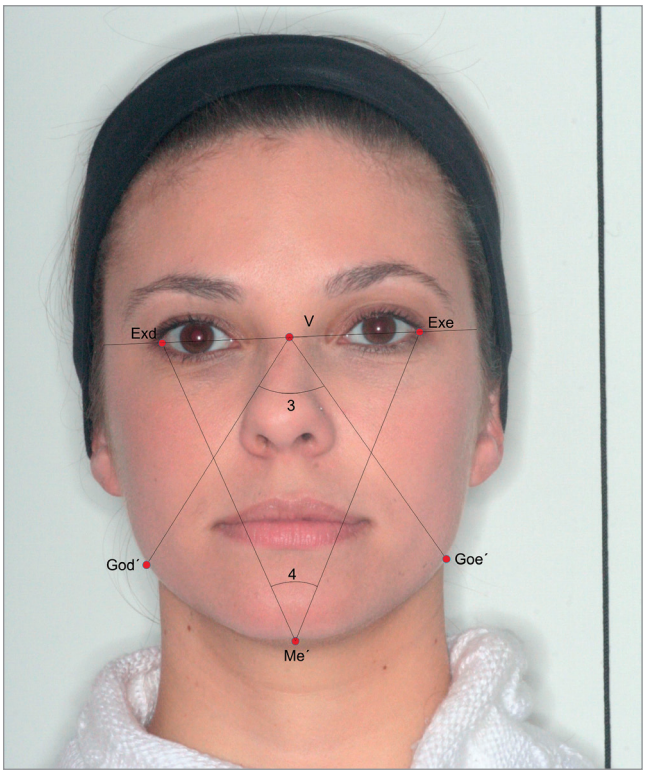

Figure 7 - Angular measures 3 and 4: 3) V Angle - angle formed by lines extending from V to God' point and from V to Goe'; 4) Facial aperture modified angle - angle formed by right and left lines extending from Exd to Exe to Me' point.

RESULTS

The data found in this research will be described and presented in tables 1 to 5.

Considering all the evaluators together (five orthodontists, five artists and five laymen), the mean score was calculated for each photograph, ranging from 1 to 9. At this point, it were added the 15 marks given for each individual and calculated the mean value obtained by dividing the sum by the total number of evaluators who constituted the group, disregarding the first decimal point by rounding the scores to the nearest integer value. Thus, to each participant it was given only one score mean, regardless the group of evaluators.

From the mean scores individuals were divided into 3 groups according to the degree of facial attractiveness. Group 2, corresponding to esthetically acceptable, was the one which contemplated the highest percentage of participants, 70.6% (Table 1).

To check the agreement level between the classifications made by different groups of evaluators (orthodontists, artists and laymen) it was used the Kappa Index of Agreement and the percentage of concordant evaluators. It was observed that the lower concordance was found between laymen and orthodontists, and the highest among laymen and plastic artists (Table 2).

Seventeen linear measurements, 2 proportional and 4 angular, were performed on the groups presented in Tables 3-5. Comparing the means, it was found that only 3 of these variables were statistically significant different, 1 being linear (extension of the lower lip vermilion border) and two angular (angle of facial aperture modified and V angle). In the other measurements no statistically significant differences were found.

DISCUSSION

Beauty is represented by balance and harmony of facial proportions, including skeletal structures, teeth and soft tissues of the face. Orthodontic treatment frequently aims to preserve our increasing facial characteristics through visible changes on soft tissues. It is important to perform a global evaluation of face, paying attention to the patient's esthetical necessities and not only to the functional and cephalometric matters. This study was developed to evaluate facial attractiveness and the characteristics of female faces in a frontal view through numeric facial analysis.

Regarding the attractiveness, the sample was characterized by 16 individuals esthetically unpleasant (18.8%), 60 esthetically acceptable (70.6%) and 9 esthetically pleasant (10.6%), indicating predominance of the esthetically acceptable standard, which was also found by other authors.[11,21,23] The smaller group in this study was the esthetically pleasant, just like in the study of Reis[23] and Morihisa,[15] demonstrating how hard are the beauty standards imposed by society, many times looking for unreachable ideals.

Facial esthetic is very subjective, thus to perform a reliable rating, the evaluator group has to be as numerous and heterogeneous as possible, trying to avoid individual influences, being composed by people from different academic contexts. In most researches found in literature it were selected orthodontists, plastic artists and/or lay people to evaluate the esthetics of the sample.[7,10,11,12,13,15,23,29] Following these orientations, in this research the evaluator group selected to classify the sample was composed by 5 orthodontists, 5 plastic artists and 5 lay people of both genders.

Table 1 - Subjective concept of facial esthetics.

Concept	Scores	Number	%
Group 1 - Unpleasants	1, 2, 3 or 4	16	18.8
Group 2 - Acceptables	5 or 6	60	70.6
Group 3 – Pleasant	7, 8 or 9	9	10.6
Total	85	100.0	

Table 2 - Kappa Index of agreement between groups.

Evaluators	% of agreements	Kappa	Interpretation
Lay x Plastic artists	41.2	0.2026	Slight
Lay x Orthodontists	21.2	-0.0364	Poor
Plastic artists x Orthodontists	38.8	0.1703	Slight

The agreement level between evaluators was assessed through Kappa index and also by the percentage of concordant evaluators, comparing groups in pairs.

Agreement between lay people and orthodontists was considered poor by the Kappa index (-0.0364), indicating only 21.2% of agreement. Between lay people and artists and then between artists and orthodontists there were a slight agreement, being respectively 0.2026 and 0.1703, corresponding to 41.2% and 38.8% of concordants. So it can be noticed that the lowest agreement was between lay people and orthodontists and the highest between lay people and plastic artists.

The obtained data show that there is little agreement between evaluation, suggesting that the criteria of esthetic appreciation are really subjective,

Table 3 - Descriptive statistic of linear measurements in the study groups (mm).

Data	n	Mean	SD	Minimum	Maximum	Median	p value[1]
Lower facial width	**85**	**23.61**	**2.32**	**16.75**	**29.64**	**-**	**0.378**
• Unpleasant	16	24.16	2.47	20.76	29.64	-	
• Acceptable	60	23.59	2.33	16.75	28.46	-	
• Pleasant	09	22.81	1.94	19.53	25.87	-	
Lower lip-mentonian height	**85**	**46.18**	**3.32**	**36.26**	**56.90**	**-**	**0.056**
• Unpleasant	16	47.89	3.22	44.26	56.90	-	
• Acceptable	60	45.89	3.14	36.26	51.07	-	
• Pleasant	09	45.06	3.99	40.99	54.40	-	
Filter length	**85**	**16.96**	**2.25**	**10.98**	**22.24**	**-**	**0.356**
• Unpleasant	16	17.53	2.23	14.34	22.24	-	
• Acceptable	60	16.92	2.31	10.98	21.10	-	
• Pleasant	09	16.19	1.85	12.85	18.52	-	
Upper lip vermillion extension	**85**	**6.67**	**1.27**	**3.16**	**11.00**	**-**	**0.987**
• Unpleasant	16	6.63	1.33	4.48	10.57	-	
• Acceptable	60	6.68	1.30	3.16	11.00	-	
• Pleasant	09	6.63	1.12	5.12	8.44	-	
Lower lip vermillion extension	**85**	**10.95**	**1.73**	**6.67**	**14.49**	**-**	**0.048**
• Unpleasant	16	11.39	1.39	8.89	13.57	-	
• Acceptable	60	10.67	1.74	6.67	14.49	-	
• Pleasant	09	12.01	1.78	9.48	14.00	-	
Mouth height	**85**	**17.60**	**2.59**	**10.83**	**24.39**	**-**	**0.303**
• Unpleasant	16	18.00	2.38	15.14	24.13	-	
• Acceptable	60	17.34	2.66	10.83	24.39	-	
• Pleasant	09	18.63	2.38	14.58	22.41	-	
Commissure line inclination	**85**	**0.94**	**0.76**	**0.00**	**4.09**	**0.82**	**0.141[2]**
• Unpleasant	16	1.19	0.65	0.05	2.05	1.20	
• Acceptable	60	0.91	0.80	0.00	4.09	0.77	
• Pleasant	09	0.67	0.53	0.11	1.59	0.82	
Mouth width	**85**	**50.54**	**3.66**	**42.91**	**59.82**	**-**	**0.213**
• Unpleasant	16	50.34	3.25	44.68	55.98	-	
• Acceptable	60	50.29	3.75	42.91	59.82	-	
• Pleasant	09	52.57	3.38	47.95	57.60	-	
Upper facial height	**85**	**142.40**	**7.07**	**125.26**	**157.77**	**-**	**0.374**
• Unpleasant	16	144.62	6.58	132.41	156.88	-	
• Acceptable	60	141.97	7.38	125.26	157.77	-	
• Pleasant	09	141.37	5.42	131.53	147.33	-	

Table 3 (continuation) - Descriptive statistic of linear measurements in the study groups (mm).

Data	n	Mean	SD	Minimum	Maximum	Median	p value(1)
Lower facial width	**85**	**113.71**	**7.36**	**95.87**	**131.91**	**-**	**0.647**
• Unpleasant	16	113.25	6.80	103.53	129.46	-	
• Acceptable	60	114.12	7.74	95.87	131.91	-	
• Pleasant	09	111.75	5.84	101.10	121.04	-	
Nose length	**85**	**44.73**	**4.57**	**35.85**	**57.21**	**-**	**0.195**
• Unpleasant	16	46.33	6.29	37.79	57.21	-	
• Acceptable	60	44.16	4.19	35.85	53.11	-	
• Pleasant	09	45.69	2.77	40.76	49.27	-	
Nose width	**85**	**36.20**	**3.01**	**28.86**	**43.89**	**-**	**0.661**
• Unpleasant	16	36.20	2.85	32.43	43.70	-	
• Acceptable	60	36.33	3.18	28.86	43.89	-	
• Pleasant	09	35.34	2.13	31.70	38.01	-	
Right eye width	**85**	**29.51**	**1.77**	**25.60**	**33.36**	**-**	**0.283**
• Unpleasant	16	29.96	1.73	26.65	33.09	-	
• Acceptable	60	29.32	1.77	25.60	33.36	-	
• Pleasant	09	30.04	1.72	26.78	32.43	-	
Left eye width	**85**	**29.85**	**1.92**	**26.02**	**34.52**	**-**	**0.347**
• Unpleasant	16	30.28	1.84	26.55	34.52	-	
• Acceptable	60	29.65	1.94	26.02	34.26	-	
• Pleasant	09	30.38	1.90	27.48	33.06	-	
Intercanthal width	**85**	**33.37**	**2.63**	**27.41**	**37.90**	**-**	**0.624**
• Unpleasant	16	32.79	3.01	27.46	37.19	-	
• Acceptable	60	33.51	2.59	27.41	37.90	-	
• Pleasant	09	33.45	2.25	29.95	35.54	-	
Middle face height	**85**	**70.56**	**5.85**	**57.42**	**87.83**	**-**	**0.215**
• Unpleasant	16	72.87	7.94	59.07	87.83	-	
• Acceptable	60	69.99	5.32	57.42	83.97	-	
• Pleasant	09	70.26	4.40	63.71	74.96	-	
Lower facial height	**85**	**69.76**	**4.89**	**56.86**	**80.88**	**-**	**0.080**
• Unpleasant	16	72.02	4.20	66.67	80.88	-	
• Acceptable	60	69.45	4.90	56.86	78.26	-	
• Pleasant	09	67.85	5.12	60.50	78.00	-	

OBSERVATION: It is recommended to use median for very high SD values. (1) ANOVA; (2) Kruskal-Wallis.

Table 4 - Descriptive statistics of proportional measurements in the study groups.

Data	n	Mean	SD	Minimum	Maximum	Median	p value (1)
Facial Index	**85**	**85.03**	**3.85**	**75.10**	**94.74**	**-**	**0.229**
• Unpleasant	16	86.52	4.30	77.99	94.03	-	
• Acceptable	60	84.70	3.59	76.91	94.74	-	
• Pleasant	09	84.58	4.48	75.10	89.12	-	
Facial height proportion	**85**	**1.01**	**0.09**	**0.81**	**1.26**	**-**	**0.677**
• Unpleasant	16	1.01	0.12	0.81	1.17	-	
• Acceptable	60	1.01	0.09	0.84	1.26	-	
• Pleasant	09	1.04	0.09	0.92	1.23	-	

(1) ANOVA.

Table 5 - Descriptive statistics of angular measurements in the study groups.

Data	n	Mean	SD	Minimum	Maximum	Median	p Value
Angle of facial symmetry	**85**	**1.45**	**1.05**	**0.01**	**4.46**	**1.24**	**0.618(1)**
• Unpleasant	16	1.66	1.07	0.32	3.67	1.26	
• Acceptable	60	1.43	1.06	0.01	4.46	1.25	
• Pleasant	09	1.19	0.96	0.34	3.31	1.16	
Facial aperture modified angle	**85**	**44.07**	**1.96**	**36.53**	**48.71**	**-**	**0.021(2)**
• Unpleasant	16	42.92	2.42	36.53	45.71	-	
• Acceptable	60	44.25	1.70	40.17	48.18	-	
• Pleasant	09	44.88	2.12	42.14	48.71	-	
V Angle	**85**	**71.02**	**3.48**	**62.51**	**80.38**	**-**	**0.011(2)**
• Unpleasant	16	68.98	4.07	62.51	75.66	-	
• Acceptable	60	71.72	3.27	63.05	80.38	-	
• Pleasant	09	69.98	1.97	67.80	73.47	-	
Symmetry of left and right side of the face	**85**	**1.35**	**0.93**	**0.01**	**3.56**	**1.20**	**0.470(1)**
• Unpleasant	16	1.47	1.01	0.05	3.50	1.38	
• Acceptable	60	1.26	0.89	0.01	3.56	1.10	
• Pleasant	09	1.69	1.10	0.03	3.50	1.67	

OBSERVATION: For very high SD values it is recommended to use the median. (1) Kruskal-Wallis; (2) ANOVA.

confirming the findings of Martins,[11] besides showing a tendency of orthodontists being more complacent, giving higher scores to the participants.

A possible explanation would be the concern of orthodontist with the symmetry, balance and facial proportions, not only with isolated shapes. Other factor is the fact that orthodontists know the facial limitations, being capable to recognize pleasant characteristics even among small imperfections. In this research the laymen were the most critical on the evaluation and the plastic artists assigned intermediate scores.

The more specialized and related to esthetics the evaluator groups, the higher were the scores assigned to the sample. However, these findings disagree with those presented in a study evaluating the attractiveness of facial profile and stated that, in general, clinicians (orthodontists and maxillofacial surgeons) were more strict about facial esthetics than non-clinician (plastic artists and laymen), although all groups have agreed on the choice of most attractive profile.[31] Thus, for more conclusive results about the degree of agreement between the assessors and the tendency of esthetic judgment between groups with different areas of expertise, it is important to emphasize that the ideal would be a group with a larger number of participants than the used in this research.

Numeric facial analysis

In five variables it were found important differences and these were related to the lower facial third and the facial standard. In the group esthetically unpleasant it was observed a tendency to more elongated faces with increased lower third, which is considered very unfavorable to the facial balance, especially in female subjects.

In the present research the mean found for the vermillion extension of lower lip was of 10.95±1.73 mm. This variable presented higher values for the esthetically pleasant group, with a mean value of 12.01 ± 1.78 mm. For the esthetically acceptable and unpleasant groups, the means were respectively 11.3 9 ± 1.39 mm and 10.67 ± 1.74 mm. The difference found between values on the 3 groups was considered statistically significant. This fact can be explained by the current preference for more thick lips spread by media.

The lower lip length was higher on the groups esthetically unpleasant.

The general mean found was 46.18 ± 3,32 mm. In the esthetically pleasant group the mean was of 45.06 ± 3.99 mm. For esthetically acceptable and unpleasant groups the mean values were respectively 45.89 ± 3.14 mm and 47.89 ± 3.22 mm. However, there was no statistically significant difference The same way, the lower facial height was also higher for esthetically unpleasant group. In this research, the mean was 69.76 ± 4,89 mm. The mean value found for the esthetically pleasant group was of 67.85 ± 5.12 mm; in the esthetically acceptable group 69.45 ± 4.90 mm and in the esthetically unpleasant 72.02 ± 4.20 mm. It was not observed statistically significant difference. Both lower lip length and lower facial height were higher in the esthetically unpleasant group. These two variables are related to a long lower third of the face.

The facial aperture modified angle was lower in the esthetically unpleasant group, being that a significant difference. The mean value obtained in this study was of 44.07 ± 1.96°. In the pleasant group the mean was 44.88 ± 2.12°, in the acceptable group was 44.25 ± 1.70° and in the unpleasant was 42.92 ± 2.42°. Lower values for this angle indicate a longer and thinner face, what agrees with the results obtained for the lower lip length and for lower facial height that also showed a tendency of esthetically unpleasant group presenting longer faces.

The V angle is related to the facial type. A lower value indicates a longer face and a higher value indicates a wider face. This angle presented significant difference compared to other groups, being higher for the esthetically acceptable group, indicating a tendency for a more horizontal facial growth for the individuals composing this group.

It was not found any other statistically significant difference for the other variables when comparing the 3 groups. This result demonstrated that the numeric facial analysis used isolated was not able to detect the attractiveness standard since beauty criteria are subjective, being influenced by cultural, racial, age and gender factors.[11]

This way, an orthodontic treatment just aiming to adequate to proposed standards by facial and cephalometric analysis do not guarantee an ideal beautiful face, but it is important that orthodontists and surgeons have the esthetics standards of orientation.[26,27]

Instead of seeking absolute values, the harmony, balance and proportionality associated to the esthetic perception of the patient should substantiate the diagnosis and treatment plan, so the esthetic benefits of the treatment is noticed by everyone.[2,21,24,27,29]

CONCLUSIONS

1) The sample was characterized by 16 individuals esthetically unpleasant 18.8%), 60 esthetically acceptable (70.6%) and 9 esthetically pleasant (10.6%), indicating dominance for the esthetically acceptable standard.
2) Obtained data showed little agreement between evaluation of orthodontists, plastic artists and lay people. The more specialized and related to esthetics the evaluator group, the higher were the scores assigned to the participants of the research. This way, orthodontists were the most complacent, followed by plastic artists, being the laymen the most critical evaluators.
3) In the evaluation of facial measurements, it was observed that in only 3 variables there were statistically significant difference, which were: Lower lip vermillion border, facial aperture modified angle and V angle. In two measurements it was observed adjacent probability: Lower lip length and anterior facial height.
4) The numeric facial analysis, when used isolated, seems to not be sensitive to detect attractiveness standards since they are highly subjective, being influenced by cultural, racial, age and gender factors.

REFERENCES

1. Ackerman JL, Proffit WR. Soft tissue limitations in orthodontics: treatment planning guidelines. Angle Orthod. 1997;67(5):327-36.
2. Angle EH. Classification of malocclusion. Dent Cosmos. 1899 Apr;41(2):248-64, 350-357.
3. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning - Part I. Am J Orthod Dentofacial Orthop. 1993 Apr;103(4):299-312.
4. Bishara SE, Jorgensen GJ, Jakobsen JR. Changes in facial dimensions assessed from lateral and frontal photographs. Part I - Methodology. Am J Orthod Dentofacial Orthop. 1995 Oct;108(4):389-93.
5. Colombo VL. Análise facial frontal em repouso e durante o sorriso em fotografias padronizadas [Monografia de Especialização]. Curitiba (PR): Associação Brasileira de Odontologia; 1998.
6. Cooke MS, Wei SH. The reproducibility of natural head posture: A methodological study. Am J Orthod Dentofacial Orthop. 1988 Apr;93(4):280-8.
7. Cox NH, Van Der Linden FPGM. Facial Harmony. Am J Orthod. 1971 Aug;60(2):175-83.
8. Farkas LG, Kolar JC. Antropometrics and art in the aesthetics of women's faces. Clin Plast Surg. 1987 Oct;14(4):599-616.
9. Ferrario VF, Sforza C, Miani A, Tartaglia G. Craniofacial morphometry by photografic evaluations. Am J Orthod Dentofacial Orthop. 1993 Apr;103(4):327-37.
10. Foster EJ. Profile preferences among diversified groups. Angle Orthod. 1973 Jan;43(1):34-40.
11. Martins LF. Análise fotométrica em norma frontal, de adultos, brasileiros, leuodermas, não tratados ortodonticamente, classificados pela estética facial [Dissertação]. São Bernardo do Campo (SP): Universidade Metodista de São Paulo, Faculdade de Odontologia; 2001.
12. Matoula S, Pancherz H. Skeletofacial morphology of attractive and nonattractive faces. Angle Orthod. 2006 Mar;76(2):204-10.
13. McKoy-White J, Evans CA, Viana G, Anderson NK, Giddon DB. Facial profile preferences of black women before and after orthodontic treatment. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):17-23.
14. Moorrees CF. Natural head position - a revival. Am J Orthod Dentofacial Orthop. 1994 May;105(5):512-3.
15. Morihisa O. Avaliação comparativa entre agradabilidade facial, Proporção àurea e padrão facial [Dissertação]. São Bernardo do Campo (SP): Universidade Metodista de São Paulo, Faculdade de Odontologia; 2006.
16. Moss J P, Linney AD, Lowey MN. Uso das técnicas tridimensionais na estética facial. In: Sadowski PL, Peck S, King G, Laskin DM. Atualidades em Ortodontia. São Paulo: Premier; 1997. p. 89-97.
17. Motoyoshi M, Namura S, Arai HY. A three-dimensional measuring system for the human face using three-directional photography. Am J Orthod Dentofacial Orthop. 1992 May;101(5):431-40.
18. Nanda RS, Ghosh J, Bazakidou E. Three-dimensional facial analysis using a vídeo imaging system. Angle Orthod. 1996;66(3):181-8.
19. Nguyen DD, Turley PK. A quantitative method for the evaluation of the soft-tissue facial profile. Am J Orthod Dentofacial Orthop. 1998 Aug;114(2):208-17.
20. Nguyen DD, Turley PK. Changes in the Caucasian male facial profile as depicted in fashion magazines during the twentieth century. Am J Orthod Dentofacial Orthop. 1998 Aug;114(2):208-17.
21. Peck H, Peck S. A concept of facial esthetics. Angle Orthod. 1970 Out;40(4);284-317.
22. Reche R. Análise do perfil facial em fotografias padronizadas. R Dental Press Ortod Ortop Facial. 2002 Jan-Fev;7(1):37-45.
23. Reis SAB. Análise facial numérica e subjetiva do perfil e análise da relação oclusal sagital de Brasileiros, adultos, leucodermas não tratados ortodonticamente [Dissertação]. São Bernardo do Campo (SP): Universidade Metodista de São Paulo, Faculdade de Odontologia; 2001.
24. Ricketts RM. Planning treatment on the basis of the facial pattern and an estimate of its growth. Angle Orthod. 1957 Jan;27(1):14-37.
25. Suguino R, Ramos AL, Terada HH, Furquim LZ, Filho OGS. Análise Facial. R Dental Press Ortod Ortop Facial. 1996 Set-Out;1(1):86-107.
26. Verona J. Análise facial frontal masculina em repouso e durante o sorriso, métodos manual e computadorizado, em fotografias padronizadas. [Monografia de Especialização]. Curitiba (PR): Associação Brasileira de Odontologia; 2004.
27. Wuerpel EH. On facial balance and harmony. Angle Orthod. 1937;7:81-9.
28. Silva NCF, Aquino ERB, Mello KCFR, Mattos JNR, Normando D. Habilidade de ortodontistas e leigos na percepção de assimetrias da mandíbula. Dental Press J Orthod. 2011 July-Aug;16(4):38.e1-8.
29. Reis SAB, Abrão J, Claro CAA, Capelozza Filho L. Avaliação dos fatores determinantes da estética do perfil facial. Dental Press J Orthod. 2011 Jan-Feb;16(1):57-67.
30. Pereira AL, De-Marchi LM, Scheibel PC, Ramos AL. Reprodutibilidade da posição natural da cabeça em fotografias de perfil de crianças de 8 a 12 anos, com e sem o auxílio de um cefalostato. Dental Press J Orthod. 2010 Jan-Fev;15(1):65-73.
31. Almeida MD, Farias ACR, Bittencourt MAV. Influência do posicionamento sagital mandibular na estética facial. Dental Press J Orthod. 2010 Mar-Apr;15(2):87-96.

Facial pattern of patients with post-foramen incisor cleft

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Objective: The assessment and establishment of the facial growth pattern for patients with a cleft palate.

Material: This cross-sectional retrospective study was based on front and profile photos of a sample of 71 patients at the HRAC-USP, 22 males and 49 females, Brazilians, young adults, with a mean age of 17 years 8 months, without previous orthodontic treatment and no associated syndromes. The method was the subjective facial diagnosis based on technical concepts, that is, the qualitative morphologic analysis of the face through clinical examination. Individuals were classified as Pattern I, II, III, Long Face or Short Face.

Results: The distribution found with the frontal morphologic analysis was: Pattern I (69%), II (6%), III (7%), Long (18%) and Short (0%). As for the profile morphologic analysis, the distribution was: Pattern I (35%), II (38%), III (10%), Long (17%) and Short (0%).The distribution observed in the frontal analysis was very positive, since individuals Pattern I prevailed. For the profile evaluation, the anterior-posterior dysplasias were essentially shown, significantly increasing their participation. Long Face Pattern maintained a balance in both ratings and Short Face Pattern was not found in the sample used, probably related to the low prevalence in the general population.

Conclusion: The prevalence of different Facial Patterns for patients with cleft palate was similar to that found in individuals without cleft.

Keywords: Cleft palate. Orthodontics. Growth.

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

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INTRODUCTION

Cleft lip and/or palate are congenital malformations that occur in the embryonic period and involve numerous consequences that can follow a person throughout life. The morphological change clinically manifested is variable and may involve the lip, palate or lip and palate.[28]

The cleft palate, which corresponds to about 23% of cleft patients,[9] the object of study of this work, appears in the prenatal life, the period between late embryonic and early fetal periods, specifically between the eighth and twelfth week of pregnancy, during which it is fused the secondary palate. The formation of the secondary palate comprises: 1) The growth of two individual palate processes, one on each side, originated from the inner part of the maxillary processes, 2) the elevation of palatal processes obliquely positioned on each side of the tongue, and 3) finally, medial growth toward the midline to the junction of two palatine processes, which culminates in the disappearance of the epithelium that covers and individualizes it, characterized by a biological mechanism called **"**mesodermization**".** These events occur until the twelfth week of prenatal life. The fusion failure of the palatine processes, due to the absence of any of these events described above, determines the cleft palate, which morphological diversity varies in length from a cleft uvula to the full impairment of the palate when it reaches the incisive foramen (Fig 2).**[3]** They can be classified as complete or incomplete and aggravating from posterior to anterior. It is believed in extra-genetic etiology for cleft palate, although it has been mentioned that several genes are involved in the formation of palate.[11,18]

The Hospital for Rehabilitation of Craniofacial Anomalies (HRAC-USP) set a routine therapy that establishes the performance of palatoplasty at 12 months old. It seems obvious the logic to reconstruct the morphology and then seek an adjustment of the functions developed by the nasopharyngeal system.[19] The anatomical restoration of cleft palate aims to develop normal speech, protection of the nasal respiratory mucosa and better functioning of the Eustachian tube. There is a consensus that the earlier the palatoplasty is performed, the better the functional responses.[16] In patients with cleft palate, palatoplasty may negatively influence the sagittal maxillary performance, according to analysis of malar projection on the face, although it does not compromise the facial behavior pattern.[29]

The configuration of the dentofacial characteristics of patients with cleft lip and / or palate has been based on cephalometry. In this context, the cephalometric pattern of patients with cleft palate displays difference in relation to cephalometric normative.[27] Due to lack of literature reports describing the facial pattern of patients with this type of cleft, there is the necessity of a larger study that is not based solely on the cephalometric pattern but also in the facial morphology.

OBJECTIVE

The purpose of this study was to diagnose the facial growth pattern in patients with cleft palate using facial morphological analysis, through frontal and profile assessments, defining the classification based on the concept of pattern suggested by Capelozza Filho.[5]

MATERIAL AND METHODS

For this retrospective cross-sectional study were selected frontal and profile photographs based on existing orthodontic records, 71 patients enrolled at HRAC-USP (Fig 1), 22 males and 49 females, Brazilian, Caucasian, young adults in permanent dentition stage, an average of 17 years and 8 months old, with no history of orthodontic treatment nor associated syndromes.

The sample distribution is in agreement with the literature, where there is a greater consensus on the frequency of cleft palate in women.[26,27]

The post-surgical morphological changes, so remarkable in cleft lip and palate,[8] ultimately redesign the maxilla during growth, they do not esthetic compromise the cleft palate maxillas, proving that palatoplasty does not induce changes in the facial pattern of patients with cleft palate.[1,2,26,29] Based on this concept, we classified the operated and non-operated patients disregarding the variable "surgery intervention".

The photographs were prepared, standardized and assembled on round black backgrounds through specific computer program (Adobe Photoshop CS2) and they were printed in size 10 x 15 cm, in order to create a photo album. The album had two photographs per page of each patient: a frontal and a profile picture. Aiming to eliminate a possible influence of incorrect head posture,[4] the photographs were assembled on

round black backgrounds (Fig 3). Thus the examiner defined the Frankfort's horizontal plane (Fig 4) in the image and, in case of not being parallel to the ground, correctly oriented the photo in the album on the proper position for evaluation.

The two examiners, orthodontists at HRAC-USP, assigned scores based on technical concepts, consisting only of qualitative morphological analysis of the face performed in two assessments and did not receive prior calibration about the photographs of this study. The purpose of the absence of calibration was to make sure that only the individual impressions were recorded when it comes to facial growth pattern of the patients. For the first assessment, the album was delivered to the examiners and they were instructed to evaluate the photographs for 1 minute and diagnose patients according to the growth pattern for the frontal view and profile: a) Pattern I, b) Pattern II, c) Pattern III d) Long Facial Pattern e) Short Facial Pattern. At this stage the examiners did not know that they would perform a second evaluation intended to verify the intra-examiner match-up. A second assessment was done 10 days after the first, and the same instructions were given.

Pattern I is identified in a normal face. When there is a malocclusion, it is only dental, not associated with any sagittal or vertical skeletal discrepancy (Fig 5). Patterns II and III (Figs 6 and 7) are characterized respectively by the positive and negative sagittal balance between maxilla and mandible. In the Long (Fig 8) and Short Facial Patterns (Fig 9) there is

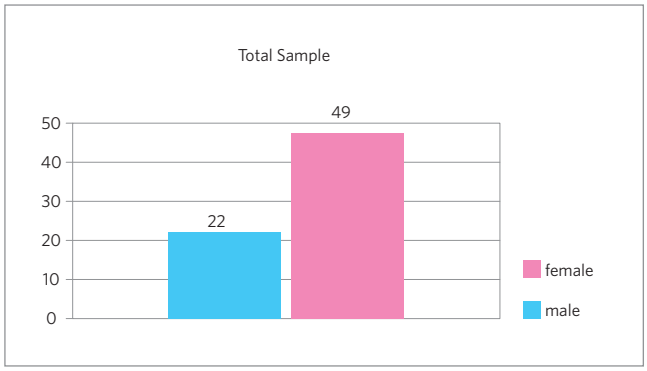

Figure 1 - Gender distribution for total sample.

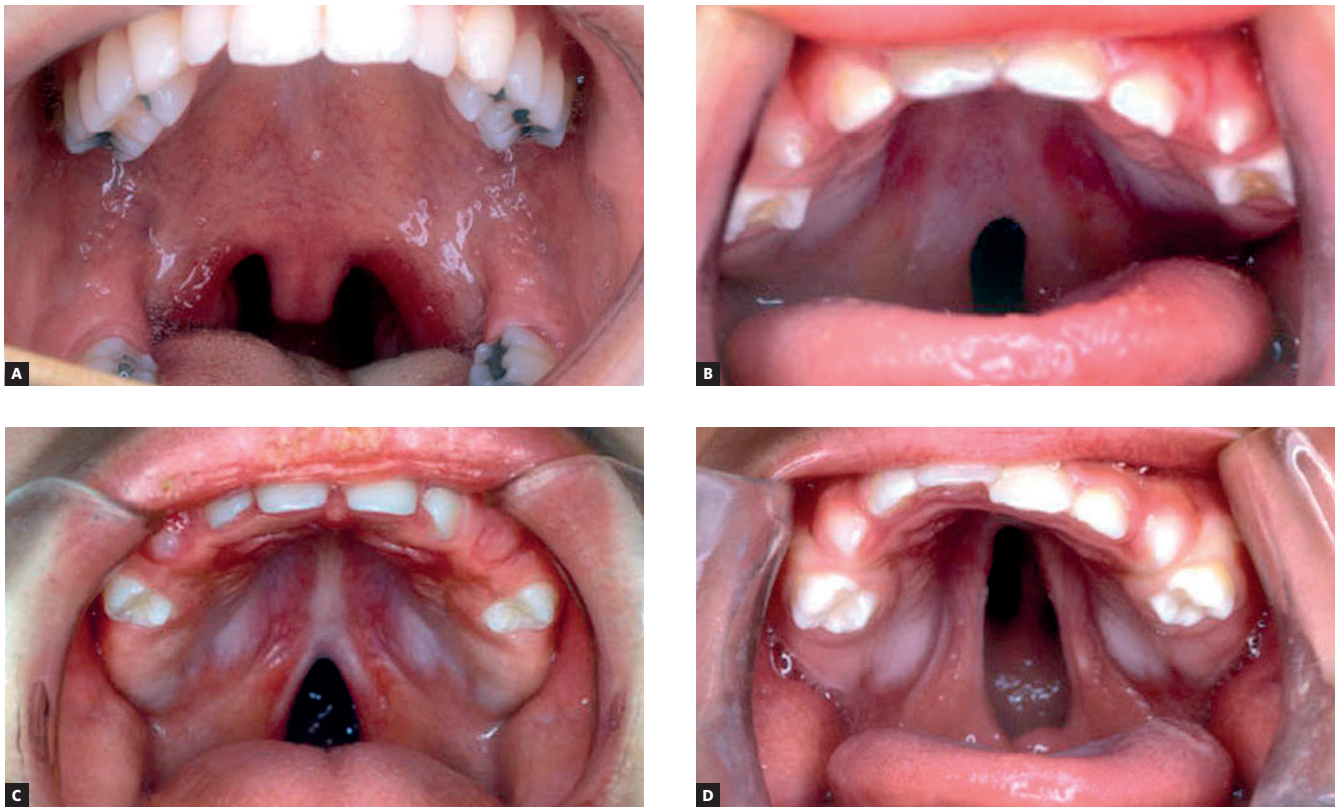

Figure 2 - **A**) Different extensions of cleft palate: In uvula (incomplete cleft palate); **B**) different extensions of cleft palate: In the soft palate (incomplete cleft palate); **C**) different extensions of cleft palate, partial hard palate (incomplete cleft palate); **D**) different extensions of cleft palate, total hard palate (complete cleft palate).

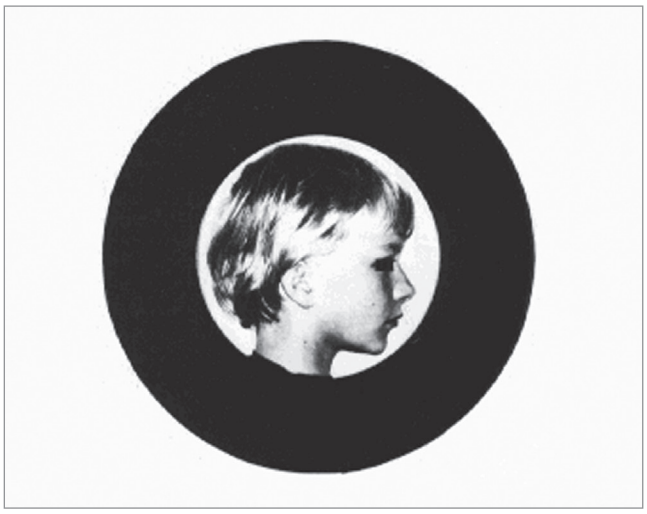

Figure 3 - Photography changed in the computer software, assembled and standardized as described by Bittner and Pancherz.[4]

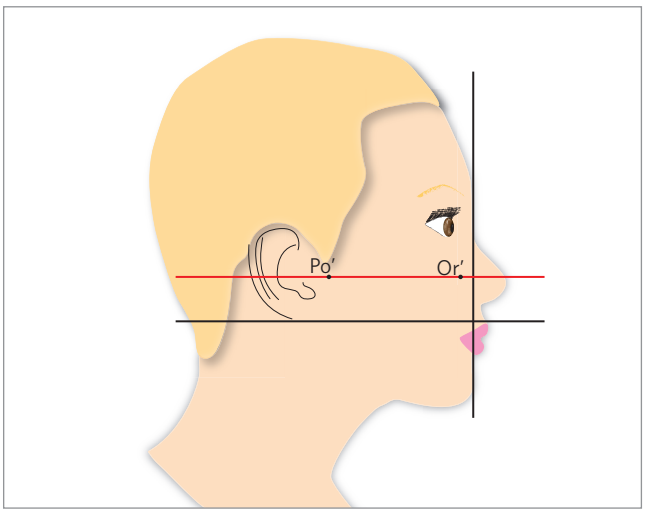

Figure 4 - Frankfort Horizontal Plane: The line between points Po'-Or '.

a vertical discrepancy. In patients with skeletal discrepancies, malocclusions are usually consequences of these disharmonies.

On the profile assessment, the Pattern I is characterized by a moderate degree of convexity. The maxillary expression on the face is identified by the presence of the zygomatic projection and infraorbital depression, which can be verified also in the front view. The nasal base line, slightly inclined to the anterior, shows proper maxillary position. The rictus nasogeniano with a slight posterior inclination, completes the assessment of the maxillary balance. The nasolabial angle evaluates the nasal base in relation to the upper lip, which position is largely determined by the inclination of upper incisors. Therefore, this angle may be appropriated, open or closed in Pattern I patients, as a consequence of the position of the upper front teeth, regardless the good maxillary position, always observed in these patients.[5,20,24]

The maxillary balance (size, shape and position) may be verified on profile assessment through the mentocervical angle. It should be expressive without being excessive and tend to parallelism with the Camper's Plane. This parallelism contributes to a proper mentocervical angle. In addition, it is expected an esthetically pleasing mentolabial sulcus and built with equal participation of the lip and chin.[5]

Patients from patterns II and III present saggital discrepancy between the maxilla and identified mandible, mainly on the lateral face assessment. Individuals classified as Pattern I in front view and in profile II or III have a better prognosis when compared to patterns II or III in front and side view, in which the unbalance is severe enough to be identified in the frontal assessment due to its vertical consequences. Pattern II presents increased facial convexity as a result of maxillary excess, rarer, or by mandibular deficiency. Generally, it is observed a maxilla with good expression on the face, while the lower third is deficient with a short mentocervical angle.[22]

In Pattern III, the facial convexity presents a decrease,[22] resulting in a straight profile or rarely concave, due to maxillary deficiency, mandibular prognathism or the combination of both. The middle facial height tends to look deficient, even if it is normal, because the mandibular excess dislocate to anterior the soft tissue of the maxilla, masking the zygomatic projection reading.[5] The lower face tends to increase, especially in prognathism, and the mentocervical angle looks normal in maxillary deficiency individuals or excessive in the prognathous.

The patients classified as Long and Short Facial Patterns have a visible vertical unconformity in the front and profile evaluations.[5] The long facial pattern is characterized by excessive facial height, resulting in the absence of lip sealing, increased facial convexity, weak maxilla expression and short mentocervical angle.[7] The Short Facial Pattern patient is identified by disabilities in the vertical dimensions, compressed lips, maxilla with appropriate position and high mentocervical angle, due to counterclockwise rotation of the mandible.[5] To perform the analysis of inter and intra-examiner

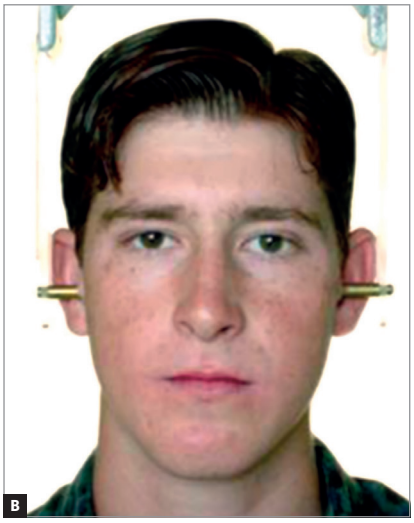

Figure 5 - **A**) Frontal facial photograph of a Pattern I patient with cleft palate; **B**) facial profile photograph of a Pattern I patient with cleft palate.

Figure 6 - **A**) Photograph of frontal facial Pattern II patients with cleft palate; **B**) facial profile photograph of a Pattern II patient with cleft palate.

Figure 7 - **A**) Frontal facial photograph of a patient with Pattern III cleft palate; **B**) facial profile photograph of Pattern III patient with cleft palate.

Figure 8 - **A**) Frontal facial photograph of a Long Facial Pattern patient with cleft palate. **B**) Facial profile photograph of a Long Facial Pattern patient with cleft palate.

Figure 9 - **A**) - Frontal facial photograph of a Short Facial Pattern patient. **B**) Profile facial photograph of a Short Facial Pattern patient.

data, the Kappa statistic[15] was used, and the confidence intervals were constructed by the methods proposed by Donner and Eliasziw.[13]

RESULTS

The facial morphological analysis is the main diagnosis tool to determine the Facial Pattern [21] that refers to treatment protocols and specific prognostic in different age groups.[5]

This study, aiming to define the prevalence of different patterns for individuals with cleft palate, yielded the values shown in figures 10 and 11, with Kappa values ranging from 0.76 to 0.98 for the frontal analysis and 0.81 to 0.98 for the profile in the intra-examiner assessment, with a high level of agreement. Kappa statistics in assessing inter examiner ranged from 0.45 to 0.79 for the frontal analysis and from 0.45 to 0.79 for the profile, with a rate of moderate to substantial agreement.

DISCUSSION

The distribution observed in the frontal aspect was potentially positive regarding the esthetic point of view, since Pattern I individuals were predominant in this analysis (69%), similar to results obtained in studies with patients without cleft, to the different patterns, not including Long Face and Short Face, where the pattern I obtained 85% of the sample.[23]

Once the profile was considered, the distribution changed significantly. This difference in ratings for Patterns in the frontal and profile, called index of

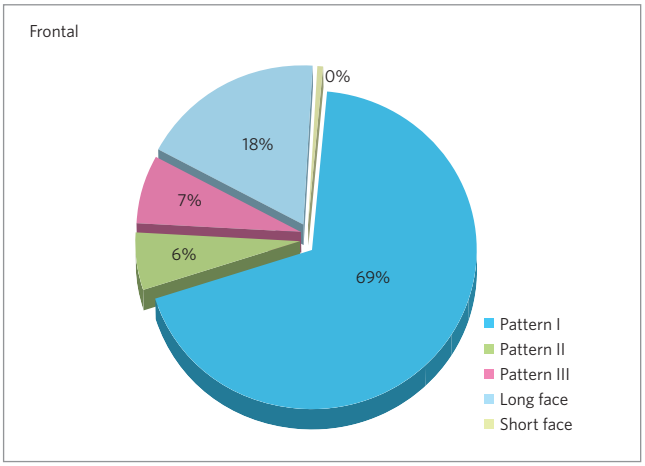

Figure 10 - Distribution of different patterns in frontal view.

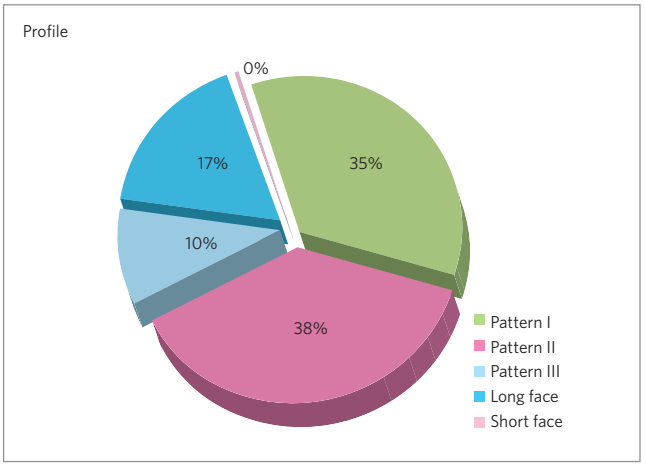

Figure 11 - Distribution of different patterns in the profile aspect.

incompatibility was 35% for the total sample, the same value found in patients without cleft.[23] This change was clearly expressed by the migration of individuals classified as frontal Pattern I to the Patterns III and especially II, by the profile classification. As suggested by Reis,[23] it is in this norm — the profile — that the malocclusions of Patterns II and III, anteroposterior dysplasia, are essentially expressed. The present work noticed the prevalence of 38% and 10% respectively in the Patterns II and III in the profile. Thus, following the higher prevalence of malocclusions in the Pattern II, many individuals that presented it with a less significant magnitude, were not marked in the frontal analysis of the face, being classified as Pattern I (32%). The same happened, in lower proportions, with Standard III (3%).

For the prevalence of Pattern I individuals, we must consider them only when the classification is repeated for the front and profile, so the prevalence would be 35%, similar to the projection for the general population of individuals without cleft, considering the characteristics of sample, in which patients with vertical discrepancies were not included.

From the cephalometric point of view, individuals with cleft palate present a retrognathic mature face, however, with an acceptable sagittal relation between the apical bases.[2,25] This satisfactory sagittal relation is followed by a facial growth with a predominant vertical component, due to mandibular structural morphology, facilitating clockwise rotation, regardless previous therapeutic approaches.[1,12,26] The Long Facial Pattern, vertical discrepancy visible in front and profile[6] assessments, is an average prevalence deformity. In a recent study,[11] the prevalence was of 14.06% for Brazilians, between 12 and 15 years old, from this group, 0.68% have a deformity severe enough to justify the indication for an orthodontic surgical treatment. In this study, the frontal and profile evaluations had balanced results (18 and 17% respectively), similar to literature.[10,14,17]

The Short Facial Pattern, due to the low prevalence in the general population, has a negative vertical discrepancy, not being found in the sample used, probably due to the predominance of vertical growth in individuals with cleft palate.

CONCLUSION

This study found the prevalence of different Patterns for individuals with cleft palate by qualitative morphological facial analysis, suggesting that:

- The prevalence of several Patterns for patients with cleft palate was similar to the one of individuals without cleft;
- Regarding the esthetic point of view, the distribution in the frontal aspect was very positive, since Pattern I individuals prevailed;
- Analyzing the profile, the anteroposterior dysplasias were expressed in essence, increasing significantly their participation;
- The Long Facial Pattern, presenting a vertical discrepancy visible in the frontal and profile assessments, maintained balanced in both evaluations.
- The Short Facial Pattern was not found in the sample used, which is probably related to the low prevalence in the general population.

REFERENCES

1. Bishara SE. Cephalometric evaluation of facial growth in operated and non-operated individuals with isolated clefts of the palate. Cleft Palate J. 1973 Jul;10:239-46..
2. Bishara SE. The influence of palatoplasty and cleft length on facial development. Cleft Palate J. 1973 Oct;10:390-8.
3. Bishara SE. Ortodontia. São Paulo: Ed. Santos; 2004.
4. Bittner C, Pancherz H. Facial morphology and malocclusions. Am J Orthod Dentofacial Orthop. 1990 Apr;97(4):308-15.
5. Capelozza Filho L. Diagnóstico em Ortodontia. Maringá (PR): Dental Press; 2004.
6. Capelozza Filho L, Cardoso MA, An TL, Bertoz FA. Características cefalométricas do padrão face longa: considerando o dimorfismo sexual. Rev Dent Press Ortodon Ortop Facial. 2007 Mar-Abr;12(2);49-60.
7. Capelozza Filho L, Cardoso MA, An TL, Lauris JRP. Proposta para classificação, segundo a severidade, dos indivíduos portadores de más oclusões do Padrão Face Longa. Rev Dent Press Ortodon Ortop Facial. 2007 Mar-Abr;12(4);124-58.
8. Capelozza Filho L, Cavassan AO, Silva Filho OG. Avaliação do crescimento craniofacial em portadores de fissura transforame incisivo unilateral: estudo transversal. Rev Bras Cirur. 1987 Mar-Abr;77(2):97-106.
9. Capelozza Filho L, Silva Filho OG. Abordagem interdisciplinar no tratamento das fissuras labiopalatinas. In: Mêlega JC. Cirurgia plástica fundamentos e arte: cirurgia reparadora da cabeça e pescoço. Rio de Janeiro: Medsi; 2002. p. 59-88.
10. Cardoso MA. Epidemiologia do Padrão Face Longa em escolares do ensino fundamental do município de Bauru – SP [Tese de Doutorado]. Araçatuba (SP): Universidade Estadual Paulista, Faculdade de Odontologia; 2007. 112f.
11. Cardoso MA, Capelozza Filho L, An TL, Lauris JRP. Epidemiologia do Padrão Face Longa em escolares do Ensino Fundamental do município de Bauru - SP. Dental Press J Orthod. [online]. 2011;16(2):108-19 .
12. Christensen K, Fogh-Andersen P. Isolated cleft palate in Danish multiple births, 1970-1990. Cleft Palate Craniofac J. 1993 Sep;30(5):469-74.
13. Dahl E. Craniofacial morphology in congenital clefts of the lip and palate: an x-ray cephalometric study of young adult males. Acta Odontol Scand. 1970;28:Suppl 57:11.
14. Donner A, Eliasziw M. A goodness-of-fit approach to inference procedures for the Kappa statistic: confidence interval construction, significance-testing and sample size estimation. Stat Med. 1992 Aug;11(11):1511-9.
15. Fitzpatrick BN. The long face and V. M. E. Aust Orthod J. 1984 Mar;8(3):82-9.
16. Fleiss JL, Levin B, Paik MC. Statistical methods for rates and proportions. 3rd ed. Hoboken (NJ): John Wiley; 2003.
17. Jolleys A. A review of the results of operations on cleft palates with reference to maxillary growth and speech functions. Br J Plast Surg. 1954 Oct;7(3):229-41.
18. Linder-Aronson S, Woodside DG. Excess face height malocclusion: etiology, diagnosis and treatment. Chicago (IL): Quintessence, 2000.
19. Miettinen PJ, Chin JR, Shum L, Slavkin HC, Shuler CF, Derynck R, Werb Z.. Epidermal growth factor receptor function is necessary for normal craniofacial development and palate closure. Nat Genet. 1999 May;22(1):69-73.
20. Piazentin SHA. A influência da palatoplastia primária nas alterações do ouvido médio [Dissertação]. São Paulo: Pontifícia Universidade Católica de São Paulo; 1989.
21. Reis SAB, Abrão J, Capelozza Filho L, Claro CAA. Análise facial numérica do perfil de brasileiros Padrão I. Rev Dent Press Ortodon Ortop Facial. 2006 Nov-Dez;11(6):24-34.
22. Reis SAB, Abrão J, Capelozza Filho L, Claro CAA. Análise Facial Subjetiva. Rev Dent Press Ortodon Ortop Facial. 2006 Set-Out;11(5):159-72.
23. Reis SAB, Abrão J, Capelozza Filho L, Claro CAA. Estudo comparativo do perfil facial de indivíduos Padrões I, II e III portadores de selamento labial passivo. Rev Dent Press Ortodon Ortop Facial. 2006 Jul-Ago;11(4):36-45.
24. Reis SAB. Análise facial numérica e subjetiva do perfil e análise da relação oclusal sagital de brasileiros, adultos, leucodermas, não tratados ortodonticamente [Dissertação]. São Paulo: UMESP; 2001.
25. Reis SAB, Capelozza Filho L, Cardoso MA, Scanavini MA. Características cefalométricas dos indivíduos padrão I. Rev Dent Press Ortodon Ortop Facial. 2005;10(1):67-78.
26. Shibasaki Y, Ross RB. Facial growth in children with isolated cleft palate. Cleft Palate J. 1969 Jul;6:290-302.
27. da Silva Filho OG, Cavassan AO, Normando ADC. Influência da palatoplastia no padrão facial de pacientes portadores de fissura pós-forame incisivo. Rev Bras Cirur. 1989 Nov-Dez;79(6):315-22.
28. da Silva Filho OG, Cavassan AO, Sampaio LL. Avaliação do padrão cefalométrico em pacientes portadores de fissura pós-forame incisivo, não operado. Rev Bras Cirur. 1989 Maio-Jun;79(3):137-47.
29. da Silva Filho OG, Ferrari Junior, FM, Rocha DL, Souza Freitas JAS. Classificação das fissuras lábio-palatais: breve histórico, considerações clinicas e sugestão de modificação. Rev Bras Cirur. 1992 Mar-Abr;82(2):59-65.
30. da Silva Filho OG, Rosa LA, Lauris Rde C. Influence of isolated cleft palate and palatoplasty on the face. J Appl Oral Sci. 2007 Jun;15(3):199-208.

Conservative treatment of a Class I malocclusion with 12 mm overjet, overbite and severe mandibular crowding

Marcos Alan Vieira Bittencourt[1], Arthur Costa Rodrigues Farias[2], Marcelo de Castellucci e Barbosa[3]

Introduction: A female patient aged 12 years and 2 months had molars and canines in Class II relationship, severe overjet (12 mm), deep overbite (100%), excessive retroclination and extrusion of the lower incisors, upper incisor proclination, with mild midline diastema. Both dental arches appeared constricted and a lower arch discrepancy of less than -6.5 mm. Facially, she had a significant upper incisors display at rest, interposition and eversion of the lower lip, acute nasolabial angle and convex profile.

Objective: To report a clinical case consisting of Angle Class I malocclusion with deep overbite and overjet in addition to severe crowding treated with a conservative approach.

Methods: Treatment consisted of slight retraction of the upper incisors and intrusion and protrusion of the lower incisors until all crowding was eliminated.

Results: Adequate overbite and overjet were achieved while maintaining the Angle Class I canine and molar relationships and coincident midlines. The facial features were improved, with the emergence of a slightly convex profile and lip competence, achieved through a slight retraction of the upper lip and protrusion of the lower lip, while improving the nasolabial and mentolabial sulcus.

Conclusions: This conservative approach with no extractions proved effective and resulted in a significant improvement of the occlusal relationship as well as in the patient's dental and facial aesthetics.

Keywords: Malocclusion. Angle Class I Malocclusion. Comprehensive Orthodontics.

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

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INTRODUCTION

Orthodontic treatment options to tackle negative discrepancy cases — with or without extractions — have always been controversial.[16]

Crowding usually affects the anterior region and, less frequently, the posterior region, often manifesting itself during puberty. It has a multifactorial etiology and may be linked to a decreased arch length, occlusion maturation, mesial force vector, muscle balance, morphology, tooth loss and retention.[17]

Crowding can be corrected without dental extractions by distalization of posterior teeth, projection of anterior teeth, arch expansion and selective stripping, or with tooth extractions, usually premolars. The position of the teeth in space, their movement, and the stability of the final result, in addition to facial aesthetics, are important conditions that must be considered in treatment planning.

Malocclusions characterized by crowding and severe overjet can interfere with social relations since facial aesthetics is regarded as a determining factor in society's as well as the individual's perceptions of themselves. Moreover, dissatisfaction with one's appearance is the main reason why people seek orthodontic treatment.[6] In this context, the severity of anterior crowding is probably one of the most important elements in the development of a treatment strategy. The approach can vary, however, depending on malocclusion severity and the orthodontist's technical-scientific knowledge.

It is a known fact that depending on how treatment is planned and carried out different responses can be induced in the soft tissues. Positive and negative correlations between incisor positioning and the lips have been found by several authors, [1,2,14,22] who reported that variables such as lip morphology, type of treatment (with or without extraction), gender and age are responsible for individual differences in soft tissue response.

This article aimed to report a case of an adolescent patient with Angle Class I malocclusion, Class II skeletal pattern with 12 mm overjet, 100% overbite and severe crowding in the premolar region, treated without extractions.

CLINICAL CASE REPORT

Female patient of mixed ethnicity, aged 12 years and 2 months, sought orthodontic treatment at the Professor José Édimo Soares Martins Center for Orthodontics and Facial Orthopedics, School of Dentistry, Federal University of Bahia, Brazil, with the chief aesthetic complaint of pronounced overjet and severe crowding.

She was in good general health. Extraoral analysis disclosed a dolichocephalic, symmetrical facial pattern, with balanced facial thirds, convex profile, proportional nose, lower lip interposition habit, nasolabial angle close to 90° and shallow mentolabial sulcus. When smiling, she displayed a wide buccal corridor (Figs 1A, B and C).

Intraoral examination revealed an elliptical upper arch and square lower arch with considerable crowding in the premolar region, deep curve of Spee and upright mandibular incisors, forming a rather shallow mentolabial sulcus due to insufficient protrusion of the lower lip. The patient presented with Angle Class I malocclusion, with a slight midline deviation to the right, 12 mm overjet and 100% overbite. The arch length discrepancy was less than -6.5 mm (Figs 1D-H). She had healthy periodontal tissues, maintained regular oral hygiene and had a slight biofilm accumulation in the cervical thirds of the regions affected by crowding.

The panoramic and periapical radiographs showed the presence of all permanent teeth, including impacted third molars (Fig 2). The lateral cephalogram can be seen in Figure 3. In the cephalometric analysis, an ANB angle of 5° underscored her Class II skeletal pattern, confirmed by analysis of Wits, with a 3 mm maxillomandibular discrepancy. The lower incisors appeared upright in their apical base, and the upper incisors proclined and protruded (1.NA = 32°, 1-NA = 9 mm, 1.NB = 17°, 1-NB = 3 mm, IMPA = 85°). Bolton analysis indicated anterior and total tooth sizes within normal limits. Examination of hand and wrist radiographs revealed that pubertal growth spurt was nearly at its peak (Fig 4).

Treatment goals

The treatment goals were as follows: 1) Ensure proper oral hygiene, 2) improve the skeletal relationship between maxillary and mandibular basal bones, 3) preserve the normal occlusion, 4) establish a normal canine occlusion, 5) correct the upper midline deviation; 6) improve the form of the upper and

Figure 1 - Pretreatment facial and intraoral photographs.

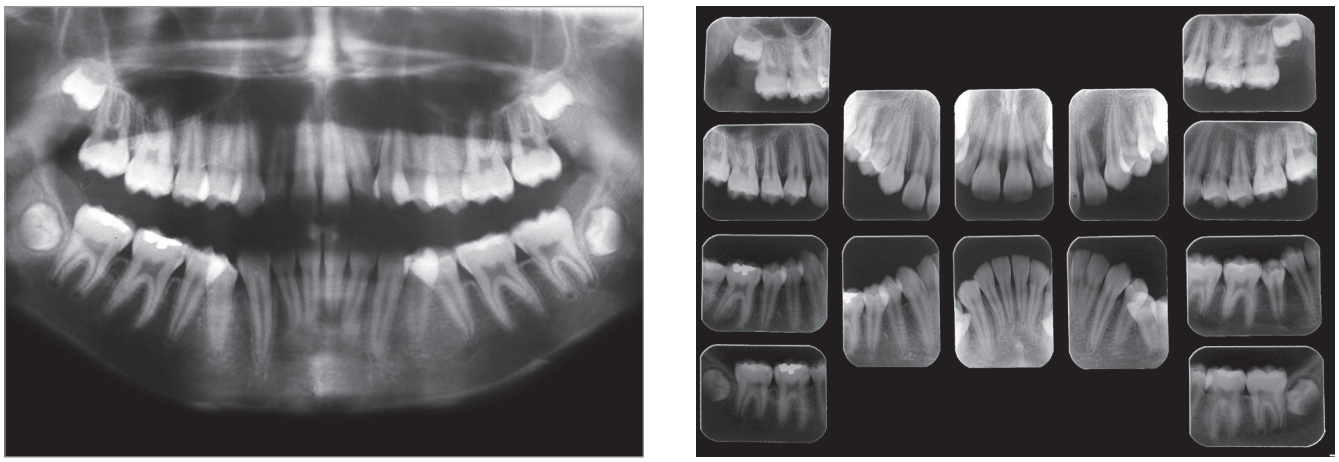


Figure 2 - Pretreatment panoramic and periapical radiographs.

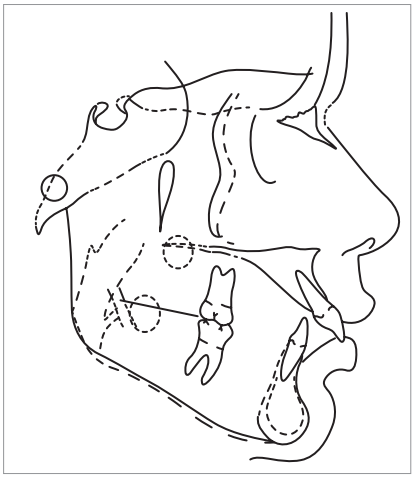


Figure 3 - Pretreatment lateral cephalometric radiographs and cephalometric tracing.

Figure 4 - Pretreatment hand-wrist radiograph.

lower arches as well as interarch coordination, 7) adjust overbite and overjet at a proper level, 8) eliminate the lower negative discrepancy, 9) restore normal masticatory function with a mutually protected occlusion, 10) enable lip competence, 11) achieve satisfactory facial aesthetics, improving the profile.

Planning

An important point to consider in the treatment plan is that the facial profile could be severely affected if the option to extract four premolars had been made, which at first seemed to be the wisest choice. However, the patient had a nasolabial angle of 90° and a shallow mentolabial sulcus, which could be worsened by the extractions. After careful study, a diagnostic simulation was carried out (orthodontic setup) without extractions as a guide to planning and to help envisage, as closely as possible, the final treatment outcome.

Based on the data, it was decided that the most suitable option would be to perform orthodontic treatment without extractions, with intrusion and protrusion of the anterior mandibular teeth and arch form adjustment.

Treatment progress

Treatment was initiated by instructing the patient on proper oral hygiene. A 0.022 x 0.028-in fixed Standard Edgewise appliance was placed on the upper arch. Thereafter, the upper arch was aligned and leveled with a 0.014-in Multiloop CrNi archwire and, subsequently, a sequence of round 0.016-in, 0.018-in and 0.020-in CrNi wires with omega loop at a distance of 0.5 mm from the molar tube to tie-back archwire. In the retraction phase, a combined headgear (350 g of force) was used for anchorage purpose. The case was finished with 0.019 x 0.025-in CrNi archwire with ideal bends and torques.

Lingual arch was bonded to the mandibular arch and accessories inserted only on the first molars and incisors. Segmental alignment and leveling was performed on these teeth using a sequence of 0.014-in, 0.016-in, 0.018-in and 0.020-in CrNi wires, and subsequently, intrusion was achieved with Ricketts utility arch (RUA) (CrNi 0.019 x 0.025-in). Class II elastics were then used to prevent the RUA from inducing tip-back in the molars, which would yield greater anteroinferior protrusion (Figs 5A-D). After an adequate intrusion was achieved, an archwire with an omega loop beyond the molar tube was placed (increased length), thereby engaging the lower incisor protrusion, which was enhanced due to the placement of a labial arch tied to the anterior mandibular arch with steel ligatures (Figs 5E-H).

After ensuring an adequate protrusion in the lower incisors, space was created to align the canines and premolars, which were bonded and aligned with Multiloop 0.016-in CrNi wire. In view of improved overbite and overjet, alignment and leveling were continued in the lower arch using 0.018-in and 0.020-in straight wires. The case was finished using 0.019 x 0.025-in archwires with ideal bends and torques (Fig 6).

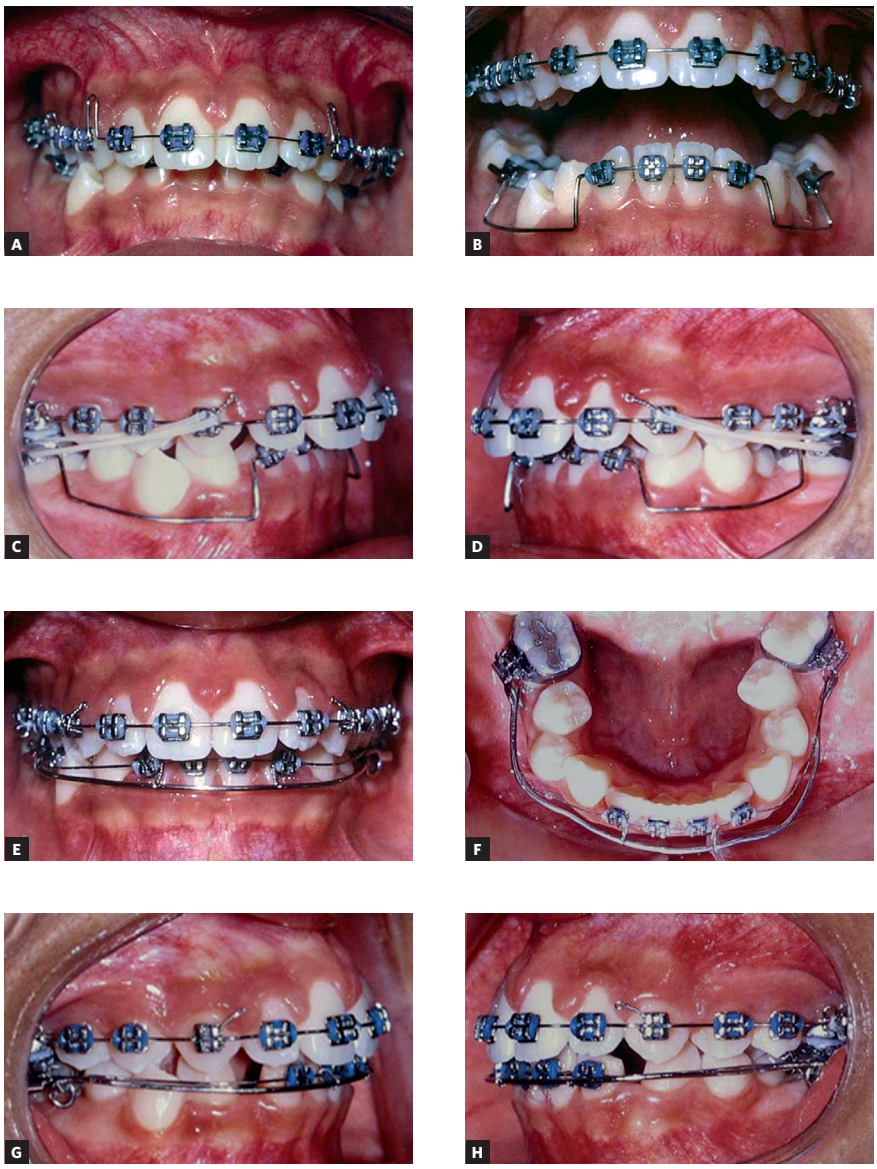


Figure 5 - Treatment progress: **A**) Alignment and leveling of the upper dental arch with Multiloop archwires; **B**) intrusion of lower incisors with Ricketts utility arch; **C**, **D**) use of Class II mechanics with orthodontic elastics, enhancing the anterior inferior protrusion and controlling molar inclination; **E**-**H**) labial archwire as an aid in lower protrusion.

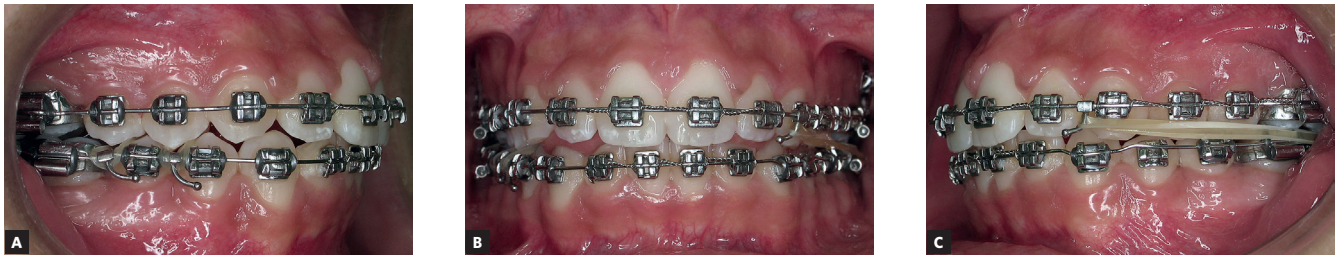


Figure 6 - Finishing phase. Rectangular 0.019 x 0.025-in CrNi archwires with ideal bends and torques.

RESULTS

At the end of treatment, a proper dental relationship was attained with normal molar and canine occlusions. The final photographs show considerable improvement in facial aesthetics. Facial features were improved, yielding a slightly convex profile with lip competence achieved through a slight retraction of the upper lip and lower lip protrusion while improving the nasolabial and mentolabial sulcus. The final evaluation of the dental arches showed that the lower negative discrepancy had been eliminated, normal overbite and overjet were achieved and the midline corrected. No impact was detected in either the stomatognathic function or the excursive movements of the mandible. The periodontal tissue remained healthy and the temporomandibular joint (TMJ) function remained normal throughout the treatment period (Fig 7).

After removal of the fixed appliance, a lower lingual retainer was bonded across from tooth 33 to tooth 43, with the recommendation that it be kept in place indefinitely. In the upper arch, a removable wraparound retainer with passive anterior stop was placed and the patient was instructed to wear it 24/7 in the first few months, then eventually remove it at mealtime and for oral hygiene (Fig 8). The patient was seen at regular 3-month intervals to assess the stability of the occlusion and monitor the upper retainer.

Figure 7 - Finished case. Posttreatment facial and intraoral photographs.

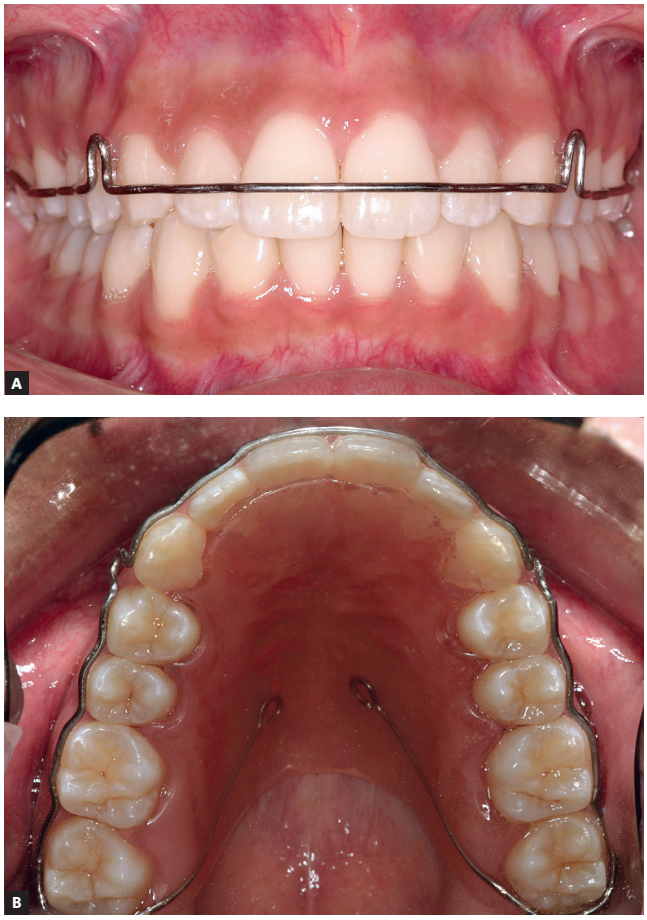


Figure 8 - Finished case. Intraoral photographs showing the upper wrap-around retainer.

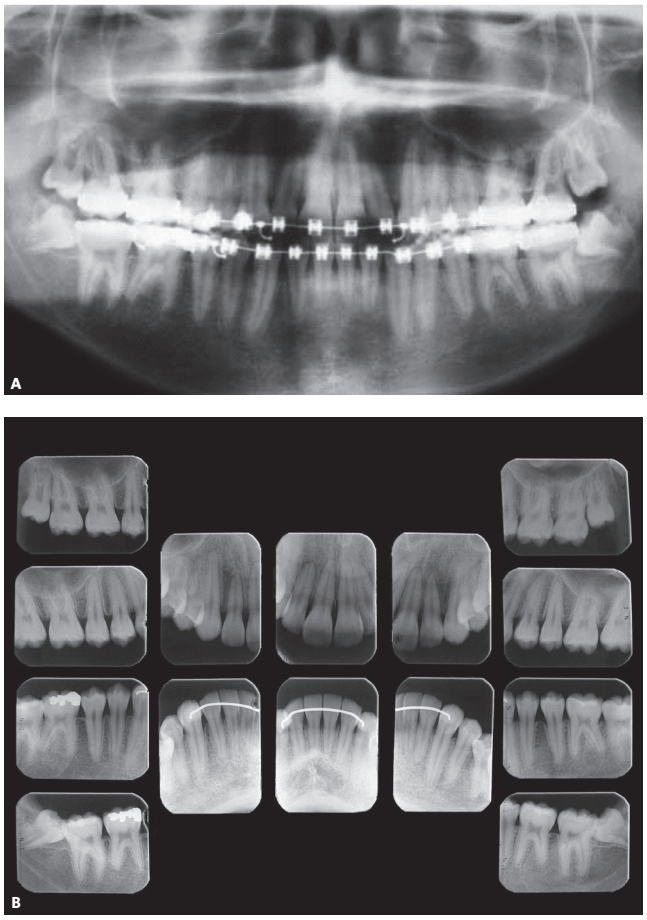


Figure 9 - **A**) Panoramic radiograph of finished case, and **B**) posttreatment periapical radiographs.

As can be observed in Figure 9, there was no significant root resorption, whereas some apical rounding can be seen in teeth 12 and 22. The posttreatment lateral cephalometric X-ray is shown in Figure 10. The total sphenoid/cribriform superimposition reveals increased vertical growth. In the partial superimpositions one can notice the lower incisor protrusion, retroclination of the lower incisors, posterior alveolar growth, as suggested by a slight molar extrusion (Fig 11). Figure 12 depicts how occlusion stability and facial aesthetics were successfully maintained after 1 year and 3 months with the retainer in place.

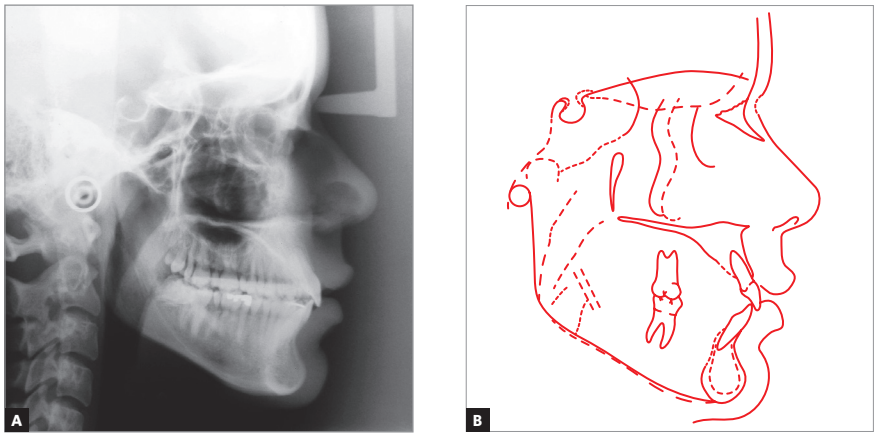
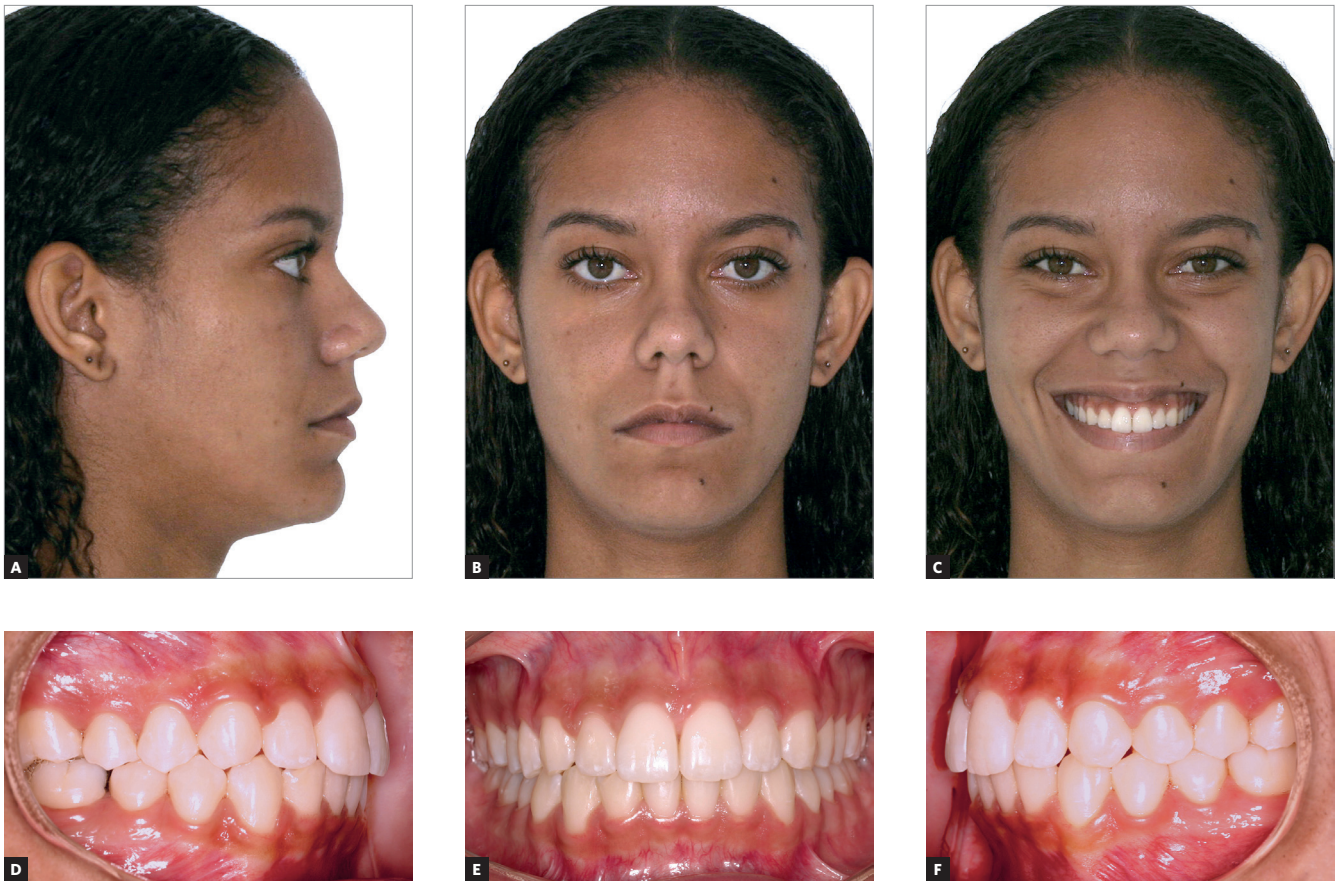


Figure 10 - Post-treatment lateral cephalometric radiograph and cephalometric tracing.

Figure 11 - Total and partial superimpositions of maxillary and mandibular initial and final cephalometric tracings.



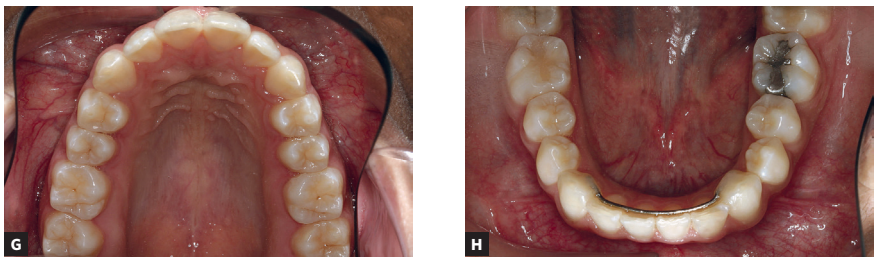


Figure 12 - Facial and intraoral photographs after 1 year and 3 months retention.

The decision to treat this patient conservatively yielded excellent results. Any extraction could have caused undesirable dental retraction, thereby lessening the likelihood of improving facial aesthetics. More importantly, the treatment fulfilled the patient's actual needs while also meeting her parents' expectations. Besides, it satisfied the professionals who treated her.

DISCUSSION

In an ideal female profile, the lips should be slightly everted towards their base, displaying several millimeters of vermilion border, and the upper lip should be positioned slightly anterior to the lower lip. The mentolabial sulcus must form an S-shaped curve in both the upper and lower portions. Furthermore, chin prominence should be slightly smaller than lower lip prominence.[11] In this patient, all these characteristics were adversely affected by increased overjet and lower lip interposition, which was adequately resolved by the treatment performed.

In this case, a combined headgear was used as anchorage for upper retraction, and also to control the vertical dimension. The latter was important because in dolichocephalic patients who present with deep overbite, despite a vertical skeletal pattern, reverse lower curve of Spee and an increased upper curve of Spee can lead to extrusion of posterior teeth, with consequent clockwise mandibular rotation, which might worsen the overjet.[3,4,8]

In most clinical conditions, according to studies by Little et al,[5] Shapiro,[18] and Thilander,[20] expanding the intercanine width may lead to a condition of instability and quick relapse. However, in cases with anteroposterior balance of the basal bones and incompatible arch forms, where there is either collapse or retention of the lower arch, especially in the anterior region, one might question this assertion. One such example is the case presented in this study, characterized by lower negative discrepancy and reduced intercanine width. In this situation, one can perform not simply an expansion of the dental arches, but this distance can be corrected by adjusting the torques and tips in the lower teeth while adjusting the arch forms.

In the posttreatment phase, there was a 0.9 mm increase in intercanine width, and a 1.2 mm increase in the lower arch. The lower incisors were moved forward by 2 mm and inclined buccally by 6º. Thus, the crowding was corrected primarily by slightly expanding the anterior segments along with intrusion and proclination of the mandibular incisors, and slight retraction of the maxillary incisors. Expansion of the arches and protrusion of lower incisors no doubt have limited indication. When carefully planned, however, great results with lasting stability can be achieved.

CONCLUSIONS

A conservative approach with no extractions proved effective and resulted in significant improvement in the occlusal relationship as well as in the patient's dental and facial aesthetics. The use of light, controlled forces and suitable torques greatly contributed to proper tooth positioning with minimal root resorption.

REFERENCES

1. Angelle PL. A Cephalometric study of the soft tissue changes during and after orthodontic treatment. Trans Eur Orthod Soc. 1973:267-80.
2. Hershey HG. Incisor tooth retraction and subsequent profile change in post-adolescent female patients. Am J Orthod. 1972 Jan;61(1):45-54.
3. Houston WJ. Mandibular growth rotations: their mechanisms and importance. Eur J Orthod. 1988 Nov;10(4):369-73.
4. Levin RI. Deep bite treatment in relation to mandibular growth rotation. Eur J Orthod. 1991 Apr;13(2):86-94.
5. Little RM, Riedel RA, Stein A. Mandibular arch length increase during the mixed dentition: postretention evaluation of stability and relapse. Am J Orthod Dentofacial Orthop. 1990 May;97(5):393-404.
6. Marques LS, Barbosa CC, Ramos-Jorge, ML, Pordeus IA, Paiva SM. Prevalência da má oclusão e necessidade de tratamento ortodôntico em escolares de 10 a 14 anos de idade em Belo Horizonte, Minas Gerais, Brasil: enfoque psicossocial. Cad Saúde Pública 2005;21(4):1099-106.
7. Moreira TC, Quintão CCA, Menezes LM, Anamaria B. Comparação entre dois instrumentos para medição das distâncias intercaninos e intermolares. Rev SBO 1997;3(4):149-56.
8. Nanda SK. Growth patterns in subjects with long and short faces. Am J Orthod Dentofacial Orthop. 1990 Sep;98(3):247-58.
9. Pinto MR, Mottin LP, Derech CD, Araújo MTS. Extração de incisivo inferior: uma opção de tratamento. Rev Dental Press Ortodon Ortop Facial. 2006 Jan-Fev;11(1):114-21.
10. Proffit WR, Fields Junior HW. Ortodontia Contemporânea. 2a ed. Rio de Janeiro: Guanabara-Koogan, 1995. p. 596.
11. Proffit WR, White Junior RP, Sarver DM. Tratamento contemporâneo de deformidades dentofaciais. Porto Alegre (RS): Artmed; 2005.
12. Riedel RA. Review of the retention problem. Angle Orthod. 1960;30(4):179-99.
13. Riedel RA, Little RM, Bui TD. Mandibular incisor extraction: post retention evaluation of stability and relapse. Angle Orthod. 1992 Summer;62(2):103-16.
14. Roos N. Soft tissue profile changes in Class II treatment. Am J Orthod. 1977 Aug;72(2):165-75.
15. Ruellas ACO. O movimento distal de molares em oposição à projeção de incisivos e expansão do arco (casos de má oclusão de Classe I). [Dissertação]. Rio de Janeiro (RJ): Universidade Federal do Rio de Janeiro. Faculdade de Odontologia; 1995.
16. Ruellas ACO. Ruellas RMO, Romanoll FL, Pihonl MM, Santos RL. Extrações dentárias em Ortodontia: avaliação de elementos de diagnóstico. Dental Press J Orthod. 2010;15(3):134-57.
17. Shah AA, Elcock C, Brook AH. Incisor crown shape and crowding. Am J Orthod Dentofacial Orthop. 2003 May;123(5):562-7.
18. Shapiro PA. Mandibular dental arch form and dimension. Am J Orthod. 1974 Jul;66(1):58-70.
19. Strang R. The fallacy of denture expansion as a treatment procedure. Angle Orthod. 1949 Mar;19(1):12-22.
20. Thilander B. Biological basis for orthodontic relapse. Semin Orthodont. 2000 Sep;6(3):195-205.
21. Tweed CH. Indications for the extraction of teeth in orthodontic procedure. Am J Orthod Oral Surg. 1944-1945;42:22-45.
22. Wisth PJ. Soft tissue response to upper incisor retraction in boys. Br J Orthod. 1974 Oct;1(5):199-204.

Orthodontic treatment in adults: Restoring smile esthetics

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Introduction: The search for orthodontic treatment by adult patients is increasing. This demand may be explained by many reasons, but the most important was the change in the concept of normality, allowing the selection of simpler and more conservative and consistent therapeutic objectives. This conceptual evolution, combined with the technological advances allowed an improvement in orthodontic management, making it more effective, fast and comfortable. The promotion of awareness of the society on the advantages of this treatment and the increase in esthetic demands, with an increasingly longer and active social, affective and professional life, creates a context in which the need for Orthodontics is absolutely established for the adult individuals.

Objective: The objective of this article is to report the nuances in diagnosis and orthodontic treatment of an adult patient, in a different perspective. Within this approach, the objective is to recover the shape, i.e. to establish occlusal conditions that would probably be present if the patient had been assisted at the proper time, namely during growth and tooth irruption.

Keywords: Orthodontics. Smile esthetics.

INTRODUCTION

The prevalence of malocclusion is certainly greater in adults. It may be stated that malocclusion is directly proportional to age, and that its characteristics reflect the good or poor care of all teeth, since the early deciduous dentition. In Brazil, we have the first generation with a significant number of individuals that reach adulthood and begin to age with all or nearly all teeth in the mouth. Therefore, similar to socially developed countries, they start to present malocclusion characterized by tooth crowding. Proffit et al[8] conducted a study based on an epidemiological survey of NIH to determine the prevalence of malocclusion and orthodontic treatment need in the American population, which revealed that, in general, 70% of adult patients have

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

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malocclusions with an objective treatment need, a value that has been considered a consensus in the literature. Individuals with tooth crowding equal to or smaller than 3.5 mm and alterations in molar relationship that did not cause significant changes in esthetics and occlusion were considered as normal. That is to say, these individuals would not have an objective treatment need, yet this does not rule out the subjective need which is increasingly significant in the Western population, including our country.

The number of adult patients searching for orthodontic treatment has been increasingly greater. American data from the early 1990s[7] demonstrate that the percentage of adult patients in specialized orthodontic clinics was 30% and this percentage was expected to increase until the end of the decade. This was clearly confirmed.

This increased demand is a consequence of four factors: The first is the use of preventive measures in Dentistry, allowing the patient to reach adulthood with a greater number of teeth in the mouth; the second is the increased esthetic demand of society; the third comprises greater access to information by the population, which promotes the awareness among adults that orthodontic treatment is an accessible resource to enhance the appearance of teeth and even the face; and the fourth factor is the modernization of more esthetic and comfortable orthodontic appliances.[2] However, the most important factor was the change in the concept of normality for adults. This changed the therapeutic goals, contributing especially to reduce the treatment time, which is the greatest factor of resistance to treatment among adults.

Adult orthodontic patients may or not differ from adolescent orthodontic patients, depending on the severity of malocclusion, quantity of restorations, previous trauma or abrasion of teeth, susceptibility to periodontal disease, temporomandibular disorders and history of dental caries. One of the main advantages in the treatment of adults is the several years of dental history to be considered, allowing a better understanding on the meaning of occlusal alterations observed and their potential as a problem.[6]

The orthodontic treatment in growing individuals nearly always aim to achieve the six keys to normal occlusion of Andrews[1] and the best esthetics possible. In adult patients, this goal should not be an obligation.

Many adults lived many years with a malocclusion without recognizing these deviations from normality as a problem. The patient may simply need to have the teeth aligned, spaces opened for restorations or replace missing teeth, dental arches leveled to improve the overbite, erupted teeth to solve periodontal problems or upright teeth for future restorations. In these cases, a dental Angle Class I relationship or other parameters considered as ideal may not be necessary. This is especially true if the patient does not have temporomandibular disorders, periodontal problems or tooth abrasions[6] or, in other words, has a functional occlusion.

Within this concept applied realistically,[2] this paper introduces one of the treatment modalities indicated for adults. Restoring the occlusion, respecting the individual characteristics of normality and assigning the dental relationships the conditions they would probably have if the eruption and growth circumstances had allowed. We call this a shape recovery, or the attempt to restore to the patient the occlusion he or she would have if ideal conditions had been allowed. Therefore, this reference or model is absolutely individual and allows treatment with well-defined goals, usually viable, conservative, faster and especially potentially stable because of the little speculation. This concept is specifically applied to the treatment of the lower dental arch in the presented case. In the upper arch, extractions were necessary, justified to attend the patient's expectations, but this did increase case complexity, interfering, mostly, with treatment time. Anyway, using the restored lower arch as a parameter to establish occlusal relations, probably the essence of what is being proposed for the treatment with shape recovery, was preserved.

CASE REPORT

Diagnosis

Adult male patient aged 36 years and 6 months, Caucasian, attended the specialization orthodontic clinic at PROFIS – HRAC-USP/Bauru with chief complaint about the esthetics of occlusion.

The initial consultation comprised clinical evaluation of the face and intraoral clinical examination. The subjective facial analysis[3] in frontal view revealed proportion between the upper, medium

and lower facial thirds, symmetry, good zygomatic projection and passive lip sealing. The profile analysis evidenced open nasolabial angle, acceptable mentolabial sulcus and Q-P line, confirming the acceptable diagnosis of a Pattern I face.

Parameters as passive lip sealing and lip relationship with the nose and chin are directly related to esthetics and are fundamental in the diagnosis of patients that will be indicated for compensatory and/or corrective treatment.[3] The patient presented an acceptable face, yet impaired in the profile analysis by the moderate retrusion of the upper lip (open nasolabial angle). The use of a moustache masks the clinical visualization of this detail (Fig 1).

The intraoral evaluation demonstrated Class II relationship (Fig 2), probable agenesis of tooth #12, considering that the patient reported no history of extraction, tooth #22 presented shape alteration (microdontia), early loss of teeth #36 and 46 and missing teeth #16 and 48. The maxillary midline deviation of 3 mm to the right side, one of the patient's chief complaints, was noticeable, because the patient presented the three alterations that the maxillary midline should not have: Deviation of dental

Figure 1 - Initial facial photographs reveal a dolichofacial Pattern I patient with acceptable face.

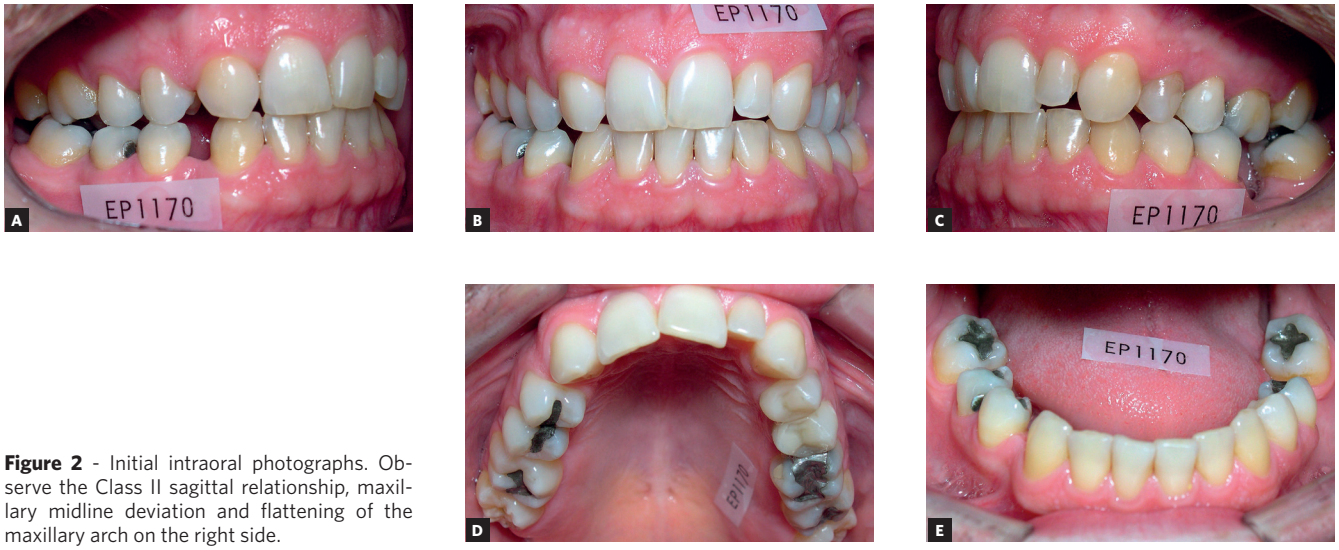


Figure 2 - Initial intraoral photographs. Observe the Class II sagittal relationship, maxillary midline deviation and flattening of the maxillary arch on the right side.

midline in relation to the facial midline, loss of perpendicular line between the mesial interincisal surfaces of central incisors and the occlusal plane, and flattening of the arch at the side of deviation. Also, the maxillary arch was atresic and the mandibular arch was compensated (Fig 2).

After consultation, the patient was referred for orthodontic records to complement the initial examinations and allow the diagnosis, prognosis and treatment planning.

Analysis of these records confirmed all clinical findings of initial evaluation. Morphological analysis of the lateral cephalogram[3] exhibited characteristics of normality for Pattern I, dolichofacial. The aspect was harmonious, with adequate soft tissue profile, passive lip sealing, proportion of medium and lower facial thirds, proportion of components of the lower third, and nasolabial angle with moderate opening, which impaired the lack of convexity. Skeletal analysis evidenced horizontal planes slightly divergent from each other. The maxillomandibular relationship was good both in vertical and anteroposterior directions, the overjet and overbite were borderline due to the missing maxillary teeth, interfering with the position of maxillary incisors, which were retroclined in the basal bone. The roots of mandibular incisors were closer to the lingual than to the buccal cortical plate, sufficient to adequately support these teeth. The root apices of maxillary molars were at a normal distance from the palatal plane, an important data to establish the normality of a dolichofacial individual[3] (Fig 3).

Evaluation of the panoramic radiograph confirmed agenesis of tooth #12 and absence of teeth #16, 36, 38, 46 and 48. The maxillary left first premolar had endodontic treatment and vertical bone loss was observed on the mesial aspect of tooth #37 (Fig 4).

Analysis of dental casts confirmed the bilateral Class II molar relationship (Fig 5) and the occlusal analysis evidenced the relative retrusion of the maxillary arch, with flattening on the right side (Fig 6A).

The prognosis was defined as good for corrective orthodontic treatment (COT),[3] aiming to restore the dental arch shape.

Treatment planning

Considering that the patient's complaint was exclusively dental esthetics, treatment was proposed with the primary goal to achieve better smile esthetics, i.e. a multidisciplinary treatment.[9] Spear et al[9] described that, in treatment planning, the sequence of procedures aiming at maintaining the biological structure and for esthetic purposes is fundamental for the final esthetic outcome.

The planning comprised extraction of tooth #24 to correct the maxillary midline with the face, allowing compensation of two missing teeth on the right side: Agenesis of tooth #12 and early extraction of tooth #16. This procedure would allow repositioning the teeth that migrated due to the spaces available.

Figure 3 - Lateral cephalogram.

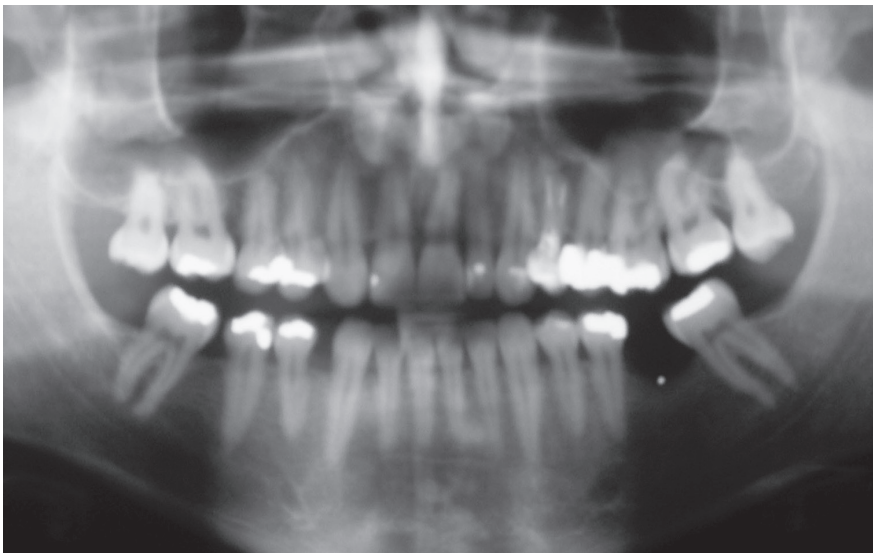


Figure 4 - Panoramic radiograph. Observe the absence of teeth #12, 16, 36, 38, 46 and 48.

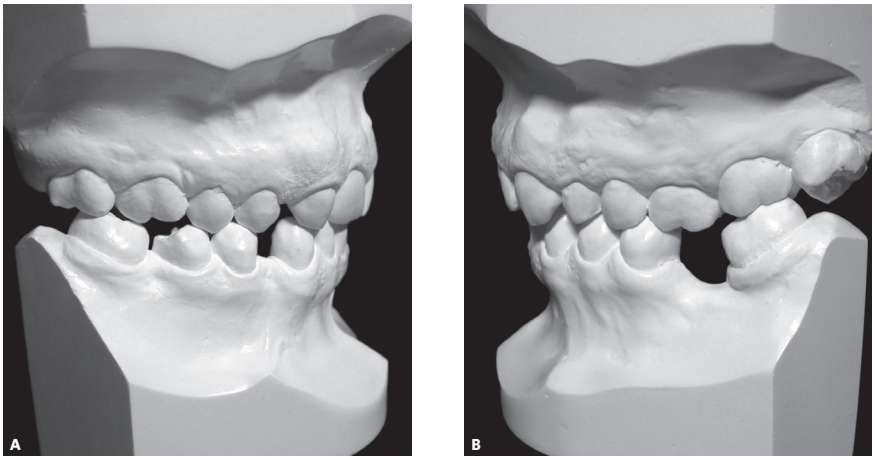
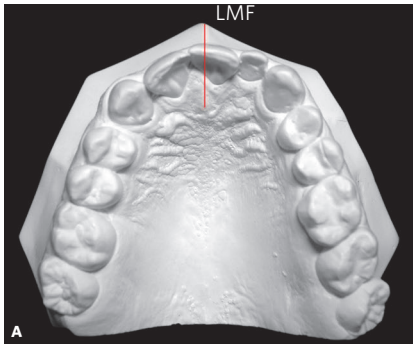


Figure 5 - Photographs of initial dental casts evidencing the bilateral Class II sagittal relationship.



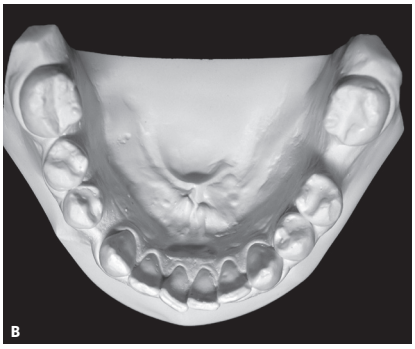


Figure 6 - Occlusal photographs of maxillary and mandibular dental casts. **A**) Observe the maxillary midline deviation to the right side due to agenesis of tooth #12, causing flattening of the maxillary arch on the right side. **B**) In the mandibular arch, observe the spaces left by missing teeth and rotation of tooth #45.

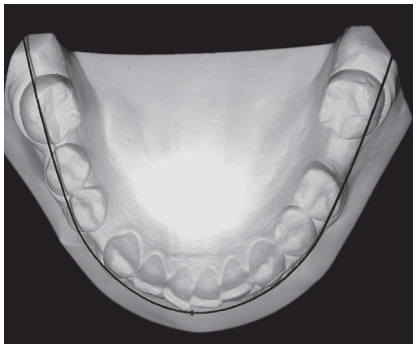


Figure 7 - Choice of the Individual Anatomic Objective Diagram.

Teeth on the left side, that invaded the midline when migrating to the right side, would be returned to their original positions, and teeth on the right side, that migrated distally, might be repositioned according to the midline, allowing space to replace tooth #12 using an implant. In other words, the maxillary arch shape would be recovered allowing conditions for a better symmetry. The potential stability of this approach is reinforced by the little speculation, since the approach adopted comprised deconstruction of the malocclusion, considering as the base for creation the agenesis of tooth #12, early extraction of tooth #16 and related disorders. From this perspective, planning defined the achievement of space to replace tooth #12 using an implant and reshaping the tooth #22.

In the mandibular arch, the goal was to maintain space between tooth #35 and 37 for implant placement at the region of tooth #36 and achievement of space between teeth #44 and 45 for placement of an implant with a mandibular third premolar between them. The advantage of this procedure, namely the achievement of space between two teeth for implant placement in this created space, is the new bone between them to provide an area with better tissue quality to receive an implant (Fig 8). The planning for implant positioning was evaluated and approved by the implantologist after planning and before treatment.

Selection of the ideal diagram for the patient is fundamental at this stage, because the treatment goals should be considered and incorporated in

the dental arch shape. This means that the leveling archwires will include the goal manifested in treatment planning[5].

The shape of maxillary and mandibular leveling archwires followed the individual objective anatomic diagram (IOAD) C4A6.[5] Selection of the diagram in young patients or submitted to conventional orthodontic treatment is always based on the mandibular arch. This is not a rule for the treatment of adult patients, in which specific and localized goals may be defined. In this case, the diagram is selected according to the dental arch or arch segment selected as reference. In the present case the mandibular arch could be taken as reference because the treatment had very conventional goals, without the objective to introduce significant changes in the contour of this dental arch. The anterior curvature should adjust to the original intercanine distance if adequate, otherwise it should be defined by the established therapeutic goal. In this case the intercanine distance was followed, as well as the original position of mandibular incisors, which was similar to the desired (to avoid protrusion). The posterior opening of the dental arch should adjust to the Wala ridge or the desirable intermolar width at treatment completion.[5] In this case, we intended to maintain the intermolar distance and thus the selected diagram should be passive in the tubes of mandibular molars. In summary, the therapeutic goal was to maintain the mandibular arch width (Fig 7), characterizing a situation in which the treatment objective is superimposed to the anatomical characteristics of normality and determines the parameters of choice for the posterior opening of the diagram, which may be coincident or not with the diagram that would be determined by the other perspective. As always, when this routine is followed, the maxillary arch should have the same shape, magnified following the classical orientation for the use of straight wire brackets. Therefore, the maxillary arch will always be coordinated with the mandibular arch and will be handled on the selected diagram throughout the leveling stage. Changes may be introduced, and as in the present case they are always introduced when the diagram arch shape is unable to introduce changes as desired. Therefore, only when absolutely necessary and with minimum speculation on treatment, as previously described, it aims to restore the arch shape and occlusion that the patient should have.

In summary, the objective of the planed therapeutic approach (Fig 8) was to recover the shape and space in the maxillary and mandibular arches, restoring the occlusal stability and providing better esthetic quality to the maxillary anterior region.

Initially, a transpalatal bar (TPB) was placed as anchorage unit. Bonding of maxillary teeth was made using Capelozza brackets prescription I,[4] with individualized angulation of 0º on tooth #11, aiming to avoid distal angulation of the root, maintaining the area for implant placement to replace the tooth #12. Extraction of tooth #24 was requested followed by maxillary leveling with initial retraction of tooth #23 from the first leveling archwire. Retraction of this tooth was very slow because the patient exhibited alveolitis after extraction of tooth #24, with consequent delay in healing of the area (Fig 9).

The mandibular appliance was placed when the maxillary arch presented a more adequate shape. Banding of teeth #37 and 47 and direct bonding of the other mandibular teeth with Capelozza brackets prescription I[4] was made, with onset of mandibular leveling with 0.016-in nickel titanium archwire. Space was gained between teeth #44 and 45 using an active open coil maintained between these teeth during leveling. This movement provides new bone in the area that will receive the implant.

The treatment was continued with the planned intra-arch mechanics for the maxillary and mandibular arches, with follow-up at every three weeks, with active intervention in one dental arch and only revision in the other, which allowed adequate control of occurrence and actual activation of the appliance at longer intervals. This is important in adult patients, whose remodeling and consequent treatment response are supposedly slower.

The maxillary leveling was continued using an open coil between teeth #11 and 13, distalization of tooth #23 and enhancement of correction of the maxillary midline deviation using a midline bend in the 0.018-in archwire. This bend is a transgression to the arch shape established by the previously selected diagram, and is adopted because the conventional shape of the leveling archwire is not transferred to the dental

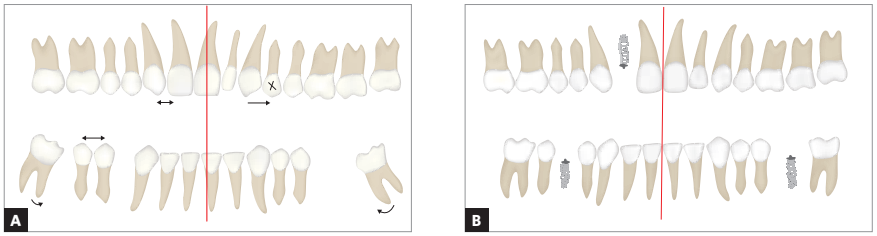


Figure 8 - Schemes graphically demonstrating the original problem, proposal of movement and expected tooth positioning at treatment completion.

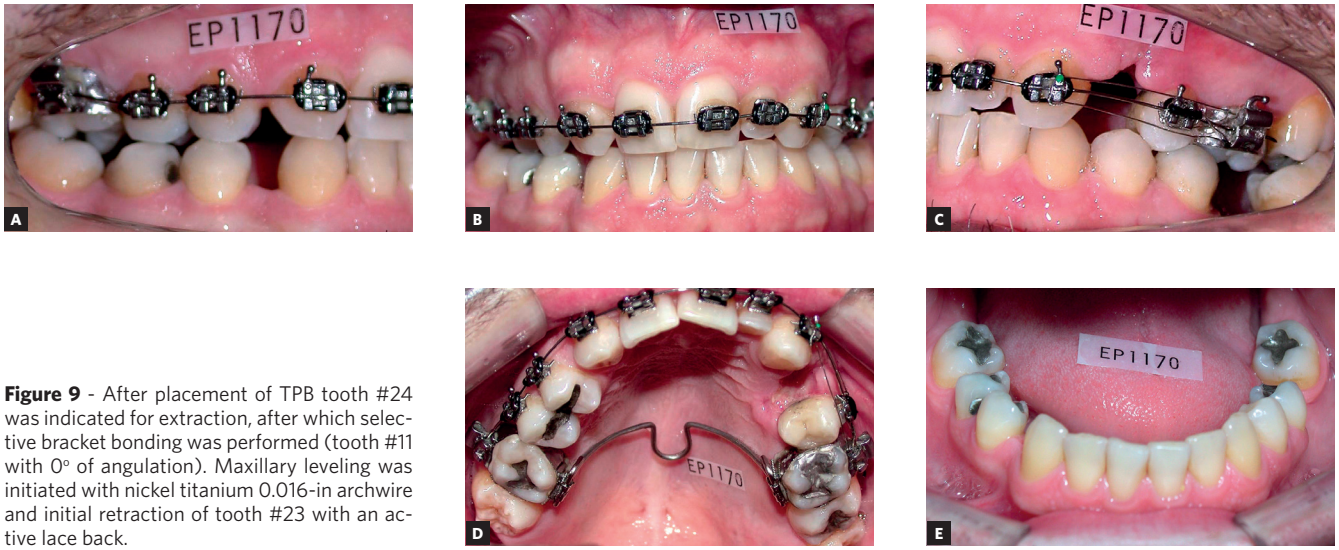


Figure 9 - After placement of TPB tooth #24 was indicated for extraction, after which selective bracket bonding was performed (tooth #11 with 0° of angulation). Maxillary leveling was initiated with nickel titanium 0.016-in archwire and initial retraction of tooth #23 with an active lace back.

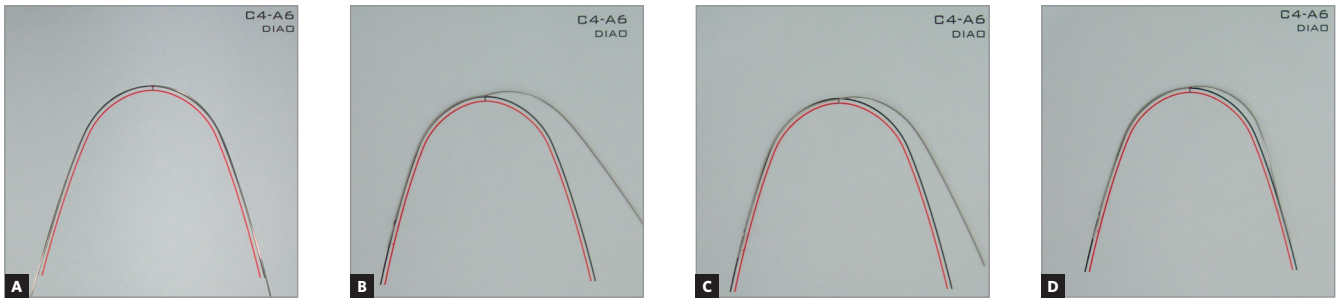


Figure 10 - Sequence of fabrication of midline bend in the maxillary 0.018-in stainless steel archwire.

arch. This bend was made in the midline of the maxillary leveling archwire (0.018-in round stainless steel), determined from the facial midline, to enlarge the flattened arch side (right side) and aid the correction of one defect that emphasizes the dental midline deviation. The leveling archwire is initially contoured on the diagram; an omega is then introduced close to the molar tube on the correct side (in this case, mesial aspect of tooth #26). The point corresponding to the facial midline is marked in the leveling archwire and the midline bend is made for transverse action (Fig 10B). The archwire portion that deviates from the diagram should involve only the teeth in which a protrusive effect is desired, namely the anterior teeth on the right side in the present case. This way, it is intended to cancel the transverse effect of the bend, allowing buccal movement of the target region, in this case the anterior teeth on the right side. The greatest distance of the archwire at the bend region to the diagram should be 3 mm. This distance in the 0.018-in round stainless steel archwire generates a force that has been clinically effective to produce movement, without negative biological response. In summary, with this contour and the omega tied to the molar tube on the opposite side, the archwire segment contained in the midline bend (segment outside the diagram) is compressed inside

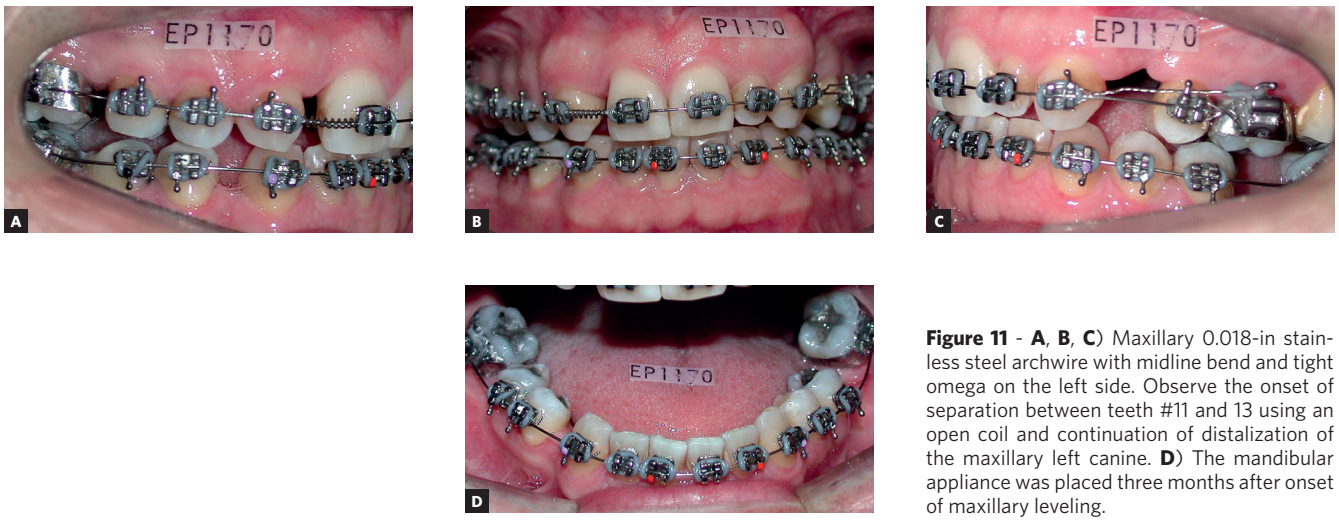


Figure 11 - **A**, **B**, **C**) Maxillary 0.018-in stainless steel archwire with midline bend and tight omega on the left side. Observe the onset of separation between teeth #11 and 13 using an open coil and continuation of distalization of the maxillary left canine. **D**) The mandibular appliance was placed three months after onset of maxillary leveling.

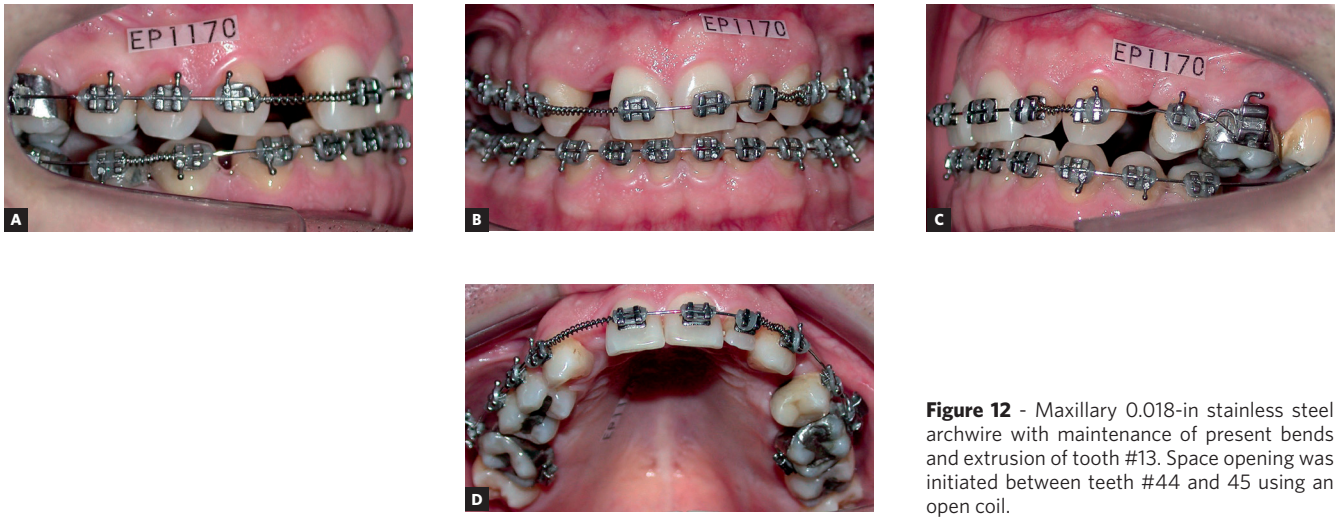


Figure 12 - Maxillary 0.018-in stainless steel archwire with maintenance of present bends and extrusion of tooth #13. Space opening was initiated between teeth #44 and 45 using an open coil.

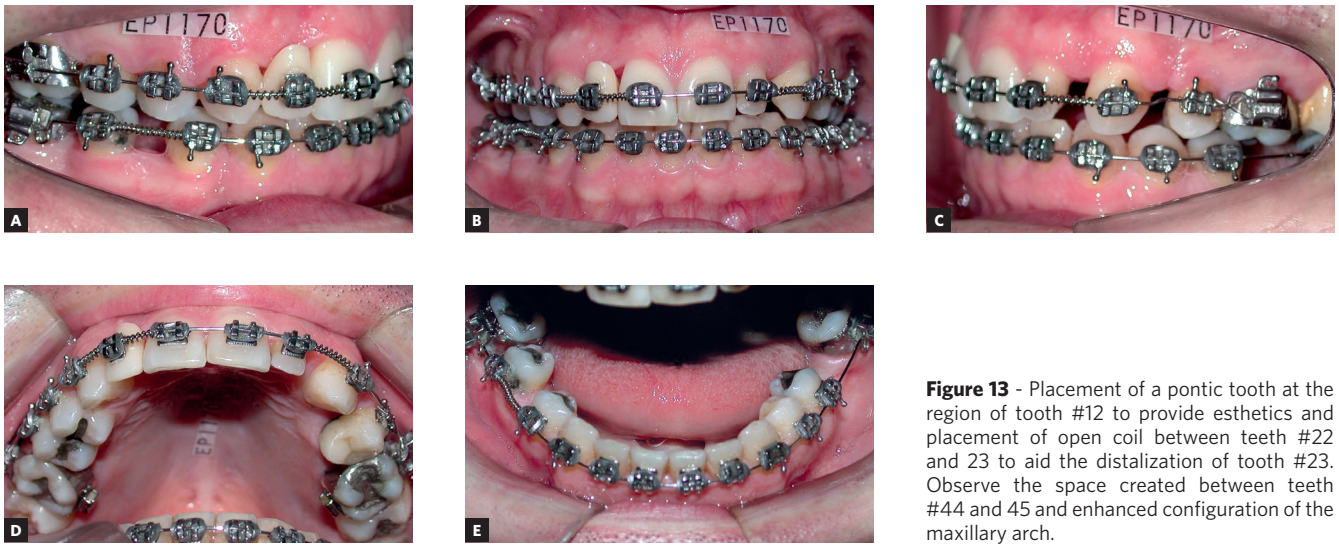


Figure 13 - Placement of a pontic tooth at the region of tooth #12 to provide esthetics and placement of open coil between teeth #22 and 23 to aid the distalization of tooth #23. Observe the space created between teeth #44 and 45 and enhanced configuration of the maxillary arch.

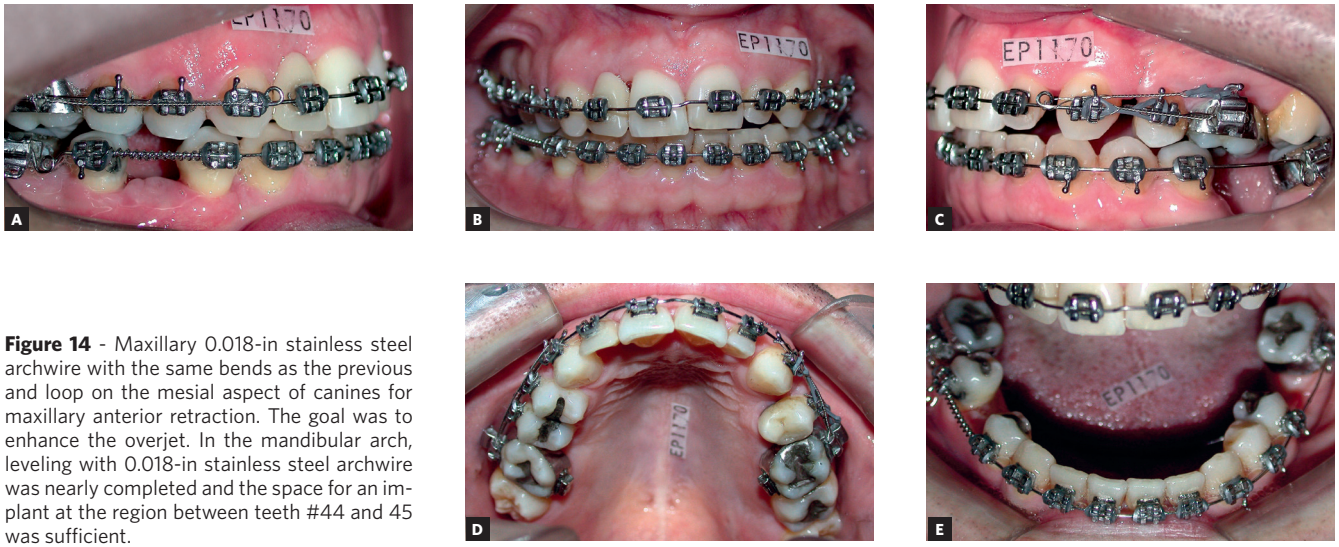


Figure 14 - Maxillary 0.018-in stainless steel archwire with the same bends as the previous and loop on the mesial aspect of canines for maxillary anterior retraction. The goal was to enhance the overjet. In the mandibular arch, leveling with 0.018-in stainless steel archwire was nearly completed and the space for an implant at the region between teeth #44 and 45 was sufficient.

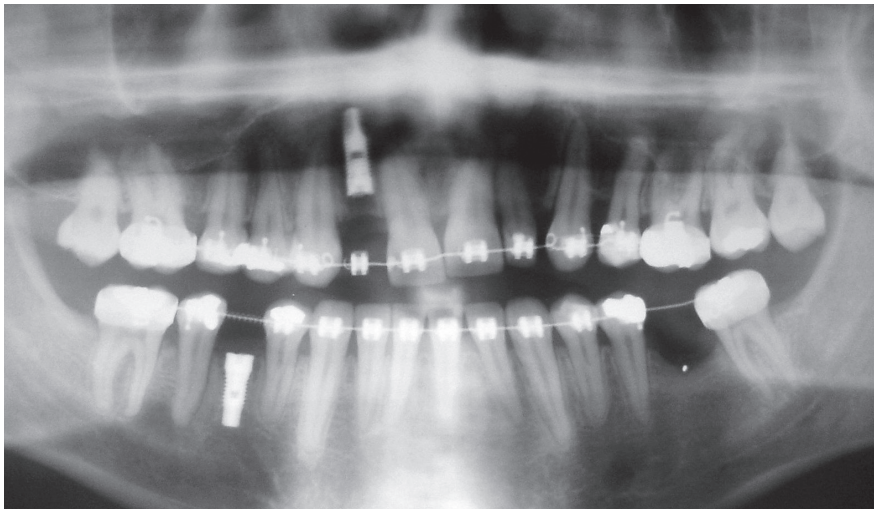


Figure 15 - Final panoramic radiograph.

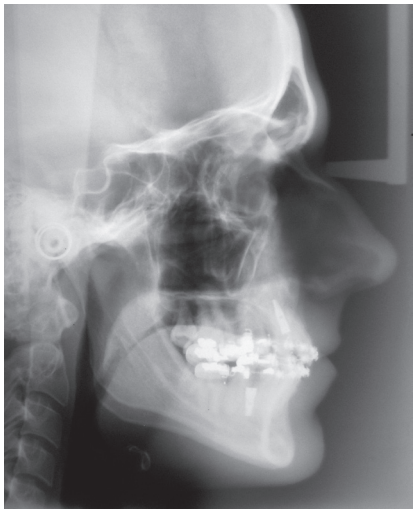


Figure 16 - Final lateral cephalogram.

the brackets and tied with ligature. The remaining archwire contained in the midline bend surpasses the molar tube and the teeth receiving the active archwire receive force in buccal direction. In the present case, this movement was occasionally potentiated by the presence of an open coil between teeth #13 and 11.

With creation of a gradually greater space between teeth #11 and 13, when possible, a pontic tooth was placed to simulate the maxillary right lateral incisor and improve the smile esthetics. Providing this to adult patients is very important to enhance the self-esteem and enthusiasm about the treatment (Fig 13).

Finishing bends were performed and the patient was referred for the implants, which were placed at the region of tooth #12 and between the teeth #44 and 45 at 15 months of treatment. At the region of the tooth #36, the patient decided to postpone the implant placement. The mandibular appliance was removed at 19 months after treatment onset and a fixed 3 x 3 retainer was placed with extension to teeth #45 and 47 (Figs 17 and 18).

In the follow-up one year after removal of the appliance, the positive aspect is achieved by the presence of a definitive crown on the implant replacing tooth #12 (Fig 20). Though early, it seems possible to admit a reasonable stability. The patient is fully satisfied with the treatment outcome, which adequately met his chief complaint, namely to improve the quality of smile (Fig 21).

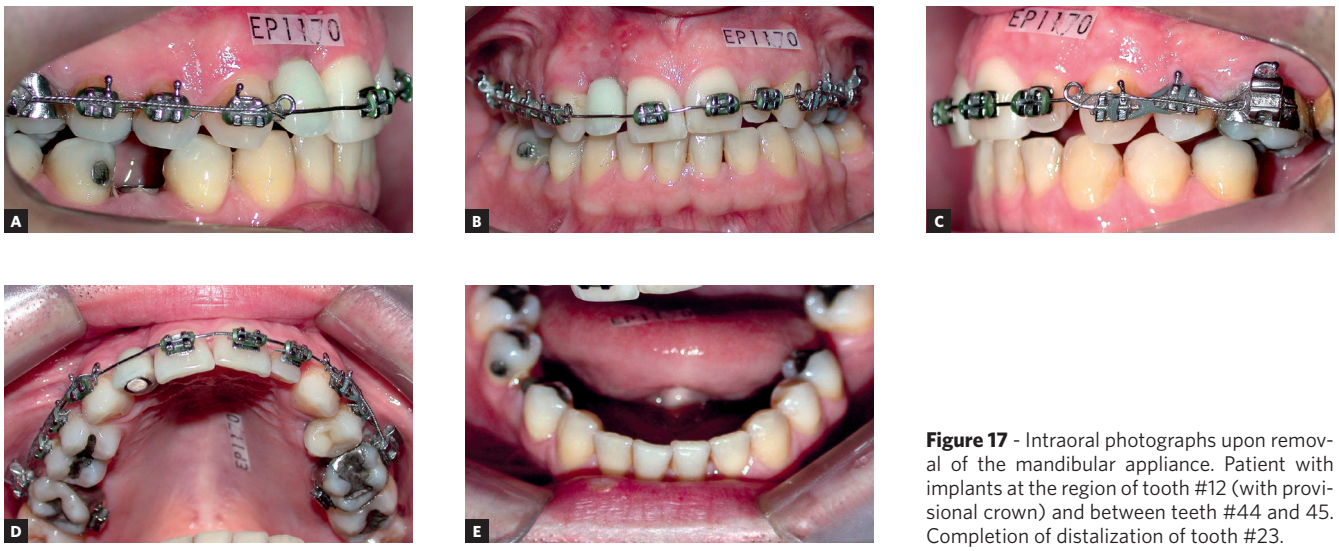


Figure 17 - Intraoral photographs upon removal of the mandibular appliance. Patient with implants at the region of tooth #12 (with provisional crown) and between teeth #44 and 45. Completion of distalization of tooth #23.

Figure 18 - Intraoral photographs after removal of maxillary appliance and esthetic restoration of teeth #21 and 22. The patient still has a provisional crown on the implant at the region of the maxillary right lateral incisor that is esthetically deviating. The maxillary appliance was removed at 20 months after treatment onset.

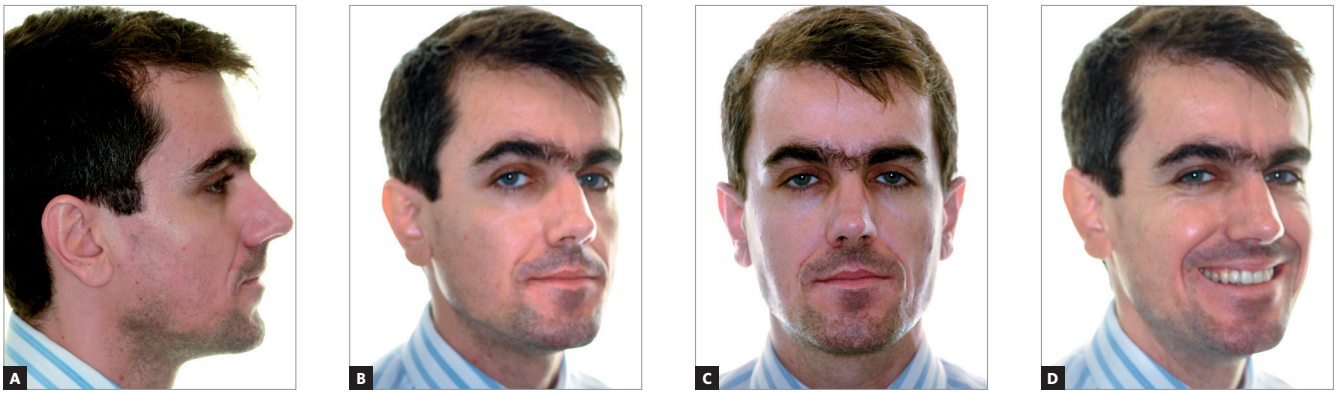


Figure 19 - Extraoral photographs after esthetic finalization of treatment, with definitive crown on the implant replacing tooth #12.

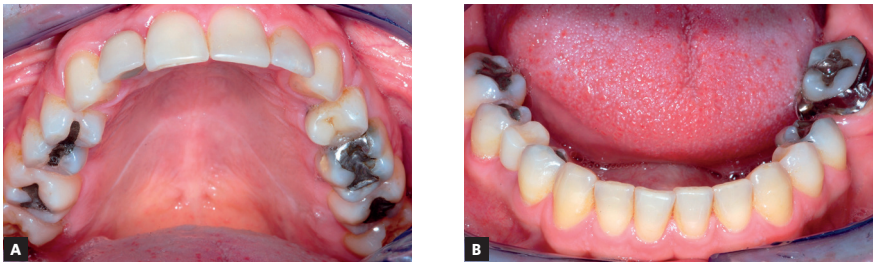


Figure 20 - Arch shape after one year of treatment, with night use of Hawley plate and maintenance of 3/3 retainer with distal extension up to the mandibular left second molar, maintaining space for the implant that was not yet placed.

Figure 21 - Comparative intraoral photographs at treatment onset and 1-year post-treatment follow-up, evidencing the positive effects on the smile, which was the patient's chief complaint.

CONCLUSION

The orthodontic treatment in adult patients is an increasingly frequent reality. A directed and effective treatment approach is necessary to meet the expectations of these patients, which are usually related to the search for enhanced esthetics, reduced treatment time and minimum discomfort during utilization of orthodontic appliances.

The present case report demonstrated a consistent mechanics, guided by enhanced objectives, which are essential and may be achieved rapidly, providing esthetic quality of smile and potential occlusal stability to the patient.

REFERENCES

1. Andrews LF. The Six keys to normal occlusion. J Orthod. 1992 Sept;62(3):296-309.
2. Braga AS, Capelozza LF, Cavassan AO, Ozawa TO. Tratamento Ortodôntico em Adultos: uma abordagem direcionada. Rev Dent Press Ortodon Ortop Facial. 2001 Set-Out;6(5):63-80.
3. Capelozza Filho L. Diagnóstico em Ortodontia. Maringá: Dental Press; 2004.
4. Capelozza Filho L, Silva Filho OG, Ozawa TO, Cavassan AO. Individualização de braquetes na técnica straight-wire: revisão de conceitos e sugestões de indicações para uso. Rev Dent Press Ortodon Ortop Facial. 1999 Jul-Ago;4(4):87-106.
5. Capelozza Filho L, Capelozza JAZ. DIAO: Diagrama individual anatômico objetivo. Uma proposta para escolha da forma dos arcos na técnica de Straight-Wire, baseada na individualidade anatômica e nos objetivos de tratamento. Rev Dent Press Ortodon Ortop Facial. 2004 Out-Nov;3(5):1-9.
6. Kokich VG. Entrevista. Rev Dent Press Ortodon Ortop Facial. 2006 Nov-Dez;11(6):19-23.
7. Proffit WR. Contemporary orthodontics. St. Louis (MO): CV. Mosby; 1993.
8. Proffit WR, Fields HW Jr, Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: Estimates from the NHANES III survey. Int J Adult Orthodon Orthognath Surg. 1998;13(2):97-106.
9. Spear FM, Kokich VG, Mathews DP. Interdisciplinary management of anterior dental esthetics. J Am Dent Assoc. 2006 Feb;137(2):160-9.

Impact of brackets on smile esthetics: Laypersons and orthodontists perception

Seandra Cordeiro de Oliveira[1], Rachel D'Aurea Furquim[2], Adilson Luiz Ramos[3]

Objective: This study evaluated the influence of orthodontic appliances on smile esthetics assessed by lay adolescents, lay adults and orthodontists.

Methods: A facial photograph of a smiling young woman was used under the following conditions: With metal orthodontic brackets ligated by different elastic ligature colors (green, red and gray), with ceramic bracket brackets (transparent elastic ligature) and without brackets, totaling five 15 x 20 cm pictures. For the photograph assessment, 16 lay adolescents, 16 lay adults and 16 orthodontists were randomly selected. The photographs were randomly arranged in an album, followed by a visual analog scale (VAS) for the scores registration. Scores in both evaluations of each group of evaluators (adolescents, adults and orthodontists) were submitted to error analysis by WILCOXON test and multiple comparison among groups performed by Kruskal – Wallis at 5% significance.

Results: Orthodontists, adults and adolescents agreed in their opinions, although the orthodontists gave lower scores in their assessments. It could be observed that ceramic brackets were more acceptable concerning the smile esthetics, whereas the metal brackets received the lowest scores.

Conclusion: Orthodontists, adults and even adolescents seem to prefer esthetic solutions during orthodontic treatment.

Keywords: Esthetics. Dental. Visual perception. Orthodontic brackets.

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

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

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INTRODUCTION

One of the main reasons that motivate patients to start an orthodontic treatment is the esthetic factor,[1-3] as well as joint dysfunction and improvement of dental health as a whole.[4] Patients that look for orthodontic treatment present a more critical self-perception, both of the face, as well as the teeth, than those who do not look for treatment. This fact suggests that patients that look for orthodontic treatment, in general, are more demanding about esthetic looks.[5]

The smile can have an important influence once that faces with better looking smiles are considered to be more acceptable esthetically[6,7] and it can be associated with psychological characteristics.[8,9]

Even considering that beauty is quite subjective and is associated with many factors, the professional has the responsibility to capture the patients' desires that is the main goal of treatment. Once the patient starts an orthodontic treatment for esthetic reasons, it is consistent to assert that during the treatment he is also concerned about his esthetics. The use of orthodontic brackets can harm the appearance, even if it is temporary.

Long term treatment and non-esthetic appearance of metal brackets are the main reasons for adult patients declining to start orthodontic treatment[4]. Facing that, the industry for dental materials has been looking to offer alternatives so the treatment becomes more esthetic, developing specific treatment techniques and technology, such as lingual orthodontics, transparent aligners, and use of esthetic brackets.[10] A recent study concluded that adult patients would pay more to use alternative appliances and ceramic brackets, once they were considered to be more acceptable and attractive than the metallic conventional ones.[11]

A German survey shows that 97% of the patients (comprised mainly by females) wishes to have their malocclusions corrected for esthetic reasons, but 62% rejected treatment with a visible appliance.[12] In Sweden, a survey showed that 67% would probably wear visible brackets if needed. However, based on appearance of the brackets alone, 33% of the adults would be unwilling to wear visible brackets if needed. The same group additionally responded that 84% would probably or definitely treated with visible brackets during adolescence if needed.[13] These responses suggest a dichotomy between acceptability of orthodontic appliance for adolescents and adults.

However, to date no studies have been published on the real impact of this kind of orthodontic accessories on smile esthetics perceived by adolescents in comparison with adults or orthodontists, even with metal brackets, being used in a larger scale in orthodontic clinics. A previous investigation[14] examining 18 years old youngsters found that orthodontic appliance attractiveness varies significantly by the following hierarchy of appliance types: Alternative appliances > ceramic appliances > all stainless steel and self-ligating appliances.[14] Recently, the impact of orthodontic brackets on the esthetics of the face when smiling, with and without premolar extraction was evaluated by lay adults and orthodontists. This investigation concluded that metal orthodontic brackets did not affect facial esthetics. On the other hand, they found that ceramic brackets were significantly less pleasant to lays. To orthodontists, ceramic brackets had no negative influence on facial esthetics. The authors also concluded that perception of lay adults and orthodontists was different.[15]

Facing the lack of studies about the impact of orthodontic brackets on smile esthetics, particularly among adolescents, it is difficult for orthodontists to inform their patients which brackets to choose based on scientific evidence. This lack of information also becomes relevant when considering the high investments done by industries of dental materials in an effort to develop and commercialize orthodontic brackets more imperceptible to human eyes.

MATERIAL AND METHODS

A female volunteer with a pleasant smile was photographed in the frontal aspect, with a CANON 30 D 8.0 megapixel camera, with a 100 mm macro lens in a distance of one meter. The metal orthodontic brackets (Abzil/3M-Brazil) and the ceramic ones (Inspire – Ice – ORMCO, California, – United States) were temporarily bonded (with easy removal and only to perform the pictures) on the volunteer's upper teeth with a cheek retractor

and no acid etching. Adhesive and Transbond® XT composite (3M Unitek, California, EUA) were used and cured for 10 seconds to this sample of brackets. A stainless steel arch 0.018-in was used as reference to level bracket position and fixed with ligatures (Morelli, São Paulo, Brazil). Photos of volunteer smiling were obtained in three conditions: Without brackets, with ceramic brackets ligated by transparent elastic ligatures and with metal brackets ligated by different ligature colors (green, red and gray).

One of the photographs in which the patient is smiling was selected as the matrix, which was used as reference to obtain smile standardization. Close up photographs were taken with metal and ceramic orthodontic brackets, which were transferred to the matrix photo, with a digital simulation using the *software* Adobe Photoshop CS2.

The teeth and orthodontic bracket images of the other photos were transferred to the matrix photo in order to maintain the same relation between lips and teeth in the smile and the same head positioning at all result photos, so that the only difference between the simulated photos was the orthodontic brackets.

The photos were: A matrix photograph (Fig 1) and four manipulated photographs with images of all kinds of brackets and elastic ligature used (Fig 2).

Color prints with picture quality in size 15 x 20 cm were obtained and randomly grouped in an album. The evaluators were randomly selected and distributed in the following groups: 16 adolescents between 13 and 17 years old (8 males and 8 females), 16 graduate adults between 25 and 50 years old (8 males and 8 females) and 16 orthodontists, aged 26-48 years old (8 males and 8 females).

Each evaluator received an album with five photos, an instruction sheet and five evaluation sheets with visual analogue scales (VAS)[16] with 10 cm each and a sheet to collect data (age, schooling level and address). On the left end of the scale was written "Very unpleasant" and on the right end "Very pleasant" (Fig 3).

The raters were instructed not to compare the smiles of the album. They had around 20 seconds to evaluate each photo. The VAS scale sheet was fulfilled in the researcher presence, without any interference. After two weeks a second evaluation was performed similar to the first one, in order to evaluate the error of method.

Statistical analysis

Scores in both evaluations of each group (adolescents, adults and orthodontists) were submitted to

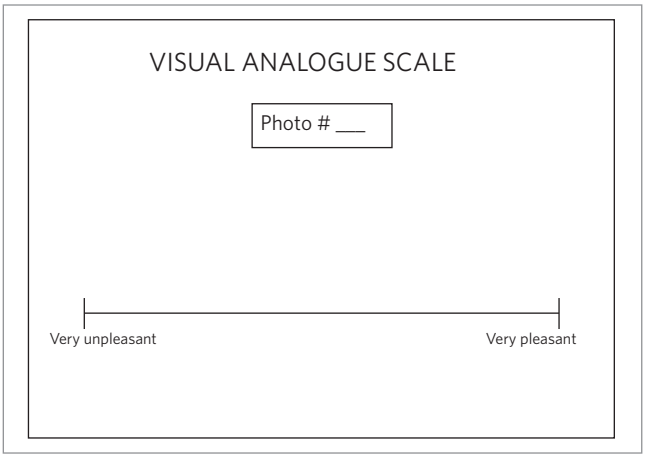

Figure 1 - Visual Analogue Scale.

Figure 2 - Smile without brackets (NB).

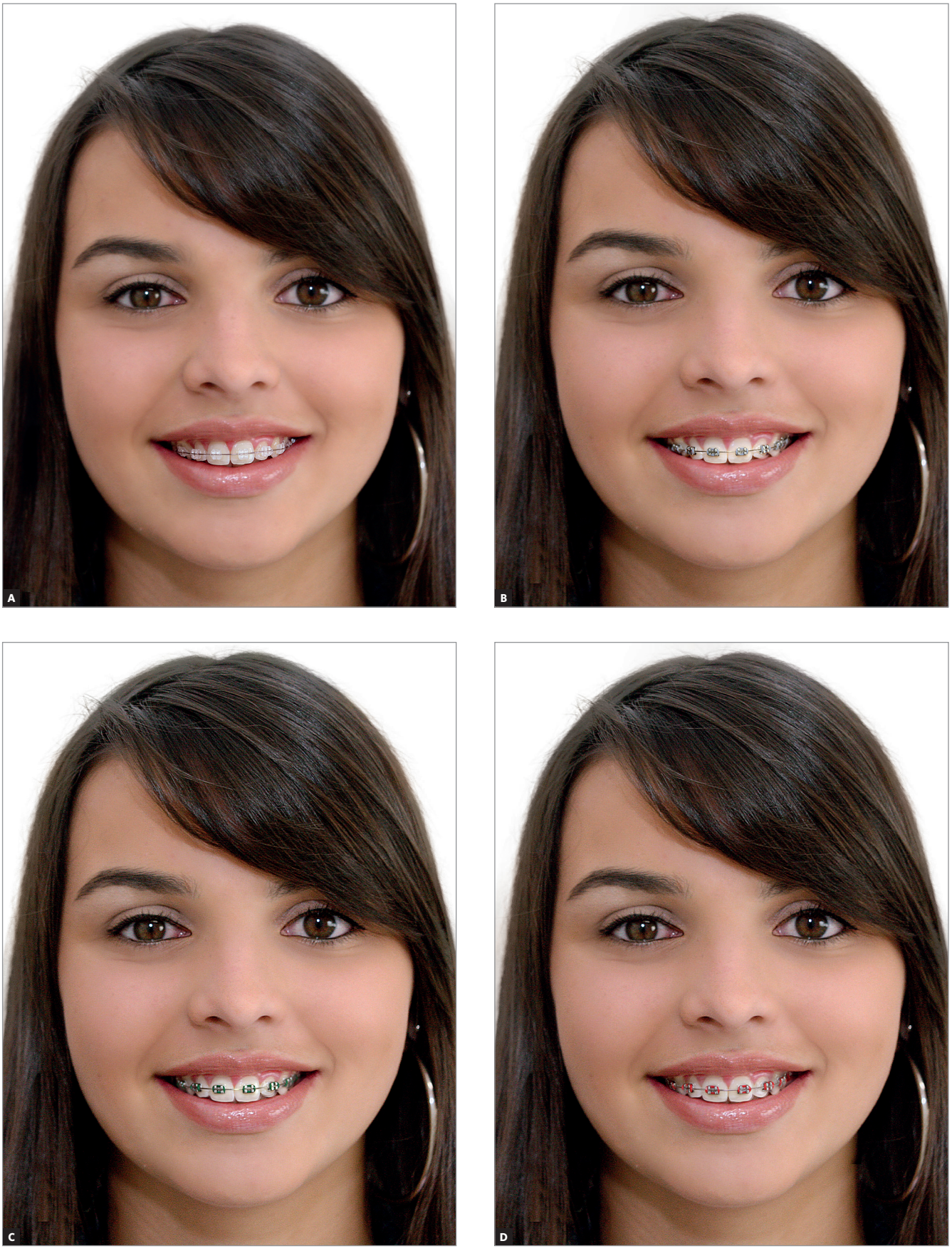

Figure 3 - **A**) Smile with ceramic brackets (CB). **B**) Metal brackets + gray ligatures (MB + GY). **C**) Metal brackets + green ligatures (MB + GN). **D**) Metal brackets + red ligatures (MB + R).

Table 1 - Descriptive data of the scores obtained by VAS.

Group	Treatment	Mean	Standard Deviation	n	95% confidence interval	
					Lower Limit	Upper Limit
Adolescents	CB	70.47	21.41	32	62.750	78.187
	MB+GN	55.81	19.98	32	48.610	63.015
	MB+R	61.56	14.84	32	56.213	66.912
	MB+GY	60.28	17.26	32	54.060	66.503
	NB	74.81	12.79	32	70.202	79.423
Adults	CB	80.56	13.46	32	75.709	85.416
	MB+GN	64.72	21.07	32	57.123	72.314
	MB+R	65.88	18.38	32	59.247	72.503
	MB+GY	66.72	19.24	32	59.782	73.655
	NB	78.63	15.01	32	73.214	84.036
Orthodontists	CB	70.34	16.30	32	64.468	76.219
	MB+GN	50.72	19.21	32	43.793	57.645
	MB+R	56.09	17.07	32	49.939	62.248
	MB+GY	57.06	20.29	32	49.748	64.377
	NM	66.50	19.84	32	59.348	73.652

an error analysis using of Wilcoxon signed-rank test. Multiple comparisons among groups were performed using Kruskal-Wallis test. All the statistics were performed using two-tailed distribution at $p > 0.05$.

RESULTS

Table 1 presents intra-group comparisons. It can be observed that all groups presented similar behaviors, scoring smiles with ceramic brackets as well as smiles without brackets as more esthetical.

The averages were tested between genders and presented on table 2. There was no significant difference between genders, except on the MB+GN combination (metal bracket+ green ligature), where the female gender presented a smaller average in comparison to the male evaluators ($p < 0.05$).

The intergroup analysis showed that orthodontists presented higher esthetic levels especially to the combinations MB+R, MB+GN, NB. For the CB and CB+ GY the lay adolescent group showed to be as demanding as orthodontists. The lay adult group showed to be less demanding than the other groups for all proposed combinations (Table 3, Fig 4), marking higher scores in general.

Figure 4 illustrates the scores behavior of all groups of evaluators. A clear similarity was found on the behavior of the curves, especially differing the lay adult's scores, as well as the best grades for the smile without brackets or with ceramic brackets.

Table 2 - Multiple comparison (Kruskal-Wallis) to the average comparison of the two genders for each combination.

Group	Average Score Treatment				
	CB	MB+GN	MB+R	MB+GY	NB
Male	74.25[a]	61.29[a]	64.08[a]	62.35[a]	73.48[a]
Female	73.33[a]	52.87[b]	58.27[a]	60.35[a]	73.14[a]

* Averages on the columns with different letters are statistically different on the 5% level of significance (p value < 0.05).

Table 3 - Multiple comparison (Kruskal Wallis) between score averages for each group of evaluators.

Group	Average score				
	CB	MB+GN	MB+R	MB+GY	NB
Adolescents	70.47[a]	55.81[a]	61.56[a]	60.28[a]	74.81[a]
Adults	80.56[b]	64.72[b]	65.88[a]	66.72[a]	78.63[a]
Orthodontists	70.34[a]	50.72[a]	56.09[b]	57.06[b]	66.50[b]

* Averages on the columns with different letters are statistically different on the 5% level of significance (p value < 0.05).

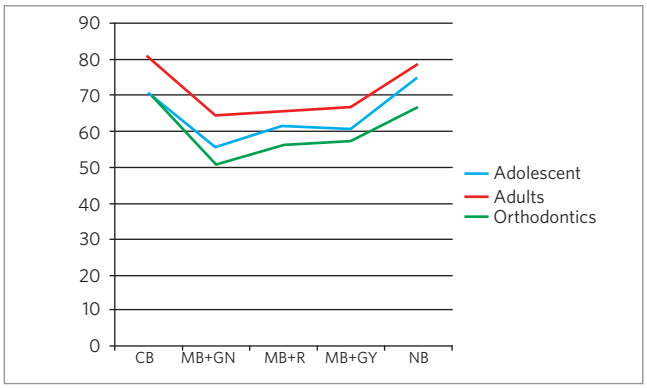

Figure 4 - Average scores for the three evaluators groups.

DISCUSSION

The adult demand for orthodontic treatment increased, inn most cases for esthetic reasons.[3,10] Because of this, it would be reasonable to assume that patients, especially adults, would not only be concerned about the esthetics in the end of the treatment, but also during the whole process. Although this affirmation is confirmed for adults,[12-15] no study had been conducted on adolescents' attractiveness perception when using brackets, maybe because it is presumed that adolescents are used to a "metallic smile".

Our results showed that adolescents recorded similar scores between the smiles with or without ceramic brackets. On the other hand, smiles with metal brackets, regardless of the ligature color used, were considered less pleasant. In fact, adolescents were more demanding in esthetic reasons than the adult evaluator group, contradicting the idea that adolescents tend to feel better with a "metallic smile". This can suggest that the esthetic requirement is very updated, even in young patients and not only restricted to the adult public. Maybe this is due to the influence of the media, the increased number of patients under orthodontic treatment, or by cultural and socio-economic aspects.[3,10,15]

Considering that orthodontic treatment requires time to be accomplished, it would be acceptable that, even adolescents would choose brackets that interfere the minimum possible on their appearance, being discrete or even non perceivable.[10,11] Thus, orthodontists should concern about the population requests. Although clear aligners, lingual and ceramic brackets are most commonly used in adults,[12-15] we can expect an increasing demand for these esthetic options among adolescents.

It is appropriate to emphasize that metal brackets ligated by green elastomers, which were the less scored, presented an average of 55.81 mm in VAS scale by adolescents, 64.72 mm by adults and 50.72 mm by orthodontist (Table 3). Thus, it can be considered that the metal brackets were not negatively scored (as VAS measurements were above 50 mm), but had a higher impact on the smile esthetics than the ceramic brackets. Although it is a value and an appearance question for patients.[11,14] the appliances should be selected on the efficiency basis. In fact, less attractive appliances are most commonly used in orthodontic practice.[21] It was pointed that ceramic brackets could be less efficient than metallic in terms of fracture resistance and sliding quality.[11,14] Furthermore, to date, it was reported that clear aligners still need improvements to achieve clinical performance compared to conventional brackets.[22]

Although there was homogeneity in respect to smile esthetics, the orthodontic group showed to be more demanding for all proposed combinations, with smaller scores in general. Other perception studies showed similar judgment behavior between orthodontists and lay people.[17-20]

Many studies have evaluated characteristics of both dental and facial esthetics, rating photographic records with a visual analog scale (VAS), which has been shown to be a valid method of assessing dental attractiveness.[1,6,11,14,15,17-20,23] Two evaluations with two weeks interval in this study showed no significant differences in all groups. When genders of evaluators were compared, metallic brackets with green ligation were the only significant different measurement found in female group, who scored less attractive than males.

In this study, evaluators judged photographs of the whole face and not by limited dental frameworks of the smile. In this way smiles are evaluated as a part of the whole esthetics of the face. In photos with guidelines about the smile, there is overvaluing of certain characteristics of the smile in question, particularly negative characteristics.[20] Despite of different evaluation methods, our results agree with Rosvall et al[11] and Ziuchkovski et al[14] where both orthodontists and lay people classified the devices in a hierarchy where the attractiveness decreased with increasing amount of metal present. In opposite, Berto et al[15] found that lay people prefer metallic brackets than ceramic, however an extraction site was present in their photographs, which could affected perception.

It is suitable to say that in the present study all brackets were temporarily bonded, then photographed and lately removed. This way, they were not allowed to pass through the environmental

conditions caused by time and the actual orthodontic treatment, which would be more significant, once they could change, mainly on the bracket/ transparent ligature, which could affect their esthetic perception. This fact suggests that more studies should be conducted with the objective of evaluating the perception of the esthetic of these devices, in long-term.

CONCLUSIONS

» Considering the esthetic aspect, smiles with metal brackets presented smaller scores than smiles without brackets and with ceramic brackets.

» Adolescents, adults and orthodontists showed similar perceptions on the evaluation of the impact of brackets on smile esthetics.

REFERENCES

1. Prahl-Andersen B, Boersma H, van der Linden FP, Moore AW. Perception of dentofacial morphology by laypersons, general dentists, and orthodontists. Am J Dent Assoc. 1979;98:209-12.
2. Giddon DB, Sconzo R, Kinchen JA, Evans CA. Quantitative comparison of computerized and animated profile preferences. Angle Orthod. 1996;66:441-8.
3. Reis SAB, Abrão J, Capelozza Filho L, Claro CAA. Análise facial subjetiva. Rev Dental Press Ortodon Ortop Facial. 2006;11(5):159-72.
4. Khan RS, Morrocks EN. A study of adult orthodontic patients and their treatment. Br J Orthod. 1991 Aug;18(3):183-94.
5. Varela M, Garcia-Camba JE. Impact of orthodontics on the psychologic profile adult patients: a prospective study. Am J Orthod Dentofacial Orthop. 1995 Aug;108(2):142-8.
6. Shaw WC, Rees G, Dawe M, Charles CR. The influence of dentofacial appearance on the attractiveness of young adults. Am J Orthod. 1985 Jan;87(1):21-6.
7. York J, Holtzman J. Facial attractiveness and the aged. Spec Care Dentist. 1999 Mar-Apr;19(2):84-8.
8. Dong JK, Jin TH, Cho HW, Oh SC. The esthetics of the smile: a review of the recent studies. Int J Prosthodont. 1999 Jan-Feb;12(1):9-19.
9. van der Geld P, Oosterveld P, Van Heck G, Kuijpers-Jagtman AM. Smile attractiveness. Self-perception and influence on personality. Angle Orthod. 2007 Sep;77(5):759-65.
10. Maltagliati LA, Feres R, Figueiredo MA, Siqueira DF. Braquetes estéticos: considerações clínicas. Rev Clín Ortodon Dental Press. 2006;5(3):75-81.
11. Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM. Attractiveness, acceptability, and value of orthodontic appliances. Am J Orthod Dentofacial Orthop. 2009 Mar;135(3):276.e1-12; discussion 276-7.
12. Meier B, Wiemer KB, Miethke R. Invisalign—patient profiling. J Orofac Orthop. 2003 Sep;64(5):352-8.
13. Bergström K, Halling A, Wilde B. Orthodontic care from the patients' perspective: perceptions of 27-year-olds. Eur J Orthod. 1998;20(3):319-29.
14. Ziuchkovski JP, Fields HW, Johnston W, Lindsey D. Assessment of perceived orthodontic appliance attractiveness. Am J Orthod Dentofacial Orthop. 2008 Apr;133(4 Suppl):S68-78.
15. Berto PM, Lima CS, Lenza MA, Faber, J. Esthetic effect of orthodontics appliances on a smiling face with and without a missing maxillary first premolar. Am J Orthod Dentofacial Orthop. 2009 Apr;135(4 Suppl):S55-60.
16. Aitken RC. Measurement of feelings using visual analogue scale. Proc R Soc Med. 1969;62(10):989-93.
17. Anderson KM, Behrents RG, McKinney T, Buschang PH. Tooth shape preferences in an esthetic smile. Am J Orthod Dentofacial Orthop. 2005 Oct;128(4):458-65.
18. Parekh S, Fields H, Beck F, Rosenstiel S. The acceptability of variations in smile arc and buccal corridor space. Orthod Craniofac Res. 2007 Feb;10(1):15-21.
19. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.
20. Flores-Mir C, Silva E, Barriga MI, Lagravere MO, Major PW. Lay person´s perception of smile aesthetic in dental and facial views. J Orthod. 2004 Sep;31(3):204-9; discussion 201.
21. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. 2002 JCO study of orthodontic diagnosis and treatment procedures. Part 1. Results and trends. J Clin Orthod. 2002 Oct;36(10):553-68.
22. Djeu G, Shelton C, Maganzini A. Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. Am J Orthod Dentofacial Orthop. 2005 Sep;128(3):292-8; discussion 298.
23. Howells DJ, Shaw WC. The validity and reliability of ratings of dental and facial attractiveness for epidemiologic use. Am J Orthod. 1985 Nov;88(5):402-8.

Photometric analysis applied in determining facial type

Luciana Flaquer Martins[1], Julio Wilson Vigorito[2]

Introduction: In orthodontics, determining the facial type is a key element in the prescription of a correct diagnosis. In the early days of our specialty, observation and measurement of craniofacial structures were done directly on the face, in photographs or plaster casts. With the development of radiographic methods, cephalometric analysis replaced the direct facial analysis. Seeking to validate the analysis of facial soft tissues, this work compares two different methods used to determining the facial types, the anthropometric and the cephalometric methods.

Methods: The sample consisted of sixty-four Brazilian individuals, adults, Caucasian, of both genders, who agreed to participate in this research. All individuals had lateral cephalograms and facial frontal photographs. The facial types were determined by the Vert Index (cephalometric) and the Facial Index (photographs).

Results: The agreement analysis (Kappa), made for both types of analysis, found an agreement of 76.5%.

Conclusions: We concluded that the Facial Index can be used as an adjunct to orthodontic diagnosis, or as an alternative method for pre-selection of a sample, avoiding that research subjects have to undergo unnecessary tests.

Keywords: Diagnostic techniques and procedures. Orthodontics. Anthropometry.

INTRODUCTION

For countless generations man observed and measured the physical characteristics of the human body.[1,2,3]

During the Renaissance period, Leonardo da Vinci made a number of studies on the proportions and indexes of the human body, characterizing the anatomical structures. Among these studies, we can find drawings of different facial types and characteristics, which even today can be found in our society[4] (Fig 1).

Angle[1], in 1899, noted that for the orthodontist to be capable to correctly diagnose malocclusions, he should also be familiar with the normal or ideal occlusion,

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

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Figure 1 - Drawings of facial features described by da Vinci in the fifteenth century.

observe normal facial lines, taking into consideration the norm, straight profile like that of Apollo Belvedere.

However, in 1907, Angle[2] noted that the goal of a straight profile as that of Apollo at the end of orthodontic treatment was a result unlikely to be achieved, since there were many different facial patterns in different human groups. Thus, he emphasized that the role of the orthodontist was to detect whether facial structures were in harmony, and that this should be in accordance with well-positioned teeth and a balanced occlusion.

The best way to develop the ability to evaluate faces is to observe them several times. With this practice the orthodontist develops the ability to determine the facial characteristics of each subject. Herzberg,[4] pointed out that standardized photographs would be the best method, because only with them it would be possible to evaluate in detail the measures and proportions, even for those who were still starting in the practice of facial evaluation.

Montangu[5] characterized the anthropometry as a branch of anthropology where individuals are categorized by measurements made by means of acquired images (photographs or radiographs) or directly on soft tissue or bone. Among other measures, he regarded the proportions of the human body, he also has described the Facial Index (where the facial height and width are correlated) which can characterize three facial types:

» Mesoprosopic (facial height and width in the same proportion).
» Euriprosopic (facial width greater than height).
» Leptoprosopic (facial height greater than width).

When there is a comparison between the reliability of photometric and anthropometric methods for evaluation of facial features, a large share of the measures and indexes are comparable.[8] In the comparison of standardized photographs and photographs taken with no specific standardization, the Facial, Frontal, Nasal, Oral, Orbital, Lip and Auricular Indexes were effective for human identification. Moreover, these indexes, both in non-standard photographs provided by patients as in standardized photographs, were able to positively identify a person.[9]

It is essential for orthodontic diagnosis and treatment and facial surgery planning to analyze the physical characteristics of the human body, with emphasis on the craniofacial complex, for orthodontic studies including measurements of height, width and angulation of structures, while taking into consideration the influence of muscles and geometric configuration of the face.

Cephalometric analysis is of great importance both for diagnosis and planning of orthodontic treatment. It is also crucial for communication among professionals. Measures related to the growth direction of the mandible — such as the mandibular angle, facial angle, facial axis, facial depth, mandibular plane, mandibular arch height and anterior lower face — determine the Vert Index, which cephalometrically distinguishes three facial types.[6,7]

» Mesofacial (balanced facial growth).
» Brachyfacial (predominance of horizontal facial growth).
» Dolichofacial (predominance of vertical facial growth).

In a first contact with the patient, some facial features can be observed only visually, such as asymmetries and facial type, but in a qualitative way. On this occasion, the most significant features should be noted, since through them we can see the facial growth trends,[10] and through this preliminary diagnosis, determine what additional exams will be needed for a more accurate diagnosis. Once this records are analyzed and with the initial notes in hand, the final diagnosis and outline of orthodontic planning can be performed.

One of our first impressions of patients' face shall give us the impression that they either have a long, medium or short face, and to confirm it, there are several analysis methods such as direct measurement on the face of patients or in photographs of the proportions between facial height and width, and the radiographic evaluation of craniofacial structures.

Determining the facial type is extremely important for orthodontic diagnosis and planning, since the muscular and skeletal configuration of each facial types responds differently to the orthodontic treatment, influencing either positively or negatively the final treatment results.

In orthodontics, the use of anthropometric measurements in the diagnosis has been gradually replaced, since it was presumed that the determination of facial types by means of anthropometric and cephalometric methods was equal. We currently use more frequently radiographic methods, which maintain a direct relationship with the craniofacial growth.

But, more than just a base for our planning on the direction of patient growth, we should also observe the craniofacial features in a comprehensive way, using indexes and anthropometric measurements,[10] allowing for a proper evaluation of both qualitative and quantitative facial asymmetry and proportion,[11] providing a more complete analysis of our patient.

In order to encourage the use of anthropometric analysis in orthodontic diagnosis, as well as to illustrate a specific situation for the application of one of its indexes, this study found a correlation between the determination of facial analysis through photographs and measurements by cephalometry.

MATERIAL AND METHODS

The sample consisted of 64 Brazilian individuals, 50 females and 14 males, Caucasians, aged between 18 and 38 years (mean age of 27 years and 9 months), who agreed to participate in this research and signed an informed consent about the nature of these studies. This study was approved by the São Paulo University Ethical Committee (approval number 131/06).

We chose Ricketts' Vert Index for the determination of cephalometric facial type, performed on lateral cephalometric radiographs, digitized by a specific scanner for radiographic films and measured with Radiocef Studio 2 software (Radio Memory Ltda, Belo Horizonte, Brazil) (Fig 2).

The cephalometric measurements used to determine Vert Index were:

1. Facial Axis (FA): Angle between the lines Basion-Nasion and Gnation-Pterygoid.
2. Facial Depth (FD): Angle formed by lines Nasion-Pogonion and Porion-Orbitale.
3. Lower Anterior Facial Height (LAFH): Angle formed by lines ANS-Xi and Xi-MP.
4. Mandibular Plane (MP): Angle formed by lines Porion-Orbitale and Gonial-Menton.
5. Mandibular Arch (MA): Angle formed by lines Dc-Xi and Xi-MP.

The facial type determined by the Vert Index in adults is given by the following equation, described by Gregoret:[12]

$$\{[(FA-90)/3]+[(FD-90)/3]+[(24,5-MP)/4]+[(47-LAFH)/4) + [(MA-28,5)/4]\}/5$$

And follow the reference bellow:

» Brachyfacial: greater than +0.5.
» Mesofacial: between -0.49 and +0.49.
» Dolichofacial: smaller than -0.5.

The determination of the facial type by the Facial Index in facial photographs was made with the subjects facing forward, in standardized photos taken with individuals in their Natural Head Position (where the subject are positioned with a straight back and their arms resting along the trunk and looking at a fixed point in the center of the lens. When the operator observed a tilt of the head, this was corrected[13]), digitized and also measured with the program Radiocef Studio 2 (Fig 3).

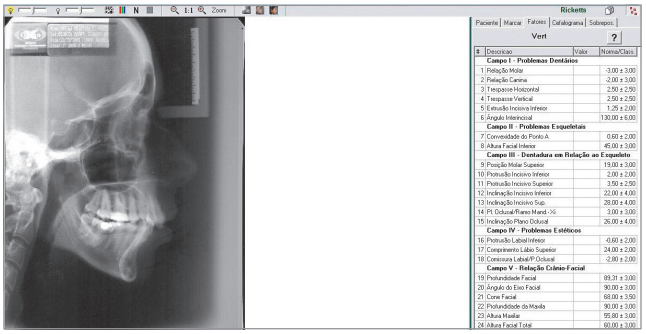

Figure 2 - Lateral cephalometric radiograph being analyzed in Radiocef Studio 2 software (configuration: Ricketts cephalometric analysis).

The distances measured for determining the Facial Index were:

1) Anterior facial height (N'-Me'): Distance between the points nasion and chin in soft tissue.

2) Facial width (Zid'- Zie'): Distance between left and right Zigium points in soft tissue corresponding to the lateral portion of the zygomatic process.

The facial type determined by the Facial Index is calculated as follows:

N' - Me' x 100 / Zid' - Zie'

According to the following reference:[9]

» Brachyfacial: smaller than 80.0 to 84.9%.

» Mesofacial: 85.0 to 89.9%.

» Dolichofacial: 90.0 to 95 % or greater.

After verifying the percentages of occurrences for each facial type by the photometric method and by Vert Index, comparisons among the groups were performed using the Kruskal-Wallis test (done in the free statistical software *Past*). The level of significance in this study was 5%. This test is designed to compare two or more independent samples in relation to a measurement of interest. Moreover, it is a non-parametric test, namely, not based on the mean and standard deviation, but in positions of the individuals in the sample. We opted for a non-parametric test because two groups showed a small number of observations to perform parametric tests.

The Kappa agreement index, which is also a non-parametric test, was used to check the level of agreement between the determinations of facial types by the two methods and followed the interpretation described next: If the range of agreement is lower than 40%, the result is considered weak; if the value ranges between 40% and 75% of agreement, the result is considered reasonable to good; and if it exceeds 75%, the correlation is high.

RESULTS

After statistical analysis of collected data, we obtained the results shown in Table 1. In Figure 4, we can observe the correlation between facial type determination by the photometric (A) and the cephalometric (B) methods.

With these results we can conclude that with a Kappa index of 76.5% (high level of agreement), cephalometric and photometric methods for determining facial types are equivalent.

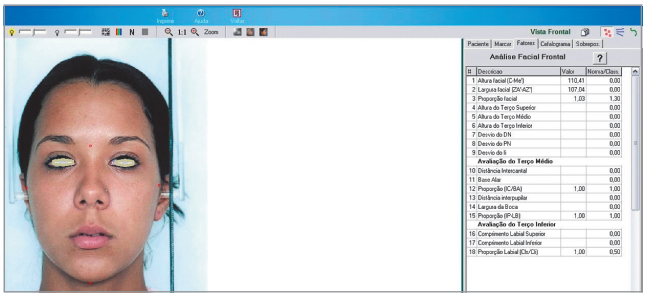

Figure 3 - Frontal photograph of a patient inserted into the Radiocef Studio 2 program (Facial Analysis configuration).

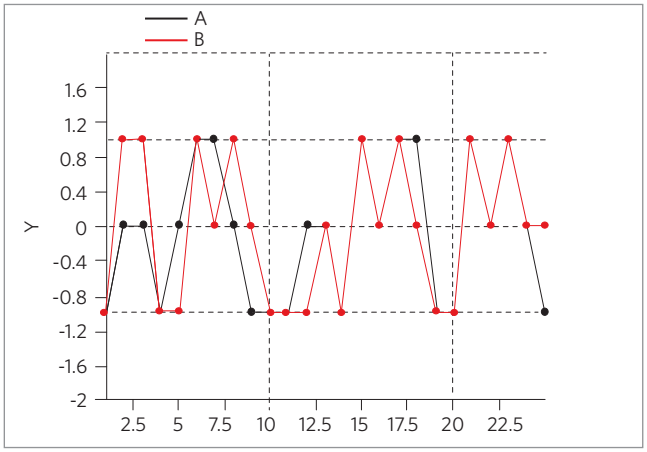

Figure 4 - Correlation between facial type determination by the photometric (**A**) and cephalometric (**B**) methods.

Table 1 - Comparison of facial type determination by anthropometric and Vert Index methods.

Anthropometric facial type	Ricketts facial type (Vert Index)								Kappa
	Dolichofacial		Mesofacial		Brachyfacial		Total		
	n	%	n	%	n	%	n	%	
Dolichofacial	19	29.7	4	6.3	0	0.0	23	35.9	0.765
Mesofacial	3	4.7	18	28.1	0	0.0	21	32.8	
Brachyfacial	0	0.0	3	4.7	17	26.6	20	31.3	
Total	22	34.4	25	39.1	17	26.6	64	100	

DISCUSSION

The evaluation of the facial features are essential for carrying out a good orthodontic diagnosis, since the positioning of the bones and teeth certainly influence the appearance of soft tissues.[1,2,6,7,10]

As facial esthetics is one of the goals to be achieved at the end of orthodontic treatment, a good facial analysis, both qualitative[1,2,4] and quantitative[10,11] must be observed when defining treatment plan.

Historically, orthodontic studies have been directed to evaluate the radiographic characteristics of craniofacial hard tissues and found scientific evidences on how these characteristics could influence the positioning of the soft tissues and its influences on facial esthetics[6,7] Among the cephalometric assessments, there is the determination of the facial type, which is crucial for orthodontic planning. One way to determine the facial type of individuals through cephalometric analysis is the calculation of the Vert Index.[6,7]

Another method to determine the facial type is calculating the photometric Facial Index.[5,8-11] The photometry is a tool of anthropology where we can quantify the tangible characteristics of individuals through photographs.

The advantage of using oriented facial photographs in orthodontic studies is that, apart from the initial diagnostic studies, one can compare the same individual at different times of treatment or of his/her growth, and to compare different individuals and find similar characteristics between them, qualifying these individuals as a unique group.[1,2,11]

Since we found hard tissues influencing the positioning of soft tissues, we are able to deduce from this result that the facial soft tissues also can mask bone characteristics.[10]

The percentage of differences found on the determination of facial types using cephalometric and photographic analysis is supposedly due to the fact that there are cephalometric studies of bone structures in profile views, while in photographs, we evaluate individuals soft tissues in frontal view.

Based on the aforementioned, it can be concluded that it is important for diagnosis to evaluate both cephalometric and photometric analyses.

CONCLUSIONS

In this study, we observed that the facial type determination by the photometric method (Facial Index) showed to be reliable when compared to cephalometry (assessed by the Vert Index). However, the facial photometric analysis should be adjuvant, or supplemental, and not substitute for the cephalometric method, since, especially in cases where the values of Vert are borderline between two facial types, the soft tissues can mask the bone characteristics.

These results support the current trend to make a morphological analysis using facial photographs in orthodontics and facial surgery studies, as an essential ally to obtain accurate diagnosis and satisfactory results.

Another available possibility is to use facial photographs, standardized for determination of the facial type, in the selection of scientific studies samples by means of a less invasive method for the patient. This way an extra dose of radiation to will not be needed to determine whether or not the subject is eligible to participate in a study involving data concerning different facial types.

REFERENCES

1. Angle EH Classification of malocclusion. Dent Cosmos. 1899;41:248-64.
2. Angle EH. Treatment of malocclusion of the teeth: Angles System. Philadelphia (PA: S.S. White Dental; 1907.
3. Hohenstatt P. Masters of Italian Art - Leonardo da Vinci. Könemann: Verlagsgesellschft; 1998.
4. Herzberg BL. Facial esthetic in relation to orthodontic treatment. Angle Orthod. 1952;22(1):3-22.
5. Montangu A. A handbook of anthropometry. Springfield: Thomas Publisher III; 1960.
6. Ricketts RM. A foundation for cephalometric communication. Am J Orthod. 1960;46(5):330-57.
7. Ricketts RM. Cephalometric synthesis. Am J Dentofacial Orthod. 1960;46(9):647-73.
8. Farkas LG, Bryson W, Klotz J. Is photogrammetry of the face reliable? Plast Reconstr Surg. 1980;66(3):346-55.
9. Daruge E, Zallaf CF. A biometria aplicada na identificação. RGO. 1985;33(2):153-55.
10. Jacobson A. Planning for orthognathic surgery - art or science? Int J Adult Orthodon Orthognath Surg. 1990;5(4):217-24.
11. Martins LF. Análise fotométrica em norma frontal, de adultos, brasileiros, leucodermas, não tratados ortodonticamente, classificados pela estética facial [Dissertação]. São Bernardo do Campo (SP): UMESP, Faculdade de Odontologia; 2001.
12. Gregoret J. Ortodontia e cirurgia ortognática. São Paulo (SP): Ed. Santos; 1999.
13. Rino Neto J, Freire-Maia BAV, Paiva JB. Método de registro de posição natural da cabeça para obtenção da radiografia cefalométrica lateral – Considerações e importância do método no diagnóstico ortodôntico-cirúrgico. Dental Press. 2003;8(3):67-71.

In vivo color changes of esthetic orthodontic ligatures

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Objective: To assess the color changes that occur in four commercial brands of esthetic orthodontic elastomeric ligatures after exposure to the oral environment.

Methods: The four elastomeric ligatures manufacturers mostly mentioned by orthodontists were investigated: Morelli, Uniden, American Orthodontics (AO) and TP. The sample comprised 25 patients. The elastomeric ligatures were randomly distributed and arranged in the four dental quadrants of each patient, r for 30 days. After this period, two units of each brand were photographed in a standardized manner. Subsequently, color changes were visually evaluated and assigned a score (0, 1, 2 or 3) by a panel of four examiners. The mean scores assigned by the examiners were statistically analyzed by ANOVA and Tukey's test ($p < 0.05$).

Results: The mean pigmentation scores assigned to Morelli (1.80 ± 0.78) and Uniden (1.92 ± 0.66) elastomeric ligatures after 30 days in the oral environment were not statistically different. However, these brands were significantly more pigmented after 30 days in the oral environment ($p < 0.01$) compared to American Orthodontics (0.97 ± 0.6) and TP (0.83 ± 0.79).

Conclusions: Although all four brands exhibited an undesirable pigmentation after 30 days in the oral environment, color change for American Orthodontics and TP Orthodontics ligatures was significantly lower than Morelli and Uniden products.

Keywords: Elastomeric ligatures. Pigmentation. Visual perception.

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INTRODUCTION

Advances in cosmetic dentistry and the increasing demand for orthodontic treatment for adult patients have compelled the industry to release increasingly esthetic and less conspicuous orthodontic appliances. Brackets bonded to the lingual surface of the teeth, clear aligning systems, esthetic brackets made from polycarbonate, composite, ceramics or sapphire, illustrate some of the products released by the industry in order to satisfy the esthetic needs of these patients.

Although the quality of these materials is thoroughly tested before clinical use, clinical orthodontists have found that some of these products undergo a number of changes in their properties, especially changes in color due to staining by food or by contact with oral fluids. Concerns have been raised about the quality of these products and whether one particular company might be superior to another in terms of efficiency or cost-effectiveness. Many studies have evaluated the effects of the oral cavity on the elastic properties of elastomeric ligatures, such as force decay, friction and dimensional changes.[1-7] However, researchers have shown little concern about the behavior of orthodontic materials after exposure to the oral environment, especially the extent to which these changes interfere with esthetics.

Ceramic brackets have gained increased popularity in orthodontic treatment over the last decades mainly due to color stability. A frequent complaint of orthodontists and patients regards color changes in the elastomeric modules used to tie orthodontic archwires to ceramic brackets.

Prolonged exposure to cola soft drinks is a proven cause of color changes in restorative composites, while spices and seasonings can cause extrinsic stains to the teeth.[8,9] In orthodontics, some laboratory studies have shown that light-colored elastomeric ligatures show color changes after immersion in liquids with high pigmentation capacity.[10-12] Since these studies were conducted *in vitro*, they may not account for numerous other factors present in the oral environment that could contribute to color changes, such as the oral flora, the mechanical effect of brushing, solid and semi-solid foods, which can also stain, among many others. Thus, it seems quite obvious that an *in vivo* study can yield a more realistic analysis of actual color changes taking place in orthodontic materials after clinical use.

OBJECTIVE

Analyze color changes in esthetic elastomeric ligatures provided by four different manufacturers after a one-month exposure to the oral environment by a visual analysis.

MATERIAL AND METHODS

This study evaluated four brands of esthetic orthodontic elastomeric ligatures: Morelli – Lot 1268512 (Sorocaba, Brazil), Uniden – Lot 040209-E1-4 (Sorocaba, Brazil), American Orthodontics – Lot 00182559 (Sheboygan, Wisconsin, USA) and TP – Lot 1419028 (La Porte, Indiana, USA). The elastomeric modules were used in 25 consecutive patients undergoing orthodontic treatment in the Specialization Course in Orthodontics, ABO-Pará State, Brazil. These brands were selected after a survey was conducted with 100 Brazilian orthodontists via e-mail. Forty-four dentists (44%) responded to the following question: Which elastomeric ligature do you use on esthetic brackets? Two respondents reported that they were not using esthetic brackets. Two Brazilian and two American manufacturers most cited by the remaining 42 orthodontists were utilized. The brands cited in this research were:

- Morelli (Sorocaba, São Paulo, Brazil): 10.
- Uniden (Sorocaba, São Paulo, Brazil): 2.
- TP (La Porte, Indiana, USA): 8.
- American Orthodontics (Sheboygan, USA): 11.
- GAC (Bohemia, NY, USA): 6.
- 3M Unitek (St. Paul, Minnesota, USA): 3.
- Orthosource (North Hollywood, USA): 1.
- Tecnident (Porto Alegre, RS, Brazil): 2.

A split-mouth, randomized, triple blind study design was employed. In each patient, the four brands were distributed by quadrant in random and ordered fashion (Fig 1), remaining in the oral environment for a period of 30 days.

The subjects participating in the research were not on any specific type of diet. After 30 days, the ligatures were removed from the oral environment, separated by quadrant, and the brands were identified by numbers. Two ligatures — used on the anterior teeth of each quadrant — were selected for analysis.

Forty two photographs (25 original and 17 duplicates) were obtained using a digital camera model Canon EOS Rebel XTi (Canon, Osaka, Japan) with

10 megapixels resolution and color depth of 12 bits (Fig 2). All photographs were taken manually by a single operator, with 1/6 seconds speed, 22 diaphragm aperture, ISO 200, without flash, self-timer mode set to trigger after 10 seconds, images stored in JPEG format. A Sigma DG 105 mm (Ronkonkoma, NY, USA), 2.8 macro lens was used in an environment with total absence of daylight, lighted by two 110W halogen lamps, positioned at a fixed distance of 16 cm from each other, according to the method described previously.[11]

The photographs were evaluated at two times: Before use (T_1) and after 30 days in the oral environment (T_2).

In order to carry out a visual analysis of the elastomeric ligatures, a PowerPoint presentation (Microsoft, Redmond, WA, USA) was created comprising 25 original photographs and 17 duplicates, randomly arranged. The images were assessed independently by a panel of four orthodontists who rated the degree of pigmentation of the elastomeric ligatures in each quadrant using a numerical scale ranging from 0 (zero) to 3, where 0 was assigned to unpigmented ligatures, 1 was assigned to slightly pigmented ligatures, 2 to moderately pigmented ligatures, and 3 to heavily pigmented ligatures. All ligatures were ranked and grouped accordingly. The photographs of the ligatures prior to use were presented to a single blinded examiner to determine the initial score.

Statistical analysis

The data obtained from the reproducibility test were tested using the Wilcoxon test. The brands were compared by means of statistical analysis using the mean scores of the four examiners for each brand, after assessing the reproducibility of each examiner's diagnosis. The data were statistically compared by ANOVA and Tukey's test. All statistical analyses were examined at a significance level of 0.05 (5%).

RESULTS

The reproducibility test failed to reveal any significant differences for any of the examiners in the test-retest analyses (Table 1).

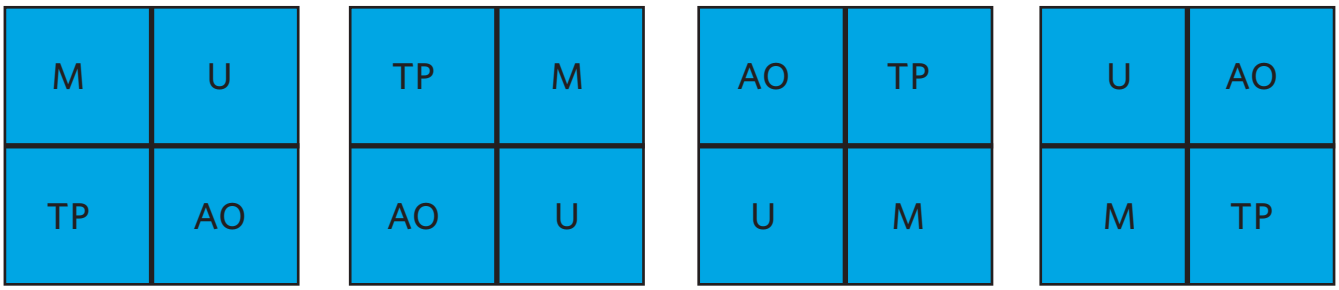

Figure 1 - Random, ordered distribution of brands by quadrant. (M = Morelli, U = Uniden, AO = American Orthodontics, TP = TP Orthodontics).

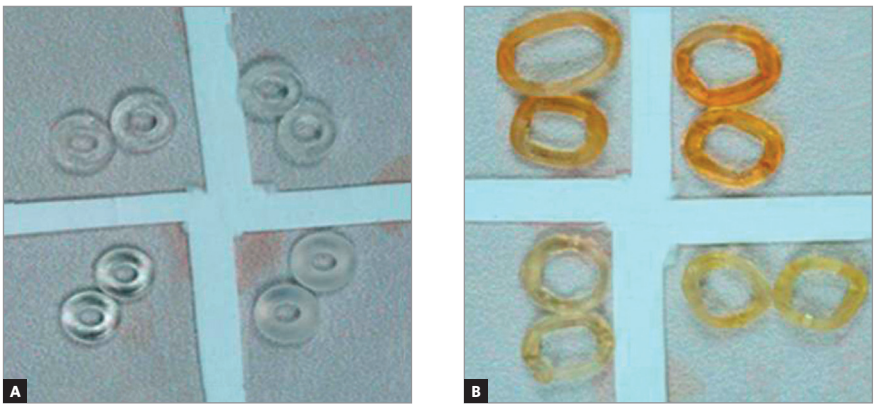

Figure 2 - Photographs of elastomeric ligatures at T_1 (**A**) and T_2 (**B**).

An analysis of the elastomeric ligatures before insertion in the mouth yielded a zero (0) score for all specimens examined (five in each group). Variance analysis showed that statistically significant differences were found between the commercial brands of elastomeric ligatures examined after 30 days of exposure to the oral environment ($p < 0.0001$). Tukey's test showed that the Brazilian brands (Morelli and Uniden) were similar, but significantly more pigmented (Fig 3, Table 2) than the US brands (American Orthodontics and TP).

DISCUSSION

Changes in the color of orthodontic ligatures have been performed by *in vitro* laboratory studies,[10-12] whereas the literature reports no *in vivo* analysis of such color changes. This study, therefore, provides results that are closer to reality by assessing color changes in elastomeric ligatures after exposure to the oral environment.

Assessments of the physical properties of elastomeric ligatures have reported significant changes in the structure and composition of these materials after exposure to the oral environment.[1-7] Variations in the friction force of elastomeric ligatures of different brands were observed after immersion in laboratory solutions in an attempt to reproduce the oral environment.[3] After exposure to the oral environment for 3 weeks and subsequent analysis by optical microscopy and spectroscopy, the elastomeric ligatures exhibited precipitates of calcium and phosphorus with the formation of calcium phosphate on the surface. A significant change was found in the structure and composition of the surface of the elastomeric ligatures after exposure to the oral environment, indicative of the severity of changes that can occur in the properties of these materials.[4]

In assessing the color, laboratory investigations were performed in an attempt to find differences in the staining of these elastomeric ligatures after immersion in different solutions. In these investigations, the change in color was measured quantitatively by means of a visual analog scale[12] or computational analyses,[10,11] The results indicated that certain substances stain more than others, such as methylene blue and red pepper sauce.[10,11]

Although a visually perceptible color change value was reported,[11] the equipment used in the research features considerable optical sensitivity and can be influenced by luminance and color of the surface on which the elastomeric ligatures are examined. Furthermore, one cannot determine to what extent color variations can compromise the visual esthetic pleasantness of an elastomeric ligature.

In the present study, a visual comparison between the four brands examined after 30 days in the oral environment was conducted by a group of four examiners using scores, disclosing significant differences between the brands tested ($p < 0.01$). Brazilian brands (Morelli and Uniden) had a similar, but poorer performance when compared to US brands (American Orthodontics and TP) which,also showed similar staining among each other (Table 2).

Table 1 - P values of reproducibility test (Wilcoxon) for the scores assigned by the four examiners using the visual method for Morelli, Uniden, American Orthodontics (AO) and TP Orthodontics brands.

Brand	p value Exam. 1	p value Exam. 2	p value Exam. 3	p value Exam. 4
Morelli	0.3173	1	0.3173	1
Uniden	0.593	1	0.3613	0.3173
AO	0.6858	0.6858	0.2367	0.593
TP	1	0.6858	1	1

Table 2 - Descriptive statistics and Tukey's test comparing the commercial brands of elastomeric ligatures examined, $F = 14.83$, $p < 0.0001$ (different letters, $p < 0.01$).

Brand	Mean	SD	Tukey
Morelli	1.80	0.78	A
Uniden	1.92	0.66	A
AO	0.97	0.60	B
TP	0.83	0.79	B

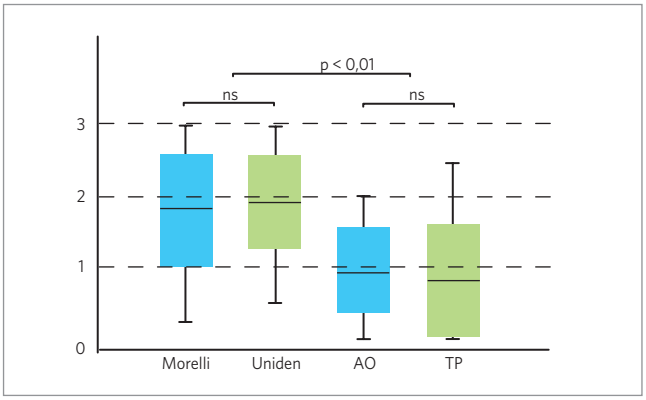

Figure 3 - Comparison between the examined elastomeric commercial brands, $F = 14.83$, $p < 0.0001$.

The visual analysis developed in this study allowed a direct comparison of the four most used brands according to a questionnaire answered by e-mail prior to the study. The results addressed a very common issue among orthodontists, that is which brand ensures for the patient greater esthetic stability during the period between two orthodontic maintenance visits. Previous attempts were made to examine the results with spectrometry (Minolta)[10] and through an analysis of photographs with Adobe Photoshop software version 10.0 (Adobe System Inc., San Jose, California, USA).[11] However, the results showed a high variability in the test-retest examination, especially spectrophotometry, due to limitations inherent in the technique, which requires a relatively large area for color analysis. Additionally, such analysis can be influenced by the curvature of elastomeric ligatures, as mentioned previously.[11]

Wide variations in the behavior of elastomeric ligatures of the same brand were observed in different patients (Fig 1). This may be due to a different diet and/or different oral hygiene habits , which may have interfered with the degree of pigmentation exhibited by elastomeric ligatures during the experiment. Studies that correlate diet and elastomeric pigmentation between experimental groups could be conducted to determine the types of foods that contribute more significantly to the esthetic degradation of elastomeric ligatures.

Based on the results, manufacturers of orthodontic materials — Brazilian companies in particular — should modify manufacturing methodology to enhance the stability of light-colored elastomeric ligatures used on ceramic brackets. This achievement would meet the needs of the adult population currently seeking orthodontic treatment with increasing esthetic concerns.

CONCLUSIONS

The results revealed that all four brands exhibited an unwanted pigmentation after 30 days of exposure to the intraoral environment, although the US brands American Orthodontics and TP Orthodontics showed less pigmentation than Morelli and Uniden.

REFERENCES

1. Baccetti T, Franchi L. Friction produced by types of elastomeric ligatures in treatment mechanics with the preadjusted appliance. Angle Orthod. 2006 Mar;76(2):211-6.
2. Baty DL, Volz JE, von Fraunhofer JA. Force delivery properties of colored elastomeric modules. Am J Orthod Dentofacial Orthop. 1994 Jul;106(1):40-6.
3. Dowling PA, Jones WB, Lagerstrom L, Sandham JA. An investigation into the behavioural characteristics of orthodontic elastomeric modules. Br J Orthod. 1998 Aug;25(3):197-202.
4. Eliades T, Eliades G, Watts DC. Structural conformation of in vitro and in vivo aged orthodontic elastomeric modules. Eur J Orthod. 1999 Dec;21(6):649-58.
5. Eliades T, Eliades G, Silikas N, Watts DC. In vitro degradation of polyurethane orthodontic elastomeric modules. J Oral Rehabil. 2005 Jan;32(1):72-7.
6. De Genova DC, McInnes-Ledoux P, Weinberg R, Shaye R. Force degradation of orthodontic elastomeric chains a product comparison study. Am J Orthod. 1985 May;87(5):377-84.
7. Taloumis LJ, Smith TM, Hondrum SO, Lorton L. Force decay and deformation of orthodontic elastomeric ligatures. Am J Orthod Dentofacial Orthop. 1997 Jan;111(1):1-11.
8. Fay RM, Servos T, Powers JM. Color of restorative materials after staining and bleaching. Oper Dent. 1999 Sept-Oct;24(5):292-6.
9. Abu-Bakr N, Han L, Okamoto A, Iwaku M. Color stability of compomer after immersion in various media. J Esthet Dent. 2000;12(5):258-63.
10. Ardeshna AP, Vaidyanathan TK. Colour changes of orthodontic elastomeric module materials exposed to in vitro dietary media. J Orthod. 2009 Sep;36(3):177-85.
11. Kim SH, Lee YK. Measurement of discolouration of orthodontic elastomeric modules with a digital camera. Eur J Orthod. 2009 Oct;31(5):556-62.
12. Lew KK. Staining of clear elastomeric modules from certain foods. J Clin Orthod. 1990 Aug;24(8):472-4.

The ability of orthodontists and laypeople in the perception of gradual reduction of dentogingival exposure while smiling

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Objective: To assess differences in how orthodontists and laypersons perceive a reduction in dentogingival display on smiling.

Methods: Sixty examiners from both genders (30 laypersons and 30 orthodontists) evaluated photographs of spontaneous smiles of two subjects , one male and one female. Based on the original images, smile height was modified by means of an image manipulation software program. The examiners assigned scores ranging from 0 to 10, according to the level of pleasantness. Method reproducibility was examined using the Wilcoxon test, while the Friedman and Wilcoxon tests ($p < 0.05$) were employed to observe intra- and interexaminer differences, respectively.

Results: No differences were found between the groups of examiners - in terms of esthetics - in response to changes in smile height of both genders . However,men smile had lower acceptability than the women smile. A mild reduction in dentogingival display on smiling (2 mm) was not perceived by either laypersons or orthodontists ($p > 0.05$).

Conclusions: women smiles achieved higher scores than men smiles however, samples involving a larger number of subjects in each group are required to ensure whether or not this finding is linked to the subjects gender.

Keywords: Esthetic Dentistry. Gingiva. Orthodontics. Smile.

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

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INTRODUCTION

Concepts underlying face and smile esthetics are often subjective, based more often on author opinion than on the scientific method.[1-5] Patient self-perception issues are further compounded by the judgment of those with whom they interact. Thus, the concepts of esthetics and beauty are biased by subjectivity and personal impressions, rendering any analysis or interpretation of smile esthetics a daunting challenge in orthodontic practice.[6]

Factors such as culture, socioeconomic status and age may influence how beauty standards arise. Moreover, ongoing changes in these variables require that treatments meet the esthetic pluralism inherent in today's society.[4] Many studies have been conducted to elucidate the factors involved in the attractiveness of the smile.[7-12] Laypersons seem capable of identifying the characteristics of an ideal smile. Deviations alert professionals to avoid unnecessary treatment of minor discrepancies that are not recognized by the patient.[13] Tooth size and visibility as well as upper lip position have been identified as the most important predictive variables in determining smile attractiveness.[9]

Visibility of anterior teeth is determined by the smile line. This line is considered low when less than 75% of the crowns of these teeth are exposed, a condition found in 30% to 70% of men. To be considered high, a smile must show a strip of gum beyond the total length of the crown. High smiles are found in 70% to 100% of women.[10] Analysis of the perception of changes in smile height by increasing dentogingival display demonstrated that orthodontists were able to detect 2 mm increases while general practitioners and laypersons considered as unattractive changes of 4 mm or larger.[14]

Another investigation on the esthetic perception of 100 subjects divided into two groups consisting of laypersons and women regarding variations in the amount of upper and lower gingival display showed attractiveness dwindles when gingival display is increased during speech and on smiling. The degree of acceptability reached 1 mm for maxillary gingival display, and 0 mm for lower incisors. Women found gingival display more acceptable in both groups while images of women were assigned lower scores by examiners of both genders, implying increased need to achieve better cosmetic results in women.[15]

Although the literature reports that a perfect smile line is one that runs at the gingival margin of maxillary central incisors,[11] and that the smile gradually loses attractiveness as dentogingival display is increased (high smile),[14,15] the esthetic impact caused when dentogingival display is decreased (smiling below) has not been evaluated so far.

MATERIAL AND METHODS

Spontaneous front view photographs of a man and a woman were obtained with a digital camera model Stylus Tough-6000, Olympus (Orlando, USA). The photographer stood at a distance of approximately one meter from the individual (Fig 1 and 2). The photos were then adjusted at different levels of brightness, contrast and cropping, and were manipulated in Adobe Photoshop 7.0 (California, USA) image processing program. Images of crown exposure were backward adjusted from 0 mm to -6 mm exposure in

Figure 1 - Masculine spontaneous smile in gingival margin level of: 0 mm (**A**), reduction of exposure in 2 mm (**B**),- 4 mm (**C**) and - 6 mm (**D**).

Figure 2 - Feminine spontaneous smile in gingival margin level of: 0 mm (**A**), reduction of -2 mm (**B**), -4 mm (**C**) and -6 mm (**D**).

-2 mm steps starting from the gingival margin of the maxillary central incisors, which was established as a reference for the smile line [M1].[16]

Photos of the smile in close-up view were printed on 10 x 15 cm photographic paper with an identification on the back to be examined by 30 orthodontists (duly registered with the Regional Council of Dentistry CRO-PA) and 30 laypersons with college degrees (except dentistry), 15 men and 15 women in each group.

Prior to the analysis, the professionals were asked to evaluate the smiles, assigning scores ranging from 0 to 10, according to their personal notion of smile balance. Scores from 0 to 4 were considered esthetically unpleasant, 5 to 7 as esthetically acceptable and 8 to 10, esthetically pleasing. No other type of information relevant to the study was given to the examiners. The photographs were randomly arranged and each photo was analyzed for up to 1 minute. Examiners were not allowed to review them.

Method reproducibility was tested using the Wilcoxon test based on scores assigned by the examiners to two duplicate photos – 4 mm reduction for the women and 2 mm reduction for the men. These duplicates were randomly displayed along with the others. Friedman's analysis of variance was employed to assess the different scores individually assigned to the photographs of both genders by orthodontists and laypersons. Differences in the assessment performed by the two groups of examiners (orthodontists x laypersons) were examined using the Wilcoxon test. Statistical analyzes were performed at 95% confidence level ($p < 0.05$).

RESULTS

Method reproducibility revealed no statistically significant difference between the results obtained for the original picture and its copy, by both examiner groups ($p > 0.05$) (Table 1).

Among the orthodontists, no significant differences were observed in the women natural smile (0 mm), nor in the changes that produced less exposure of the dentogingival complex at -2 and -4 mm (Fig 3). Nonetheless, the difference was found to be significant when the 6 mm image was analyzed ($p < 0.05$), although a slight decrease in the scores assigned to 2 mm and 4 mm was noted (Fig 3). Investigation of the men's smiles disclosed statistically significant differences starting from -4 mm changes ($p < 0.05$) (Fig 4).

Laypersons' perception of the female smile showed a similar pattern to that of orthodontists. Assessments of the -2 mm and -4 mm images were not statistically different from those of the original image (0 mm). Thus, statistically significant differences were only found in analyzing the 6 mm image ($p < 0.05$, Fig 4). Analysis of the male patient only yielded statistically significant differences starting at 4 mm ($p < 0.05$), consistent with the results found for the orthodontists (Fig 4).

In comparing the scores assigned to female and male smiles in both examiner groups, disregarding other factors that might have had a bearing on these scores, female smiles were found to be more attractive (Figs 3 and 4).

However, comparative analysis of the scores assigned by the groups of examiners — orthodontists

Table 1 - Median, Interquartile (IQ) deviation and p value (Wilcoxon test) to analyze reproducibility of the images examined by laypersons and orthodontists.

	Orthodontists		Orthodontists		Laypersons		Laypersons	
	4 mm (I)	4 mm (II)	2 mm (I)	2 mm (II)	4 mm (I)	4 mm (II)	2 mm (I)	2 mm (II)
Median	7	7	6	6	7	7.5	7	6
IQ Deviation	3	1	2	2	2.75	3	1	2
p value	0.3088 (ns)		0.8767 (ns)		0.7228 (ns)		0.3202 (ns)	

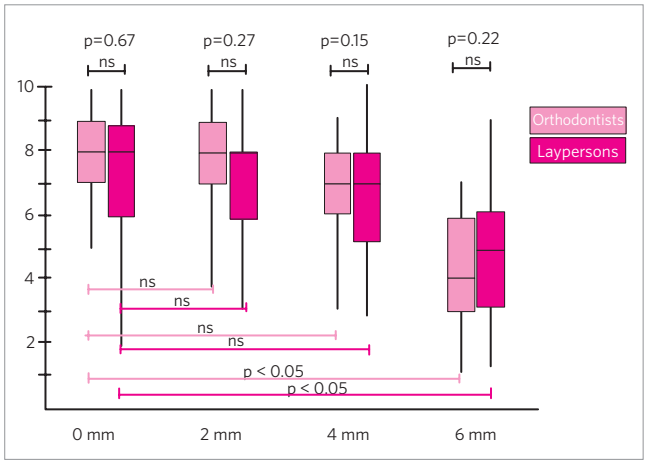

Figure 3 - Assessment of female subject's smile performed by orthodontists (pale pink) and laypersons (dark pink). P values in the upper portion of the chart reflect a comparative analysis between examiner groups (orthodontists x laypersons), whereas p values in the lower portion of the chart depict a comparison between the original image and changes in smile height (-2, -4 and -6 mm).

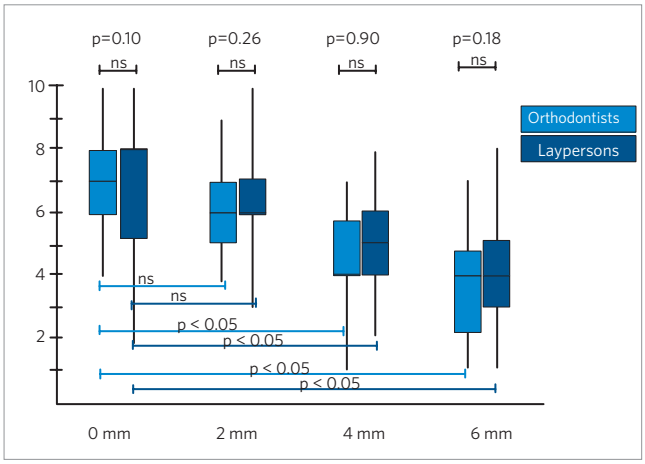

Figure 4 - Assessment of the male subject's smile performed by orthodontists (light blue) and laypersons (dark blue). P values in the upper portion of the chart reflect a comparative analysis between examiner groups (orthodontists x laypersons), whereas p values in the lower portion of the chart depict a comparison between the original image and changes in smile height (-2, -4 and -6 mm).

and laypersons —, showed no statistically significant difference in any of the images assessed (Figs 3 and 4).

DISCUSSION

Studies have been conducted to determine scientifically the features that characterize an esthetically acceptable smile, and particularly the patient's perception of what features depart from an ideal smile.[3,4,11,12,17-20]

Three important aspects are involved in analyzing smile esthetics, such as, gingival display, curvature formed by the incisal edge of anterior superior teeth and the upper lip, and width of the buccal corridor.[18] From a strictly orthodontic perspective, dentogingival display and transverse dimension are usually considered the most important factors in smile analysis.[7] Preference is given to a smile line where the elevation of the upper lip is close to the gingival margin of maxillary incisors.[11,15,22,24] Thus, the present study was conducted on the assumption that the border of the upper lip should be on the same level as the gingival margin (0 mm).

Firstly, it should be noted that in the present study only close-up photographs of the smile of one male and one female individual were assessed. However, studies in the literature have shown that smile esthetics perception is affected when one looks at the whole face.[23] Others showed that by capturing the smile with a video camera, anatomical and physiological changes can be better viewed compared to images produced by a digital camera.[24,25] The methodology employed in this study enables to analyze the entire face since changes in gingival display were performed by lowering the lip, which would become visible on the images taken of the entire face. Besides, the changes simply cannot be recorded on video at this point.

Few studies have assessed the effects of dentogingival display on smiling, and generally aimed to investigate the effects of increased display on the smile.[14,15]

In the present study, an attempt was made to determine how many millimeters the crowns of the maxillary incisors would need to be covered by the upper lip in order to compromise the pleasantness of the smile in two individuals - one of each gender - examined by orthodontists and laypersons. The women smile was considered acceptable until 4 mm of the upper incisor crowns were covered by the upper lip, while the men smile was rated unpleasant at 4 mm and above (Fig 3 and 4). These findings refute prior reports indicating that low smiles, with no gingival display and partially covered crowns, were more acceptable in men than in women.[3,6,22] Thus,women smiles would tend to be higher and men's lower, due to a significant difference in the length of the upper lip and height of the maxilla in men.[3,6,10,22]

In this study, the women smiles were assigned higher scores than the men , as depicted in Figures 3 and 4, showing that there was greater attractiveness in the women photographs, which corroborates previous study results.[26,21] These findings are also in disagreement with results found in women studied by Geron and Athaliah.[15] When the incisors are not fully visible, a balance between incisal edges and lower lip improves, to a great extent, the appearance of the smile.[17] Based on this assumption, one could conclude that the lower scores assigned to the men smiles in this study might be related to dental esthetics and/or a less pleasant lip contour, since the men ideal images (0 mm) were assigned lower scores than the women.

Contemporary dentistry seeks to combine esthetics and function by taking into account not just the professional's views, but above all the patient's opinion.[9,13,27] In this context,, it can be observed that the examiners,, (orthodontists and laypersons), assigned similar scores to the men and women smiles, which demonstrated that their esthetic perception was equivalent, corroborating findings of previous studies.[5,27,28] Other studies,[1,13,14,29] however, reported significant differences in assessments by orthodontists versus laypersons concerning the degree of esthetic demand, with laypersons showing greater tolerance towards most dentogingival changes.

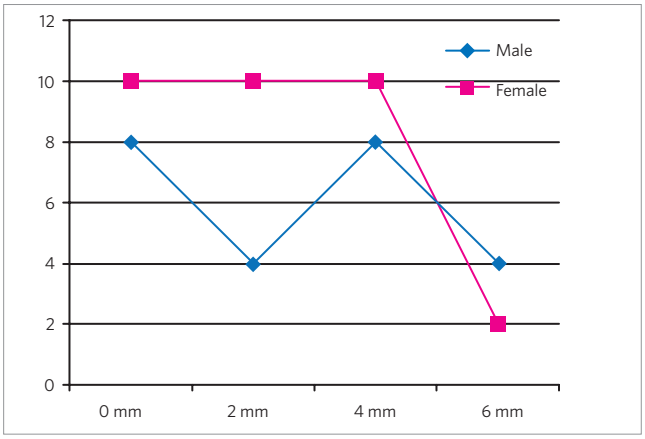

Figure 5 - Self-perception of masculine patients (blue line) and feminine (pink line).

Examiner self-perception remained similar to that of orthodontists and laypersons (Fig 5). The male subject was more demanding of himself, assigning only unpleasantness scores, while the woman was unable to distinguish 0–4 mm variations, always assigning the same esthetically acceptable scores. This result, although limited by sample size, disagrees with previous studies[9] which, after analyzing male self-perception, determined that dominance, high self-esteem and greater tolerance are related to behavioral characteristics typical of a man.

CONCLUSIONS

No differences were found in the esthetic perception of orthodontists versus laypersons in assessing photos of spontaneous smiles with a normal vertical dentogingival display, or smiles with less display. Changes in smile height are perceived differently depending on the gender of the individual being examined. It can therefore be inferred that gender has a bearing on this type of assessment. Nevertheless, further studies involving a larger number of subjects are clearly required.

REFERENCES

1. Pinho S, Ciriaco C, Faber J, Lenza M A. Impact of dental asymmetries on the perception of smile esthetics. Am J Orthod Dentofacial Orthop. 2007;132:748-53.
2. PecK S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod. 1995;1:105-26.
3. Tjan AHL, Miller GD, The JGP. Some esthetic factors in a smile. J Prosthet Dent. 1984 Jan;51(1):24-8.
4. Isiksal E, Hazar S, Akyalçin S. Smile esthetics: Perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop. 2006;129:8-16.
5. Rosenstiel S F, Pappas M, Pulido M T, Rashid R G. Quantification of the esthetics of dentists' before and after photographs J Dent. 2009;37 Suppl 1:e64-9.
6. Cardoso IL. Desenho estético do sorriso: identificação dos parâmetros de normalidade. Rev Clín Ortodon Dental Press. 2009 Out-Nov;8(5):68-73.
7. Sarver DM. The importance of incisor positioning in the esthetics smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001;120:98-111.
8. Loi H, Nakata S, Counts ML. Effects of buccal corridors on smile esthetics in Japanese. Angle Orthodontist. 2009;79(4):628-33.
9. Van der Geld P, Oosterveld P, Heck G V, Kuijpers-Jagtman A M. Smile attractiveness. Angle Orthod. 2007;77(5):759-65.
10. Peck S, Peck L, Kataja M. The gingival smile line. Angle Orthod. 1999;62(2):91-100; discussion 101-2.
11. Peck S, Peck L, Kataja M. Some vertical lineaments of lip position. Am J Orthod Dentofacial Orthop. 1992;101:519-24.
12. Pagani C, Bottino M C. Proporção áurea e a odontologia estética. J Bras Dent Estet. 2003;2(5):80-5.
13. Ker A J, Chan R, Fields H W, Beck M Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective. JADA 2008; 139(10): 1318-1327.
14. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11:311-24.
15. Geron A, Atalia W. Influence of sex on the perception of oral and smile esthetics with different gingival display and incisal plane inclination. Angle Orthod. 2005;75(5):778-84.
16. Silva NCF, Aquino ERB, Mello KCR, Mattos JNR, Normando D. Habilidade de ortodontistas e leigos na percepção de assimetrias da mandíbula. Dental Press J Orthod. 2011 Ago;16(4):38e1-38E8.
17. Câmara CALP. Estética em ortodontia: diagramas de referências estéticas dentárias (DRED) e faciais (DREF). Rev Clín Ortodon Dental Press. 2006 Nov-Dez;11(6):130-56.
18. Câmara CA. Estética em ortodontia seis linhas horizontais do sorriso. Rev Clín Ortodon Dental Press. 2010 Jan-Feb;15(1):118-31.
19. Bos A, Hoogstraten J, Prahl-Andersen B. Expectations of treatment and satisfaction with dentofacial appearance in orthodontic patients. Am J Orthod Dentofacial Orthop. 2003;123:127-32.
20. Panossian AJ, Block MS. Evaluation of the smile: facial and dental considerations. J Oral Maxillofac Surg. 2010;68:547-54.
21. Schabel BJ, McNamara Jr JA, Franchi L, Baccetti T. Q-sort assessment vs visual analog scale in the evaluation of smile esthetics. Am J Orthod Dentofacial Orthop. 2009;135:S61-71.
22. Caetano SRO, Telles CS. Estética do sorriso: relação dos lábios com os dentes e alinha do sorriso. J Bras Ortodon Ortop Facial. 2005;10(58):421-9.
23. Rodrigues CDT, Magnani R, Machado MSC, Oliveira Jr OB. The perception of smile attractiveness. Angle Orthodontist. 2009;79:634-39.
24. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: Changes with age. Am J Orthod Dentofacial Orthop. 2009;136:310.e1-310.e10.
25. Ackerman M B, Brensiger C, Landis R. An evaluation of dynamic lip-tooth characteristics during speech and smile in adolescents. Angle Orthodontist. 2004;74:43-50.
26. Hunt O, Jonhston C, Hepper P, Burden D, Stevenson M. The influence of maxillary gingival exposure on dental attractiveness ratings Eur J Orthod. 2002 Apr;24(2):199-204.
27. Schabel B J, Franchi L, Baccetti T, McNamara Jr J A. Subjective vs objective evaluations of smile esthetics. Am J Orthod Dentofacial Orthop. 2009;135:S72-9.
28. Kokich VO Jr., Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006;130(2):141-51.
29. Peck S. An evaluation of smiles. Angle Orthod. 1993;63(3):190.

Analysis of width/height ratio and gingival zenith in patients with bilateral agenesis of maxillary lateral incisor

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Objective: The purpose of this study was to evaluate the width/length ratio and the gingival zenith (GZ), by means of dental casts and digital caliper, in patients with missing maxillary lateral incisors after treatment.

Methods: The sample was composed of 52 subjects divided into 3 groups: BRG (n = 18), patients with bilateral agenesis treated with tooth re-contouring; BIG (n = 10) patients with agenesis treated with implants and CG (n = 24), control group. The data were analyzed using Shapiro-Wilk, Spearman correlation, Wilcoxon, Kruskal-Wallis, *t* test and ANOVA tests ($p < 0.05$).

Results: For the width/length ratio of the lateral incisors, BIG presented the lowest mean values (0.72 right and left), when compared with other groups. However, comparison between groups presented statistically significant differences for the right lateral incisor (BIG x CG) and for the canine (BRG x CG). GZ data evaluation showed the greatest difference for BRG (0.5 right and 0.48 left). BIG (0.95 right and 0.98 left) and CG (0.98 right and 0.8 left) presented more similar values, nevertheless, without statistical difference ($p > 0.05$). GZ data for the right and left sides of the smile were not considered statistically different.

Conclusion: Although no statistical difference was found in the comparison between the groups, analysis of the descriptive values showed that group BIG showed the greatest difference in values with regard to width/length ratio. Regarding gingival zenith, BRG showed the greatest difference.

Keywords: Dental agenesis. Width/length ratio. Gingival zenith.

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INTRODUCTION

Dental agenesis in the anterior maxillary region compromise the balance and symmetry of the smile, interfering negatively in the patient's interpersonal relationships and self esteem.[1,2] esthetics of the smile is related to various parameters, and therefore, all professionals involved in the treatment of agenesis of the lateral incisors should aim dentofacial esthetic.

According to contemporary cosmetic literature, an adequate width-length ratio of teeth and the gingival zenith are desirable characteristics for the smile, and may thus be references for esthetic rehabilitation,[3-5] such as the treatment required by patients with agenesis. Different authors[6-12] have studied the above-mentioned esthetic principles, nevertheless, there is little information about how they have been applied in the rehabilitative treatment of patients with agenesis.

Treatment of patients with unilateral or bilateral agenesis of maxillary lateral incisors is an interdisciplinary challenge, requiring correct diagnosis and individual planning in order to restore the long term function and esthetics of the smile.[13-15] The treatment options generally indicated for these patients are closure of spaces and re-contouring of the canines into lateral incisors or maintaining the spaces for placement of dental implants.[16-20] Whatever the chosen option may be, procedures are still need to be performed by the orthodontist, either to improve the position of the canine (adequate crown torque and leveling of the gingival margin) , or to suit the width of the area of agenesis that will be the implant receptor site to the width of a natural lateral incisor.[15,21,22]

The purpose of the present study was to analyze the width/length ratio and gingival zenith of anterior teeth in patients with agenesis of the maxillary lateral incisor after treatment and discuss the applicability of these esthetic principles and their relationship with the final esthetic appearance of patients with agenesis of the maxillary lateral incisor, treated with space closure and dental re-contouring, or with space opening and implant placement.

MATERIAL AND METHODS

For this study, 28 patients with bilateral agenesis of the maxillary lateral incisor were selected, and divided into 2 groups according to the treatment performed: BRG (n = 18) – patients with bilateral agenesis treated with orthodontic space closure and dental re-contouring; and BIG (n = 10) – patients with bilateral agenesis treated with space opening and implant placement. The control group (CG) was composed of 24 patients, selected according to the following criteria: (1) the patient should not have received previous orthodontic or orthopedic treatment; (2) presented no history of facial pain during the previous year; (3) does not use a bruxism plate; (4) presented all teeth in mouth, except the third molar; (5) presented no skeletal discrepancy and (6) has good tooth alignment. The patients in Groups BRG and BIG were evaluated, on an average of 5.03 years and 3.08 years, respectively, after conclusion of interdisciplinary rehabilitative treatment. All the patients were invited to participate in this research and signed a free and informed term of consent approved by the Ethics Committee of the State University of Maringá (Protocol No. 582/2009).

For evaluation of the esthetic principles, study models made of orthodontic plaster (Asfer – Asfer Indústria Química Ltda, São Caetano do Sul) were obtained from impressions of all patients, taken using alginate (Jeltrate Plus – Dentsply, Petrópolis). The width (W) and length (L) of teeth were measured on the models, using a digital caliper (MITUTOYO® - São Paulo/Brazil), and the width/length ratio (W/L) of each tooth was calculated by dividing the width by the height. The gingival zenith (GZ) level of the maxillary lateral incisors (MLI) was evaluated in relation to a line tangent to the GZ of the canines and central incisors, drawn on the study models of the patients (Fig 1). The distance between this line and GZ of the MLI was measured with a digital caliper at 4X magnification.

For statistical analysis the Software R 2.10.1 was used and the statistical significance level was defined at 5%. For all the analyses, the Shapiro-Wilk test was

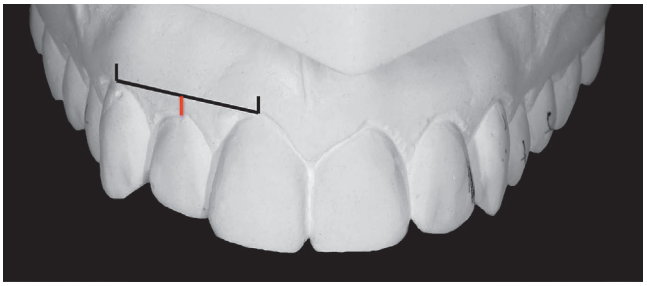

Figure 1 - Analysis of the gingival zenith of the maxillary lateral incisor, obtained from a line tangent to the GZ of the canines and central incisors.

applied to verify the normality of the data. Spearman's correlation test was applied for the intra-examiner analysis regarding width/length ratio. All the measurements were repeated at two different time intervals by the same observer (interval of 30 days), and abnormal distribution of the sample was verified. To compare the findings of the right and left sides of the smile; (symmetry of the smile), the Wilcoxon test for paired data was applied. For the inter-group comparison the Mann-Whitney U test was applied. In respect to the gingival zenith, observer calibration was performed by means of three analyses, with an interval of 7 days between them, of a sample of 5 randomly selected patients. The three observations were compared by the Spearman Correlation test again. This test was chosen because normal distribution of the data was not verified. To measure equality of the GZ on the right and left sides of the smile, the paired *t* test was applied, and for inter-group comparison, the ANOVA Test.

Table 1 - Descriptive Measurements, Normality (SW) and Intra-Observer Correlation (R) for analysis of the width/length ratios in the patients treated with re-contouring (BRG), with implants (BIG) and in patients in the Control Group (CG).

Group	Side	Tooth	Median (interquartile rage)	SW	R
BRG	Right	IC	0.8186 (0.7776 - 0.8934)	0.3936	0.8968
		IL	0.8093 (0.7202 - 0.8911)	0.9297	0.9216
		C	0.7602 (0.7215 - 0.8879)	0.0005	0.9236
	Left	IC	0.8424 (0.7827 - 0.9160)	0.8785	0.9587
		IL	0.7813 (0.7419 - 0.8663)	0.9198	0.8122
		C	0.8409 (0.7531 - 0.8915)	0.7118	0.8658
BIG	Right	IC	0.8510 (0.7688 - 0.9038)	0.1738	0.9030
		IL	0.7299 (0.672 - 0.7662)	<0.0001	0.5030
		C	0.7784 (0.7515 - 0.8075)	0.0087	0.7818
	Left	IC	0.8478 (0.8156 - 0.9301)	0.2900	0.9152
		IL	0.7299 (0.7125 - 0.7813)	0.2582	0.8303
		C	0.7574 (0.7029 - 0.8184)	0.8632	0.9030
CG	Right	IC	0.8524 (0.8073 - 0.9234)	0.0017	0.8585
		IL	0.7740 (0.7740 - 0.8438)	0.0028	0.8192
		C	0.8817 (0.8244 - 0.9287)	0.6642	0.7646
	Left	IC	0.8488 (0.8011 - 0.9109)	0.0275	0.5808
		IL	0.7619 (0.7251 - 0.8299)	0.0002	0.6392
		C	0.8439 (0.7847 - 0.8664)	0.2357	0.8715

RESULTS

With regard to the width/length ratio, the values of the lateral incisors of BRG (0.81 right/0.84 left) were found to be the closest to those of CG (0.85 right/0.84 left). The analysis of normality by the Shapiro-Wilk (SW) test showed abnormal distribution of the data, which justified the use of parametric tests (Table 1). The comparison made between the two observations showed no statistically significant differences, demonstrating that the examiner was duly calibrated for the measurements (Table 1). Figure 2 demonstrated that although the width/length ratio presented very similar values for the three groups, the medians of each dimension, in particular width and length, revealed that proportionally, the canines transformed into lateral incisors in BRG were larger than the lateral incisors in CG.

Analysis of the symmetry of the smile using the data obtained for the right and left sides of the width/height ratio, revealed that there was no statistically significant difference among the groups ($p > 0.05$) (Table 2).

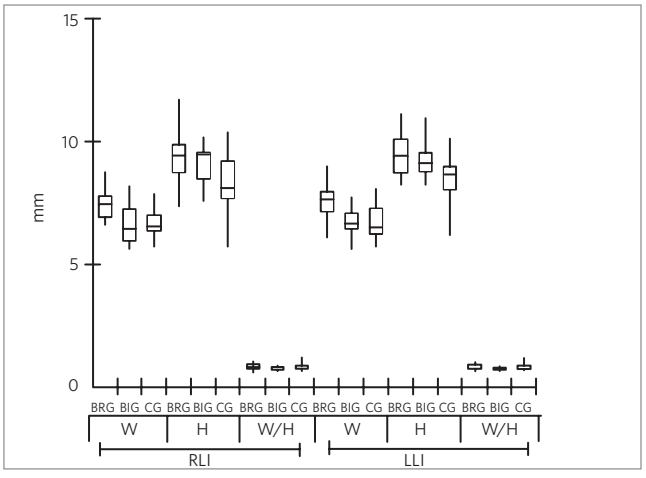

Figure 2 - Analysis of the width (W), height (H) and the width/height ratio (W/H) for the right and left lateral incisors (LI) of do BRG (Group with bilateral agenesis treated with re-contouring), BIG (Group with bilateral agenesis treated with implants) and CG (Control Group).

According the Kruskal-Wallis test, the inter-group comparison revealed statistically significant differences only between BIG and CG for the right lateral incisor; and between BRG and CG, for the right canine (Table 3).

For evaluation of the gingival zenith, the three analyses performed by the same observer could not be considered statistically different , according to the Spearman Correlation test (coefficient R > 0.9). Evaluation of the medians obtained for GZ demonstrated that BRG was the group that differed most from the others, and that the values shown between BIG and CG were the most similar (Table 4). According to the *t* test, the data obtained for the gingival zenith for the right and left sides of the smile could be considered not statistically different (Table 4). In the inter-group comparison by the ANOVA test, no statistically significant difference was shown among the groups (Table 4).

Table 2 - Analysis of the symmetry of data of each group for the right and left sides by the Wilcoxon Test. (BRG – patients treated with re-contouring; BIG – patients treated with implants; CG – Control Group).

Group	Tooth	p value
BRG	CI	0.286
	LI	0.6165
	C	0.4204
BIG	IC	0.2411
	LI	0.7989
	C	0.0593
CG	IC	0.9678
	LI	0.326
	C	0.0004

DISCUSSION

This is a pioneer study in contemplating analysis of esthetic principles, such as the width/length ratio and gingival zenith, in a sample composed of patients with agenesis of the maxillary lateral incisor. According to the literature, the treatment modalities applicable to patients with agenesis of the maxillary lateral incisor have been widely studied from a functional point of view.[41-45] However, there is a lack of studies that relate esthetic principles to the final outcome of treatments applicable to these patients. Quantitative and qualitative evaluation of the width/length ratio of teeth and position of the lateral incisor zenith in relation to formation of the gingival triangle has not yet been a widely performed analysis in the literature. Conduct this study in patients with agenesis of the maxillary lateral incisor after treatment with implants or re-contouring, in comparison with a control group, provided an opportunity to evaluate this esthetic principle and its behavior in cases of multidisciplinary esthetic rehabilitation. Descriptive analysis of the measurements of width/length ratio revealed important peculiarities in each group with regard to this esthetic

Table 3 - Inter-group comparison for the width/length data by the Kruskal-Wallis test (P < 0.05).

Groups	RCI	RLI	RC	LCI	LLI	LC
BRGxBIG	0.6661	0.0615	0.7372	0.5651	0.551	0.1503
BRGxCG	0.1151	0.9411	0.0193	0.6052	0.5383	0.7119
BIGxCG	0.401	0.0236	0.06	0.9128	0.1344	0.118

(BRG – patients treated with re-contouring; BIG – patients treated with implants; CG – Control Group).

Table 4 - Medians and quartiles, comparison for the data of right and left sides of the smile by the *t* test and inter-group comparison for the gingival zenith data for each group.

Tooth	Data	BRG	BIG	CG	BRG x BIG	BRG x CG	BIG x CG
ILD	Median	0.58	0.95	0.98	0.8884	0.9467	0.0956
	(Quartil)	(-1.72 – 2.09)	(0 – 1.87)	(0 – 1.9)			
ILE	Median	0.48	0.98	0.8	0.7478	0.0942	0.7092
	(Quartil)	(-0.55 – 1.96)	(0 – 1.68)	(-0.56 – 2.08)			
t test (p value)		0.95	0.95	0.36			

(BRG – patients treated with re-contouring; BIG – patients treated with implants; CG – Control Group).

principle. The values (Table 1) of the width/length ratio of the incisors in all the groups were in agreement with the values found by Hasanreisoglu et al,[9] and Sterret et al.[11] The canine measurements were shown to be within the values found by Sterret et al,[11] ranging between 75-84%, except for the width/length ratio value found for the right canine in the control group. Regarding the lateral incisors, BRG and CG presented values comparable with those related by Hasanreisoglu et al,[9] and Gillen et al,[12] ranging between 79-82%. BIG presented width/length ratio values of approximately 72% for lateral incisors, which have not yet been related by any author.

The fact that the values found for lateral incisors in BRG were higher than those found in BIG demonstrated that for BRG group, the width and length measurements of the teeth presented values that were closer to one another (Fig 2), which resulted in a high quotient, when the width was divided by the length. Actually, In BRG, it is the transformed canine that is being analyzed, and in BIG, orthodontic treatment is normally necessary before implant therapy to adjust the width of the receptor area to that of a natural lateral incisor. Therefore, this data can be explained by the anatomic differences existent between the canine and lateral incisor, as canines are generally larger than lateral incisors.[9-12,23,24]

The values found for the width/length ratio in CG were higher than those found in the other groups. However, when comparing the medians of each dimension of this tooth in particular, it could be verified that BRG presented higher values for width and length, this can be explained by the fact that a re-contoured canine from BRG was being compared with a natural lateral incisor from CG. In addition, Figure 2 demonstrates that although the medians found for BIG were lower than those found for CG, both groups presented width dimension values that were very close, and greatly divergent values for length. This may be a result of limitations of the implant technique, because although the width of the receptor area may be adjusted to that of a natural lateral incisor, the height cannot always be re-established proportionally to the width. Such limitations are related to the height of the bone crest and thickness of keratinized tissue around the implant, which vary according to the type of platform or connection used, the relationship of the implant with the adjacent teeth, level of location of the implant/connector junction in relation to the bone crest, and the gingival biotype.[24,25,26]

When comparing the data obtained for the width/length ratio of teeth on the right and left sides of the smile, for the two variables, all the patients in all the groups may be considered symmetrical. This comparison was necessary to find out whether the clinicians were taking into account the re-establishment of symmetry and balance of the smile in the rehabilitation of cases of agenesis. This symmetry is guaranteed by orthodontics, either in the distribution of spaces for re-contouring of the anterior segment of the smile, as in the case of patients in BRG, or in adjusting the receptor area of the implant, in the case of BIG. In spite of the absence of statistically significant differences in this comparison, variations with regard to the medians of the width/length ratio were found in a large portion of the sample. It could be inferred that this was as a result of small alterations in the dimensions of some of the anterior teeth, which are generally not noticed. Kokich et al[27,28] reported that small alterations of up to 2 mm in width of the lateral incisor were not perceived by orthodontists, general clinicians and laypersons, which justifies the results observed in the present study.

In the inter-group comparison, for the width/length ratio, statistically significant difference between BIG and CG was found only for the right lateral incisor ($p = 0.0236$), with the justification that in BIG, the dentures showed elongated lengths when compared with CG. Another statistical difference found was for the right canine in the comparison between BRG and CG ($p = 0.0193$), due to the fact that between these two groups, the premolars that substituted the canines in BRG were being compared with the canines in CG.

For analysis of the gingival zenith, the GZ of teeth were marked according to the pattern established in the literature.[4,6,7,29] For central incisors and canines, GZ is the most apical point of the gingival outline, generally located distally to the long axis of the tooth, whereas for the lateral incisors, in the majority of cases, this point is coincident with the long axis of the tooth.

Although no statistically differences were found in the comparison between BIG and CG ($p = 0.0956$),

analysis of the medians demonstrated differences in the position of the gingival zenith between the 3 groups: Re-contoured canines of the patients in BRG, the implants of the patients in BIG and the natural lateral incisor of the patients in CG. The presence of lower values in BRG demonstrated that in this group, the mesialization of the canines promoted the formation of this triangle in an opposite manner in the majority of the patients; that is to say, the zeniths of the lateral incisors in this group were predominantly found to be coincident or above the reference line of analysis. This is explained by the difference between the GZ of canines and premolars, in relation to the teeth they are replacing; in other words, the lateral incisors and canines respectively. Although these differences can be minimized with orthodontic space closure treatment before dental re-contouring, the discrepancy between the measurements of the right and left lateral incisors (Table 3) demonstrated that in the majority of the cases, this is not always possible, in disagreement with the pattern proposed in the literature.[4,5,29,30] However, BRG was the group that presented the most similar values between RLI and LLI; that is to say, presented a greater trend towards symmetry in relation to GZ, ratifying the importance of orthodontic therapy associated with restorative therapy in the treatment with space closure and dental re-contouring. Although BIG was not shown to be as symmetrical as BRG, when compared with CG, the proximity between the values found for right and left GZ demonstrated that symmetry is also of concern to orthodontists in the treatment of opening or maintaining space for the placement of dental implants in patients with agenesis of the maxillary lateral incisors.

It is known that in addition to the variables under study, the width/length ratio and gingival zenith, many others that are difficult to quantify deserve attention when analyzing a peculiar sample, such as patients with agenesis of the maxillary lateral incisor. Clinicians must take other clinical parameters into consideration, both in planning and in the final stage of their clinical cases. The literature relates that both treatment options have their peculiarities. Re-contouring of the lateral incisors into canines is considered advantageous because it leads to minimal or no clinical and radiographic alteration over the course of time,[15,22] less dental plaque accumulation, gingival inflammation and fewer periodontal pockets.[14,16,19] In addition it is considered an easily reversible procedure for color adjustment and adaptation of the restoration when necessary, when compared with prosthetic treatments. The disadvantage generally pointed out for this treatment is the lack of occlusion mutually protected by the canine.[16] Nevertheless, the literature is emphatic about not correlating this fact with possible temporomandibular dysfunction, and consider that the premolar may be considered a suitable substitute for the canine, from a functional point of view.[14,18,19,20,31] dental implants, are also a treatment option in the absence of lateral incisors, substituting adhesive dentures and fixed partial or removable dentures. This alternative has been considered conservative due to the preservation of permanent teeth adjacent to the prosthetic space;[31] and shorter orthodontic treatment time required.[32] However, the quantity and quality of bone, with consequent risk of infra-occlusion, and bone maturation of the individual are factors that interfere in the longitudinal results of dental implants.[33]

Whatever may be the treatment option chosen, Orthodontics is essential in the multidisciplinary team for the treatment of patients with agenesis of the maxillary lateral incisor, as these procedures are necessary to restore the shape and proportionality of the smile and contribute to both the functional and esthetic re-establishment of the patient.[21,22]

The limitations and differences in the results between this study and others may be attributed to various factors ranging from variations in methods; such as using models or photographs, rulers, compasses or caliper, and size and ethnicity of the sample. It is worth pointing out that patients with agenesis of the maxillary lateral incisors constitute a peculiar sample, and difficult to be available. Finally, the results of this study and the literary findings indicate the need for further research about the application of the principles of esthetic proportions in the treatment of patients with agenesis of the maxillary lateral incisor. It is necessary to increase these analysis, with a larger number of patients to establish the differences among groups and patterns, and with control of these patients, in order to enable evaluation of the long term esthetic results of the treatments.

CONCLUSIONS

According to the results obtained in the evaluation of the three groups, it could be concluded that:

» There was no statistically significant difference in the width/length ratio among patients with bilateral agenesis of the lateral incisors treated with re-contouring (BRG) or implants (BIG) and the control group (CG), however, when comparing the medians found for the lateral incisors, BIG presented lower values than BRG and CG;

» Regarding the gingival zenith, BRG was the group that differed most from the others, presenting negative values, suggesting that replacing lateral incisors and canines by re-contoured canines and premolars respectively, does not contemplate the formation of the gingival triangle, as esthetically recommended.

REFERENCES

1. Araújo EA, Oliveira DS, Araújo MT. Diagnostic protocol in cases of congenitally missing maxillary lateral incisors. World J Orthod. 2006;7:376-388.
2. Cunningham SJ, O'Brien C. Quality of life and orthodontics. Seminars in Orthod. 2006;13(2):96-103.
3. Fradeane M. Evaluation of dentolalabial parameters as part of a comprehensive esthetic analysis. Eur J Esthet Dent. 2006;1(1):62-69.
4. Magne P. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago (IL): Quintessence; 2002.
5. Goldstein RE. Esthetics in Dentistry. 2nd Ed. London: Hamilton; 1998. p. 11-49.
6. Chu SJ, Tan JHP, Stappert CFJ, Tarnow DP. Gingival zenith positions and levels of the maxillary anterior dentition. J Esthet Restor Dent. 2009;21(2):113-120.
7. Mattos CML, Santana RB. A quantitative evaluation of the spatial displacement of the gingival zenith in the maxillary anterior dentition. J Periodontol. 2008;79(10):1880-5.
8. Zlataric DK, Kristek E, Celebic A. Analysis of width/length ratios of normal clinical crowns of the maxillary anterior dentition: Correlation between dental proportions and facial measurements. Int J Prosthod. 2007;20:313-5.
9. Hasanreisoglu U, Berskun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: Facial and dental proportions. J Prosthet Dent. 2005;94:530-8.
10. Magne P; Galluci GO. Belser UC. Anatomic crown width/length ratios of unworn and worn teeth in white subjects. J Prosthet Dent. 2003;89:453-61.
11. Sterret JD, Oliver T, Robinson F, Fortson W, Knaak B, Russel CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J ClinPeriodontol. 1999;26:153-7.
12. Gillen RJ, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont. 1994;7:410-7.
13. Sabri R. Management of missing lateral incisors. J Am Dent Assoc. 1999;130:80-4.
14. Turpin LT. Treatment of missing lateral incisors. Am J Orthod Dentofacial Orthop. 2004 Feb;125(2):129.
15. Rosa M, Zachirisson BU. Integrating esthetic dentistry and space closure in patients with missing maxillary lateral incisors. J Clin Orthod. 2001;35(4):221-33.
16. Robertsson S, Mohlin B. The congenitally missing upper lateral incisor. A retrospective study of orthodontic space closure versus restorative treatment. Eur J Orthod. 2005;22:697-710.
17. Araújo EA, Oliveira DS, Araújo MT. Diagnostic protocol in cases of congenitally missing maxillary lateral incisors. World J Orthod. 2006;7: 376-88.
18. Senty EL. The maxillary cuspid and missing lateral incisors: Esthetics and occlusion. Angle Orthod. 1976;46:365-71.
19. Nordquist GC, McNeill RW. Orthodontic vs. restorative treatment of the congenitally absent lateral incisor – long term periodontal and occlusal evaluation. J Period. 1975;46:139-43.
20. Tuverson DL. Orthodontic treatment using canines in place of missing lateral incisors. Am J Orthod Dentof Orthop. 1970;58:109-27.
21. Sunguino R, Furquim LZ. Uma abordagem estética e funcional do tratamento ortodôntico em pacientes com agenesias de incisivos laterais superiores. R Dental Press Ortodont Ortop Facial. 2003;8(6):119-57.
22. Zachrisson BU. Improving the esthetic outcome of canine substitution for missing maxillary lateral incisors. World J Orthod. 2007;8:72-9.
23. Ker AJ, Chan R, Fields HW, Beck M, Rosentiel S. Esthetics and smile characteristics from the layperson's perspective: A computer-based survey study. J Am Dent Assoc. 2008;139:1318-27.
24. Cappiello M, Luongo R, Di Lorio R, Bugea C, Cocchetto R, Celltti R. Evaluation of peri-implant bone loss around platform-switched implants. Int J Period Restor Dent. 2008;28(4):346-55.
25. Guirado JLC, Yuguero MRS, Zamora GP, Barrio EM. Immediate provisionalization on a new implant design for esthetic restoration and preserving crestal bone. Impl Dent. 2007;16(2):155-64.
26. Hermann F, Lerner H, Palti A. Factors influencing the preservation of the periimplant marginal bone. Imp Dent 2007;16(2):165-175.
27. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: Asymmetric and symmetric situations. Am J Orthod Dentofac Orthop. 2006;2:141-51.
28. Kokich Jr VO, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;6:311-24.
29. Sarver DM. Principles of cosmetic dentistry in orthodontics. Part 1: Shape and proportionality of anterior teeth. Am J Orthod Dentofacial Orthop. 2004;126:749-53.
30. Davis NC. Smile design. Dent Clin N Am. 2007;52:299-318.
31. Richardson G, Russel KA. Congenitally missing maxillary lateral incisors and orthodontic treatment considerations for the single-tooth implant. J Can Dent Assoc. 2001;67:25-28.
32. Thilander B, Ödman J, Lekholm U. Orthodontic aspects of the use of oral implants in adolescents: a 10 year follow-up study. Eur J Orthod. 2001;23(6):715-31.
33. Kinzer GA, Kokich Jr VO. Managing Congenitally Missing Lateral Incisors Part III: single-tooth implants. J Esthet Rest Dent. 2005;17:202-10.

Assessment of changes in smile after rapid maxillary expansion

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Introduction: This study evaluated changes in the smile characteristics of patients with maxillary constriction submitted to rapid maxillary expansion (RME).

Methods: The sample consisted of 81 extraoral photographs of maximum smile of 27 patients with mean age of 10 years, before expansion and 3 and 6 months after fixation of the expanding screw. The photographs were analyzed on the software Cef X 2001, with achievement of the following measurements: Transverse smile area, buccal corridors, exposure of maxillary incisors, gingival exposure of maxillary incisors, smile height, upper and lower lip thickness, smile symmetry and smile arch. Statistical analysis was performed by analysis of variance (ANOVA), at a significance level of 5%.

Results: RME promoted statistically significant increase in the transverse smile dimension and exposure of maxillary central and lateral incisors; maintenance of right and left side smile symmetry and of the lack of parallelism between the curvature of the maxillary incisal edges and lower lip border.

Conclusions: RME was beneficial for the smile esthetics with the increase of the transverse smile dimension and exposure of maxillary central and lateral incisors.

Keywords: Orthodontics. Smile. Interceptive orthodontics.

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INTRODUCTION

Recent years have seen an increasing emphasis given to face and smile esthetics by dental professionals and patients alike.

Smile analysis is part of a broader facial morphology analysis and allows dentists to recognize positive and negative elements in each patient's smile. The literature suggests that some characteristics, such as the following, should be assessed: Smile line,[1] curvature of the upper and lower lip,[1-5] parallelism between the curvature of the incisal edges and the lower lip,[2,6,7] transverse dimension, smile height,[8] upper and lower lip thickness,[1] lip symmetry,[1] buccal corridor,[1,4,8] extent of elevation of the upper lip,[1] amount of exposure of central[1] and lateral[1] incisors, and gingival display.[2,8,9,10]

Depending on the type of malocclusion, patient's facial pattern and mechanics adopted, orthodontic treatment can prove either beneficial or harmful to smile esthetics. Thus, it is reasonable to regard facial analysis as an important tool for diagnosis and orthodontic treatment planning.

Maxillary constriction is very common in orthodontic patients in the mixed dentition stage, which can affect occlusion, facial development and smile esthetics. Rapid maxillary expansion (RME) is a treatment often indicated for correction of transverse skeletal deficiency by means of maxillary expansion appliances.[6,12,21,22]

Based on the belief that it is important to learn in advance about the effects of orthodontic mechanics on smile esthetics with a view to benefitting patients, this study aimed to verify the possible changes in smile characteristics after RME in patients with mixed dentition.

MATERIAL AND METHODS

Sample

The sample consisted of 81 extraoral photographs of maximum smiles of 27 patients from the Department of the Graduate Program in Orthodontics at UMESP, mean age 10 years and 3 months (between 8 and 11 years), 15 women and 12 men with maxillary constriction, after RME. The following patient inclusion criteria were used: Presence of posterior unilateral or bilateral crossbite requiring maxillary expansion as the first phase of orthodontic treatment; mixed dentition with complete eruption of permanent first molars and incisors; absence of congenital syndromes or deformities; no prior orthodontic treatment, mutilations or dental agenesis. This study was approved by the UMESP Ethics Committee (file #164761).

Methods

Rapid maxillary expansion

The appliance used to perform RME was a modified[11] Hyrax type expander, which was attached to the patient's arch by cementing bands with glass ionomer and bonding metal stop rests to the buccal and palatal surfaces of the deciduous canines using composite resin (Fig 1).

The activation protocol was as follows:[12] A full turn applied by the researcher immediately after placement of the appliance, 2/4 turn once a day applied by the patient's legal guardian until the desired expansion overcorrection was achieved (palatal cusp of the upper first permanent molar occluding with the buccal cusp of the first lower permanent molar). As soon as activation was completed, the appliance was kept in place for retention for 3 months.[12] Thereafter, the expander was removed and an acrylic plate was used for retention for 3 months.

Photographs

In order to evaluate the smiles, standardized frontal photographs of the patients' faces were taken at the following times:

- » T_1: Before placing the expander
- » T_2: 3 months after completing expansion
- » T_3: Six months after completing expansion (3 months after removal of the expander).

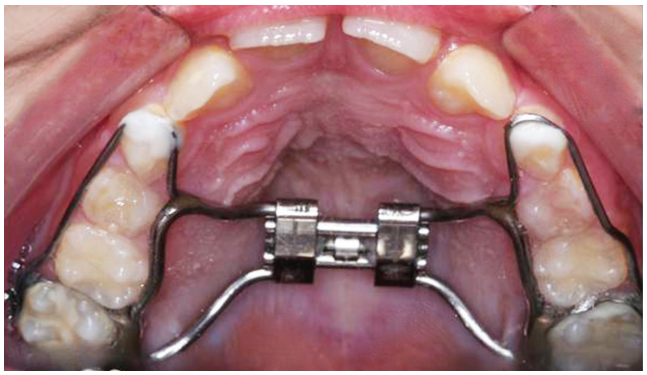

Figure 1 - Modified Hyrax expander.

All photographs were taken in the same room to ensure uninterrupted lighting, with the same camera (Canon EOS Rebel XT) and focal length, which was achieved by attaching the camera to a stabilizing mount specially designed for this purpose.[10,13]

The patients were instructed to stand upright and position their heads in front view one meter away from the camera. Oriented Natural Head Position was adopted as it is considered reliably reproducible in literature.[7,14-17] The cephalostat had a millimeter ruler attached to its horizontal structure and was adapted to the external auditory canal of the patients for head stability. The ruler was incorporated into the photographs to assist in calibrating all linear measurements.

To standardize the smile at the three study times, patients were instructed to produce a posed, voluntary, self-induced smile, which can be repeated at different times as it involves maximum lip expansion.[1]

Smile analysis

To calibrate the size of the photographic image to a real dimension, all digital images were imported into Cef X 2001 (CDT) software. This program provides a tool to measure the virtual distance of 1 cm viewed on the millimeter ruler (actual value) for each photograph. The digital images of the patients were then loaded into Adobe Photoshop 7.0 (Adobe Systems) and by manipulating the image size tool and using the percentage value of magnification previously obtained, each image was converted to their real size.

Smile analysis measurements

Once converted to their real size, the images were imported into the Cef X 2001 program for analyzing the smiles at the three different times. Some of the measurements required the construction of the following reference lines (Fig 2):

1) Right and left labial commissures: Horizontal line joining the right (RLC) and left (LLC) labial commissures.
2) Smile center: Geometric center of the rectangle formed by two lines parallel to the line of the rima oris and tangent to the uppermost points on the edge of the upper lip and the lowermost points on the edge of the lower lip, in addition to 2 perpendicular lines passing through RLC and LLC.
3) Vertical line at the center of the smile: perpendicular to the line of the rima oris, passing through the center of the smile.
4) Horizontal line at the center of the smile: parallel to the line of the rima oris, passing through the center of the smile.
5) Facial midline: Line passing through the lip philtrum.

After establishing the reference lines on the images of the smiles of each patient at the three different times, linear measurements were obtained with Cef X 2001 and used in analyzing the smile in the horizontal and vertical directions as well as its symmetry:

Horizontal evaluation of the smile (Fig 3)

1) Transverse dimension of the smile: Distance between the right and left labial commissures (RLC and LLC).

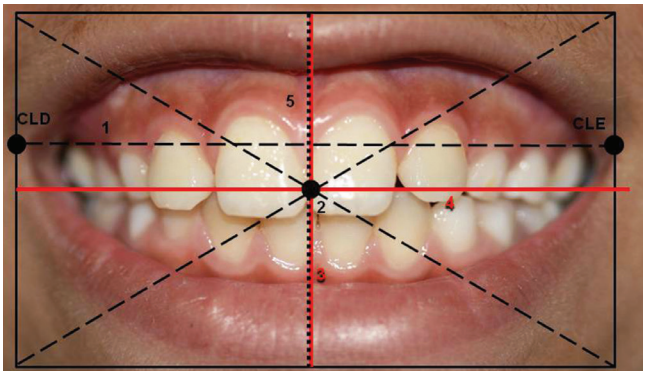

Figure 2 - Reference lines for smile analysis.

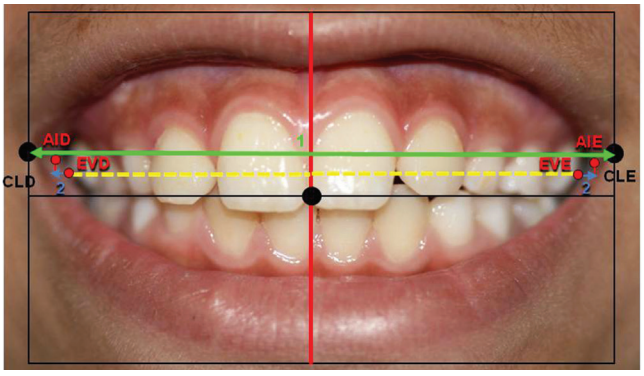

Figure 3 - Horizontal measurements of the smile: Transverse dimension of the smile, and right and left buccal corridors.

2) Right and left buccal corridors: Distances between the right (RBE) and left (LBE) buccal extremes and their respective inner portions of the labial commissures, i.e., right internal angle (RIA) and left internal angle (LIA), orthogonally to the vertical smile.

Vertical smile evaluation (Figs 4 and 5)

1) Incisor exposure: Distances between the midpoints on the incisal edges of central incisors and right and left upper laterals (I11, I21, I12, I22) and their respective uppermost points at the intersection with the long axis of these teeth.
2) Gingival display: Distances between the cervical points of the right and left central incisors (C11 and C21) and their respective points of intersection between the lower edge of the upper lip and the long axes of these teeth (UL-11 and UL-21).
3) Smile height: Distance between the uppermost points on the upper edge of the upper lip and the lowermost points on the lower edge of the lower lip, projected onto the vertical line at the center of the smile.
4) Upper lip thickness: Distance between the lower edge of the upper lip (UL) and the Stomion, projected onto the vertical line at the center of the smile.
5) Lower lip thickness: Distance between the upper edge of the lower lip (LL) and the Stomion, projected onto the vertical line at the center of the smile.

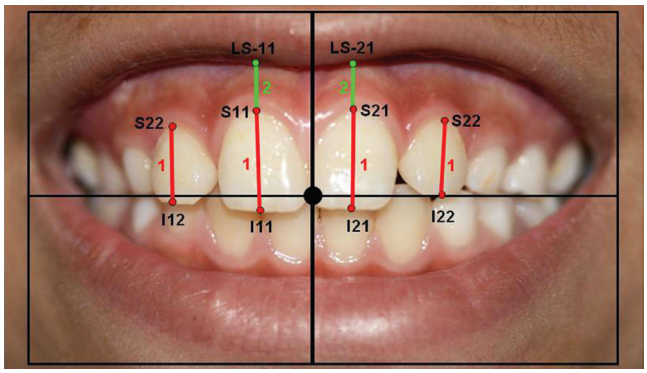

Figure 4 - Vertical measurements of the smile: Incisor exposure and gingival display.

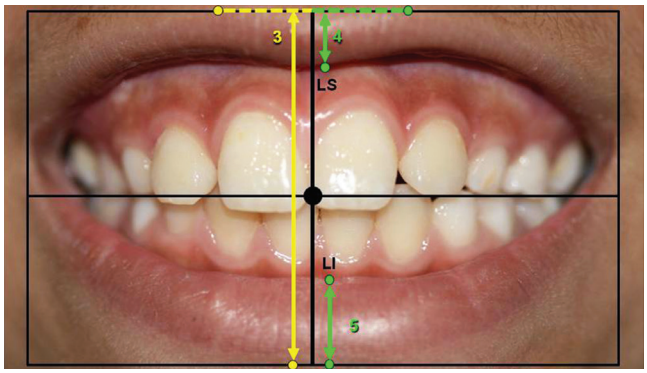

Figure 5 - Vertical measurements of the smile: Smile height and upper and lower lip thickness.

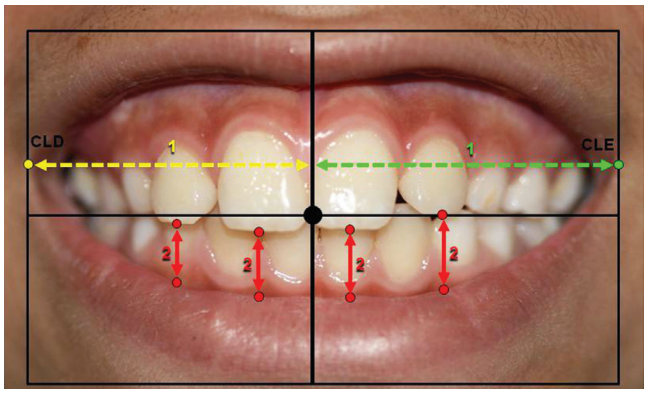

Figure 6 - Smile symmetry: Right and left sides, and smile arch.

Symmetry assessment and smile arch (Fig 6)

1) Right and left sides of the smile: Distances between the left and right labial commissures (LLC and RLC) and the facial midline
2) Smile arch: Comparison of the distances between the edges of the upper incisors and the lower lip, projected onto the vertical line of the smile.

Statistical analysis

To evaluate method error all measurements of one of the smile photographs of each patient were repeated 30 days after the first measurement. Random error was verified using Dahlberg's formula[18] and systematic error by Intraclass Correlation.[19]

To evaluate changes in the characteristics of the smile during the different phases, analysis of variance (ANOVA) was employed at a significance level of 0.05 (α=5%). Variables that showed statistically significant differences were tested using Bonferroni's multiple comparisons test[19] to assess at what time(s) the changes occurred.

To verify smile symmetry, the measurements from the incisors to the lower lip were compared using analysis of variance (ANOVA) with repeated measurements

of two factors, assuming a symmetrical component correlation matrix,[20] followed by Bonferroni's[19] multiple comparisons test to compare pairs of interest.

RESULTS

Method error

All measurements were found to be very consistent since the intraclass correlation values were close to 1, and random error could be considered acceptable given its low values in light of the magnitude of the measurements (mean = 0.367 mm, SD = 0.192).

Smile analysis

Horizontal evaluation of the smile (Table 1)

The transverse dimension of the smile and the right buccal corridor showed statistically significant differences during the study period ($p < 0.05$). It was found that the transverse distance of the smile had a statistically significant increase from time T_1 to times T_2 and T_3, and the right buccal corridor experienced a statistically significant decrease from time T_1 to times T_2 and T_3.

Vertical evaluation of the smile

The amount of exposure of the upper incisors was the only variable to exhibit a statistically significant increase ($p < 0.05$) between T_1 and T_2, and T_1 and T_3. Gingival display, smile height and thickness of the upper and lower lips did not show any statistically significant changes during the study period ($p > 0.05$).

Symmetry assessment and smile arch

As regards the smile arch, no statistically significant difference was found in the distances of the incisal edges and the lower lip at different times. In comparing these distances according to place and time, there were statistically significant differences in terms of place ($p < 0.05$). The distance between the incisal edge of the right lateral incisor and lower lip was statistically higher than those of the right and left central incisors. This behavior was kept at the three different times ($p > 0.05$), i.e., the line formed by the incisal edges of the upper incisors was not parallel to the lower lip during treatment.

The smile showed symmetry between the left and right sides at all times as there was no statistically significant change in place ($p = 0.852$). However, a statistically significant increase was noted in the measurements of the right side of the smile during treatment between time T_1 and the other treatment times (T_2 and T_3).

Table 1 - Comparison of changes in horizontal and vertical characteristics of the smile: ANOVA and Bonferroni test of multiple comparisons.

	Initial (T_1) Mean + SD	3 months (T_2) Mean + SD	6 months (T_3) Mean + SD	p
Horizontal evaluation				
Transverse dimension	61.91 ± 4.16[a]	63.76 ± 4.85[b]	64.64 ± 4.99[b]	0.001*
Right buccal corridor	4.83 ± 1.95[a]	3.55 ± 1.73[b]	3.70 ± 1.48[b]	0.001*
Left buccal corridor	4.49 ± 1.91	3.77 ± 1.41	4.47 ± 1.52	0.102
Vertical evaluation				
Tooth 11 exposition	8.09 ± 1.68[a]	9.03 ± 1.61[b]	9.05 ± 1.50[b]	<0.001*
Tooth 21 exposition	7.88 ± 1.91[a]	8.91 ± 1.44[b]	8.85 ± 1.47[b]	0.003*
Tooth 12 exposition	5.76 ± 1.45[a]	6.38 ± 1.52[b]	6.39 ± 1.34[b]	0.002*
Tooth 22 exposition	5.84 ± 1.58[a]	6.72 ± 1.24[b]	6.52 ± 1.06[a;b]	0.002*
Tooth 11 gingival display	0.53 ± 1.03	0.68 ± 0.93	0.55 ± 0.67	0.684
Tooth 21 gingival display	0.54 ± 1.14	0.71 ± 0.89	0.66 ± 0.91	0.554
Smile height	25.90 ± 6.07	27.28 ± 4.78	27.01 ± 4.92	0.362
Upper lip thickness	5.49 ± 1.75	5.81 ± 1.80	5.88 ± 1.84	0.409
Lower lip thickness	8.05 ± 1.55	8.38 ± 1.02	8.50 ± 1.31	0.249

* Statistically significant – $p < 0.05$ (ANOVA).
[a;b]: Different superscript letters mean statistically significant differences, according to the smile characteristics (Bonferroni multiple comparisons).

Table 2 - Comparison of changes in the characteristics of smile symmetry according to the site and time: ANOVA and Bonferroni multiple comparisons.

	Smile symmetry evaluation	Time			p
		Initial (T_1)	3 months (T_2)	6 months (T_3)	
		Mean (mm) ± SD	Mean (mm) ± SD	Mean (mm) ± SD	
SITE	Tooth 11 incisal – LL	3.34 ± 2.29[a]	3.73 ± 2.84[a]	3.53 ± 2.79[a]	0.562
	Tooth 21 incisal – LL	3.17 ± 2.45[a]	3.56 ± 2.78[a]	3.54 ± 2.94[a]	0.544
	Tooth 12 incisal – LL	4.08 ± 2.64[b]	4.57 ± 2.99[b]	4.46 ± 2.74[b]	0.505
	Tooth 22 incisal – LL	3.64 ± 2.69[a.b]	3.84 ± 2.94[a.b]	4.03 ± 2.74[a.b]	0.683
			p = 0.001*		
	Right side of smile	30.62 ± 2.72[a]	32.13 ± 3.45[b]	33.01 ± 2.59[b]	<0.001*
	Left side of smile	31.44 ± 2.20	32.29 ± 3.36	32.22 ± 3.50	0.328
			p = 0.852		

* Statistically significant – p < 0.05 (ANOVA).
[a,b]: Different superscript letters mean statistically significant differences (Bonferroni multiple comparisons).

DISCUSSION

While esthetics is one of the goals of the orthodontist and a paramount issue for most patients seeking orthodontic treatment, the importance of an objective analysis of the smile is still underestimate in diagnosing, planning and monitoring the results of the mechanics applied.[2,4,10] This study aimed to assess changes in the smile of patients undergoing RME, a technique which has been well established in literature. It consists in expanding the maxilla by splitting the palate in the region of the sutures to correct maxillary constriction and posterior crossbites.[6,21,22]

According to the literature, smile evaluations can be conducted in either subjective or objective manner.[3,4,10,23,24] An attempt was made to focus on some features considered important and objective in analyzing the esthetics of the smile so that tangible results could be achieved unaffected by the researcher's personal or subjective interpretation.

Horizontal aspect of the smile

The dimension of the buccal corridor is seen as one of the characteristics that influence smile esthetics.[1,4,25] According to some authors,[4] the smaller the corridor, the better the esthetics. Although this study employed RME as its key mechanics, which might lead to expectations of a significant decrease in the buccal corridor, there was a statistically significant decrease only in the right buccal corridor, between T_1 and T_2, and T_1 and T_3. However, changes of 1.29 mm (T_1-T_2) and 1.13 mm (T_1-T_3) do not seem to be clinically significant in view of the amount of expansion achieved (mean 5.96 mm).

The increased bone tissue support produced by expanding the dental arches also affects soft tissues.[4] Thus, the expected buccal corridor reduction effect may have been minimized by an increase in the transverse dimension of the smile caused by expansion of the soft tissues, which occurred concurrently with RME. The transverse dimension of the smile, measured between the labial commissures, showed a statistically significant increase between baseline and 3 months, and between baseline and 6 months. However, in the retention phase (3-6 months) the transverse dimension of the smile remained stable.

Although further studies are needed, the difference in the responses of the right and left buccal corridors could be explained by a difference in muscle tone between the two sides due to asymmetric chewing (predominance of one side over the other) in many patients.

Vertical aspect of the smile

This study showed that RME did not induce significant changes in the soft tissues in the vertical direction. Smile height and thickness of the upper and lower lips showed no statistically significant differences during the treatment. Thus, the thicker the lips, the greater the improvement in smile esthetics.[26]

Central and lateral incisor's crown exposure was greater 3 and 6 months after expansion completion, compared to T_1, with statistically significant differences, which corroborates the work of Ackerman and Ackerman.[2] This effect may have been produced by the anterior and inferior displacement of point A, found by many researchers after this procedure,[12,27-30] since there was no change in smile height or upper lip thickness, which might influence this measure. Increases in the amount of central and lateral incisor exposure can also be linked to improvement in some aspects given an increase in the perimeter of the dental arch brought about by expansion. To illustrate this finding, one can mention the dental arch form, the spontaneous correction of crowding and of lateral incisor inclination, which were initially influenced by the intra-bone canines. Regarding the possible influence of growth on this result, the authors believe that this factor had little or no influence on the increased exposure of the incisors, whereas this increase occurred only after palate splitting (between T_1 and T_2) and this change remained between the subsequent periods (T_2 and T_3) (Table 1). Thus, this study shows that RME contributed to increased smile esthetics since ideally there should be total or partial incisor exposure, i.e., the greater the incisor exposure, the more enhanced the esthetics.[1,8] Exposures of less than 75% of the incisor crown are considered non-esthetic.[4]

Another factor considered relevant to the analysis of the smile is the amount of gingival display in the region of maxillary central incisors.[2,4,8,9,28] According to some authors, the lower the gingival display, the more enhanced is smile esthetics. Although a slight tendency towards increased display of the gingival region of the central incisors could be noticed, especially between T_1 and T_2, the differences were not statistically significant throughout the treatment and therefore did not influence smile esthetics in this sample.

Symmetry and smile arch

Alterations were found in the measurements of the right side of the smile during treatment, with a statistically significant increase between T_1 and T_2, and T_1 and T_3. However, smile symmetry was preserved between the left and right sides at all times studied (T_1, T_2 and T_3). Another important aspect of smile esthetics is the relationship between the curvature of the incisal edges of maxillary anterior teeth and the curvature of the lower lip, called smile arch. The smile arch is considered esthetic when there is parallelism between these two reference lines.[5,9,24] To verify parallelism between the curvatures, measurements were made between the incisal edges of upper incisors and the corresponding points on the upper edge of the lower lip, and these measurements were then compared. The greater the similarity, the greater the perceived parallelism.

The distances between the incisal edges and the lower lip showed, on average, the same behavior throughout the treatment. The line formed by the incisal edges of the maxillary incisors was not parallel to the lower lip during treatment, whereas the distance between the incisal edge of the right lateral incisor and the lower lip was statistically higher than those of the right and left central incisors.

Given that orthodontic treatment can modify the smile, analyzing it is of utmost importance for diagnosis and planning, and to enable professionals to pursue and achieve a more esthetic smile. The author of this study therefore believes that learning about the effects of orthodontic mechanics on the smile by means of continued scientific endeavors can be very fruitful as it allows a prognosis to be set prior to starting the treatment, which can benefit the patient's facial esthetic. This study showed that RME helped to improve the esthetics of the smile. It should be emphasized, however, that other factors such as type of malocclusion and facial pattern also influence the patient's smile esthetics. Therefore, depending on the nature of the patient's condition, RME alone may not be sufficient to improve smile esthetics.

CONCLUSIONS

According to the results, it is reasonable to conclude that RME enabled:

A statistically significant increase in the transverse dimension of the smile, while the buccal corridor remained virtually unchanged.

» An increase in the amount of exposure of the upper incisors. However, the smile height and the thickness of the upper and lower lips remained stable.

» Symmetry between the right and left sides was preserved, as well as a lack of parallelism between the curvature of the edges of the upper incisors and the curvature of the lower lip.

REFERENCES

1. Sabri R. The eight components of a balanced smile. J Clin Orthod. 2005;39(3):155-67.
2. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002;36(4):231-6.
3. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001;120(2):98-111.
4. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. Evolution of the concept and dynamic records for smile capture. Am J Orthod Dentofac Orthop. 2003;124(2):116-27.
5. Wong NKC, Kassim AA, Foong KWC. Analysis of esthetic smiles by using computer vision techniques. Am J Orthod Dentofac Orthop. 2005;128:404-11.
6. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. Am J Orthod. 1970;57(3):219-55.
7. Martins LF. Análise fotométrica em normas frontal de adultos brasileiros, leucodermas, não tratados ortodonticamente, classificados pela estética facial [Dissertação]. São Bernardo do Campo (SP): Universidade Metodista de São Paulo, Faculdade de Odontologia; 2002.
8. Moskowitz ME, Nayyar A. Determinants of dental esthetics: a rationale for smile analysis and treatment. Comp Cont Ed Dent. 1995;16:1164-86.
9. Basting RT, Trindade RS, Flório FM. Comparative study of smile analysis by subjective and computerized methods. Oper Dent 2006;31(6):652-9.
10. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 1. Evolution of the concept and dynamic records for smile capture. Am J Orthod Dentofac Orthop. 2003;124(1):4-12.
11. Cohen M, Silverman E. A new and simple palate splitting device. J Clin Orthod. 1973;7(6):368-9.
12. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the midpalatal suture. Angle Orthod. 1960;31(2):73-90.
13. Trevisan F. Análise Fotogramétrica e subjetiva do perfil facial de jovens brasileiros, leucodermas, com oclusão normal [Dissertação]. São Bernardo do Campo (SP): Universidade Metodista de São Paulo, Faculdade de Odontologia; 2003.
14. Chui CS, Clark RKF. Reproducibility of natural head position. J Dent. 1991;19:130-1.
15. Lundström A. A comparison between estimated and registered natural head posture. Eur J Orthod. 1991;13:59-64.
16. Strauss RA. Variability of facial photographs for use in treatment planning for orthodontic and orthognatic surgery. Int J Adult Orthod Orthog Surg. 1997;12(3):197-203.
17. Viazis AD. Avaliação do tecido mole. In: Viazis AD. Atlas de Ortodontia: Princípios e aplicações clínicas. São Paulo (SP): Ed. Santos; 1996. p. 49-57.
18. Dahlberg G. Statistical methods for medical and biological students. New York (NY): Interscience; 1940.
19. Neter J, Kutner MH, Nachtsheim CJ, Wasserman W. Applied Linear Statistical Models. 4th ed. Chicago (IL): Richard D. Irwing; 1996.
20. Singer JM, Andrade DF. Analysis of longitudinal data. In: Handbook of Statistics: Bio-Environmental and Public Health Statistics. Amsterdam: PK Sen and CR Rao; 2000. p. 115-60.
21. Geran RG, McNamara Jr JA, Baccetti T, Shapiro LM. A prospective long term study on the effects of rapid maxillary expansion in the early mixed dentition. Am J Orthod Dentofac Orthop. 2006;129(5):631-40.
22. Haas AJ. The treatment of maxillary deficiency by opening midpalatal suture. Angle Orthod. 1965;35(3):200-17.
23. Berger JL, Pangrazio-Kulbersh V, Thomas BW, Kaczynski R. Photographic analysis of facial changes associated with maxillary expansion. Am J Orthod Dentofac Orthop. 1999;116:563-71.
24. Sarver DM, Ackerman JL. Orthodontics about face: the re-emergence of the esthetic paradigm. Am J Orthod Dentofac Orthop. 2000;117(5):575-6.
25. Ritter DE, Gandini Jr LG, Pinto AS. Analysis of the smile photograph. World J Orthod. 2006;7(3):279-85.
26. McNamara Jr AJ, Ackerman MB, Baccetti T. Hard and soft tissue contributions to the esthetics of the posed smile in growing patients seeking orthodontic treatment. Am J Orthod Dentofac Orthop. 2008;133(4):491-500.
27. Brandt S. Interview with Dr. Andrew J. Haas. J Clin Orthod. 1973;7(4):227-45.
28. Chang C, Font B. Skeletal and dental changes in the sagittal, vertical, and transverse dimensions after rapid palatal expansion. Am J Orthod Dentofac Orthop. 2004;126:569-75.
29. Silva Filho OG, Villas-Boas MC, Capelozza Filho L. Rapid maxillary expansion in the primary and mixed dentitions: a cephalometric evaluation. Am J Orthod Dentofac Orthop. 1991;100:171-81.
30. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. Am J Orthod. 1970;58(1):41-61.

Esthetic perception and economic value of orthodontic appliances by lay Brazilian adults

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Objective: To evaluate the esthetic perception of different appliances by Brazilian lay adults and its influence in the attributed value of orthodontic treatment, considering evaluators' socioeconomic status, age and gender.

Methods: Eight different combinations of orthodontic appliances and clear tray aligners were placed in a consenting adult with pleasing smile. Standardized frontal photographs were captured and incorporated into a research album. A sample of adults (n = 252, median = 26 years old) were asked to rate each image for (1) its attractiveness on a visual analog scale and (2) the willingness to pay (WTP) for a cosmetic appliance when compared to a standard metalic appliance and a clear tray aligner. Comparisons between the appliances' attractiveness were performed using the Friedman's test and Dann's post-hoc test. Correlation between appliances' attributed value, socioeconomic status, age, gender, and esthetic perception was assessed using Spearman's correlation analysis.

Results: Attractiveness ratings of orthodontic appliances varied significantly in the following hierarchy: Clear aligners>sapphire brackets>self-ligating/conventional stainless steel brackets>and golden metal appliances. The correlation between WTP and esthetic perception was week. However, for individuals with better socioeconomic status and aged between 17-26 years old significantly, a significantly higher WTP was found.

Conclusion: Clear aligners and sapphire brackets with esthetic archwire were considered better esthetic options in this sample. Nevertheless, patients were not willing to pay more money for appliances they deemed more esthetic, however, they were significantly influenced by their socioeconomic level and age.

Keywords: Orthodontic appliances. Esthetics. Corrective orthodontic treatment. Cost-benefit analysis.

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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 the past years, orthodontics has greatly evolved regarding esthetic materials. Nowadays, orthodontic brackets are becoming smaller and more discrete; in addition, the esthetic appliances represent an alternative for patients that are reluctant to use metallic appliances. Orthodontic appliances have evolved according to public demand and available technology, especially with the underlying goal of reducing the appliances' visibility.[1,2] The esthetic paradigm shift in dentistry, especially in orthodontics, has shown the urgency to incorporate esthetics to the functional goals and requirements of the orthodontic treatment,[2], leading to an increase in the demand for orthodontic appliances even more inconspicuous. Therefore, this demand has been primarily driven by the consumers' desire for esthetic alternatives and the competitiveness of the orthodontic industry and specialty.[3]

Innovations in the aesthetics of orthodontic appliances may also be a major factor in the increase in adult patients' acceptability to orthodontic treatment. Patients considering to undergo orthodontic treatment now have can choose from different appliances currently available, including conventional stainless-steel, ceramic, lingual and clear plastic aligners.[1] Even though orthodontists can use these resources to increase patients' acceptability to orthodontic treatment, few studies have evaluated the attributed value of orthodontic appliances.[4]

A previous study assessing perceived orthodontic appliance attractiveness indicated that adult patients prefer less metal showing in their orthodontic appliances and were less willing to accept treatment with appliances they consider to be unesthetic.[3,4] In the same way, another study revealed that 67% of Sweden young adults would probably not or definitely not wear visible appliances in spite of a functional treatment indication; and there was also a rejection rate of 33% to conventional orthodontic treatment.[5] Another aspect is the social perceptions of adults wearing orthodontic appliances, since the judgments concerning their personal characteristics are influenced by dental appearance and orthodontic appliance design.[6]

Just as a variety of social, cultural, psychological and personal factors influence the self-perception of dental appearance and the decision to undergo orthodontic treatment,[7,8,9] these factors may also exert an important influence in the perception and acceptability of different orthodontic appliances, indicating that, different populations should be investigated. Understanding the factors involved in the perception of different orthodontic appliances in a particular population enables a better planning of resources and strategies in the private practice, since the appearance of orthodontic appliances plays a significant role in patients' decisions to undergo orthodontic therapy.[4]

The preferences for appliances can also be evaluated in terms of their attributed value to patients.[10,11] The employment of the willingness-to-pay (WTP) assessment technique has been increasing in different areas , allowing to estimate the attributed value of the health care technologies.[11] It is a way of measuring value in monetary terms by a cost-benefit analysis once it assigns monetary values to both costs and outcomes of health care and calculates the net benefit. WTP allows a monetary rating to be attributed to novel health care interventions or outcomes by asking people how much they would pay to obtain the benefits of a specific treatment. This value is set as raters are asked to respond to a hypothetical, conditional question - e.g., "what is the maximum amount you would be willing to pay to access a new intervention, existing the need to undergo treatment?" Such a question is intended to elicit a monetary valuation of the merit, worth or benefit which each subject associates with the specific intervention under consideration. Although the same general question is asked any WTP study, the question can be asked in various formats to adapt to the study.[12] When applied to orthodontics, this method may provide a way to determine the value of different appliances for patients of different ages and sociocultural realities.[3]

The purpose of this study was to evaluate the esthetic perception of lay Brazilian adults on different orthodontic appliances designs and its influence in the attributed value of orthodontic treatment, considering raters' socioeconomic status, age and gender.

MATERIAL AND METHODS

This research was approved by the ethics research committee of Rio de Janeiro State University where this study was performed.

An adult volunteer was selected for receiving the appliances and pictures capturing. Selection criteria were: Well aligned teeth, proper gingival and incisor display and the absence of strong gender markers in the circum-oral region. The volunteer was also asked to sign de informed consent. Digital image capture was made in frontal view with an SLR camera (EOS Rebel T1, Canon, Oita, Japan) equipped with a 100 mm macro lens (Macro Lens EF 100 mm, Canon, Oita, Japan) and a ring flash (Macro Ring Light MR-14ex, Canon, Oita, Japan). Traditional metal brackets (Masel, California, USA), self-ligated metal brackets (Tellus, Eurodonto, Brazil), golden metal brackets (GAC International, New York, USA) and sapphire esthetic orthodontic brackets (Radiance, American Orthodontics, Wisconsin, USA) were temporarily bonded to the dental surfaces of the maxillary arch without acid etching. For the simulated bonding of the appliances, Transbond XT (3M Unitek, California, USA) adhesive was used. A 0.020-in stainless steel archwire (GAC International, New York, USA) was used as reference for brackets positioning, allowing reproducibility for placement of various bracket systems. Brackets were bonded from upper right second molar to upper left second molar. A clear tray was fabricated and imaged to simulate clear tray alignment systems such as Invisalign (Invisalign, Align Technology, California, USA). Two trays were produced: One simulating attachments in front teeth (12 and 22 in vestibular side) and one with no attachments. Attachments were transparent, rounded, and had approximately a three millimeters radius.

Camera settings were manually set, and all in-camera image enhancement features were turned off to ensure images' reproducibility. Lighting conditions were constant for all images acquired.

All photographs of the volunteer's smile were performed in the natural head position, with the aid of the cephalostat of the UERJ Dental Radiology Clinics, thus ensuring the correct positioning of the head. The ear positioners restricted excessive lateral movement while the nasion positioner limited vertical movements. (Fig 1). The camera was attached to a tripod and positioned at a fixed distance of 110 cm in a straight line between the patient's face and the camera lens.

Photos of the volunteer's smile were obtained in eight different situations: (1) With clear tray and attachments, (2) with clear tray without attachments; (3) with fixed traditional metallic brackets using gray elastomeric ligatures and (4) green elastomeric ligatures (Morelli, São Paulo, Brazil), (5) with fixed metallic self-ligated brackets; (6) with fixed golden orthodontic brackets and clear elastomeric ligatures (American Orthodontics, Wisconsin, USA); (7) with fixed esthetic brackets, clear elastomeric ligatures (American Orthodontics, Wisconsin, USA) and 0.020-in stainless steel archwire (GAC International, New York, USA), as in all previous described situations, and (8) with fixed esthetic brackets, clear elastomeric ligatures (American Orthodontics, Wisconsin, USA) and 0.018-in esthetic nickel titanium coated archwire (American Orthodontics, Wisconsin, USA). Image incorporation and standardization was performed with Photoshop (version 9.0, Adobe, California, USA).

The photo album was composed of three sheets of photo-quality color prints. Each sheet had 29.7 cm x 21 cm. The first sheet comprised eight images, with all compositions of orthodontic appliances described

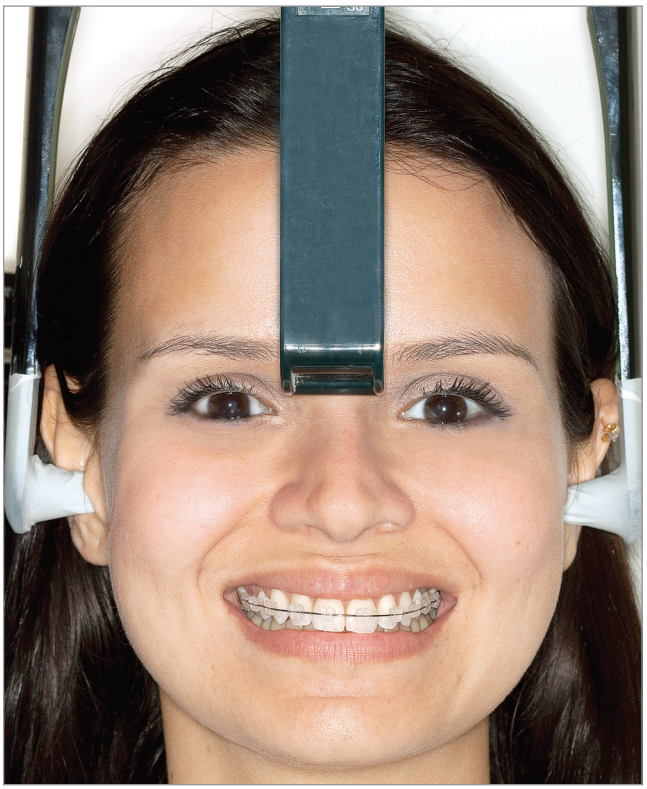

Figure 1 - Volunteer positioned in the cephalostat.

above randomly grouped in a grid and labeled with letters A to H (Fig 2). Each photograph had a 10 cm x 5 cm size. The second and third sheets was composed of two pictures each and had the purpose of evaluating the monetary value of the apparatus. The second sheet (Fig 3) had a picture of the traditional fixed metallic appliance labeled "Picture A" and one of a fixed esthetic appliance labeled "Picture B". The third sheet had a picture of a fixed esthetic appliance labeled "Picture A" and one of the clear tray aligner labeled "Picture B" (Fig 4). These sheets also had 29.7 cm x 21 cm, and each picture had 10 cm x 5 cm.

Eligibility to participate in the survey included any willing adult from 17 to 63 years old who had never undergone orthodontic treatment with brackets or aligners, was not a dentist or a dental student, was at the University campus in the four days of data collection and signed the informed consent form.

Two trained and blinded dental students collected the data. All surveys included a demographic and socioeconomic status information forms, instructions, the image-rating scales and the album. Socioeconomic status was measured with the "Brazil Economic Classification Criteria",[13] which classifies people into eight socioeconomic categories according to the educational level of the head of the household and the ownership and consumption of common goods and services (e.g., VCRs, DVDs, color TVs, housekeeper).

Each rater (n = 252) received the album containing the smiles' photographs and a rating sheet with a 100 mm visual analog scale (VAS). The straight lines on the left side indicated "very unattractive" and, on the right side, "very attractive." The subjects were presented the images that should be rated (Fig 2) and instructed to use the VAS. They were also told not to compare the album smiles. After the attractiveness evaluation, questions were asked to determine the perceived value of cosmetic orthodontic appliances by using the WTP method.

The questions were directed to the evaluation of sheets 2 and 3. The rater received these instructions: "Assume the appliances in picture B are more expensive than those in Picture A. How much more would you be willing to pay for them to be placed on your teeth?" After that question, a second question asked how much more money the rater would be willing to pay to have Picture B appliances placed on "your child's teeth". The rater could check a box to represent the amount he or she would pay for Picture B appliances, ranging from US$50 to US$3500 (Table 1). Alternatively, if the rater would not pay additional money for the appliances in Picture B, the option: "None, I would prefer Picture A appliance" could be chosen. The procedure was repeated for sheets 2 (Fig 3) and 3 (Fig 4).

The scores were measured by a calibrated dentist using a digital caliper (MGF 505646, Mitutoyo, Tokyo, Japan) that was positioned on the left-most point of each line of the visual analog scale and opened to the mark made by the rater. Values in millimeters were registered as scores.

Table 1 - Box representing how much more raters would pay for Picture B appliances, ranging from US$50 to US$3500, in sheets 2 and 3.

[ ] US$50	[ ] US$1000
[ ] US$100	[ ] US$1500
[ ] US$200	[ ] US$2500
[ ] US$250	[ ] US$3500
[ ] US$500	[ ] None of the above. I would prefer picture A appliance

Statistical analysis

Sample size calculation showed that a total of 252 individuals would provide a 80% probability to the study of detecting a treatment difference at a one-sided 0.05 significance level, if the true difference between treatments is 0.30 times the standard deviation.[3] The VAS scores were evaluated by intraclass correlation coefficient (ICC) with 95% upper and lower confidence bounds. For the WTP responses, the weighted kappa statistic was applied. Twenty subjects from the same University Campus, which were not included in the study group, were used to test the intrarater reliability. The interviews were repeated seven to ten days latter.

Descriptive statistics for perceived attractiveness VAS ratings were calculated. The Kolmogorov-Smirnov test showed lack of normality of distribution and heteroscedasticity for all groups except for sapphire esthetic brackets with metal wire.

Figure 2 - Images employed for attractiveness evaluation (first sheet): **A**) Sapphire esthetic brackets with metal archwire; **B**) clear tray with attachments ; **C**) golden metal brackets; **D**) self-ligated metallic brackets; **E**) traditional metallic brackets; **F**) sapphire esthetic brackets with esthetic archwire; **G**) clear aligner and **H**) traditional metallic brackets with green elastomeric ligatures.

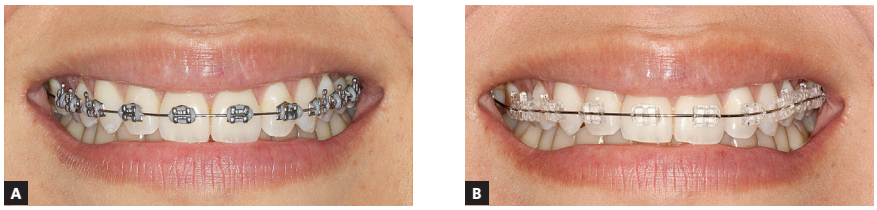

Figure 3 - Images captured for the first WTP evaluation (second sheet): **A**) Traditional metallic brackets; **B**) sapphire esthetic brackets with metal archwire.

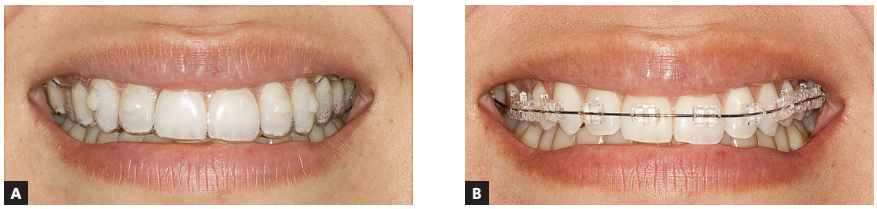

Figure 4 - Images captured for the second WTP evaluation (third sheet): **A**) Clear aligner with attachments; **B**) sapphire esthetic brackets with metal archwire.

Comparisons of groups' attractiveness were carried out using nonparametric statistics with the Friedman test (analysis of variance [ANOVA] on ranks for repeated measures) followed by Dann's multiple comparison post-hoc test (GraphPad Prism 5 software). The correlation between the economic value (WTP), socioeconomic status, age, gender and esthetic perception was calculated by using the Spearman correlation analysis and represented with the r value. Raters' ages were divided at the median (26 years) to assess whether it could influence the results.

RESULTS

Intraexaminer reliability was high for attractiveness assessment: Mean ICC = 0.83 (95% CI, 0.78-0.99) and for attributed value assessments: Kappa, 0.89 [95% CI, 0.81-0.98], indicating substantial consistency.[14]

The median for raters' age was 26 years old (IR= 22-40) and the socioeconomic status is described in Table 2. Descriptive statistics for the perceived attractiveness VAS ratings of sheet 1 are reported in Table 3 and Figure 5. Higher VAS scores (scored 0-100) indicate greater appliance attractiveness.

The clear aligner without attachments had the best evaluation scores, followed by the sapphire brackets with esthetic wire and then by the clear aligner with attachments. The golden metal brackets received the worse scores. The data show a general score hierarchy, with decreasing attractiveness as the amount of displayed metal increases, and worsening with the golden version.

Appliances perceived attractiveness for males and females was compared, showing significant difference between them, and it is described in Figure 6 and Table 4. Men showed a general tendency to assign lower scores than women. Similarly, there was a significant difference in the perception of groups of 17-26 years and 27-63 years of age, which is shown in Figure 7 and Table 5.

The correlation assessment between the attributed value (WTP) and the esthetic perception of the metal brackets with gray elastomeric ligatures (option A) in comparison with sapphire brackets with metal archwire (Option B) in sheet 2 revealed a weak[14] but significant correlation regarding the raters themselves, and an even weaker and non significant result for their child. For the sapphire brackets with metal archwire (Option A) in comparison with the clear aligner with attachments (Option B) in sheet 3; there was also a weak[14] but significant correlation for the raters themselves, with similar results for their child (Table 6). Comparison between genders regarding WTP (Table 7) showed similar results to the total sample, with more significant results for sheet 3, with a slight tendency for women to pay less for appliances they considered more esthetic.

In sheet 2, the correlation between WTP and age showed a weak and non-significant correlation for the two age groups (Table 8). However, younger subjects (17-26 years) showed a tendency to pay more for the aligner in sheet 3. Correlation was significant and moderate.[14] Socioeconomic status had a significant correlation, showing that as better is the socioeconomic status, as higher is the WTP for an esthetic appliance (Table 9). Correlation was similar and statistically significant for sheets 2 and 3.

DISCUSSION

Adult patients display pronounced different attitudes to the type of appliance they wear.[15] They have indicated embarrassment and bashfulness,[16] arising from the presence of a perceptible appliance, and negative peer reaction,[15] especially from their partners, as discouraging aspects of treatment. The perception of young adults undergoing orthodontics by others is particularly important for major life events such as employment and finding a partner. Therefore, an orthodontic appliance with the most positive social assessment would favor patient acceptance.[6]

Table 2 - Sample description.

AGE (n = 252)	Mean	Standard Deviation	Min.	25% Percentile	median	75% Percentile	Max.
	31	11.2	17	22	26	40	63
GENDER (n = 252)	**Frequency**	**Percentage**					
Male	152	60.3					
Female	100	39.7					
SOCIOECONOMIC STATUS (n = 252)	**Frequency**	**Percentage**					
A1	6	2.4					
A2	61	24.2					
B1	62	24.6					
B2	68	26.9					
C1	42	16.6					
C2	10	3.9					
D	3	1.2					

Table 3 - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0.001$) and Dunn's post-hoc test.

n = 252			
VAS	**Median**	**25% Percentile**	**75% Percentile**
A) Sapphire brackets with metal archwire	54[a]	38	70
B) Clear aligner with attachments	68[a]	37.5	83
C) Golden metal brackets	17[b]	7.5	39.5
D) Self-ligated metal brackets	30[b]	15	48.5
E) Metal brackets with gray ties	34[b]	20	53.5
F) Sapphire brackets with esthetic archwire	69[a,c]	53	82.5
G) Clear aligner without attachments	81[c]	55	92
H) Metal brackets with green ties	29[b]	13	50

* Distinct superscripts indicate statistical significance.

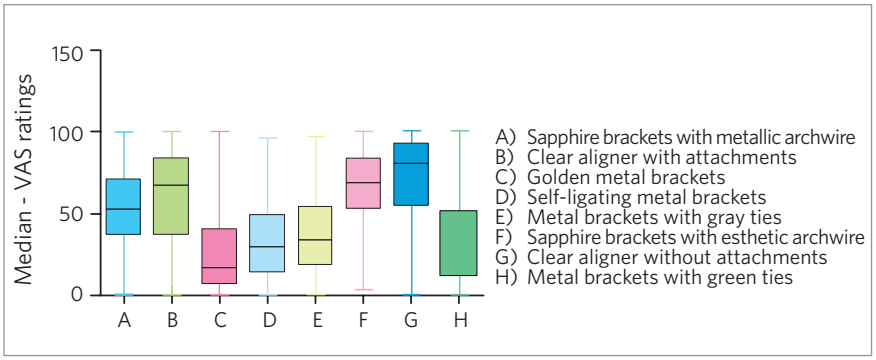

Figure 5 - Descriptive VAS ratings representing attractiveness evaluation for each appliance type.

Table 4 - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0,001$) and Dunn's post-hoc test by gender.

Males (n = 152)			
VAS	**Median**	**25% Percentile**	**75% Percentile**
A) Sapphire brackets with metal archwire	53[a]	40	67
B) Clear aligner with attachments	66.5[a,b]	38	83
C) Golden metal brackets	15.5[c]	5	42.75
D) Self-ligated metal brackets	30[c,d]	14	47.75
E) Metal brackets with gray ties	34[d,e]	20.25	54
F) Sapphire brackets with esthetic archwire	68[b,f]	53	84.5
G) Clear aligner without attachments	76[f]	48.25	92
H) Metal brackets with green ties	29.5[c,d,e]	13.25	50
Females (n = 100)			
VAS	**Median**	**25% Percentile**	**75% Percentile**
A) Sapphire brackets with metal archwire	53[a,b]	36	74
B) Clear aligner with attachments	71[a,c]	38	85
C) Golden metal brackets	20[c]	11	38
D) Self-ligated metal brackets	31[d]	18	50
E) Metal brackets with gray ties	32[d]	19	52
F) Sapphire brackets with esthetic archwire	71[b]	51	81
G) Clear aligner without attachments	83[c]	63	93
H) Metal brackets with green ties	27[d]	11	50

* Distinct superscripts indicate statistical significance.

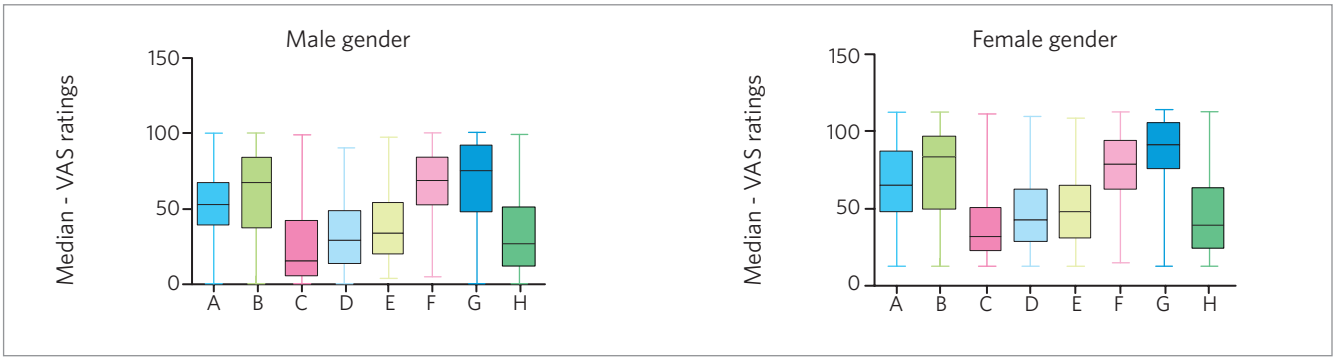

Figure 6 - Descriptive VAS ratings representing attractiveness evaluation for appliance type by gender.

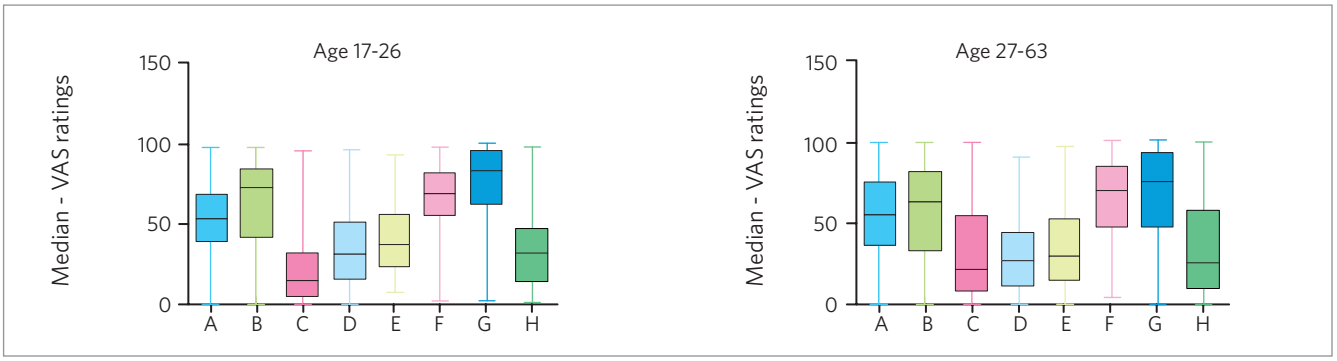

Figure 7 - Descriptive VAS ratings representing attractiveness evaluation for appliance type by age.

Table 5 - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0,001$) and Dunn's post-hoc test by age.

17 - 26 years (n = 128)			
VAS	**Median**	**25% Percentile**	**75% Percentile**
A) Sapphire brackets with metal archwire	52[a]	39	67
B) Clear aligner with attachments	72[a,b]	42	84
C) Golden metal brackets	15	5	31
D) Self-ligated metal brackets	32[c]	16	51
E) Metal brackets with gray ties	36[c]	23	55
F) Sapphire brackets with esthetic archwire	68[b,d]	56	81
G) Clear aligner without attachments	83[d]	63	95
H) Metal brackets with green ties	31[c]	16	47
27 - 63 years (n = 124)			
VAS	**Median**	**25% Percentile**	**75% Percentile**
A) Sapphire brackets with metal archwire	54[a]	36	75
B) Clear aligner with attachments	63[a,b]	33.5	83.5
C) Golden metal brackets	22 [c]	9	53.5
D) Self-ligated metal brackets	27[c]	11.5	43.5
E) Metal brackets with gray ties	29[c]	15	52
F) Sapphire brackets with esthetic archwire	70[a,d]	47	85
G) Clear aligner without attachments	75[b,d]	48	91.5
H) Metal brackets with green ties	26[c]	10	57

* Distinct superscripts indicate statistical significance.

Table 6 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP).

Total sample (n = 152)	Attributed value (WTP)	Attributed value (WTP)
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.141* (p = 0.021)	0.090 (p = 0.143)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligners with attachments)	-0.211** (p < 0.001)	-0.217** (p < 0.001)

*p < 0.05; **p < 0.01.

Table 7 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP) by gender.

Males (n = 152)	Attributed value (WTP)	Attributed value (WTP)
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0,141 (p = 0,067)	0,070 (p = 0,364)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0,340** (p < 0.001)	-0,289** (p < 0.001)
Females (n = 100)	**Attributed value (WTP)**	**Attributed value (WTP)**
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal wire) - VAS score E (Metal brackets with gray ties)	0.143 (p = 0.162)	0.130 (p = 0.205)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal wire) - VAS score B (Clear aligner with attachments)	-0.224* (p = 0.027)	-0.213* (p = 0.036)

*p < 0.05; **p < 0.01.

Table 8 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP) by age.

17 – 26 years (n = 128)	Attributed value (WTP)	Attributed value (WTP)
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.161 (p = 0.064)	0.089 (p = 0.309)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0.370** (p < 0.001)	-0.311** (p < 0.001)
27 – 63 years (n = 124)	**Attributed value (WTP)**	**Attributed value (WTP)**
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.093 (p = 0.293)	0.048 (p = 0.588)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0.218* (p = 0.013)	-0.234** (p < 0.001)

*p < 0.05; **p < 0.01.

Table 9 - Spearman rank correlation coefficients and p values between socioeconomic status and attributed value (WTP).

n = 252	Attributed value (WTP)	Attributed value (WTP)
SHEET 2	Personal attributed value	Children attributed value
Socioeconomic status	0.367** (p < 0.001)	0.164** (p < 0.001)
SHEET 3	Personal attributed value	Children attributed value
Socioeconomic status	0.375** (p < 0.001)	0.172** (p < 0.001)

*p < 0.05; **p < 0.01.

For this reason, this study's findings have direct clinical implications for the orthodontics practice. Orthodontists must choose between available appliances to provide options that are acceptable to patients and work in harmony with their biomechanical philosophy. This study showed that there were four general preference levels regarding types of appliances based on their appearance: 1) Clear aligners are preferred over sapphire appliances, except when attachments are present on anterior teeth; 2) In these cases, sapphire appliances with esthetic wires are preferred over the clear trays, but this was not statistically significant; 3) Sapphire brackets with both archwires are also preferred over stainless steel, but among those, traditional metal brackets with gray ties were preferred over self-ligated brackets and over metal brackets with green ties; 4) Golden metal brackets had the worse esthetic perception in this sample.

In the present study, all raters were University students or employees. This could have introduced bias into the results; especially with regard to their cultural and social background.[26] This was the main reason to apply a socioeconomic survey that allowed investigating whether it would influence the results. The survey showed that this sample was homogeneously distributed between the status A2, B1, B2 and C1 and socioeconomic status did not influence the esthetic perception of the appliances. However, it did influence the WTP for a more esthetic appliance.

Another issue worth discussing was the brackets positioning, which in spite of the 0.020-in archwire used as reference, showed minor variations. However, it is most likely that these minor variations did not significantly impact our findings, especially because all appliances were installed on a model with well-aligned teeth. Although this situation might not represent the clinical appearance of these appliances during the early stages of treatment, well-aligned teeth were chosen to reduce variables that could distract from the evaluation of appliance esthetics and allow a more accurate comparison with the results of previous studies.

A similar study was recently carried out,[6] interestingly, however, no significant differences were found between metallic, golden, and ceramic brackets for any of the assessed sample. Golden appliances are not widely used, leading the authors to believe that this may have influenced the results, since raters would not be able of identifying it properly Nevertheless, the present study showed that this brackets had the worse esthetic perception in the studied population. According to Jeremiah et al,[6] the clear aligner also had the higher attractiveness ratings. These findings indicate that a reduced appliance visibility appears to be the standard for social acceptance, corroborating our findings. In the present study, when the clear aligner was noticed, due to the presence of anterior attachments, it became less attractive than ceramic brackets. However no other study has previously evaluated the perception of anterior attachments, therefore, these results cannot be compared with other population.

Roswall et al[3] and Ziuchkovski et al[4] also evaluated appliances' esthetic perception and obtained similar results when compared with the present study.

The authors found that the overall trend in appliance attractiveness seems to relate to the amount of visible metal. Clear tray appliances with no visible metal received the highest ratings in attractiveness. Authors believe that this could explain why alternative orthodontic appliance systems such as clear tray aligners have grown in popularity.[18] In fact, the present study and other three[3,4,6] researches have shown similar results about clear tray aligners. Besides the positive esthetic perception and the increasing consumer and professional demand for such appliances, questions regarding this system's efficacy requires further research, since there is still much to learn about its biomechanics.[19,20]

A possible reason for the marked differences in the results shown by Jeremiah et al[6] and Ziuchkovski et al,[4] Roswall et al,[3] and the present study, regarding the perception of esthetic and metal brackets is that Jeremiah et al[6] used standardized full-face photographs of a young adult female, whereas the other studies used smiles with no strong gender markers in the circum-oral region. The findings from Berto et al,[21] who also used standardized lateral full-face close-ups photographs (modified by adding appliances) of a young female adult, differ from all studies discussed above. In their study, Brazilian laypeople perceived a smile with an esthetic appliance as significantly less attractive than a smile with a metal appliance or with no appliance. This could have been caused due to a different perception of the sapphire appliance, used in the present study, and the ceramic appliance, used in Berto et al[21] and Jeremiah et al[6] studies. On the other hand, this possibility is questionable once Roswall et al[3] and Ziuchkovski et al[4] also used ceramic brackets and found results that corroborates the present study.

It is important to know whether the attractiveness of a smile is influenced by the type of photographic framing used in the analysis. In addition, one must analyze methodologies that might influence the results achieved, such as, the order and fashion of presenting the photographs and the scale used to evaluate the perception.[22] Some authors believe that facial structures, such as nose and chin, may act as confounding factors, as my also happen with gender markers apparent in the smile, and therefore influence the smile evaluation.[23] The model's gender is very influential when grading smiles attractiveness, as was found by Thomas et al.[24] The use of a Lickert scale to rank esthetic perception and a structured questionnaire about characteristics strongly associated with the model's physical appearance may also have influenced the results of Jeremiah et al,[6] since all other studies used a VAS scale.

Similarly, the sample's characteristics can also be related to differences in findings. In this study, raters' age and gender influenced attractiveness perception of the appliances. Younger patients (17-26 years old) evaluated sapphire appliances and clear aligners more positively, i.e. with highest scores, and golden and metallic brackets with green ties with worse scores than patients aged 27-63 years. Regarding gender, men showed a general tendency to assign lower scores than women for all evaluated appliances. Male subjects rated sapphire appliances and clear aligners without attachments statistically equal. On the other hand, for women there was no difference between clear aligners with and without attachments, conversely to what happened to men who perceived attachments negatively. Metallic brackets with gray and green ties and also self-ligated metal appliances were similar for women, but gold metal brackets had worse evaluation. Men also perceived metal brackets differently, considering only traditional metal appliances with gray ties more attractive than the others. Walton et al[25] also found significant differences in esthetic perception of appliances between genders and different age groups.

WTP method was used to evaluate the attributed value of various orthodontic appliances by means of a cost-benefit analysis. The WTP was assessed using the payment scale method, described in Table 1, rather than an open-ended format due to the study design and also because no difference was found between these two methods in previous studies.[26]

The correlation between the attributed value (WTP) and the esthetic perception was weak, and showed that despite raters' preference for esthetic appliances, they would not be willing to pay more for clear tray and sapphire appliances according to the simulations made in sheets 2 and 3. Their socioeconomic status was significantly correlated with these results: The higher the socioeconomic status, the more raters were willing to pay for treatment with the appliances, as observed in the results for sheets 2 and 3.

This may be the reason for the different result found by Roswall et al,[3] in which sample, raters with higher socioeconomic status responded with the highest WTP values for lingual appliances and a clear tray aligner. In another socioeconomic reality, different results may be found in Brazilian samples, therefore indicating that more studies are necessary to further conclusions regarding the subject. Therefore, it is important to note that this study's results cannot be indiscriminately applied to other cultural groups, with socioeconomic differences. These aspects must be analyzed and considered in this kind of analysis. When patients declared they would pay more for the esthetic appliances, adults were equally willing to pay more for appliances they deemed more desirable for their children too.

Gender had no significant influence on WTP, however, male subjects had a greater trend to pay more for treatment with a clear aligner. However, age had a significant influence in WTP for appliances compared in sheet 3, with younger patients being significantly more willing to pay more for a clear aligner. Similarly, attractiveness analysis was also influenced by age, as previously described. Walton et al[25] evaluated children and adolescents and found that they also showed high preference for clear tray aligners. However, following the aligners, child preferred metal appliances with colored ties above all other options. This was an opposite perception when compared to adults' rates and suggests that the comparison between different age groups influenced appliances' perceived esthetics and could also have an effect on the attributed value. However, more studies comparing different age groups are required for definitive conclusions on the subject.

CONCLUSION

Orthodontic appliance attractiveness varied significantly by the following hierarchy of appliance types: Clear tray aligners > sapphire brackets > stainless steel traditional and self-ligating brackets > golden metal appliances. Metal appliances, commonly used in orthodontic practice, were considered unattractive, while clear aligners and sapphire appliances were considered better esthetic options. Nevertheless, patients are not willing to pay more for appliances they deem more esthetic. On the other hand, socioeconomic status and age was significantly correlated with WTP. Higher socioeconomic level and age between 17 and 26 years old were significantly correlated with the willingness to pay more for an esthetic appliance. Gender was not significantly correlated with WTP. These data show that results could vary depending on the studied sample. Therefore, a socioeconomic and age analysis is mandatory in this kind of study.

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REFERENCES

1. Russel JS. Current Products and Practice Aesthetic Orthodontic Brackets. J Orthod. 2005;32:146-163.
2. Sarver DM, Ackerman JL. Orthodontics about face: the re- emergence of the esthetic paradigm. Am J Orthod Dentofacial Orthop. 2000;117:575-6.
3. Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM. Attractiveness, acceptability, and value of orthodontic appliances. Am J Orthod Dentofacial Orthop. 2009;135:276.e1-12.
4. Ziuchkovski JP, Fields HW, Johnston WM, Lindsey DT. Assessment of perceived orthodontic appliance attractiveness. Am J Orthod Dentofacial Orthop. 2008;133(Suppl):S68-78.
5. Bergstrom K, Halling A, Wilde B. Orthodontic care from the patients' perspective: perceptions of 27-year-olds. Eur J Orthod. 1998;20:319-29.
6. Jeremiah HG, Bister D, Newton JT. Social perceptions of adults wearing orthodontic appliances: a cross-sectional study. Eur J Orthod. 2010;33:476-482.
7. Kiyak HA. Comparison of esthetic values among Caucasians and Pacific-Asians. Community Dent Oral Epidemiol. 1981;9:219-223.
8. Miguel JAM, Sales HX, Quintão CC, Oliveira BH, Feu D. Factors associated with orthodontic treatment seeking by 12-15-year-old children at a state university-funded clinic. J Orthod. 2010; 37:100-106.
9. Mugonzibwa EA, Kuijpers-Jagtman AM, Van t Hof MA, Kikwilu EN. Perceptions of dental attractiveness and orthodontic treatment need among Tanzanian children. Am J Orthod Dentofacial Orthop. 2004;125:426-433.
10. Robinson R. Economic evaluation. What does it mean? Br Med J. 1993;307:670-3.
11. Zarnke KB, Levine MAH, O'Brien JO. Cost-benefit analyses in the health care literature: don't judge a study by its label. J Clin Epidemiol. 1997;50:813-22.
12. Whynes DK, Frew EJ, Wolstenholme JL. Willingness-to-pay and demand curves: a comparison of results obtained using different elicitation formats. Int J Health Care Finance Econ. 2005;5:369-86.
13. Associação Brasileira de Empresas de Pesquisa (ABEP). Critério de Classificação Econômica Brasil. São Paulo; 2003.
14. Hetherington EM, Parke RD, Locke VO. Child psychology: a contemporary viewpoint. 5th ed. New York: McGraw-Hill; 1999.
15. Tayer BH, Burek MJ. A survey of adults' attitudes towards orthodontic therapy. Am J Orthod Dentofacial Orthop. 1981;79:305-315.
16. Lew KK. Attitudes and perceptions of adults towards orthodontic treatment in an Asian community. Comm Dent Oral Epidemiol. 1993;21:31-35.
17. Kerosuo H, Hausen H, Laine T, Shaw W C. The influence of incisal malocclusion on the social attractiveness of young adults in Finland. Eur J Orthod. 1995;17: 505–512.
18. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. 2007 JCO orthodontic practice study. Part 1: trends. J Clin Orthod. 2007;41:617-26.
19. Kravitz ND, Kusnoto B, BeGole E, Obrez A, Agrane B. How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. Am J Orthod Dentofacial Orthop. 2009; 135:27-35.
20. Sheridan JJ. The readers' corner. 2. What percentage of your patients are being treated with Invisalign appliances? J Clin Orthod. 2004;38:544-5.
21. Berto PM, Lima CS, Lenza MA, Faber J. Esthetic effect of orthodontic appliances on a smiling face with and without a missing maxillary first premolar. Am J Orthod Dentofacial Orthop. 2009;135:S55-60.
22. Rodrigues CDP, Magnanib R; Machado MSC,Oliveira Jr OB. The Perception of Smile Attractiveness. Angle Orthod. 2009;79:634–639.
23. Dong JK, Jin TH, Cho HW, Oh SC. The esthetics of the smile: a review of some recent studies. Int J Prosthodont. 1999;12:9-19.
24. Thomas JL, Hayes C, Zawaideh S. The effect of axial mid- line angulation on dental esthetics. Angle Orthod. 2003;3:359–64.
25. Walton DK, Fields HW, Johnston WM, Rosenstiel SF, Firestone AR, Christensen JC. Orthodontic appliance preferences of children and adolescents. Am J Orthod Dentofacial Orthop. 2010;138:698.e1-698.e12.
26. Whynes DK, Frew EJ, Wolstenholme JL. Willingness-to-pay and demand curves: a comparison of results obtained using different elicitation formats. Int J Health Care Finance Econ. 2005;5:369-86.

Influence of different width/height ratio of maxillary anterior teeth in the attractiveness of gingival smiles

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Objective: To evaluate, among laypersons and orthodontists, the influence of the width/height proportions of upper anterior teeth on the smile attractiveness, in photographs of close up smile from three adult Caucasian women, with 4 mm of gingival exposure.

Methods: The photographs of close up smiles were digitally manipulated and six images were created from each smile with teeth's width/height proportions in 65%, 70%, 75%, 80%, 85% and 90%. Then, all these images were manipulated again and a black mask covering all teeth from the lower arch was created. The figures were then assessed by 60 evaluators, 30 orthodontists and 30 laypersons, who assigned, in a visual analog scale, the level of attractiveness of each image.

Results: The obtained results, in general, showed that the proportions of 75%, 80% and 85% received the highest scores while the proportion of 65% received the lowest scores, for both groups of examiners ($p < 0.05$). When orthodontists and laypersons were compared, it was not found, in most situations, a significant statistical difference between their assessments ($p > 0.05$). Yet, the comparison between scores assigned to smiles with and without inferior teeth showed that, for all situations, there was no statistically significant difference between them ($p > 0.05$).

Conclusion: For patients with gingival smile, the width/height proportions of upper anterior teeth considered more esthetic were the ones of 75%,80% and 85% for laypersons and orthodontists, and the presence or absence of inferior teeth did not affect the attractiveness level of the assessed smiles.

Keywords: Smile. Dental esthetic. Gingiva.

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

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INTRODUCTION

Nowadays, the number of adults seeking esthetic treatment is high. Many times inspired by beautiful smiles of artists from the media, patients show more and more interest in treatments that improve the smile's esthetic.[1] Generally, the literature suggests that the ideal smile should not present gingival exposure[2-6] or only little exposure of this tissue.[7-10] Although this information is well accepted in literature, a quantification of this little gingival exposure is a point of great scientific and clinical discussion. How many millimeters of gingival exposure will be considered non- esthetic?

The classic work published by Kokich et al[11] showed that smiles with gingival exposure of 4 mm were considered, by laypersons, less attractive. Recent studies confirm these findings, showing that large levels of gingival exposure on the smile are highly detrimental to the smile's esthetic.[12,13,22]

This way, one can observe the need to treat the gingival smile to optimize the esthetic result of orthodontic treatments. This problem presents multifactorial etiology such as: Maxillary vertical excess, hyperactivity and reduced length of superior lip and changes on the heights of the upper anterior teeth's clinical crowns.[14] And therefore, the treatment is quite diversified.

From a clinical view, due to the need for individualization of the esthetic parameters for patients with gingival smile, the following questioning can be made: Would gingival smile patients, already considered non-esthetic, have as width/height ideal proportion of upper anterior teeth, the same as patients with ideal smiles? In other words, could the modification of width/height proportion of upper anterior teeth affect the attractiveness of these smiles?

These questioning came up because, after orthodontic treatment of some patients, increasing the size of upper anterior teeth by cosmetic increment of the incisal edges, it was noticed a possible disguise of the gingival smile. Actually, patients reported a sense of reduction on the amount of gingival exposure.

Beside this aspect, it is known that modifying the width/height proportion of upper anterior teeth, the level of exposure of inferior teeth may also be altered. Thus, another question arises: Does the modification of width/height proportion of upper anterior teeth, exposing more or less the inferior teeth, affect the level of attractiveness of the smile's esthetic?

These questions were explored in this study which objective was to evaluate the influence of altering width/height proportions of upper anterior teeth on the attractiveness of three female smiles with 4 mm of gingival exposure.

MATERIAL AND METHODS

A photograph of close up smile was used from three adult Caucasian women between 25 and 33 years old. The selected photographs had good smile's esthetic, absence of restoration procedures on upper anterior teeth and presented a minimum gingival smile of 4 mm.

After selection, images were edited and manipulated with the aid of Adobe® Photoshop® software CS4 (Seattle, USA). Initially they were paired to assure visualization in magnification of 1:1, i.e., during assessment, one millimeter on the image was equivalent to one millimeter on the real patients. For that, it was used the measurement of the clinical crown's height of the upper central incisors from the study model.

Then, the images were edited to correct brightness, contrast, color adjustment and removal of eventual stains or marks that could affect the assessment process. Also, one side of the smile was selected for maintenance and/or creation of some inclusion criteria such as: (A) Gingival exposure of 4 mm;[11] (B) leveled gingival margins of canine and central incisor;[15,16] (C) gingival margin of lateral incisor 0.5 mm below margin of central and canine[11]; (D) incisal edge of lateral incisor 1 mm above the central incisor edge;[17] (E) central incisor length of 10 mm and width of 8 mm creating a height/width proportion of 80%;[18] (F) adequate smile curvature with the edges of upper anterior teeth contouring the lower lip.[16] This way, three new images were created, one for each patient, and called standard images.

These images were then manipulated to create different proportions of upper anterior teeth. For the first proportion, of 80%, the image was mirrored creating perfectly symmetric sides. Five new width/height proportions of central incisors were created: 65%, 70%, 75%, 85% and 90%. For that, based on these proportions, the central incisor length of one side was altered (increased or reduced) and lateral

and canines were also modified (in same magnification) to maintain the characteristics previously described. These five new images were also mirrored to maintain the images' symmetry eliminating another possible bias in the assessment.

As a result of this process, six images were created, with six different width/height proportions of upper anterior teeth, for each patient, totaling 18 images (Fig 1).

All images were manipulated once again to remove lower teeth creating a black mask over this region (Fig 2) totaling another 18 images. From that it was possible to evaluate, initially, the different width/height proportions considering different levels of lower teeth exposure and then excluding this variable.

After this process, an album was assembled, with six sheets, in photographic paper Fujicolor Crystal Archive Paper© (Fujifilm do Brasil Ltda., Manaus, Brazil)

Figure 1 - Example of figures diagramming, for one of the used smiles, with the six width/height proportions assessed, displaying inferior teeth: **A**) 65%; **B**)70%; **C**)75%; **D**)80%; **E**)85% and **F**)90%.

Figure 2 - Example of figures diagramming, for one of the used smiles, with the six width/height proportions assessed, without displaying inferior teeth (black mask): **A**) 65%; **B**)70%; **C**)75%; **D**)80%; **E**)85% and **F**)90%.

size A4 (21.0 cm x 29.7 cm). Each sheet displayed the six smile images, of the same patient, with the different proportions. The images disposition was randomly defined, by draw, given that each patient presented the sequence of six smiles photos displaying all teeth followed by the photos of the same smiles, now with the mask.

The images were subjected to assessment from 30 orthodontists properly enrolled at the Brazilian Association of Orthodontics and Facial Orthopedics and 30 lay people, with graduate level for evaluation of the attractiveness level of each image. Along with the album, each evaluator received a form containing printed simulations with visual analog scales (VAS).

The scales were configured presenting an ascending order of quality from the left to the right. To each evaluator it was explained that it was possible to mark the point in any region of the rule. The visual analog scales[12,13,19,22,25,26] had 10 cm and on the left end it was written "VERY BAD" and on the right end "VERY GOOD". The center was marked to give the evaluator the notion of regular.

After images analysis, the distance between the mark assigned by the evaluator and the left end in all scales, was measured with a digital caliper rule

Table 1 - Mean and standard deviation of patient's 1 smile attractiveness level with presence of inferior teeth.

Overbite Smile	Orthodontists			Laypersons			Difference
	Mean	SD	Results*	Mean	SD	Results*	
65%	20.05	10.92	C	38.55	21.23	B	
70%	28.86	14.13	B	46.31	22.03	A. B	
75%	40.15	17.35	A	45.91	22.07	A. B	**
80%	38.94	20.18	A	54.32	18.58	A	
85%	34.6	18.46	A. B	46.00	18.56	A. B	
90%	28.47	17.51	B	40.89	17.69	B	

*Smiles with the same letters do not differ (p < 0.05). ** Statistically significant difference between the two groups of evaluators (p < 0.05).

Table 2 - Mean and standard deviation of patient's 2 smile attractiveness level with the presence of inferior teeth.

Overbite Smile	Orthodontists			Laypersons			Difference
	Mean	SD	Results*	Mean	SD	Results*	
65%	22.88	15.84	B	34.36	24.99	B	
70%	32.30	19.57	A. B	45.17	21.83	A. B	
75%	38.79	18.91	A	55.19	19.52	A	
80%	36.02	20.06	A	48.01	16.44	A. B	
85%	38.59	22.16	A	51.95	16.67	A	
90%	35.83	20.90	A	44.87	16.64	A. B	**

*Smiles with the same letters do not differ (p < 0.05). **Statistically significant difference between the two groups of evaluators (p < 0.05).

Table 3 - Mean and standard deviation of patient's 3 smile attractiveness level with the presence of inferior teeth.

Overbite Smile	Orthodontists			Laypersons			Difference
	Mean	SD	Results*	Mean	SD	Results*	
65%	24.39	15.05	C	23.96	19.57	B	
70%	30.38	15.88	B. C	34.60	21.77	A. B	
75%	35.32	17.05	A. B	43.81	24.85	A	
80%	44.83	16.53	A	44.66	24.87	A	
85%	40.73	17.41	A. B	39.14	19.07	A	
90%	35.40	17.40	A. B	37.83	24.32	A	

*Smiles with the same letters do not differ (p < 0.05). **There was no statistically significant difference between orthodontists and laypersons (p < 0.05).

Zeusan® (Zeusan, Campinas, Brazil) and were used as measure, in millimeters, of the attractiveness level of each assessed image corresponding to each evaluator's score.[12,13] The data from each survey were compiled in a spread sheet, using Minitab software version 14® (Minitab Inc., State College, EUA), and received statistical treatment. It was applied ANOVA test and Tukey post test to perform comparison between smiles with different proportions. For comparison between both groups of evaluators and between smiles with and without the black mask, student *t* test was used. For all analysis, a significant level of 5% was used

RESULTS

On Table 1, it is possible to observe mean and standard deviation of orthodontists' and laypersons' assessment for the smile of patient 1. According to orthodontists, the scores assigned to smiles with proportions of 75%, 80% and 85% were the highest ones and did not show statistically significant difference with one another. The proportion of 65%, on the other hand, obtained the lowest scores. According to laypersons' opinion the highest scores were the proportions 70%, 75%, 80% and 85% and they did not show statistically significant difference with one another. The proportions of 65% and 90% presented the lowest scores.

Table 4 - Mean and standard deviation of patient's 1 smile attractiveness level with and without black mask covering the lower teeth, for both groups of evaluators.

Different proportions	*Overbite Smile* Orthodontist		With black mask Orthodontist		p	*Overbite Smile* Laypersons		With black mask Laypersons		p
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
65%	20.05	10.92	25.60	16.22	0.126	38.55	21.23	31.67	22.05	0.223
70%	28.86	14.13	25.78	16.44	0.440	46.31	22.03	47.89	22.84	0.786
75%	40.15	17.35	35.35	19.72	0.321	45.91	22.07	50.42	21.28	0.424
80%	38.94	20.18	41.41	18.57	0.623	54.32	18.58	52.94	16.85	0.764
85%	34.6	18.46	39.13	21.39	0.384	46.00	18.56	47.86	17.55	0.692
90%	28.47	17.51	30.93	15.06	0.562	40.89	17.69	41.40	22.97	1.000

Table 5 - Mean and standard deviation of patient's 2 smile attractiveness level with and without black mask covering the lower teeth, for both groups of evaluators.

Different proportions	*Overbite Smile* Orthodontist		With black mask Orthodontist		p	*Overbite Smile* Laypersons		With black mask Laypersons		p
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
65%	22.88	15.84	26.18	17.95	0.453	34.36	24.99	48.18	23.59	0.032
70%	32.30	19.57	31.10	22.36	0.825	45.17	21.83	53.26	22.60	0.164
75%	38.79	18.91	42.10	19.04	0.503	55.19	19.52	60.05	18.40	0.325
80%	36.02	20.06	42.72	21.74	0.220	48.01	16.44	54.76	17.92	0.134
85%	38.59	22.16	36.17	20.47	0.661	51.95	16.67	52.33	17.87	0.932
90%	35.83	20.90	35.97	17.83	0.979	44.87	16.64	42.37	18.73	0.586

Table 6 - Mean and standard deviation of patient's 3 smile attractiveness level with and without black mask covering the lower teeth, for both groups of evaluators.

Different proportions	*Overbite Smile* Orthodontist		With black mask Orthodontist		p	*Overbite Smile* Laypersons		With black mask Laypersons		p
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
65%	24.39	15.05	26.15	12.26	0.622	23.96	19.57	33.80	21.53	0.069
70%	30.38	15.88	28.15	16.80	0.618	34.60	21.77	43.34	22.32	0.130
75%	35.32	17.05	41.78	18.51	0.205	43.81	24.85	50.47	23.09	0.287
80%	44.83	16.53	46.02	16.88	0.783	44.66	24.87	55.29	18.68	0.067
85%	40.73	17.41	49.28	18.27	0.068	39.14	19.07	48.21	23.01	0.059
90%	35.40	17.40	43.48	18.75	0.089	37.83	24.32	44.90	24.36	0.265

On Table 2, shows the mean and standard deviation of orthodontists' and laypersons' assessment for the smile of patient 2. According to orthodontists and laypersons, the scores assigned to smiles with proportions of 70%, 75%, 80%, 85% and 90% were the highest ones and did not show statistically significant difference with one another. The proportion of 65% on the other hand obtained the lowest scores.

On Table 3, it is observed the ratings' mean and standard deviation assigned by orthodontists and laypersons for the smile of patient 3. According to orthodontists, the scores assigned to smile with proportions of 75%, 80%, 85% and 90% were the highest ones and did not have statistically significant difference with one another. The proportion of 65% on the other hand had the lowest scores. According to laypersons' opinion the highest scores were the proportions 70%, 75%, 80%, 85% and 90% and they did not have statistically significant difference with one another. The proportion of 65% presented the lowest score.

The comparison between orthodontists' and laypersons' opinion regarding patients' 1, 2 and 3 smiles, showed that from a total of 18 analyses, 16 did not have statistically significant difference. Only for patient 1, at a proportion of 75% and for patient 2, at a proportion of 90% these scores revealed statistically significant difference, with laypersons assigning higher scores than orthodontists. Tables 4, 5, 6 show student's *t* test, applied to compare the smiles with and without display of lower arch teeth, using a black mask to cover them. It is possible to observe that for all situations there was no statistically significant difference between the scores assigned to the two types of assessed smiles.

DISCUSSION

Cosmetic dentistry concepts present several considerations about the dental proportion and morphology. The width/height proportion considered as "gold standard" determines that the width of superior central incisors must be of approximately 80% of its height, with accepted variation between 75% to 85%.[15,16,18] However these proportions were established for ideal smiles, with no gingival exposure when smiling.

The analysis of the present study showed that the proportions of 75%,80% and 85%, received the highest scores, from laypersons and orthodontists for the three assessed smiles. The hypothesis raised previously in this research, that longer teeth, i.e. with smaller width/height proportions (65% and 70%), would be capable of disguising the excessively gingival smile was not accepted. The clinical impact on these data is that the specialties directly related to cosmetics, such as Restorative Dentistry and Dental Prosthesis will not have great results on the masking of gingival smile. The increase of white esthetic, i.e., resin increments or longer upper anterior prosthesis, aiming to increase the dental length (reducing the width/height proportion), according to our results would not be capable to disguise the gingival excess. It is suggested for patients with gingival smile a specific approach to the gingival tissue, that affect directly the problem: The amount of exposed gingiva. This approach is multidisciplinary and may involve Periodontics, when it is identified gingival excess on probing, having as solution the procedure of gingivectomy. In cases of maxillary vertical excess, the problem's solution involves orthognathic surgery and in cases of interrelation with esthetic medicine, in which the problem's etiology may be associated to hyperactivity of muscles responsible for the upper lip elevation during smile.[14] In these cases some procedures are available, among them is the use of silicone at the bottom of the vestibule, the infiltration of Botulinic toxin and resection procedures on the muscles responsible for the upper lip mobility.[20,21]

It was also observed that in some smiles the proportions of 70% and 90% were also considered the most attractive ones. This variability can be explained due to the subjectivity of the smile attractiveness assessment. These findings emphasize the necessity of individualization of esthetic planning for the upper anterior region. Some authors[11-13,22] recommend that these results should be discussed with patients, once the preference for longer or shorter teeth, may vary among individuals. In this study, smiles images were digitally manipulated to test the esthetic perception of individuals for a certain variant. For this purpose, the proposed methodology used visual analog scales, a methodology frequently used in literature[12,13,19,22,25,26]

for it allows the use of appropriate statistical tests to compare the scores assigned to different types of smiles, as well as for the different groups of raters. Thus, the proportion of esthetic zone as a whole was altered, avoiding an excessive disproportion between central incisors, lateral incisors and canines. Besides, for the evaluation of the photographs' attractiveness, a close-up image of the smile was used, for literature does not show difference between this type of visualization and full face analysis.[13,23]

Another important finding was the absence of a statistically significant difference between smiles with and without display of inferior teeth. These two forms of evaluation were necessary to identify the possible influence of the presence of inferior teeth on the smile's perceived esthetic. When smile images are manipulated to created different proportions, the evaluators analyze two variants: The different proportions individually and the amount of vertical exposure of inferior teeth. This aspect can be considered a methodological bias, according reports in the literature of studies that were evaluating a single smile characteristic, and after manipulating the images, the raters end up assessing two variants of the smile,[11-13,17,22-24] making the results questionable. To fix this problem, it was incorporated a black mask covering all inferior teeth to allow the individualization of proportions modification on the smile attractiveness. Ker[24] found greater preference for smiles that presented deep overbite over reduced overbite ones. The data found in the present study do not confirm these findings, for the comparison between smiles with and without black mask did not present statistically significant difference, evidencing that variation in the extent of inferior teeth exposure did not affect the attractiveness of the assessed smiles.

Another important factor was the use of three smiles with different esthetic variants, that allowed evaluation of different smile components, such as wide, medium and narrow buccal corridors, teeth shapes (more squared or more rounded), and even lip thickness, from larger to thinner ones. Some studies found in literature used only one manipulated smile for the attractiveness assessment of a chosen variant.[11,22,23,24] In this methodology, the results can be questioned, for the opinion will be directed to only one type of smile. On the other hand, other authors[12,13] used more than one smile on their methodology. Similarly, we used three smiles to attenuate this problem and obtain further conclusions about the variant width/height proportion of teeth in the esthetic zone.

In this study, the evaluators were orthodontists and laypersons. The first group was chosen because previous researches showed that they are more strict on the identification of deviation from the ideal concept.[11,12,22,25,26] The group of laypersons was chosen because they are the main consumers of dental services, instead of professionals who provide these services.[39] Literature shows that orthodontists are more critical than laypersons, assigning lower scores.[11,12,22,25,26] However, in most situations, our study did not find significant differences between these two groups of evaluators.

It is important to emphasize the present study assessed smiles that already had a very low level of attractiveness, due to increased level of gingival exposure (4 mm). The choice for this value is justified because literature shows that for different groups of individuals, smiles with this level of gingival exposure are considered non-esthetic.[11,12,13,22] This aspect can be proven by the higher mean scores assigned to the smiles. Among them, the ones considered more attractive obtained means around 60 points. Thus, it can be concluded that this statistic equivalence of opinions between these groups may have been affected by this variant. In other words, the modification on teeth's width/height proportion in the esthetic zone did not affect the smile attractiveness nor affected the esthetic perception of the distinct evaluators. Besides, when evaluating laypersons' scores, it was observed high values of standard deviation, which affects the statistical analysis of comparison between groups, approaching the similarity with one another. It occurs because the attractiveness evaluation is a subjective characteristic, being more evidenced on the smile assessment by laypersons.

CONCLUSION

According to the results obtained in this research, it can be concluded that:

1) Generally, the width/height proportions of upper anterior teeth that received the highest

scores were of 75%, 80% and 85% in both groups of evaluators, orthodontists and laypersons. On the other hand, the width/height proportion of upper anterior teeth of 65% received the lowest scores from the two groups of evaluators ($p < 0.05$).

2) When comparing the opinion of orthodontists and laypersons regarding the three assessed smiles, it was verified that in most situations the scores in both groups did not present significant statistic difference with one another ($p > 0.05$).

3) When comparing the smiles with and without display of inferior teeth, it was not observed a statistically significant difference in all situations ($p > 0.05$).

REFERENCES

1. Machado AW, Santos TC, Araujo TM, Gandini Júnior LG Integração Ortodontia e Dermatologia na busca da excelência na estética labial. Rev Clín Ortodon Dental Press. 2010 Jun-Jul;9(3):47-56.
2. Hulsey CM. An esthetic evaluation of lip-teeth relationship present in the smile. Am J Orthod. 1970 Feb;57(2):132-44.
3. Legan HL, Burstone CJ. Soft tissue cephalometric analysis for orthodontic surgery. J Oral Surg. 1980 Oct;38(10):744-51.
4. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod. 1993;63(3):183-189.
5. Levine RA, Macguire M. The diagnosis and treatment of the gummy smile. Compend Contin Educ Dent. 1997 Aug;18(8):757-62.
6. Ahmad I. Geometric considerations in anterior dental aesthetics: restorative principles. Pract Periodontics Aesthet Dent. 1998 Sep;10(7):813-22.
7. Peck S, Peck l, Kataja, M. The gingival smile line. Angle Orthod. 1992; 62(2):91-100.
8. Graber TM, Vanarsdall JR. Ortodontia: princípios e técnicas atuais. 3a ed. Rio de Janeiro: Guanabara Koogan; 2002.
9. Câmara CALP. Estética em Ortodontia: Diagramas de Referências Estéticas Dentárias (DRED) e Faciais (DREF). Rev Dental Press Ortodon Ortop Facial. 2004 Nov-Dez;11(6):130-56.
10. Geron S, Atalaia W. Influence of sex on the perception of oral and smile esthetics with different gingival display and incisal plane inclination. Angle Orthod. 2005 Sep;75(5):778-84.
11. Kokich VO, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthetic Dent. 1999 Nov;11(6):311-24.
12. Suzuki L, Machado AW, Bittencourt MAV. Perceptions of gingival display aesthetics among orthodontists, maxillofacial surgeons and laypersons. Rev Odonto Ciênc. 2009 Jul;24(4):367-71.
13. Suzuki L, Machado AW, Bittencourt MAV. An evaluation of the influence of gingival display level in the smile esthetics. Dental Press J Orthod. 2011 Sept-Oct;16(5):37.e1-10.
14. Seixas MR, Costa-Pinto RA, Araújo TM. Checklist dos aspectos estéticos a serem considerados no diagnóstico e tratamento do sorriso gengival. Dental Press J Orthod. 2011 Mar-Abr;16(2):131-57.
15. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. J Prosthet Dent. 1973 Apr;29(4):358-82.
16. Rufenacht CR. Fundamentals of esthetics. Chicago (IL): Quintessence; 1990.
17. King KL, Evans CA, Grace V, Begolle E, Obrez A. References for vertical position of the maxillary lateral incisors. World J Orthod. 2008;9(2):147-54.
18. Levin EL. Dental esthetics and golden proportion. J Prosthet Dent. 1978 Sep;40(3):244-52.
19. Maple JR, Vig KW, Beck FM, Larsen PE, Shanker S. A comparison of providers' and consumers' perceptions of facial-profile attractiveness. Am J Orthod Dentofacial Orthop. 2005 Dec;128(6):690-96.
20. Simon Z, Rosenblatt A, Dorfman W. Eliminating a gummy smile with surgical lip repositioning. J Cosmetic Dentistry. 2007;1(23):100-8.
21. Polo M. Botulinum toxin type A in the treatment of excessive gingival display. Am J Orthod Dentofacial Orthop. 2008 Feb;133(2):195-203.
22. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.
23. Rodrigues CDP, Magnani R, Machado MS, Oliveira OB. The perception of smile attractiveness. Angle Orthod. 2009 Jul;79(4)4:634-9.
24. Ker AJ, Chan R, Fields HW, Beck M, Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective: a computer-based survey study. J Am Dent Assoc. 2008 Oct;139(10):1318-27.
25. Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod. 2006 Jul;76(4):557-63.
26. Pinho S, Ciriaco C, Faber J, Lanza MA. Impact of dental asymmetries on the perception of smile esthetics. Am J Orthod Dentofacial Orthop. 2007 Dec;132(6):748-53.

Influence of *in vitro* pigmenting of esthetic orthodontic ligatures on smile attractiveness

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Objective: To evaluate the perception of dental students and orthodontists on the degree of influence that pigmented esthetic elastic ligatures have on smile attractiveness, by judging clinical photographs.

Methods: Sixteen clinical facial photographs of the smile and 16 close up images of the smile of a single patient wearing monocrystalline porcelain orthodontic brackets, Teflon coated NiTi wire brackets and esthetic elastic ligatures of five different commercial brands were distributed into eight groups, G1 to G8 (Morelli®, Ortho Tecnology™, TP Orthodontics™, Unitek/3M™clear, Unitek/3M™ obscure, American Orthodontics™ clear, American Orthodontics™ pearl and American Orthodontics™ metallic pearl). Twenty ligatures were used in each group, totaling 160 ligatures. Half of them were used in their natural state, and the other half after *in vitro* pigmentation. All the photographs were judged by 40 evaluators, 20 orthodontists and 20 dental students.

Results: For orthodontists, American™ pearl (G7) ligatures were those that least influenced the degree of attractiveness of the smile in the two types of photographs used. For the dental students, in the facial photographs of the smile, ligatures with the best performance were Morelli® (G1), American™ clear (G6) and American™ pearl (G7) and in the close up photographs of the smile, American™ pearl, metallic pearl and clear (G7, G8 and G6).

Conclusions: For both orthodontists and dental students, pigmentation of the elastic ligatures had a negative influence on the degree of attractiveness of smiles in the two types of clinical photographs evaluated.

Keywords: Elastomers. Esthetics. Pigmentation. Photograph. Smile.

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

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INTRODUCTION

Elastic ligatures are accessories commonly used in orthodontics and have wide application in holding the arch wires to the brackets.

Some laboratory studies have proved that these elastomeric materials are susceptible to pigmentation when in contact with some pigments, saliva and bacteria.[1,2,3] This leads to a reduction in their useful life and compromises esthetics during the course of treatment. These alterations have a direct relationship with the composition, raw material quality and degree of technology used in their manufacture, which in turn, varies greatly according to each manufacturer.[4,5,6]

With the purpose of masking these pigments, many manufacturers add colors to ligatures, however, this procedure makes them unsuitable for use in esthetic appliances. Moreover, acceptance of the use of colored ligatures varies a great deal according to the patients' gender and age.[7,8]

Knowledge about the alterations in their physical and mechanical properties is of great interest for the clinical application of these materials, considering that they may remain in the oral cavity for an average of 30 days, and during this interval, it is very important for the properties with regard to elasticity and esthetics to remain stable.[1,4,5,6,9,10,11]

When evaluating the susceptibility to pigmentation of elastic orthodontic ligatures, some authors have used digital photographs and computerized analysis by means of the Adobe Photoshop program, and have concluded that these ligatures underwent change in color after an *in vitro* process of pigmentation. However, there are still no studies that prove the clinical relevance of these color alterations on the appearance of the orthodontic appliance set during the smile.

Evaluations made by means of photographs may be used to analyze color alterations of various types of dental materials, as well as in analyzing facial attractiveness and esthetics and of the smile, before, during and after orthodontic treatment by the most diverse group of examiners possible.[8,12,13,14,15,16,17]

Knowing that the phenomenon of color is a psychophysical response to the light/object interaction, which depends on the individual subjective perception of the observer, and with the aim of obtaining greater knowledge about the esthetic influence of these pigmented elastomer materials on the appearance of the patient's smile during orthodontic treatment, makes it necessary to conduct clinical studies on the mentioned subject.

With this intention, the perception of the degree of influence esthetic elastic ligatures submitted to a process of pigmentation have on the attractiveness of the smile was evaluated between dental students and orthodontists by means of judging clinical photographs

MATERIAL AND METHODS

The present study is characterized by an experimental approach in which clinical facial photographs of the smile, and of the close up of a smile were used. The photographs had been taken of a single adult patient with a harmonious face and smile,[14] who had adequate tooth alignment and leveling in the maxillary arch, required fixed orthodontic treatment, and wished to use an esthetic appliance.

The sample consisted of 16 clinical facial photographs of the smile (12.8 cm x 17.1 cm) and 16 close up images of the smile (19.2 cm x 9.07 cm) of a single patient.

The orthodontic appliance was composed of monocrystalline porcelain brackets (Ortho Technology™, Tampa, Florida, USA), NiTi wire 0.016-in Teflon coated (PTFE – polytetrafluorethylene), shade A2 (Beijing Smart Technology CO™, Beijing, China) and esthetic elastic ligatures of five different commercial brands, distributed into eight groups, G1 to G8 (Morelli®, Sorocaba, São Paulo, Brazil, Ortho Technology™, Tampa, Florida, USA, TP Orthodontics™, La Porte, Indiana, USA, Unitek/3M™clear, Unitek/3M™obscure, St. Paul, Minnesota, USA, American Orthodontics™ clear, American Orthodontics™ pearl and American Orthodontics™ metallic pearl, Sheboygan, Wisconsin, USA).

Twenty ligatures were used in each group, totaling 160 ligatures. Half of them were used in their natural state, and the other half were submitted to an *in vitro* pigmentation process, as has previously been performed by other authors,[2] by immersion in a solution composed of 250 ml of each of the following solutions: coffee, black tea, red wine, Coca-Cola soft drink without gas, infusion made with a roll of tobacco and artificial saliva.

The ligatures were placed in disposable plastic cups, previously identified and separated into groups. The homogenized pigmentation solution was deposited into each of these cups covered with PVC film (polyvinyl chloride), and all the were stored in a plastic

receptacle with a lid on, and placed in an oven (Biomatic – VOLT:220/110, AMP: 2/4, WATTS: 400) at 37°C for five days.[18] Five days of immersion was defined after conducting a pilot study in which the ligatures from all the groups went through a pigmentation process for ten days. Only on the fifth day was there evident visual differentiation between the degree of pigmentation and the ligatures in each of the evaluated groups.

After removing the cups from the oven, each of the ligatures was removed with Mathieu plier (Starlet®, São Paulo, São Paulo, Brazil), rinsed in tap water for five seconds, dried with absorbent paper, stored in new, dry disposable plastic cups, also previously identified according to each group, and immediately used for taking the photographs.

The present study was approved by the Research Ethics Committee of the UFBA School of Dentistry, Protocol Number 37/10 and registered with SISNEP FR 357694, CAAE 0023.0.368.000-10 on November 12, 2010.

After the patient had signed the Free and Informed Consent Term, the research began with placement of the maxillary fixed appliance from the central incisors to the second premolars. After the orthodontic brackets were bonded, the esthetic wire was introduced and fixed to the brackets by means of the elastic ligatures distended using the Mathieu pliers (Starlet®, São Paulo, São Paulo, Brazil). Initially ligatures without pigmentation were used, and eight facial photographs were taken (F) and eight close up photographs of the smile (SA) (Fig 1). Afterwards, the same procedure was performed with pigmented ligatures, totaling 32 photographs. To distinguish the groups of photographs, those that were taken with pigmented ligatures had the letter "P" added (FP and SAP) (Fig 2).

To standardize the photographs, the patient's head was positioned with the aid of the head positioners of a cephalostat fixed to the clinic wall, in which the patient sat, with the Frankfort plane and bipupilar line parallel to the ground. In addition, the patient was instructed to keep a posed smile[14,19] at the time the photographs were taken. In order to obtain a real front view contour of the patient's face, the two head positioners of the cephalostat were at the same distance from the camera, at 90º. This position was determined by the coincidence between the two points previously demarcated on the cephalostat with the

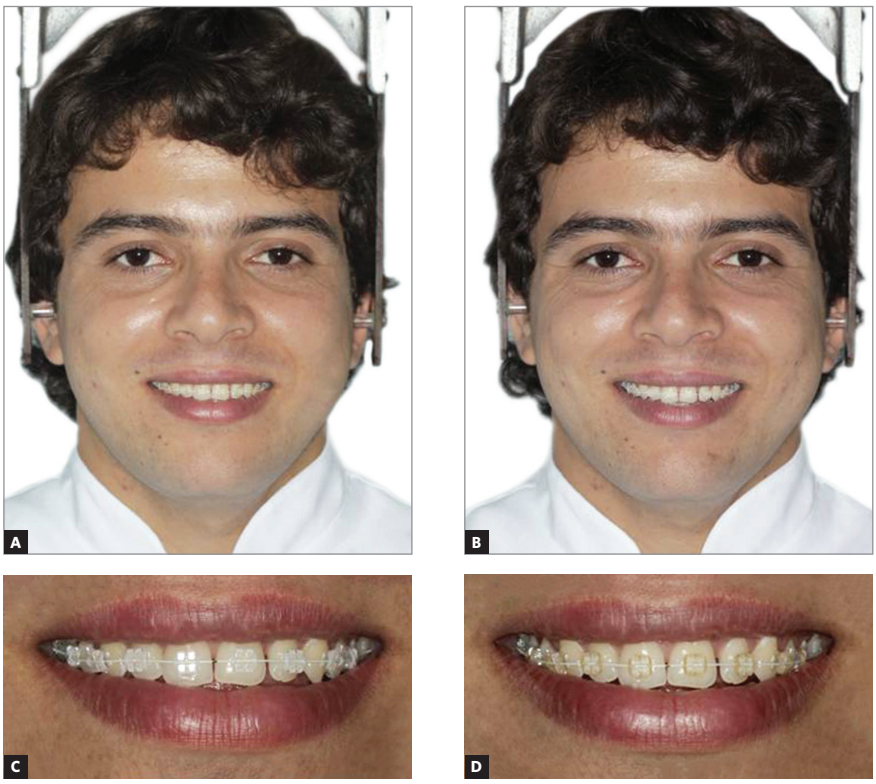

Figure 1 - Facial photographs of the smile: (**A**) without pigmentation and (**B**) with pigmentation. Close up photographs of the smile: (**C**) without pigmentation and (**D**) with pigmentation.

Table 1 - Distribution of elastic ligatures in the sample of photographs. *G - Group; F – Facial Photograph; FP – Pigmented Facial Photograph; SA – Close up Photograph of the Smile; SAP – Pigmented Close up Photograph of the Smile.

Brand	Shade	Groups	Facial photographs		Close up photographs of the smile	
			Without Pigmentation	With pigmentation	Without Pigmentation	With pigmentation
Morelli	Cristal	G1	G1F	G1FP	G1SA	G1SAP
Ortho Technology	Pearl	G2	G2F	G2FP	G2SA	G2SAP
TP Orthodontics™	Clear	G3	G3F	G3FP	G3SA	G3SAP
Unitek/3M	Clear	G4	G4F	G4FP	G4SA	G4SAP
Unitek/3M	Obscure	G5	G5F	G5FP	G5SA	G5SAP
American Orthodontics™	Clear	G6	G6F	G6FP	G6SA	G6SAP
American Orthodontics™	Pearl	G7	G7F	G7FP	G7SA	G7SAP
American Orthodontics™	Metalic Pearl	G8	G8F	G8FP	G8SA	G8SAP
TOTAL			8	8	8	8

aid of a protractor (Unitek/3M™, St. Paul, Minnesota, USA), one on the base and the other on the rotating support.[20] This setting enabled one to record the patient's real facial image and her approximate smile.

Digital photographic equipment EOS Rebel-EOS T1-i (Canon) was used, with a Macro EF 60 mm (Canon) lens and circular flash MR14EX (Canon), with exposure compensation of +1. The distance between focus and object was 1.0 m for the facial photographs of the smile, and 44 cm for the smile close up. The speed used was 1/125 s with a diaphragm aperture of 8.0.

After having obtained the 32 photographs, an album was prepared, using eight pages of photographic paper Fujicolor Crystal Archive Paper® (Fujifilm do Brasil Ltda., Manaus, Amazonas), size A3 (29.5 cm x 40.5 cm) containing four photographs per page. All the images were named according to the group to which each commercial brand belonged, and whether or not they were pigmented. The order of disposition of each photograph in the album, facial (F) or close up smile (SA), was defined in increasing numerical order of the group of the commercial brand of ligatures. These numbers were randomly defined, and only the researcher responsible for the project had information about the commercial brand to which each group belonged. The first 16 photographs were facial, and the following were the close up smile, both non pigmented and pigmented in this sequence.

For esthetic evaluation of the smile, all the photographs were judged by 40 evaluators, of whom 20 were orthodontists, members of the Bahia Orthodontic Association - ABOR-BA - ("Associação de Ortodontia da Bahia"), aged between 28 and 58 years (mean of 37.8 years), with time since graduation ranging between one and 32 years (mean of 10.8 years) and 20 dental students, from the 1st semester of the undergraduate course in dentistry at the Federal University of Bahia (UFBA, "Universidade Federal da Bahia"). Although these students already had a certain degree of instruction, at this academic stage, they did not yet have the technical-scientific knowledge of an orthodontist, and for the purpose of the present study, were considered lay persons. The number of evaluators was defined after sample calculation, in accordance with the mean obtained from the quantity of pigmentation, with a level of significance of 5% and power of 80%.

Together with the photograph albums, each examiner received a form containing 32 rulers (visual analog scale), one for each photograph. Afterwards, they were asked to mark with a vertical line, the degree of satisfaction with the esthetics of the set formed by the brackets, wire and esthetic ligatures for each of the photographs. The evaluators were instructed that it would be possible to mark the line in any region of the ruler. The visual analog scale[15,16,17,21,22] is 40 mm long, and on its extreme left, the words "VERY BAD" and on the extreme right "VERY GOOD" are written. The distance, in millimeters between the mark made by the evaluator of the photograph and the point at the extreme left served as measurement of the degree of attractiveness of each smile evaluated.[21] The forms were applied to the examiners belonging to the group of dental students at the end of a regular undergraduate lesson. To the orthodontists, the forms were applied at the Orthodontic and Facial Orthopedic Center of Prof. José Édimo Soares

Martins, or at his consulting rooms, so that the degree of lighting in these rooms was adequate and did not compromise evaluation of the photographs.

The data from each questionnaire were compiled in a spreadsheet, and after this, they underwent statistical treatment. Initially, the central trend and dispersion measurements were calculated, and after confirmation of normality of the data, the Student's t -test and ANOVA were performed, with a level of significance of 5% to define the difference between them. The Kappa test was performed to evaluate agreement among the orthodontists themselves, among the dental students themselves, and between the dental students and orthodontists. For the orthodontists, Kappa 0.91 and among the dental students 0.87 was obtained, which means there was very good agreement among the evaluators of each group, but there was statistical difference between the two groups.

RESULTS

Facial photographs of the smile

The evaluation of the orthodontists and dental students varied with regard to the amount of loss of esthetics of the smile after pigmentation. According to the orthodontists, these alterations were very significant, as the smiles in which the patient was using the American™ pearl (G7), American™ metallic pearl (G8) and Morelli® (G1) were those that underwent the least alterations as regards degree of attractiveness. For the dental students these differences were smaller and the ligatures that least influenced the esthetics of the smile were Morelli® (G1), American™ clear (G6) and American™ pearl (G7) (Fig 2). Whereas those with the most unfavorable behavior, both from the point of view of orthodontists and dental students were ligatures of the Ortho Technology™ (G2) and Unitek/3M™ obscure (G5) commercial brands, respectively (Fig 2).

In the analysis of the absolute values with reference to the degree of attractiveness attributed to this type of photograph, it was verified that the orthodontists evaluated the smiles in which the ligatures were without pigmentation (F) as being more esthetic than the dental students did, whereas their scores for attractiveness of the smiles obtained higher means, and there were statistically significant differences in all the groups (Table 2). As regards the photographs with ligatures submitted to pigmentation (FP), the orthodontists were stricter and attributed lower scores to all groups, however, the majority without statistically significant difference, except for those in Group G8FP (p=0.02), in which the dental students did not identify the presence of important darkening in this group, and attributed much higher scores than the orthodontists did (Table 2). For the orthodontists, all the ligatures used were pigmented to a considerable extent.

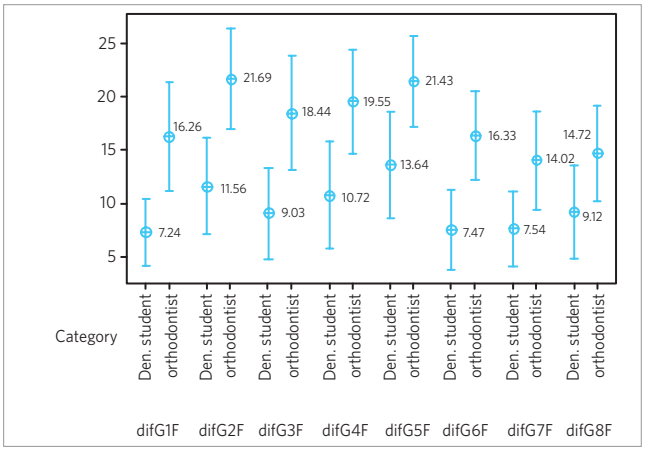

Figure 2 - Mean and standard deviation of the difference FP – F between the commercial brands and categories evaluated.

Table 2 - Mean, standard deviation F and FP and p value of the difference between the professional categories in each group.

Group	Dentistry Students mean (SD)	Orthodontists mean (SD)	p value
G1F	22.78 (8.68)	32.02 (6.35)	0.00*
G1FP	16.99 (9.42)	15.85 (10.04)	0.70
G2F	27.17 (7.41)	34.61 (5.35)	0.00*
G2FP	16.10 (8.33)	15.80 (10.04)	0.29
G3F	25.89 (7.63)	32.79 (6.36)	0.01*
G3FP	17.13 (9.16)	14.35 (11.11)	0.39
G4F	27.59 (7.58)	33.90 (6.09)	0.01*
G4FP	19.28 (9.82)	14.34 (10.25)	0.13
G5F	29.07 (5.00)	34.00 (5.61)	0.01*
G5FP	15.52 (10.11)	12.57 (9.38)	0.35
G6F	28.73 (6.53)	33.68 (6.17)	0.02*
G6FP	22.32 (8.90)	17.35 (9.39)	0.09
G7F	26.03 (8.65)	33.18 (6.09)	0.01*
G7FP	23.99 (8.48)	19.36 (10.87)	0.14
G8F	24.45 (9.75)	31.89 (7.82)	0.01*
G8FP	24.28 (7.85)	17.17 (9.72)	0.02*

*Statistically significant difference.

Close up photographs of the smile

In these photographs the orthodontists' and dental students' evaluation was very close as regards the amount of loss of esthetics after pigmentation. According to the orthodontists the smiles that showed smaller variations were those in which the patient was using American™ pearl (G7) ligatures. Whereas for the dental students, they were American™ pearl (G7), metallic pearl (G8) and clear (G6) (Fig 3). Those with the most unfavorable behavior, according to the orthodontists, were Ortho Technology™(G2), Unitek/3M™ (G4) and TP Orthodontics™ (G3), respectively, and according to the dental students they were Ortho Technology™(G2) and Morelli® (G1) (Fig 3).

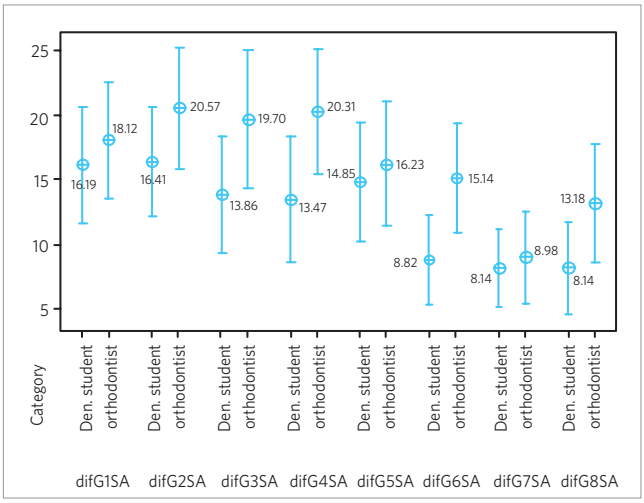

Figure 3 - Mean and standard deviation of the difference SAP – SA between the commercial brands and categories evaluated.

Table 3 - Mean, standard deviation SA and SAP and p value of the difference between the professional categories in each group.

Group	Dentistry students Mean (SD)	Orthodontists Mean (SD)	p value
G1SA	32.51 (5.19)	33.75 (6.82)	0.52
G1SAP	14.29 (7.43)	12.89 (8.59)	0.59
G2SA	31.79 (5.47)	33.49 (7.85)	0.43
G2SAP	11.84 (7.34)	10.46 (7.72)	0.57
G3SA	30.95 (5.23)	34.05 (6.38)	0.10
G3SAP	12.04 (6.77)	9.89 (7.93)	0.36
G4SA	30.85 (7.86)	34.65 (6.28)	0.10
G4SAP	11.77 (7.09)	9.51 (8.16)	0.36
G5SA	30.10 (4.99)	28.80 (9.54)	0.59
G5SAP	13.39 (8.11)	8.56 (6.25)	0.04*
G6SA	30.68 (5.23)	32.23 (8.39)	0.49
G6SAP	15.44 (7.04)	12.12 (8.05)	0.17
G7SA	29.26 (5.32)	25.40 (10.70)	0.16
G7SAP	19.73 (5.03)	16.81 (8.97)	0.21
G8SA	31.30 (4.78)	29.75 (9.43)	0.52
G8SAP	19.12 (9.68)	12.23 (7.67)	0.02*

*Statistically significant difference.

In the analysis of absolute values with reference to the degree of attractiveness attributed to this type of photograph, there was no clear difference between the evaluations made by dental students and orthodontists. Both groups attributed high scores to all the photos in which the ligatures were not pigmented (SA) and low scores to the majority of those with pigmented ligatures (SAP), except for those with Unitek/3M™ obscure (G5SAP) (p = 0.04) and American™ metallic pearl (G8SAP) ligatures (p = 0.02), in which the dental students did not observe important variations in the attractiveness of the smile (Table 3).

DISCUSSION

Some laboratory studies have proved that esthetic elastic ligatures are susceptible to pigmentation when in contact with some types of pigments[1,2,3]. Nevertheless, these color changes were observed only by means of a computer program, thus did not evaluate as from which point these alterations could be noted in daily life, and become disturbing to the patient.

In 2009, Cavalcante[2] observed that the brand that showed the worst performance; that is to say, that became most pigmented was Unitek/3M™ obscure, which is confirmed by the present study, in which the commercial brands of ligatures that most compromised the degree of attractiveness of the smile clinically after pigmentation, in the evaluation by both orthodontists and dental students of the facial photographs of the smile were Unitek/3M™ obscure (G5) and Ortho Technology™ (G2). This could not be observed in the close up of the same, in which the data of these two studies differ, as the orthodontists indicated the brands Ortho Technology™ (G2), Unitek/3M™ clear (G4) and TP Orthodontics™ (G3) and the dental students the commercial brands Ortho Technology™ (G2) and Morelli® (G1) as those that had the greatest degree of variation.

In the present study, according to the orthodontists, the degree of attractiveness of the smiles with the ligatures American™ pearl (G7) were those that underwent the smallest alterations in the two types of photographs used, which differs from the data

previously found,[2] in which the ligatures that became least pigmented were those of the TP Orthodontics™ and American™ Clear brands.

According to the dental students, the smiles that underwent the smallest variations were those in which the patient was using Morelli® (G1), American™ clear (G6) and American™ pearl (G7) ligatures in the facial photographs of the smile, and American™ pearl, metallic pearl and clear (G7, G8 and G6) in the close up photographs of the smile, obtaining a result close to those found by other authors,[2,1] in which the American™ clear ligatures were also considered among the most stable.

Nevertheless, Cavalcante[2] evaluated color changes by means of computerized comparison, using the Adobe Photoshop program RGB indices, color histogram observation at the level of red, green and blue of digital photographs of pigmented and unpigmented ligatures, instead of clinical evaluation of photographs, as was done in the present study. A similar evaluation was performed in another study[1], in which the variation in ligature pigmentation was evaluated only by means of a color measuring device.

Thus, it could be concluded that the perception and interpretation of color are subjective, and can vary according to the type of evaluator.[12,17] Moreover, an isolated numerical evaluation alone is not sufficient for an adequate observation of the color changes each elastic ligature undergoes, as the factors such as the oral environment itself and the set formed by the tooth, bracket and ligature may mask the results of color changes that have already been proved numerically.

Knowing that the degree of stability as well as the other physical and mechanical properties of each of these ligatures is directly related to its components and the particular manufacturing process of each of the commercial brands, it is important to understand that the variation between the natural, non pigmented state and pigmented state (Δ) is more important than the initial and final absolute color values of each of them, since we cannot ignore the initial characteristics inherent to the material[1] which, undoubtedly, will have a repercussion on the final aspect of the ligature evaluated.

This fact associated with the interval between consultations during orthodontic treatment will have a direct influence on the indication and use of the esthetic elastic ligature, in the same way as it influenced the selection of the type of esthetic bracket.[18] Therefore, before treatment begins, some aspects of esthetic accessories with respect to pigmentation must be explained to patients, so that unpleasant surprises concerning color alteration do not arise during the course of treatment.

In the present study, the pigmentation was performed *in vitro*, because of the difficulty of standardizing variables such as the patient's diet and oral habits during the entire period required for conducting the research. However, the number of days of immersion of the ligatures in the pigmentation solutions was defined so that it would very closely simulate the clinical pigmentation process so commonly observed in orthodontic practice. Thus, five days of immersion was defined after conducting a pilot study in which the ligatures from all the groups went through a pigmentation process for ten days. It may be observed that it was only on the fifth day that there was evident visual differentiation between the degree of pigmentation among the ligatures used in the study, and that as from this day, not only was there little difference among the groups, but the degree of pigmentation obtained was higher, with the ligatures being much darker than is routinely observed in clinical practice after an interval of 21 days between consultations.

The posed smile[14,19] was used to enable visualization of the set formed by the tooth, bracket and ligatures. For this evaluation, the presence of subtle variables in the standardized photographs was not relevant to the investigation. Moreover, this research did not relate the color alterations with degradation of the effectiveness of elastic ligatures, and therefore, the brands with the best color stability may not necessarily correspond to the brands with the best clinical effectiveness. Thus, further studies must be conducted to elucidate this question.

It is therefore, of fundamental importance for the professional to know the behavior of esthetic ligatures before using them, because specific aspects of color, type of diet and time the ligature remains in the oral medium will influence the final esthetic appearance of the orthodontic appliance, and may frustrate the expectations of a patient who did not receive a previous explanation about the possibility of pigmentations.[1,2] It is therefore the professional's responsibility to select the commercial brands for daily use, which provide the least loss in degree of attractiveness of the smile during the course of orthodontic treatments that require the use of esthetic devices.

CONCLUSIONS

1) According to the orthodontists, there were alterations in the degree of attractiveness of the smile to a very significant extent when pigmented ligatures were used, with those of the American™ pearl (G7) brand being the ones that underwent the smallest alterations in the two types of photographs used.
2) According to the dental students, these differences were smaller and the ligatures with the least influence on the attractiveness of the smile were Morelli® (G1), American™ clear (G6) and American™ pearl (G7) in the facial photographs of the smile, and American™ pearl, metallic pearl and clear (G7, G8 and G6) and in the close up photographs of the smile.
3) The ligatures that most compromised the degree of attractiveness of the smile, clinically, after pigmentation, both in the evaluation of orthodontists and dental students were Ortho Technology™ (G2) and Unitek/3M™ obscure (G5) in the facial photographs of the smile. In the close up photographs of the smile, the orthodontists pointed out the brands Ortho Technology™ (G2), Unitek/3M™ clear (G4) and TP Orthodontics™ (G3) and the dental students those of the brands Ortho Technology™ (G2) and Morelli® (G1).

REFERENCES

1. Ardeshna AP, Vaidyanathan TK. Colour changes of orthodontic elastomeric module materials exposed to in vitro dietary media. J Orthod. 2009 Sep;36:177-185.
2. Cavalcante J. Avaliação da suscetibilidade à pigmentação de ligaduras elásticas ortodônticas utilizando fotografia digital [Dissertação]. Salvador (BA): Universidade Federal da Bahia, Faculdade de Odontologia; 2009.
3. Kim S, Lee Y. Mensurement of discoloration of orthodontic elastomeric modules with a digital camera. Eur J Orthod. 2009 May;31:556-562.
4. Martins MM, Mendes AM, Almeida MAO, Goldner MTA, Ramos VF, Guimarães SS. Estudo comparativo entre as diferentes cores de ligaduras elásticas. Rev Dental Press Ortodon Ortop Facial. 2006 Jul-ago;11(4):81-90.
5. Taloumis LJ, Smith TM, Hondrum SO, Lorton L. Force decay deformation of orthodontic elastomeric ligatures. Am J Orthod Dentofac Orthop. 1997 Jan;111(1):1-11.
6. Wong AK. Orthodontic Elastic Materials. Angle Orthod. 1976 Apr;46(2):196-204.
7. Elekdag-Turk S, Ozkalayci N, Isci D, Turk T. Color Preferences of Patients Receiving Elastic Ligatures. Eur J Dent. 2010 Apr;4:171-4.
8. Walton DK, Fields HW, Johnston WM, Rosenstiel SF, Firestone AR, Christensen JC. Orthodontic appliance preferences of children and adolescents. Am J Orthod Dentofac Orthop. 2010 Dec;138(6):698-9.
9. Loriato LB, Machado AW, Pacheco W. Considerações clínicas e biomecânicas de elásticos em ortodontia. Rev Clín Ortodon Dental Press. 2006 Fev-Mar;5(1):43-55.
10. Renick MR, Brantley WA, Beck FM, Vig KWL, Webb CS. Studies of orthodontic elastomeric modules. Part 1: Glass transition temperatures for representative pigmented products in the as-received condition and after orthodontic use. Am J Orthod Dentofac Orthop. 2004 Sep;126(3):337-43.
11. Souza EV, Mendes AM, Almeida MAO, Quintão CCA. Percentual de degradação das forças liberadas por ligaduras elásticas. Rev Dental Press Ortodon Ortop Facial. 2008 Mar-Abr;13(2):138-45.
12. Berto PM, Lima CS, Lenza MA, Faber J. Esthetic effect of orthodontic appliances on a smiling face with and without a missing maxillary first premolar. Am J Orthod Dentofac Orthop. 2009 Abr;135(4)supl.1:S55-S60.
13. Delalíbera HVC, Silva MC, Pascotto RC, Terada HH, Terada RSS. Avaliação estética de pacientes submetidos a tratamento ortodôntico. Acta Sci Health Sci. 2010; 32(1):93-100.
14. Havens DC, McNamara Jr JA, Sigler LM, Baccetti T. The role of the posed smile in overall facial esthetics. Angle Orthod. 2010 Mar;80(2):322-328.
15. Maple JR, Vig KWL, Beck FM, Larsen PE, Shankere S. A comparison of providers' and consumers' perceptions of facial-profile attractiveness. Am J Orthod Dentofac Orthop. 2005 Dec;128(6):690-96.
16. Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM. Attractiveness, acceptability, and value of orthodontic appliances. Am J Orthod Dentofac Orthop. 2009 Mar;135(3):276-7.
17. Zange SE, Ramos AL, Cuoghi OA, Mendonça MR, Suguino R. Perceptions of laypersons and orthodontists regarding the buccal corridor in long- and short-face individuals. Angle Orthod. 2011 Jan;81(1):86-90.
18. Libório AO. Avaliação da suscetibilidade à pigmentação de brackets estéticos utilizando a fotografia digital [dissertação]. Salvador (BA): Universidade Federal da Bahia, Faculdade de Odontologia; 2006.
19. Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of the posed smile. Clin Orthod Res. 1998 Aug;1(1):2-11.
20. Costa MCC, Barbosa MC, Bittencourt MAV. Avaliação da proporção facial vertical: relação das alturas tegumentar e esquelética. Rev Dental Press Ortodon Ortop Facial. 2011 Jan-Fev;16(1):99-106.
21. Scott SH, Johnston lE. The perceived impact of extraction and nonextraction treatments on matched samples of African American patients. Am J Orthod Dentofac Orthop. 1999 Sep;116(3):352-8.
22. Montini RW, McGorray SP, Wheeler TT, Dolce C. Perceptions of orthognathic surgery patient´s change in profile. Angle Orthod. 2007 Jan;77(1);5-11.

Assessment of facial profile changes in patients treated with maxillary premolar extractions

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Objective: Evaluate the facial profile changes of orthodontic treatment with extraction of two upper first premolars, from the perspective of orthodontists, dentists and lay people.

Methods: Facial profiles of radiographs taken before and after treatment of 70 patients with Class II, division 1 malocclusion were traced. The silhouettes of the 70 patients were randomly assembled in an album with, being two profiles on each sheet of the same patient. Then, 30 orthodontists, 30 dentists and 30 lay people chose the more esthetic facial profile (A or B), and the amount of change they perceived between the two profiles before and after treatment, according to a visual analog scale (VAS).

Results: The results revealed that 83 examiners preferred the post-treatment profiles, and only three dentists and four lay people chose the profiles pre-treatment more frequently. Thus, the orthodontists often chose the profiles after treatment, followed by dentists, with no statistically significant differences found between dentists and lay people. There were significant differences within groups in the preference of pre- and post-treatment profile. Furthermore, the three groups of evaluators indicated that pre and post-treatment profiles did not differ substantially.

Conclusions: The treatment of Class II, division 1 malocclusion with extraction of two first premolars has a positive effect on facial profile esthetics.

Keywords: Tooth extraction. Angle Class II malocclusion. Corrective orthodontics. Perception.

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INTRODUCTION

For years, orthodontists have studied the soft tissue profile in patients treated orthodontically, seeking facial harmony, and the correct dental positioning.[16] In the past, the esthetic facial profile was described very subjectively, and the concept of beauty would refer to the figure of the Greek God Apollo of Belvedere. But, the standards of beauty have changed possibly due to the mixing of races, global media, customs, religion and age; with stronger traits than the straight lines from the Greeks.

Facial appearance plays an important role when judging the self-attractiveness and also the development of self-esteem.[18] The perception of appearance, especially of the face, affects mental health and social behavior with significant implications in the educational and professional areas, as well as in the emotional life.[14]

The Class II malocclusion may affect facial harmony in various degrees, according to the intensity of dental overjet and its interaction with the soft tissues, interfering with the image and self-esteem of the patient. [1] Thus, the treatment of malocclusions is important for the social inclusion of the patient and it is of great interest to orthodontists, and the demand for treatment is significant in clinical orthodontic. This malocclusion is presented as the most common in orthodontic clinics around the world, reaching rates of 55%.[7]

Among the different treatments of Class II, Division 1, there is an alternative therapy, the extraction of two upper first premolars.[5,24] The debate on extractions has lasted for many years and there are researchers in favor of no extraction, because they think that this form of treatment tends to flatten the face (with retruded lips). On the other hand, those in favor of extraction, assume that in the treatment without extraction lips are too protruded due to protruded incisors.[23]

The literature on the extraction dilemma in orthodontics is abundant and most studies show little soft tissue post-treatment alterations in patients with and without extractions.[2,12] Although cephalometric studies exhibit differences mainly in dento-skeletal components among patients treated with and without extraction, an important point would be to check the effect of these therapies in facial esthetics under the point of view of orthodontists, dentists and lay people, since the studies in this area are scarce.

The search for a balanced facial profile is a constant challenge for orthodontists, who continue to debate the extraction issue to improve dento-skeletal relations. However, the literature is still short on the effects of extraction of two first premolars in facial esthetic profile in patients with Class II.

Therefore, knowledge about the possibilities of changes in facial profile resulting from this treatment protocol is necessary for professionals in Orthodontics.

This work aimed to evaluate the facial profile changes from orthodontic treatment with extraction of two upper first premolars, from the perspective of orthodontists, dentists and lay people.

MATERIAL AND METHODS

The sample consisted of 140 lateral cephalograms of 70 young Brazilians of both genders from the collection of the Centro Dental de Almeida Rodrigues - CORA. The lateral cephalometric radiographs were obtained in the same X-ray device before installation and after removal of the appliance. The criteria for sample selection were based on the following characteristics:

1) Young patients showed initial Class II malocclusion of dentoalveolar origin, without skeletal compromise, assessed clinically and by means of study casts.

2) Caucasian, Italian, Portuguese and Spanish descendants.

3) Lack of agenesis or loss of permanent teeth.

4) Treated with extraction of two upper first premolars.

The 70 patients, 38 females and 22 males with Class II malocclusion, were treated with orthodontic pre-adjusted appliances (Straight Wire) Andrews prescription and 0.022 x 0.030-in slot followed by extractions only in the upper arch (first premolars). All patients used transpalatal bar (TPA) in the first upper molars. The leveling of the dental arches was obtained with nickel titanium wire 0.014-in, 0.016-in, 0.016 x 0.022-in and 0.019 x 0.025-in. After alignment and leveling stainless steel arches were installed 0.019. x 0.025-in with hooks on the mesial of maxillary canines and the retraction of the anterior block was performed

with sliding mechanics. After closing the spaces the intercuspation and finishing was obtained with 0.019 x 0.025-in braided stainless steel arches. The appliances were removed after obtaining Class I canine occlusion, complete correction of overjet, overbite and tooth alignment.

Characteristics such as age of patients and duration of treatment are shown in Table 1.

Table 1 - Mean, minimum and maximum values of initial and final ages, and treatment duration.

Variable	Mean value	Minimum value	Maximum value
Initial age	15.33[a]	12[A]	29.25[A]
Final age	18.15[a]	13.17[A]	32.67[A]
Treatment period	2.85[a]	1.08[A]	4.25[A]

Methods

After obtaining the lateral radiographs, we proceeded to the preparation of cephalograms and handouts. The tracings were performed by a single researcher (LBM) and checked by another (RRAP) in a darkened room, for identification of anatomical structures. Only the soft tissue profile silhouette was traced with a lead pencil on a 0.5 mm HB acetate paper "Ultraphan" 0.07 mm thick and 17.5 mm width and length, adjusted to the radiographs (Fig 1).

The tracings were scanned to the computer and a task of completing the profile was done in Corel Draw by a single computer technician. The two profiles (pre-treatment) and (post- treatment) were inserted for each patient on the same sheet, but in a random order, ie, the initial profile could be to the right or left of the sheet (Fig 2). Thus, it was possible to assemble an album with all the silhouettes of the 70 patients.

Examiners and assessment method

A group of 90 evaluators participated in the survey in order to judge the profiles of each patient.

The evaluators were divided into three distinct groups:

» **Orthodontists group:** Comprised of 30 specialists in Orthodontics, 16 females and 14 males, mean age of 31.03 years.

» **Dentists group:** Consisting of 30 dentists with no orthodontic training, 18 females and 12 males, mean age of 38.96 years.

» **Lay group:** Comprised of 30 people with no dental knowledge, classified as lay in the area. In this group, 12 were male and 18 female and the mean age was 33.63 years.

Each evaluator received an album containing the profiles of 70 patients with two profiles on each sheet (pre- and post-treatment of the same patient).

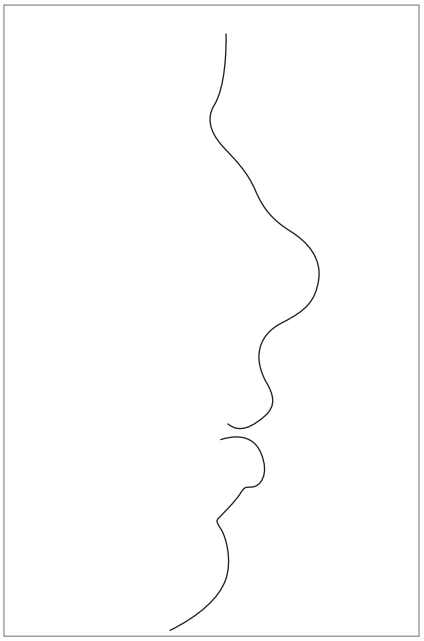

Figure 1 - Anatomical drawing of the soft tissue profile.

Figure 2 - Silhouette of profiles pre-and post-treatment from the patient number 31.

Along with the album, the evaluators received instructions on how to answer, and a sheet for scores, in which the category to which they belonged to should be marked (layman, orthodontist or dentist), as well as gender and age. They were asked to indicate their preferences in relation to the profile (A or B) and the amount of change they perceived between the two profiles, according to a visual analog scale (VAS).

The visual analog scale used was characterized by a 100 mm line, where the demarcation at zero, at the left end, meant that the profiles contained in the same sheet were the same and in the opposite extreme, in the right end, that they were very different.

Statistical analysis

In order to verify the degree of similarity between the groups with regard to profile preferences pre- or post-treatment, a comparison was carried out by an analysis of variance test (ANOVA) and when statistically significant differences were found between the groups, the Tukey test was used.

In order to verify within-group differences in choosing the profile pre-or post-treatment, we used the paired *t* test.

To check the amount of noticeable difference between the pre- and post-treatment profiles resulting from the values attributed to the visual analogue scale the analysis of variance (ANOVA) was used, followed by Tukey's test. In all analyses employed statistically significant results were considered for $p \leq 0.05$ and $p \leq 0.001$.

RESULTS

The results showed that the three groups of evaluators preferred more often the profiles after orthodontic treatment (Table 2).

Only seven people, four belonging to the lay group and three from the dentists group, chose the profiles pre-treatment more often. All other reviewers (83) preferred the post-treatment profiles (Fig 1).

In order to verify the degree of similarity between the groups of evaluators, in relation to the profile preferences for pre or post-treatment comparison was carried out using the ANOVA analysis (Table 3). The comparison results indicated statistically significant differences between groups, being the group of orthodontists the one that more often chose the profiles after treatment, followed by dentists and finally, the laymen.

In order to verify intragroup differences in choosing the pre- or post-treatment profile, the paired t test was used (Table 4). In evaluating preferences, assuming a total of 70 patients, orthodontists chose 27 profiles pre- and 43 profiles post-treatment, the dentists 29 pre and 41 post-treatment and the lay people chosen 30 pre and 40 post-treatment and this difference was statistically significant.

To quantify the pre- and post-treatment profiles the visual analogue scale was used and then the results were submitted to the analysis of variance to see if there was agreement among the examiners (Table 5). According to the VAS scale, the mean values assigned by orthodontists, dentists and by the laymen were not statistically significant different ($p = 0.37$). Although the evaluators had chosen, in most cases, the after treatment profile, they indicated that it did not differ substantially.

Table 2 - Evaluation of profile preferences (pre- and post-treatment) by three groups of examiners.

GROUP	Pre-treatment Preference	Post-treatment preference	Total of patients	p
Orthodontists	27	43	70	0.00**
Dentists	29	41	70	0.00**
Lay people	30	40	70	0.00**

* Significant for $p \leq 0.05$. ** Significant for $p \leq 0.01$.

Table 3 - Results from the analysis of variance (ANOVA) applied to the profile preference among the three groups of evaluators.

Preference %	Orthodontist (1)	Dentist (2)	Lay people (3)	ANOVA-P 1-2	1-3	2-3
Pre-treatment	38.04%	42.23%	43.14%	0.03*	0.00**	0.85
Post-treatment	61.95%	57.76%	56.85%	0.03*	0.00**	0.85

* Significant for $p \leq 0.05$. ** Significant for $p \leq 0.01$.

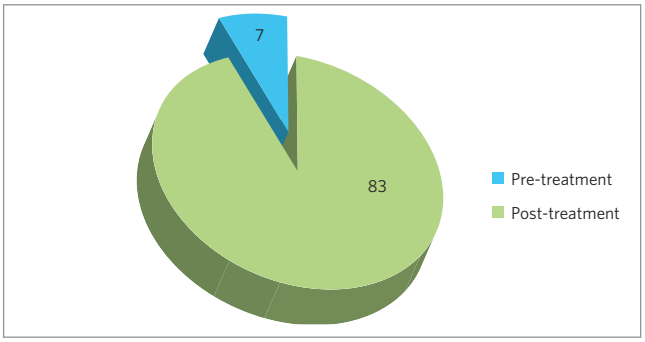

Figure 3 - Distribution of preferences of examiners (n = 90).

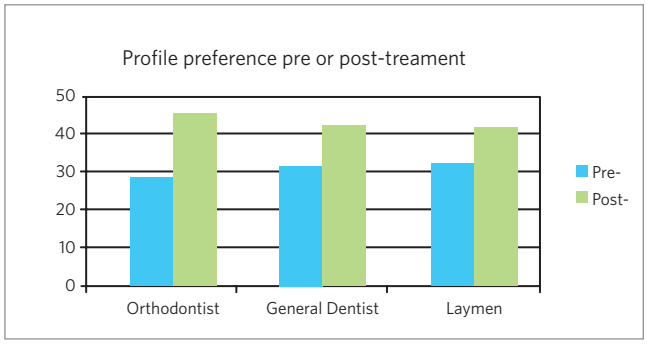

Figure 4 - Within-group comparison pre-and post-treatment.

Table 4 - Results from the paired t test applied by within-group preference profile before and after treatment.

Group	Pre-treatment preference	Post-treatment preference	Total of patients	p
Orthodontists	27	43	70	0.00**
Dentists	29	41	70	0.00**
Lay people	30	40	70	0.00**

* Significant for p ≤ 0.05. ** Significant for p ≤ 0.01.

Table 5 - Results from the analysis of variance applied to the visual analogue scale (VAS).

Mean	Orthodontists (1)	Dentists (2)	Lay (3)	ANOVA – p 1-2	1-3	2-3
VAS	4.65	4.75	5.02	0.93 ns	0.36 ns	0.57 ns

DISCUSSION

The evaluation of the changes introduced by orthodontic treatment in the facial profile of patients treated with extraction of two upper first premolars generates considerable interest.[2] It is known that extraction of premolars is often chosen as alternative[4] for the treatment of patients with Class II division 1 malocclusion, once they no longer present significant growth and have more severe overjet. However, studies on the effect of this treatment on the soft tissue are scarce.

The results of this study provided an insight regarding the perception of orthodontists, dentists and lay people about the amount of changes in the profiles before and after treatment in patients with Class II division 1 malocclusions. The results revealed that eighty-three evaluators of the three groups preferred the post-treatment profile and only three dentists and four lay people chose the pre-treatment profiles more often. On the preferences average, considering a total of 70 patients, orthodontists chose 27 pre-treatment profiles and 43 post-treatment profiles, the dentists 29 pre and 41 post-treatment and laymen 30 pre and 40 post-treatment (Table 2).

Thus, in the opinion of the evaluators, treatment with extraction of first upper premolars produced a positive effect on soft tissue profile, for they chose the profiles after treatment more often. From this we can infer that this type of treatment has a beneficial effect on the esthetics of the facial profile.

Our results showed differences between the groups of evaluators in the preference after treatment, statistically significant difference in the profile evaluation performed by orthodontists (61.95%), compared with the group of dentists (57.76%) and laymen (56.85%), but no statistically significant difference between dentists and lay people. The analysis of variance (ANOVA) denoted agreement between the choices of dentists and lay people (p = 0.85), but a disagreement with orthodontists (p = 0.03 and p = 0.00, respectively). Thus it is clear that the higher the degree of information of the evaluator in the specific area, the greater the degree of criterion.

Similar results, regarding the discrepancy between orthodontists and lay people in the area, are observed in several studies. In a study[15] on the preference of the soft tissue profile in young Caucasian, African and Asian descendents, the author did not observe correlation between the evaluators' opinions (orthodontists, laymen and artists), demonstrating that the esthetic criteria, besides being subjective, are also personal. Another research[17] carried out in order to assess

facial profile preferences for the anteroposterior position of the mandible showed that the preference of orthodontists also differed in relation to both lay groups (Caucasian and Japanese). Disagreements were also observed between orthodontist evaluators in studies of facial attractiveness,[10,11] showing that lay people were less careful in the assessment of this issue. The results of studies[2,3] on the effect of treatment with and without extraction showed that orthodontists demonstrated a more accurate perception of small changes in facial profile. Moreover, in a study[22] assessing the importance of the soft profile in esthetic, when lay and orthodontists were compared, it was found that orthodontists took into greater consideration the facial profile than lay people in the evaluation of facial esthetics. In researches[25,13] on profile preference of the Turkish population and black women, respectively, there were statistically significant differences between the judgments of laypeople and orthodontists.

Disagreeing with the results of this study, it was observed that[23] orthodontists and laypeople perceived similarity between the profile changes after treatment. Contrary also to the results of this research, another work[21] did not denote significant differences between orthodontists and dentists. In researches[6,19,20] on the profile preference the authors indicated that all groups of evaluators were consistent in the judgment of the profiles. In the work[16] on ratings of profile attractiveness after treatment with functional appliances, the three groups of evaluators (dental students, arts students and parents of patients), showed no difference in their judgments.

The results denote statistically significant differences within-groups, with a predominant choice for the facial profile after treatment in all groups. Thus, orthodontists preferred 43 pre-treatment profiles and 27 post-treatment indicating statistically significant differences in this evaluation ($p = 0.00$). The same occurred with the dentists who chose more ($p = 0.00$) profiles after treatment (41) in relation to pre-treatment (29) and with the lay people, who had a preference of 40 post-treatment and 30 pre-treatment profiles ($p = 0.00$).

The visual analog scale was used in this study to quantify the perception of evaluators in relation to the amount of similarities or differences between the facial profiles before and after treatment. This method was endorsed by several investigators[4,8,9,16,19,23] because of its simplicity and speed, being easily understood by the examiners and widespread in literature. In this study the VAS scale was characterized as a 100 mm line, where zero represented that profiles contained in the same sheet were the same and in the opposite extreme, that they were very different.

The results from the evaluation of this scale were subjected to analysis of variance (ANOVA) to determine whether there was agreement between the values assigned by the three groups of evaluators. These profiles indicated that pre and post-treatment did not differ significantly, however, were not classified as the same. According to the VAS scale, the mean values assigned by the orthodontists was 4.65 mm, by the dentists was 4.75 mm and 5.02 mm by the lay people, with no statistically significant difference between them ($p = 0.37$). Thus, although most reviewers have chosen the post-treatment profile, they did not identify major differences between the profiles before and after treatment.

Considering the results of this survey, it is noted that the assessment of facial profile should be a continuous learning process for orthodontists, since patients are increasingly concerned about the effect that orthodontic treatment can induce in facial esthetics. The opinion of patients should always be mandatory in orthodontic planning.

CONCLUSION

Based on the methods and analysis of results, it was possible to concluded that orthodontic treatment of Class II, division 1 malocclusion with extraction of two first upper premolars had a positive effect on facial profile esthetics, since orthodontists, dentists and lay people preferred the large majority of the profiles after orthodontic treatment.

REFERENCES

1. Almeida-Pedrin RR, Pinzan A, Almeida RR, Almeida MR, Henriques JFC. Efeitos do AEB conjugado e do Bionator no tratamento da Classe II, 1ª divisão. R Dental Press Ortodon Ortop Facial. 2005 Out;10(5):37-54.
2. Bishara SE, Jakobsen JR. Profile changes in patients treated with and without extractions: Assessments by lay people. Am J Orthod Dentofacial Orthop. 1997 Dec;112(6):639-44.
3. Boley JC, Pontier JP, Smith S, Fulbright M. Facial changes in extration and nonextraction patients. Angle Orthod. 1998 Dec;68(6):539-46.
4. Bowman SJ, Johnston LE Jr. The esthetic impact of extraction and nonextraction treatments on Caucasion patients. Angle Orthod. 2000 Feb;70(1):3-10.
5. Scott Conley R, Jernigan C. Soft tissue changes after upper premolar extraction in Class II camouflage therapy. Angle Orthod. 2006 Jan;76(1):59-65.
6. Foster EJ. Profile preferences among diversified groups. Angle Orthod. 1973 Jan;43(1):34-40.
7. Freitas MR, Freitas DS, Pinheiro FHSL, Freitas KMS. Prevalência das más oclusões em pacientes inscritos para tratamento ortodôntico na Faculdade de Odontologia de Bauru-USP. Rev Fac Odont Bauru. 2002;10(3):164-9.
8. Hall D, Taylor RW, Jacobson A, Sadowsky PL, Bartolucci A. The perception of optimal profile in African Americans versus white Americans as assessed by orthodontists and lay public. Am J Orthod Dentofacial Orthop. 2000 Nov;118(5):514-25.
9. Howells DJ, Shaw WC. The validity and reliability of ratings of dental and facial attractiveness for epidemiologic use. Am J Orthod. 1985 Nov;88(5):402-8.
10. Kerr WJS, O`Donnell JM. Panel perception of facial attractiveness. Brit J Orthod. 1990 Nov;17(4):299-304.
11. Knight H, Keith O. Ranking facial attractiveness. Eur J Orthod. 2005 Aug;27(4):340-8.
12. Kocadereli I. Changes in soft tissue profile after orthodontic treatment with and without extractions. Am J Orthod Dentofacial Orthop. 2002 Jul;122(1):67-72.
13. McKoy-White J, Evans CA, Viana G, Anderson NK, Giddon DB. Facial profile preferences of black women before and after orthodontic treatment. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):17-23.
14. Mejia-Maidl M, Evans CA, Viana G, Anderson NK, Giddon DB. Preferences for facial profiles between Mexican Americans and Caucasians. Angle Orthod. 2005 Nov;75(6):953-8.
15. Okuyama CC. Preferência do perfil facial tegumentar, em jovens leucodermas, melanodermas e xantodermas de ambos os sexos, avaliados por ortodontistas, leigos e artistas plásticos [Dissertação]. Bauru (SP): Universidade de São Paulo, Faculdade de Odontologia de Bauru; 1995. 94 p
16. O'Neill K, Harkness M, Knight R. Ratings of profile attractiveness after functional appliance treatment. Am J Orthod Dentofacial Orthop. 2000 Oct;118(4):371-6; discussion 377.
17. Orsini MG, Huang GJ, Kiyak HA, Ramsay DS, Bollen AM, Anderson NK, et al. Methods to evaluate profile preferences for the anteroposterior position of the mandible. Am J Orthod Dentofacial Orthop. 2006 Sep;130(3):283-91.
18. Reis ASB, Abrão J, Capelozza Filho L, Claro CAA. Análise facial subjetiva. R Dental Press Ortodon Ortop Facial. 2006 Set-Out;11(5):159-72.
19. Schlosser JB, Preston CB, Lampasso J. The effects of computer-aided anteroposterior maxillary incisor movement on ratings of facial attractiveness. Am J Orthod Dentofacial Orthop. 2005 Jan;127(1):17-24.
20. De Smit A, Dermaut L. Soft-tissue profile preference. Am J Orthod. 1984 Jul;86(1):67-73.
21. Soh J, Chew MT, Wong HB. Professional assessment of facial profile attractiveness. Am J Orthod Dentofacial Orthop. 2005 Aug;128(2):201-5.
22. Spyropoulos MN, Halazonetis DJ. Significance of the soft tissue profile on facial esthetics. Am J Orthod Dentofacial Orthop. 2001 May;119(5):464-71.
23. Stephens CK, Boley JC, Behrents RG, Alexander RG, Buschang PH. Long-term profile changes in extraction and nonextraction patients. Am J Orthod Dentofacial Orthop. 2005 Oct;128(4):450-7.
24. Tadic N, Woods MG. Incisal and soft tissue effects of maxillary premolar extraction in Class II treatment. Angle Orthod. 2007 Sep;77(5):808-16.
25. Türkkahraman H, Gökalp H. Facial profile preferences among various layers of turkish population. Angle Orthod. 2004 Oct;74(5):640-7.

Width of buccal and posterior corridors: Differences between cases treated with asymmetric and symmetric extractions

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Objective: To verify if there is difference in the buccal and posterior corridor width in cases treated with extraction of one and four premolars.

Methods: Through posed smile photographs of 23 Class II patients, subdivision, treated with extraction of one premolar and 25 Class I and Class II patients, subdivision, treated with extraction of four premolars, the percentage of buccal and posterior corridor width was calculated. The two protocols of extractions were compared regarding the buccal and posterior corridor width by independent t tests.

Results: There was no statistically significant difference on the buccal and posterior corridor widths between patients treated with symmetric and asymmetric extraction.

Conclusion: The buccal and posterior corridor did not differ between the evaluated protocols of extractions.

Keywords: Orthodontics. Tooth extraction. Premolar.

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

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INTRODUCTION

According to the definition of Frush and Fixher,[5] buccal corridor is the space between the labial surface of the most posterior tooth and the labial commissure during smile. However, some authors used the distal surface of the canine instead of the labial surface of the posterior tooth as reference.[10,18,23]

For Sarver,[24,25] one of the factors that leads a patient to have a wide buccal corridor is the maxillary position in relation to the skull base. A patient with retracted maxilla, therefore, could have a wide corridor. Although the maxilla has a normal width, the buccal corridor might seem prominent, for the wider portion of the dental arch is most posterior. However, a study by McNamara[18] tested this concept and verified that there was no correlation between the buccal corridor and the skull base.

In 1987, it was speculated that the treatment with extractions resulted in constriction of the dental arch, leading to formation of 'negative' lateral spaces. Spahls[27] said that the removal of a tooth in each quadrant results in a reduction on the radius of curvature of the dental arch. However, Johnson[12] argued that the dental arch is not a circle that contracts when a tooth is removed. This speculation stimulated some authors to investigate the real consequence of the extractions on the transverse dimension of the arch.[6,12,14]

In order to have a scientific basis about the polemic between extraction of premolars and arch width, Johnson,[12] through pictures, verified the proportions of the intercanine distance and the distance between the last visible teeth in relation to the smile width of patients treated with and without extraction of four premolars. It was concluded that there was no significant difference on the proportions of the intercanine distance and the distance between the last visible teeth in relation to the smile width, contradicting the speculation that the treatment with extraction of premolars results in a discrepancy between the arch width and the smile width. According to other authors, usually the transverse dimension of the arch is kept or increased after an extraction. What changes is the position that the tooth occupies in the arch. The intermolar distance may decrease after the extraction of premolars, but it is due to the molar movement to a narrower part of the arch. Consequently, the second molar would occupy part of what previously would be the location of the first molar, on the same arch width where this last one was originally found.[3,17,20]

In 2003, Gianelly,[6] instigated by the speculation of Witzig,[27] compared through dental casts the intercanine and intermolar distance of patients that were treated with and without extraction of four premolars. It was observed that the arch width, in both groups, was similar, except the intercanine width of the lower arch which was 1 mm larger after treatment with extractions. Spahl,[26] after reading Gianelly's article,[6] wrote a review saying that dental casts cannot give us any information about the human face or the lip support it can or cannot provide.

However, still in 2003, Kim[14] compared the changes on the widths of anterior and posterior segments of the dental arch of orthodontically treated patients with and without extraction of four premolars. According to the results, there was a reduction of the interpremolar and intermolar distance in both arches on the extraction group, while on the non-extraction group there was an increase. As the anteroposterior position of premolars and molars change during the treatment with extractions, the posterior arch width would be better represented in a specific location, instead of the intermolar and interpremolar distances. This way, by measuring the arch width in a specific arch length on the maxilla and on the mandible, it was observed that the arch width on the extraction group was larger than on the non-extraction one.

The buccal and posterior corridor widths of patients treated with asymmetric and symmetric extractions were not yet compared, which motivated the present study.

MATERIAL AND METHODS

The sample was constituted of posed smile photographs of 48 patients from the Department of Orthodontics at the School of Dentistry of Bauru-USP, divided in two groups according to protocol of treatment. Group 1 was formed by 23 patients (9 men and 14 women) Class II, subdivision, treated with extraction of one premolar. Group 2 was constituted by 25 patients (6 men and 19 women), being 3 Class I (1 man and 2 women), 5 Class II (1 man and 4 women) and 17 Class II, subdivision, (4 men and 13 women) patients treated with extraction of four premolars. The mean age of the sample was 23.26 ± 6.72 years to group 1 and 25.1 ± 6.51 years to group 2.

The basic criteria for selection of the sample included the following features: 1) Class II malocclusion, subdivision, treated with extraction of one premolar; 2) class I and II malocclusion and Class II subdivision treated with extraction of four premolars; 3) presence of all permanent teeth until the first molars; 4) absence of tooth size and shape anomalies; 5) absence of active periodontal disease.

As the frontal close-up photograph of the smile is not part of the standard photographic documentation, it was necessary to obtain it from the 48 patients of the sample. To obtain the photos, it was used the following equipment: Photo camera Nikon D40 (Nikon Corporation, Tokyo, Japan); Sigma macro lens 105 mm and Sigma ring flash (Sigma Corporation of America, New York, USA). All photographs were obtained in manual mode, color, with fine quality, ISO (International Organization for Standardization) 800, minimum aperture at *f* 16 and shutter speed of 60. The macro lens was adjusted to focus the lips of the patient[11] at a distance of 60 cm from the soft tissue, obtaining an image of the lower third of the face,[22] which goes from the tip of the nose to the middle of the chin. The ring flash was standardized in multi ¼.

The smile pictures were obtained with the patient sitting down, facing the researcher, so that the lens were at the level of the lips. Each individual was instructed to keep the natural position of the head, which is a standard and reproducible position in an upright and natural posture, with eyes focused in an imaginary spot at the eyes level, resulting in a horizontal vision axis.[19]

The patients were oriented to pose smile[8] as natural as possible[12,14] with the teeth in UMI (Usual Maximum Intercuspation). Several photographs were taken of the same patient to choose the best one to be included on the sample.[11,12,13]

Through the Adobe Photoshop 9.0 software (San Jose, CA, USA) it was done the photograph cropping that had as objective to correct the small inclinations of the head and reduce the evaluated area, leaving apparent only part of the skin, the teeth and the lips[2,8,10,12,14,15,21,22,23] (Fig 1). For the width and height standardization of the photographs that should be cropped, the widest smile from all the sample was used as size standard, with 21 cm of intercommissural width, according to the ruler tool from Adobe Photoshop (Fig 2). With the software manipulated to crop the photographs in a proportion of 10 x 17 cm, the height was automatically determined. From that, the measurement to be reproduced on the horizontal and vertical rulers of the software was of 12.2 x 21 cm. This way, all photographs maintained real size proportions of the dental structures and the soft tissues when seen from the same distance.

Using the Adobe Photoshop 9.0 software, six vertical lines were projected on the images of the smiles and positioned on the outer commissures, distal of upper canines and on the distal of last visible upper

Figure 1 - Photograph cropping. **A**) Original photograph. **B**) Photograph after cropping, reducing the area to be evaluated.

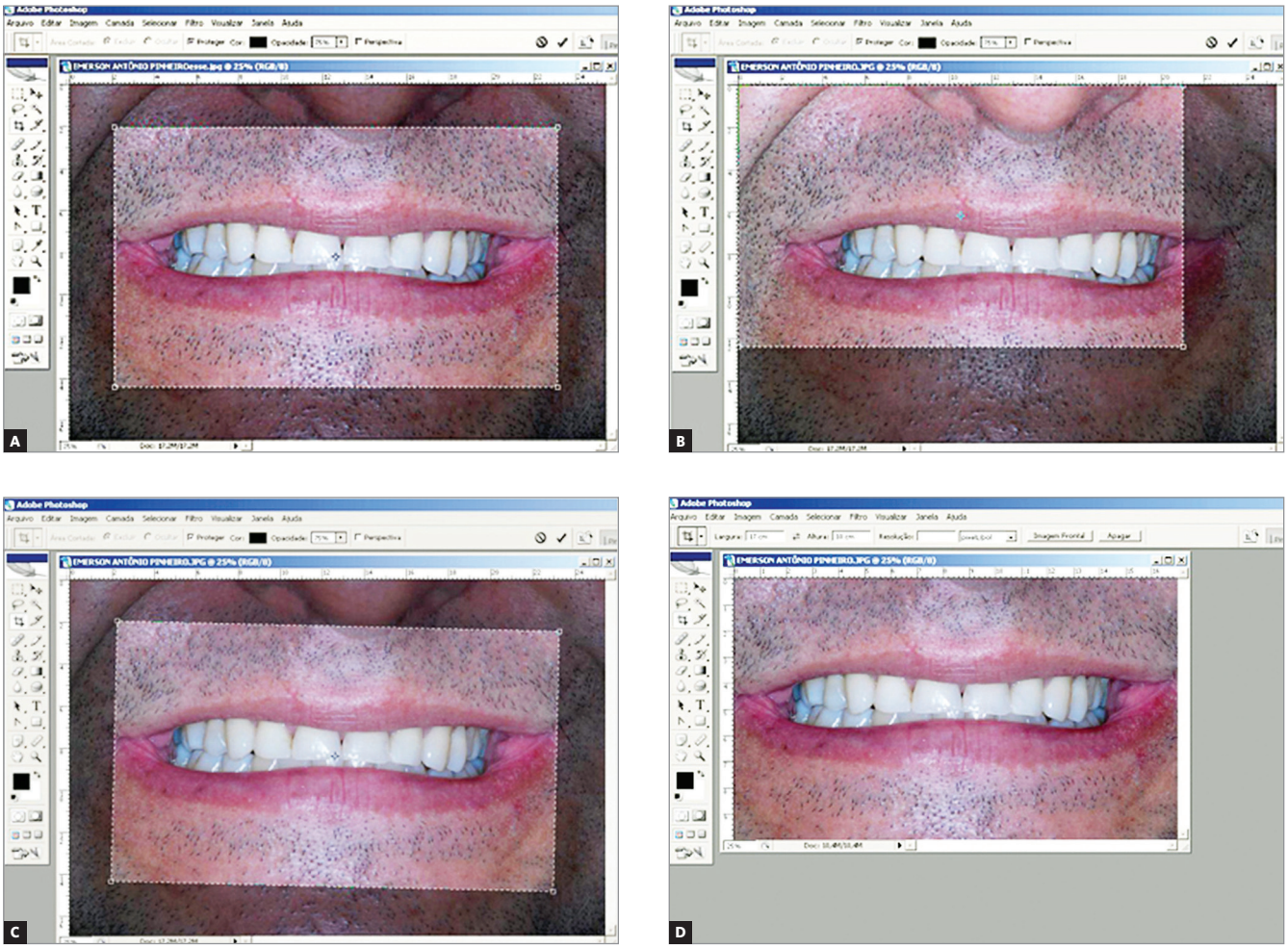

Figure 2 - Standardization of height and width of the photograph by the widest smile from the sample using the Adobe Photoshop 6.0 software. **A**) Determination of the standard width for photograph cropping by the intercommissural distance using a size proportion defined as 10 x 17. **B**) Verification of height and width measurements to be reproduced on the remaining sample: 12.2 cm in height and 21 cm in width. **C**) Centralization of standard size to be cropped and correction of head inclination. **D**) Cropped photograph.

posterior teeth (Fig 3). Using this lines as limits, the following smile attributes were measured in millimeters:

- » Smile Width (SW): distance between the corners of the lips.
- » Upper Intercanine Distance (UID): distance between the most distal point on the right and the most distal point on the left.
- » Distance between the Last Visible Teeth of the Maxilla (DLVTM): distance between the most distal point of the last visible posterior tooth on the right and the most distal point of the last visible posterior tooth on the left.

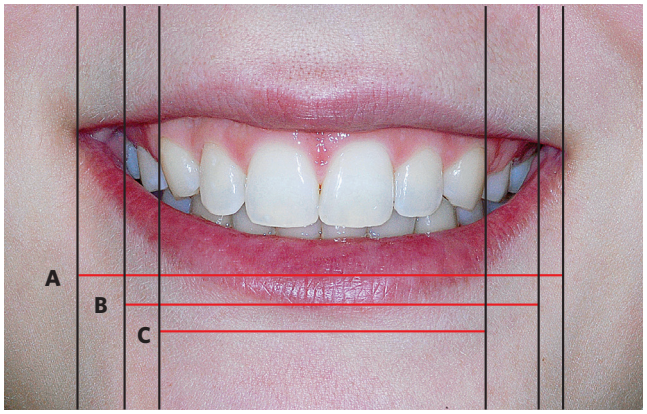

Figure 3 - **A**) Smile width. **B**) Distance between the last visible teeth in the maxilla. **C**) Upper intercanine distance.

Through these measurements, the proportions in percentage of the buccal and posterior corridor were calculated:

» Buccal corridor: $\frac{SW - UID}{SW} X\ 100$

» Posterior corridor: $\frac{SW - DLVTM}{SW} X\ 100$

Statistical analysis

For evaluation of the researcher's intra-examiner error on the measurement of the buccal and posterior corridors, 12 photographs (6 from each group) were retraced and the smile attributes were measured again with an interval of two weeks after the first measurement. The systematic errors were analyzed by applying the independent t test, according to Houston.[9] For evaluation of random errors, it was used the Dahlberg error,[4] which shows the mean variation between the first and the second evaluation/measurement. The test is calculated by the following formula: $Se^2=\Sigma d^2/2n$. The error variation is represented by Se,[2] d is the difference between the first and the second evaluation/measurement and n is the number of double evaluations/measurements. The calculation of the random error was done using a spread sheet from Microsoft Excel XP.

To test the data hypothesis of normality, it was applied the Kolmogorov-Smirnov test for the buccal and posterior corridor measurements in each sample group.

To verify the compatibility regarding the age, the two groups were compared with one another by the independent *t* test, while the chi-square test determined the genres proportion. Finally, the independent t test was applied to know if there is difference between the size of the buccal corridor and the posterior corridor between the two groups. All tests were performed with Statistica program (Version 6.0; StatSoft Inc., Tulsa, OK, USA), using a significance level of 5%.

Table 1 - Results of the paired t test and the Dahlberg's formula applied to measurement of the variables smile width (SW), upper intercanine distance (UID) and distance between the last visible teeth of the maxilla (DLVTM) to evaluate the systematic and random intra-examiner errors, respectively.

Smile attributes	1st measurement (n = 14)		2nd measurement (n = 14)		p	Dahlberg
	Mean	SD	Mean	SD		
SW	13.15	1.03	13.15	1.21	1	0.18
UID	8.12	0.35	8.21	0.39	0.23	0.18
DLVTM	10.71	0.59	10.66	0.69	0.46	0.19

Table 2 - Results of the intergroup comparisons (independent *t* test and chi-square).

Variables	Group 1 (n = 23)	Group 2 (n = 25)	p
Age	23.26 ± 6.72	25.10 ± 6.51	0.3400*
Gender			
Masculine	9	6	0.2586**
Feminine	14	19	

*Independent *t* test; **chi-square.

Table 3 - Results of the independent *t* test to compare the percentage of the BC (buccal corridor) width and PC (posterior corridor) width between group 1 (treatment with extraction of one premolar) and group 2 (treatment with extraction of four premolars).

Variables	Group 1 (n = 23)		Group 2 (n = 25)		p
	Mean	SD	Mean	SD	
Buccal corridor	39.46	4.01	37.56	4.72	0.1416
Posterior corridor	17.76	5.29	18.53	5.60	0.6261

RESULTS

Table 1 shows results of the paired *t* test and Dahlberg's formula applied to measurement of the variables smile width (SW), upper intercanine distance (UID) and distance between the last visible teeth of the maxilla (DLVTM) to evaluate the systematic and random intra-examiner errors, respectively.

On Table 2, the results of independent t test applied on evaluation of compatibility of the groups 1 and 2 regarding the age are demonstrated. It also displays results of the chi-square test regarding the genres proportion.

Table 3 presents results of independent *t* test, applied to compare the size of buccal and posterior corridor between the groups.

DISCUSSION

Method accuracy and Sample compatibility

The significant absence of systematic errors and the reduced value of detected random errors, in this study, result from the evaluation and accuracy of measurements of the smile attributes by the researcher (Table 1).

The mean age for both groups were statistically similar. Regarding the distribution of genres, the groups were statistically similar although the sample presented, numerically, more female individuals than male individuals (Table 2).

Comparison result of buccal and posterior corridor between patients treated with symmetric and asymmetric extractions

One of the criticisms for premolars extraction concerns to the relation between the arch width and the smile width.[12] Spahl[27] argued that the removal of a tooth in each quadrant results in reduction on radius of curvature of the dental arch, contracting the arch and leading to a dentition that is not enough to fill in the buccal cavity during smile. In a study performed by Johnson,[12] there was no difference on the proportion of intercanine width and the distance between the last visible posterior teeth of the smile in patients orthodontically treated with and without extraction of four premolars, contradicting that treatments with extractions result in a discrepancy between the arch width and the soft tissues. Kim,[14] by measuring the upper and lower arch width, in a constant arch depth, of cases treated with and without extraction of four premolars verified that, actually, on the extraction group the arches were from 1 to 2 mm wider when compared to patients without extractions. In this study, analyzing the buccal and posterior corridor width, in cases treated with extraction of one and four premolars, it was observed that there was also no statistically significant difference between the two groups (Table 3). It is incorrect to believe that extraction of premolars results in a reduction on radius of curvature of the dental arch, for the arch is not a circle and does not behave as a circle.[12] If the treatment with extractions leads to a contraction of dental arches, then the buccal corridor width in individuals with extraction of one premolar should be smaller than the extraction group of four premolars.

In this study, the proportions of the buccal corridor found were of 39.46% and 37.56%, while the proportions of the posterior corridor were of 17.76% and 18.53% for the groups with extraction of one and four premolars, respectively (Table 3). Ritter[22] found a mean value of 19.20% for the posterior corridor in patients with good dental alignment not orthodontically treated. In a later study, McNamara[18] observed an equivalent proportion of 36.6% for the buccal corridor and 24.71% for the posterior corridor in patients that sought orthodontic treatment.

One factor that might have affected the results, causing this size difference on buccal and posterior corridors between the studies, is the illumination condition in which the photographs were taken. As the teeth are positioned more posteriorly on buccal corridors, the light is reduced, which causes a gradual darkening and, consequently, a poor observation of the posterior teeth.[5,7,16,23] The less illumination on the photograph, the larger is the buccal corridor, for less teeth are observed, reducing the arch width when the smile width is the same.[22] This way, what would be called "negative space"[16] is not really a space, but only an illusion.[1] This possible difference on the standardization of illumination conditions between studies is a factor that complicates the comparison between them.[22]

Clinical considerations

There was a dogma that the treatment with extraction resulted in contraction of the dental arch

and led to an increase of the buccal corridor.[27] However, several studies showed that there is no difference on the buccal corridor width between cases treated with and without extraction of four premolars and a control group.[11,12,14] This work demonstrated that among individuals treated with extractions of one and four premolars there is also no difference on the buccal and posterior corridors width, excluding a possible criticism to the protocol of asymmetric extractions in the Class II malocclusion, subdivision.

CONCLUSION

Buccal and posterior corridor width were not affected by the protocols of extractions of one and four premolars.

REFERENCES

1. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002 Apr;36(4):221-36.
2. Andrade F, Souza D, Nascimento AP, Gomes A. Percepção estética entre as especialidades odontológicas. UFES Rev Odontol. 2006;8(1):46-54.
3. Bishara SE, Cummins DM, Zaher AR. Treatment and posttreatment changes in patients with Class II, Division 1 malocclusion after extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop. 1997 Jan;111(1):18-27.
4. Dahlberg G. Statistical methods for medical and biological students. London (UK): G. Allen & Uniwin; 1940.
5. Frush JO, Fisher RD. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent. 1958;8(4):558-2.
6. Gianelly AA. Arch width after extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop. 2003 Jan;123(1):25-8.
7. Graber LW, Lucker GW. Dental esthetic self-evaluation and satisfaction. Am J Orthod. 1980 Feb;77(2):163-73.
8. Gracco A, Cozzani M, D'Elia L, Manfrini M, Peverada C, Siciliani G. The smile buccal corridors: aesthetic value for dentists and laypersons. Prog Orthod. 2006;7(1):56-65.
9. Houston WJ. The analysis of errors in orthodontics measurements. Am J Orthod. 1983 May;83(5):382-90.
10. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. 1970 Feb;57(2):132-44.
11. Işiksal E, Hazar S, Akyalçin S. Smile esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):8-16.
12. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop. 1995 Aug;108(2):162-7.
13. Kerns LL, Silveira AM, Kerns DG, Regennitter FJ. Esthetic preference of the frontal and profile views of the same smile. J Esthet Dent. 1997;9(2):76-85.
14. Kim E, Gianelly AA. Extraction vs nonextraction: arch widths and smile esthetics. Angle Orthod. 2003 Aug;73(4):354-8.
15. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.
16. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. J Prosthet Dent. 1973 Apr;29(4):358-82.
17. Luppanapornlarp S, Johnston LE Jr. The effects of premolar-extraction: a long-term comparison of outcomes in "clear-cut" extraction and nonextraction Class II patients. Angle Orthod. 1993 Winter;63(4):257-72.
18. McNamara L, McNamara JA Jr, Ackerman MB, Baccetti T. Hard- and soft-tissue contributions to the esthetics of the posed smile in growing patients seeking orthodontic treatment. Am J Orthod Dentofacial Orthop. 2008 Apr;133(4):491-9.
19. Moorrees CF. Natural head position--a revival. Am J Orthod Dentofacial Orthop. 1994 May;105(5):512-3.
20. Paquette DE, Beattie JR, Johnston LE Jr. A long-term comparison of nonextraction and premolar extraction edgewise therapy in "borderline" Class II patients. Am J Orthod Dentofacial Orthop. 1992 Jul;102(1):1-14.
21. Pinho S, Ciriaco C, Faber J, Lenza MA. Impact of dental asymmetries on the perception of smile esthetics. Am J Orthod Dentofacial Orthop. 2007 Dec;132(6):748-53.
22. Ritter DE, Gandini LG, Pinto Ados S, Locks A. Esthetic influence of negative space in the buccal corridor during smiling. Angle Orthod. 2006a Mar;76(2):198-203..
23. Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Mar;127(3):343-50.
24. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001b Aug;120(2):98-111.
25. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 1. Evolution of the concept and dynamic records for smile capture. Am J Orthod Dentofacial Orthop. 2003a Jul;124(1):4-12..
26. Spahl TJ. Premolar extractions and smile esthetics. Am J Orthod Dentofacial Orthop. 2003 Jul;124(1):16A-17A; author reply 17A.
27. Spahl TJ, Witzig JW. The clinical management of basic maxillofacial orthopedic appliances. Litteton (MA): PSG Cop; 1987.

Influence of buccal corridor dimension on smile esthetics

Diana Cunha Nascimento[1], Êmeli Rodrigues dos Santos[2], Andre Wilson Lima Machado[3], Marcos Alan Vieira Bittencourt[4]

Objective: To assess the influence of buccal corridor width on smile esthetics of male and female, Caucasian and Afro-descendant subjects by means of digitally manipulated photographs, as well as compare assessments of full-face view (FFV) and close-up view of the mouth (CUVM) images.

Methods: Facial photographs were taken of four adults' smile, two Caucasians and two Afro-descendants of both genders. The resulting images were digitally manipulated with the aim of rendering — from each original smile — three other smiles simulating three different buccal corridor widths, namely, narrow, medium width and wide. The rendered images, 12 of which portraying FFVs and 12 providing CUVMs, were assessed by 60 examiners who rated the attractiveness of each smile by means of a visual analog scale (VAS). The data were treated with ANOVA and Tukey's post test to compare the different buccal corridors, and Student's *t* test to compare the two image views (FFV and CUVM).

Results: Medium width buccal corridors were considered the most attractive in the four individuals investigated, both in the assessment of FFVs and CUVMs ($p < 0.05$). Comparison between the narrow and wide buccal corridors, in general, showed no statistically significant differences ($p > 0.05$). Furthermore, no statistically significant difference was found between the analyses of FFVs and CUVMs ($p > 0.05$).

Conclusion: The buccal corridor exercised a remarkable influence on smile esthetics, with the medium width group being rated as the most attractive. No influence was exerted by the individuals' face, ethnicity or gender.

Keywords: Dental esthetic. Smile. Orthodontics.

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INTRODUCTION

The smile is the most primitive form of human communication. It enhances facial beauty and plays a part in defining the qualities and virtues of one's personality.[1] Its impact, however, is not linked solely to the individual dental beauty.[2] A pleasant smile depends directly — above and beyond the appearance of teeth and gums — on conformity with the standards of structural beauty, the relationship between teeth and lips and their integration into the facial composition.[1]

The smile characteristics regarded as the most important ones are: The smile arc, dental alignment, tooth color and shape, incisal edge regularity, amount of incisor and gum display, and buccal corridor.[3-5] The buccal corridor concept emerged during the 50's out of concern with ensuring natural looking dentures.[6,7] This aspect of smile esthetics, also called lateral dark space, lateral negative space or "shadow tunnel," constitutes the existing dynamic space that appears, when a person smiles, between the labial surface of maxillary posterior teeth and the inner mucosa of the soft tissues that form the corners of the mouth and the cheeks.[1,6,8-10] This space arises from the dark background of the mouth, and depends on the shape and width of the upper dental arch and the facial muscles responsible for the breadth of the smile.[11]

Although some information on the ideal buccal corridor size is available in the literature, most of it is based on clinical opinions, whereas the scientific studies that addressed this issue yielded controversial outcomes.[8,10,12-16] Several studies showed that broad smiles with narrower buccal corridors are seen as more attractive.[13,14,16] On the other hand, other authors noted that buccal corridor width does not affect how the smile is judged from an esthetic viewpoint.[8,10,12,15] Likewise, according to Isiksal et al,[17] transverse characteristics seem to be of little significance in smile attractiveness. By the same token, some researchers argue that the lateral negative space influences smile esthetics only when it becomes excessively wide.[15]

Other issues related to this debate can also be found in the literature: The possibility that culture can influence esthetic perception, and the differences in perception between different genders and ethnicities. To illustrate this point, articles that investigated the esthetic influence of the buccal corridor used Caucasian women's smiles,[8,10,12-16] thereby raising the question of whether these findings can be used to assess men's smiles and Afro-descendant individuals. Moreover, another issue relevant to the dispute is that esthetic preference for specific features may vary between individuals of different countries,[18] which calls into question the use of esthetic parameters in places where the research has not been conducted.

The lack of consensus between results found in the literature,[8,10,12-16] combined with the scarcity of data on the esthetic preference for male smiles and Afro-descendant individuals, and especially the absence of studies that reveal the esthetic preference of the Brazilian population demonstrates the need for further research in this area. Thus, the aim of this study was to assess the influence of buccal corridor width on smile esthetics of male and female, Caucasian and Afro-descendant subjects by means of digitally manipulated photographs, as well as to compare assessments of these photos in full-face view (FFV) and close-up view of the mouth (CUVM).

MATERIAL AND METHODS

Eight photographs were selected from the image databank of the Orthodontic Department of the School of Dentistry, Bahia State Federal University. Four of these images depicted a full-face view (FFV) and the other four, a close-up view of the mouth (CUVM) of four adult individuals, i.e., two Caucasian - one from each gender – and two Afro-descendants, also from both genders. The ethnicity of these individuals was characterized using the classification parameters established by the Brazilian Institute of Geography and Statistics (IBGE) (São Paulo State Health Secretariat/ USP/FSP, IBGE, 2000). Images were selected for exhibiting adequate dental alignment, proper display of the upper incisors on smiling, coincidence of the upper and lower midlines with the facial midline, and no apparent facial asymmetry.

After selection, the images were digitally manipulated using Adobe Photoshop® 9.0 software (Seattle, Washington, USA). In order to standardize and render more accurate the analysis and changes, dental inclinations and gingival contours were corrected in all original photographs, and a near golden ratio was obtained in one half of the smile. This digitally manipulated half of the face was duplicated in order to become completely symmetric.

Thereafter, the buccal corridor was changed in order to produce three widths: Narrow, medium width and wide. To define these standards, the distance between the outer commissures of each smile was measured and a space between the outer commissure and the labial surface of the last viewed maxillary molar was established. On the narrow buccal corridor this space was defined at 6% of the distance between the outer commissures, with 3% for each side; on the medium width corridor, 16%, with 8% for each side; and on the wide corridor, 26%, 13% for each side. During this second phase of digital manipulation only the tooth positions and their gingival margins were changed. The three images depicting the narrow, medium width and wide buccal corridors, at the two different views, of the Caucasian female can be seen in Figures 1 and 2.

Two photograph albums were organized with the three images of each individual on the same page. One album comprised images showing each individual's full face whilst in the other album, the images in close-up view. Each photograph was randomly laid out on the pages as was the sequence of photographs of each individual in the album.

In order to assess the 24 images, a group of 60 judges — 30 orthodontists and 30 laypersons with graduate degrees in different areas — was deployed. Raters were made aware of study goals and signed a free and informed consent form. Along with the albums, each examiner received a form comprising eight rulers (visual analog scale),[10,13,19] one on each page, and were then requested to mark with a dot, identify the letter corresponding to the image, and rate each image according to their perceived attractiveness. Each judge was allowed to mark the dot anywhere on the ruler and place two or more letters at each dot, if necessary. The visual analog scale[24,25,26] was 10 cm long and had "VERY BAD" written on the left end and "VERY GOOD" at the opposite end. The center of the ruler was marked with a dash to give raters a perception of "average." The distance (in mm) between the rater's mark and the left end was measured with a Mitutoyo digital caliper, and served not only as a parameter for judging the attractiveness of each smile, but also constituted the actual rating assigned by each examiner.

The data were compiled and treated statistically. Kolmogorov-Smirnov test was employed to ascertain that

Figure 1 - Images of Caucasian woman's smile in full-face view, showing narrow (**A**), medium width (**B**) and wide (**C**) buccal corridors.

Figure 2 - Images of Caucasian woman's smile in close-up view of the mouth, showing narrow (**A**), medium width (**B**) and wide (**C**) buccal corridors.

the sample had a normal distribution. Next, after establishing sample normality, ANOVA and Tukey's post test were used to compare the different widths of the buccal corridor, while Student's *t* test was applied to compare the assessments made of FFV vs. CUVM images. A 95% significance level was adopted in all analyses.

RESULTS

Tables 1 and 2 show the means and standard deviations of the level of attractiveness exerted by the different buccal corridor widths on the raters regarding the female and male smiles, respectively. In all cases, medium width buccal corridors were considered the most attractive ones ($p < 0.05$). When comparing narrow vs. wide corridors, statistically significant differences arose on occasion, with narrow corridors showing superiority in the Afro-descendant woman in both views (FFV and CVVM), and in the Afro-descendant man, in FFV assessments ($p < 0.05$).

Table 3 shows unpaired Student's *t* test comparing assessments of full-face (FFV) images with close-up views of the mouth (CUVM). As can be seen, no statistically significant difference was found between these two types of assessment ($p > 0.05$).

Table 1 - Means and standard deviations of the attractiveness levels of Caucasian and Afro-descendant women's smiles, according to different buccal corridor widths, in both image views (FFV and CUVM) (ANOVA and Tukey's post test).

	Buccal corridor	Caucasian Woman			Afro-descendant Woman		
		Mean	SD	Results*	Mean	SD	Results*
Close-up view (CUVM)	A-Narrow	49.03	27.81		54.49	29.98	
	B-Medium	75.90	22.97	B > A, C	80.51	22.06	B > A > C
	C-Wide	38.12	24.39		31.72	24.35	
Full-face view (FFV)	A-Narrow	47.73	27.88		49.19	25.95	
	B-Medium	72.24	23.32	B > A, C	84.39	19.39	B > A > C
	C-Wide	35.81	25.00		35.39	23.46	

*Images with the same letter do not differ significantly ($p < 0.05$).

Table 2 - Means and standard deviations of attractiveness levels of Caucasian and Afro-descendant men's smiles, according to different buccal corridor widths, in both image views (FFV and CUVM) (ANOVA and Tukey's post test).

	Buccal corridor	Caucasian Man			Afro-descendant Man		
		Mean	SD	Results*	Mean	SD	Results*
Close-up view (CUVM)	A-Narrow	44.51	27.91		48.37	28.96	
	B-Medium	75.06	22.69	B > A, C	76.46	21.28	B > A, C
	C-Wide	43.50	25.39		39.00	27.10	
Full-face view (FFV)	A-Narrow	49.15	26.06		49.40	27.66	
	B-Medium	72.10	24.30	B > A, C	77.94	20.14	B > A > C
	C-Wide	40.96	27.56		33.35	25.09	

*Images with the same letter do not differ significantly ($p < 0.05$).

Table 3 - Mean and standard deviation of attractiveness levels of male (M) and female (F) smiles, in close-up and full-face views (Student unpaired t test).

	Buccal corridor	Afro-descendant (M)		Caucasian (M)		Afro-descendant (F)		Caucasian (F)		Results
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Close-up view	Narrow	48.37	28.96	44.51	27.91	54.49	29.98	49.03	27.81	Close-up view = Full-face view ($p > 0.05$)
	Medium	76.46	21.28	75.06	22.69	80.51	22.06	75.90	22.97	
	Wide	39.00	27.10	43.50	25.39	31.72	24.35	38.12	24.39	
Full-face view	Narrow	49.40	27.66	49.15	26.06	49.19	25.95	47.73	27.88	
	Medium	77.94	20.14	72.10	24.30	84.39	19.39	72.24	23.32	
	Wide	33.35	25.09	40.96	27.56	35.39	23.46	35.81	25.00	

DISCUSSION

The impact of buccal corridor width on the smile's esthetic perception is still controversial. Parekh et al[5] argued that this feature does not contribute significantly to smile attractiveness. However, they included changes in the smile arc and lateral dark space in the same analysis. Johnson and Smith,[8] and Gianelly[12] compared the esthetics of the smile after treatment with and without extractions and found no differences. Roden-Johnson et al[10] and Ritter et al[15] corroborated these findings when reporting that buccal corridor does not influence the esthetic evaluation of smile photographs.

Unlike these findings and agreeing with Dunn et al,[20] the results of this study demonstrated that varying buccal corridor widths significantly affected smile attractiveness. This influence was not affected by gender, coinciding with the findings of Moore et al,[14] nor by ethnicity, as shown in Tables 1 and 2. By the same token, these findings support the study of Tedesco et al,[21] who found that ethnicity and gender do not interfere with the judgment of dentofacial attractiveness.

In all subject categories, the medium width buccal corridor — with a 16% distance between the outer commissures — was considered the most pleasant one. This result was similar to the one found by Gracco et al,[4] who detected a preference for an image with buccal corridor equivalent to 18.46% of the width of the smile, and disagreed with Moore et al,[14] who reported as more attractive a smile with a lateral negative space of 2%. Such difference may have occurred as a result of the fact that in the study by Moore et al,[20] the buccal corridor was measured based on inner commissures. Moreover, their method for changing the variable was different, i.e., the intercanine width was maintained while the number and width of the posterior teeth were modified.

A comparison between the narrow and wide buccal corridors after analyzing the four individuals studied showed greater predilection for the narrow buccal corridor in the Afro-descendant woman, in both views, and for FFV only in the Afro-descendant man. No other statistically significant difference was found between them. These findings disagrees with other studies in which broad smiles with narrow buccal corridors were considered more attractive.[4,5,14,20] This divergence underscores the need for further studies involving esthetic parameters for Afro-descendant individuals, which was also noted by Suzuki et al.[22]

The present study utilized full-face and close up smile photographs based on the assertion of Parekh et al.[5] that photographic images enable the evaluation of a given aspect or combination of elements which can be accurately and reliably modified at will. According to these authors, if a proper evaluation is to be achieved, images should be standardized by removing any elements that might distract an examiner's attention. For this reason, in all original photographs some corrections were made in order to adjust the smiles is such manner as to allow the individualization of the main variable studied, i.e., the buccal corridor.

In several studies, authors have compared photographs of smiles with different buccal corridor widths.[5,10,14,15,23] Some modified the same smile by adding or removing teeth,[5,10] changing the width of the teeth starting from the first maxillary premolars,[4] or changing the number and transverse width of posterior teeth.[14] Others compared smiles of different individuals whose lateral dark space shared no similarity, either by extracting premolars or otherwise.[15,23] In this study the lateral dark space was changed by altering tooth position, starting from the upper canines, since, according to Frush and Fisher,[10] although the buccal corridor can only be viewed posteriorly to the canines, the position and inclination of these teeth control their size and shape. This is due to the fact that canines play a key role in shaping the dental arch, which can be attested to when mounting teeth in a complete denture.

This study also assessed manipulated images in two views: Full-face view (FFV) and close-up view of the mouth (CUVM). The results showed no statistically significant difference between the two views ($p>0.05$). These findings corroborate the literature,[22,25] showing that for the evaluation of the esthetic influence of different buccal corridor dimension, that both views, i.e., full-face view, including nose, hair, eyes, face features, etc., and close-up view, highlighting only the smile, afford the same level of perception. Likewise, Gracco et al,[6] suggest that in assessing smile esthetics through photographs it would be advisable to employ images that exhibit subjects' lips only so as to keep the focus on the smile itself and avoid distractions from other facial features. Moreover, authors argue that the

esthetic impact made by showing the teeth is reduced in FFV, thus recommending the use of full-face photos to assess smile esthetics.[26]

This study made use of a visual analog scale which allowed fast and straightforward measurements to be taken while streamlining and clarifying the process for the raters. This scale recently gained in popularity to measure subtle differences in dental and facial attractiveness.[10,13,19] Maple et al[19] stated that grading with a continuous variable enables greater freedom in data analysis, averting bias related to preferred values, as is the case in the scale of numeric intervals.

In the past, studying smile esthetics was a more complex task since it was difficult to standardize actual models and to change the variables of interest. More recently, however, given the ability to digitally manipulate images of the same subject, changing the region of the buccal corridor and having the images assessed is a methodology that has been applied by some researchers.[4,5,10,14] It is, however, essential to bear in mind that this methodology uses artificial images and should therefore not be used as a single parameter for all patients. The findings of these studies are but guidelines, and should be applied with caution, taking into account, in particular, the individual characteristics of each patient and their esthetic expectations.

CONCLUSIONS

According to the data analyzed in this study, the smiles considered most attractive were those with medium width buccal corridor. Furthermore, it was found that, in general, there was no statistically significant difference between the narrow and wide buccal corridor. In addition, analysis of the smiling images revealed no statistical differences between FFV vs. CUVM images.

REFERENCES

1. Mondelli J. Estética e cosmética em clínica integrada restauradora. São Paulo (SP): Quintessence; 2003.
2. Ong E, Brown RA, Richmond S. Peer assessment of dental attractiveness. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):163-9.
3. Ackerman MB. Buccal smile corridors. Am J Orthod Dentofacial Orthop. 2005 May;127(5):528-9.
4. Gracco A, Cazzani M, D'Elia L, Manfrini M, Peverada C, Siciliani G. The smile buccal corridors: esthetic value for dentists and laypersons. Prog Orthod. 2006;7(1):56-65.
5. Parekh S, Fields HW, Beck FM, Rosenstiel SF. The acceptability of variations in smile arc and buccal corridor space. Orthod Craniofac Res. 2007 Feb;10(1):15-21.
6. Frush JP, Fisher RD. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent. 1958 July;8(4):558-81.
7. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification. Part 2: Smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop. 2003 Aug;124(2):116-27.
8. Johnson DK, Smith R. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop. 1995 Aug;108(2):162-7.
9. McNamara JA. Maxillary transverse deficiency. Am J Orthod Dentofacial Orthop. 2000 May;117(5):567-70.
10. Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Mar;127(3):343-50.
11. Mendes WB, Bonfante G. Fundamentos de Estética em Odontologia. 2a ed. São Paulo (SP): Santos; 1996.
12. Gianelly AA. Arch width after extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop. 2003 Jan;123(1):25-8.
13. Kokich VO, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11(6):311-24.
14. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Feb;127(2):208-13.
15. Ritter DE, Gardini LG, Pinto A, Locks A. Esthetic influence of negative space in the buccal corridor during smiling. Angle Orthod. 2006 Mar;76(2):198-203.
16. Abu Alhaija ES, Al-Shamsi NO, Al-Khateeb S. Perceptions of Jordanian laypersons and dental professionals to altered smile esthetics. Eur J Orthod. 2011 Aug;33(4):450-6.
17. Isiksal E, Hazar S, Akvalçin S. Smiles esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):8-16.
18. McLeod C, Fields HW, Hechter F, Wiltshire W, Rody W, Christensen J. Esthetics and smile characteristics evaluated by laypersons: a comparison of Canadian and US data. Angle Orthod. 2011 Mar;81(2):198-205.
19. Maple JR, Vig KW, Beck FM, Larsen PE, Shanker S. A comparison of providers' and consumers' perceptions of facial-profile attractiveness. Am J Orthod Dentofacial Orthop. 2005 Dec;128(6):690-6.
20. Dunn WJ, Murchison DF, Broome JC. Esthetics: patients' perceptions of dental attractiveness. J Prosthodont. 1996 Sept;5(3):166-71.
21. Tedesco LA, Albino JE, Cunat JJ, Slakter MJ, Waltz KJ. A dentofacial attractiveness scale. Parte II: consistency of perception. Am J Orthod. 1983 Jan;83(1):44-6.
22. Suzuki L, Machado AW, Bittencourt MAV. Avaliação da influência da quantidade de exposição gengival na estética do sorriso. Dental Press J Orthod. 2011 Sept/Oct;16(5):37.e1-10.
23. Yang IH, Nahm DS, Baek SH. Which hard and soft tissue factors relate with the amount of buccal corridor space during smiling? Angle Orthod. 2008 Jan;78(1):5-11.
24. Telles D, Hollweg H, Castellucci L. Prótese Total: convencional e sobre implantes. São Paulo (SP): Ed. Santos; 2003.
25. Rodrigues CD, Magnani R, Machado MS, Oliveira OB. The perception of smile attractiveness. Angle Orthod. 2009 July;79(4):634-9.
26. Flores-Mir C, Silva E, Barriga MI, Lagravère MO, Major PW. Layperson's perception of smile esthetics in dental and facial views. J Orthod. 2004 Sept;31(3):204-9.

Capture, analysis and measurement of images of speech and smile dynamics

Vera Lúcia Cosendey[1], Stephanie Drummond[2], Jonas Capelli Junior[3]

Introduction: Dynamic analysis of smile and speech makes it easier to identify the features that define facial esthetics while allowing researchers to study different variables and observe the effects of aging.

Objective: The aim of this study is to present a method for capturing, analyzing and measuring video images to support the study of speech and smile dynamics.

Methods: Natural head positioning was standardized with the aid of a head holder (cephalostat). Image acquisition is performed with a video camera attached to a tripod, positioned at a fixed distance of 0.90 m. The subjects are trained to say out loud: "Tia Ema torcia pelo antigo time da Tchecoslováquia" and then to smile. The resulting images are fragmented and yielded four pictures that best represent a resting position, the least exposure of maxillary incisors, the greatest exposure of upper and lower incisors, and a posed smile. A freeware computer program called VIDEOMED was used to carry out measurements.

Conclusion: The method presented in this study is an effective resource to record images captured during rest, speech and smile, thereby enabling a better understanding of changes in perioral soft tissues.

Keywords: Aging. Video recording. Facial expression.

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INTRODUCTION

In orthodontics three methods are commonly suggested when studying the smile, namely: Qualitative, semi-quantitative and quantitative methods. The qualitative method is strictly visual. Typically, an orthodontist will look at a patient's smile and assess, for example, the smile line height. In the semi-quantitative method, analysis of the smile is performed by means of photographs, and in the quantitative method smile line height is determined with the aid of instruments. Measurements range from the simplest to the most sophisticated approaches.[1]

Capturing the smile image through photography presents certain difficulties: Photograph standardization is difficult due to differences in camera positioning, control of the distance to the focal point of the patient, head angle and the clinician's inability to capture the social smile twice in different photographic sessions.[2]

Image capture with a camera and video edition for subsequent analysis with computer programs seems to be a highly efficient method in the dynamic analysis of speech and smile. Ackerman et al[2,3,4] spearheaded the development of this technique. According to Maulik and Nanda,[5] videos allow researchers to select frames, increasing accuracy when choosing the images that more faithfully depict posed smiles and incisors exposure during speech while concurrently enabling observation of the patient in conversation. This also facilitates the identification of strengths and weaknesses in facial esthetics, allowing observation of the effects of aging on perioral soft tissues.[4]

Exposure of anterior teeth is not the same during speech vs. smile. This is evidenced in the rest, speech and posed smile video clips. A reasonable camcorder can record thirty frames per second, producing a five-second video clip in a total of about one hundred and fifty frames.[2]

This study aims to present a method to enable the capture, analysis and measurement of images through videos clips as a foundation for studying the dynamics of speech and smile.

MATERIAL AND METHODS

Image capture

Natural head position should be chosen, and for this reason a head holder (cephalostat) was used as the gold standard to stabilize the head of each individual. In this case, ear positioners restricted excessive lateral movements and the nasion positioner limited vertical movements (Fig 1).

Image capture can be performed by any video camera that uses digital tape MINI-DV format (for example: Sony model DCR-HC15 VTSC). The camera was attached to a tripod and positioned at a fixed distance in a straight line of 0.90 m between the patient's face and the camera lens. A second tripod should be positioned with an acrylic plate having a millimeter marker, of known dimension (30 mm x 50 mm) positioned flush to the patient's lips and orthogonally to the camera, for later image calibration in the computer program. This marker must fully cover the lips of the individual, and the upper portion of the plate should be parallel to the ground. Both tripods have

Figure 1 - Image capture: **A**) Positioning participant in head holder (cephalostat) and capturing image with acrylic calibration plate, **B**) capturing posed smile, **C**) acrylic plate used for calibration of image with bubble level.

to have a bubble level indicator to ensure parallelism of the camera and the acrylic plate with the floor. An additional bubble level was then positioned on the acrylic plate, in order to ensure greater accuracy in its positioning in the horizontal plane (Fig 1).

After leveling, the bubble level can be removed, once the tripod has been properly adjusted. The camera must be raised to the level of the lower face, with the lens perpendicular to the ground. The captured image will be that related to the lower face, so that the mouth of the subject is in the center of the camera's LCD display. Due to variations in facial heights between individuals, the resulting images may suffer differences in the framework.

To standardize the analysis of exposure of the teeth and soft tissues at different time intervals, the pronunciation of the same phrase can be employed. The sentence in Portuguese: *"Tia Ema torcia pelo antigo time da Tchecoslováquia"* followed by a smile was created with the guidance of a speech therapist who translated it phonetically from its original in English: "*Chelsea eats cheesecake on the cheasapeake*" created by Ackerman and Ackerman[2] in 2002 for capturing the greatest exposure of the incisor teeth during speech. According to Morley and Eubank,[6] enunciation of the phoneme "M" is used to obtain the exposure of the incisor teeth at rest. This phoneme was therefore added to record the lowest exposure of the incisors.

Shooting then begun, with a light source and diffuser being used as indirect lighting, with the calibrator positioned in front of the mouth for further calibration. This calibrator was then removed to visualize the pronunciation of the sentence previously trained, beginning at rest, and ending the session with a smile.

Video editing

The videos obtained were transferred to a computer, using Adobe Premiere Pro 2.0 software (Adobe Systems Incorporated, USA), in order to generate files in AVI format. The resulting videos have on average 12 seconds duration with an average 47 MB file size, in a total of about 360 picture frames per video. These videos were analyzed and split up at rest, during speech and smile, in order to produce the four static frames (corresponding to a photograph) that best represented a resting position, the least exposure of maxillary incisors, the greatest exposure of maxillary and mandibular incisors, and a posed smile.

The first frame selected was the image of a resting position, where the length of the lip and the height of the commissures were measured. Following the video sequence, the next frame showed the end of the utterance of the syllable "ma" in the word Ema; where the amount of maxillary incisor exposure, considered as the lowest exposure in speech was measured. On enunciation of the syllable "tche" in Tchecoslováquia, maxillary incisor exposure considered as the greatest exposure during speech was measured, as well as the amount of mandibular incisor exposure, if it ever came into view. As regards to the posed smile, measurements were made of the maximum maxillary incisor exposure and gingival exposure (Fig 2).

To ensure an accurate choice of picture frames it was necessary to carefully observe all the video fragments of each individual, so that only those that best represented each particular frame could be selected. Figure 3 shows nine different frames extracted from the same video, where frame number 6 best represents the ending utterance of the phoneme "tche."

Measurements in the selected frames were performed with the aid of a specific freeware program for measuring distance and area on video, called VIDEOMED 1-16.9.2002 ALPHA (version PAEDD) produced in the Multimedia Laboratory of the Electronic Computer Center of the Federal University of Rio de Janeiro. This program allowed researchers to view the images and hear the speech of the subjects, which facilitated the selection of frames corresponding to each phoneme. To use VIDEOMED, it was executed initially the calibration of the image (obtained with the calibration plate positioned in front of the area to be measured) with linear correction factor for X and Y, thus enabling measurements with the lowest error coefficient possible (Fig 4). Using a cursor and a lens that magnified the view of the marked points, it was possible to carry out specific measurements in each selected frame.

Image analysis

Direct measurements were made of each individual's cervical incisal height of the maxillary right central incisor and mandibular right central incisor with a digital caliper. This measure was obtained by

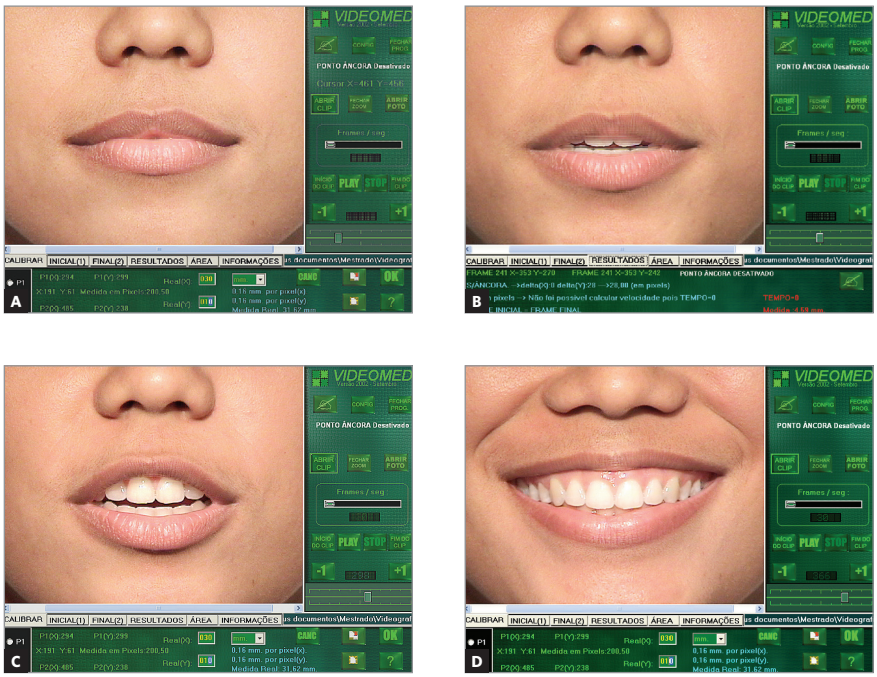

Figure 2 - Selection of four picture frames: **A**) At rest; **B**) uttering syllable "ma" – considered the least exposure of maxillary incisors during speech; **C**) uttering of syllable "tche" – considered as the moment of greatest exposure of maxillary and mandibular incisors; **D**) posed smile.

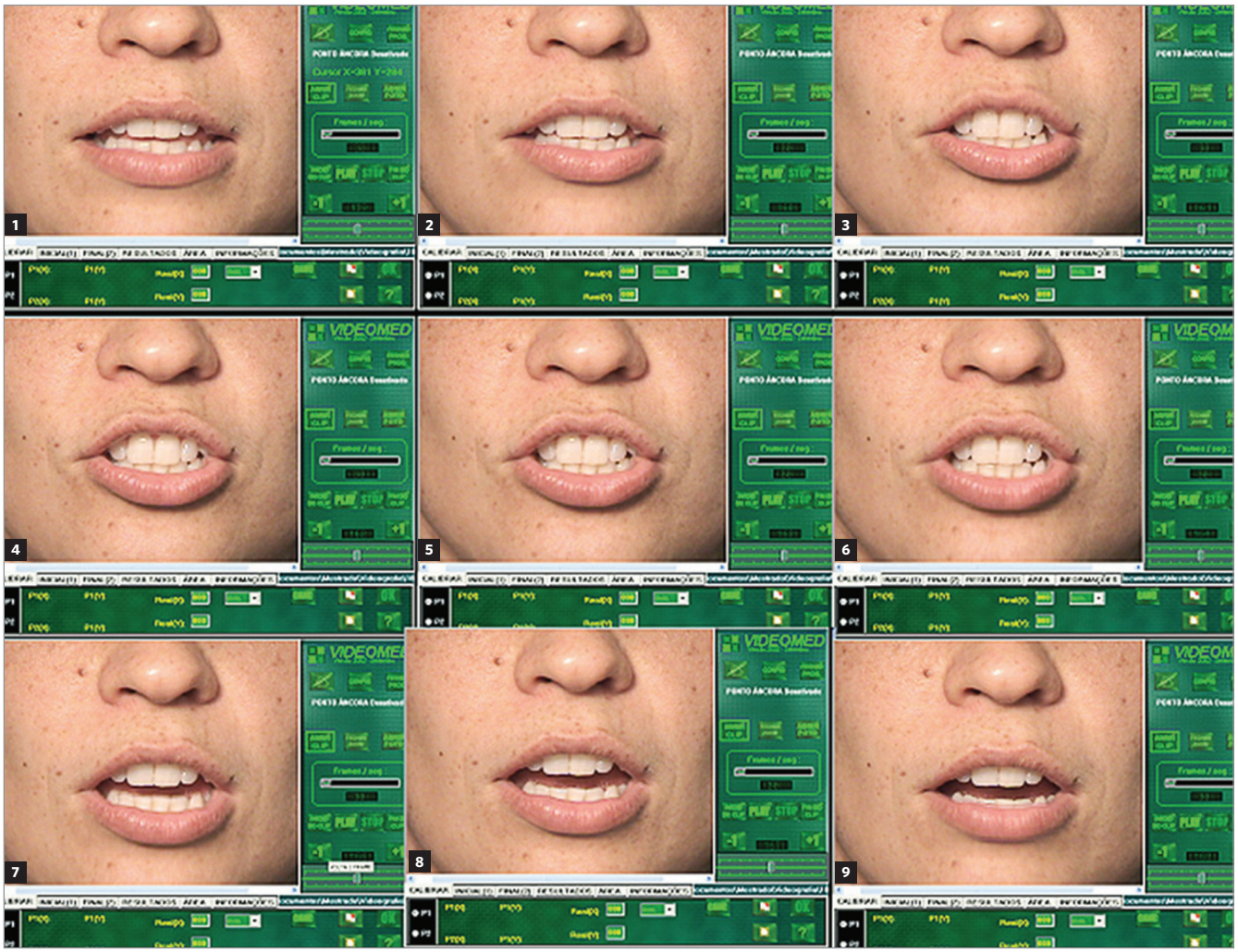

Figure 3 - Different pictures frames showing utterance of syllable "tche". Frame no. 6 best represents utterance of this phoneme.

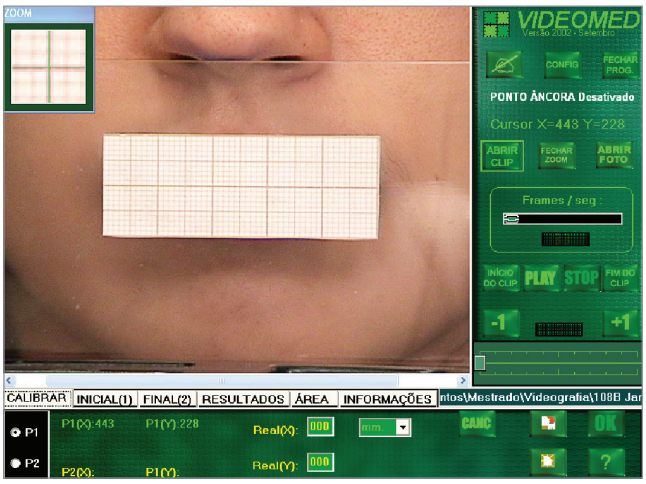

Figure 4 - Image frame captured for calibration on computer and subsequent measurement using VIDEOMED software.

the distance between the incisal edge and the neck of the tooth in question, in the direction of its long axis. In each frame analyzed, specific measures on the teeth and soft tissue could be assessed. Noteworthy among these were:

A) Lip length (LL): Measured in millimeters from the base of the nose, on the midline, as far as the lowest portion of the upper lip vermillion, on the philtral column, at rest. This imaginary line must pass through the arch of the cupid.

B) Lip commissure height (LC) and (RC): Measured from a vertical line tangent to the external commissures and perpendicular to a horizontal line passing through the lower portion of the bases of the nose wings.

C) Least exposure of maxillary incisors during speech (EMA): Measurement of the cervical incisal length of the maxillary right central incisor exposed at the end point of utterance of the syllable "ma," in the word Ema.

D) Maxillary incisor exposure during speech (TCHE): Measurement of the cervical incisal length of the maxillary right central incisor exposed during the utterance of the syllable "tche," in the word Tchecoslováquia.

E) Mandibular incisor exposure during speech (TCHE lower): Measurement of the cervical incisal length of the mandibular right central incisor exposed during the utterance of the syllable "tche," in the word Tchecoslováquia.

F) Maximum exposure of maxillary incisor during posed smile (SMILE): Measurement of the cervical incisal length of the maxillary right central incisor exposed during posed smile.

G) Gingival exposure during smile (GE): Measurement of the amount of gum exposed during posed smile: Distance between the lower edge of the upper lip and the gingival margin of the maxillary right central incisor. Exposure of a strip of gum above the maxillary right central incisor was regarded as a positive value. The value was considered zero when the lower edge of the upper lip was leveled with the gingival margin of the incisor. It was considered negative, when one cannot view the total cervical incisal length of the maxillary right central incisor, which was calculated by subtracting the measurement of incisor exposure during smile from its total length.

To determine the reliability and validity of the method presented, 124 subjects were randomly selected at the School of Dentistry of Rio de Janeiro State University to voluntary participate in the shooting in question.

The intra-class correlation test regarding the reproducibility of the operator showed a high correlation (1.0) considering the level of significance of 5%. The reliability of the method was evaluated measuring two times each variable in the subjects investigated, with an interval of 1 week. The intra-class correlation test was used for this assessment, obtaining also for all variables a high correlation coefficient considering the level of significance of 5% (Table 1).

Table 1 - Intra-class correlation coefficient between the first and second measurement of the variables in the subjects investigated.

Variables	Intra-class correlation
EMA 1 X EMA 2	0.991
TCHE 1 X TCHE 2	0.998
SMILE 1 X SMILE 2	0.989
TCHE low 1 X TCHE low 2	0.974
LL 1 X LL 2	0.975
LC 1 X LC 2	0.981
RC 1 X RC 2	0.962
GE 1 X GE 2	0.996

DISCUSSION

Incisor and gingival exposure, as well as the lip shape are significantly different during speech vs. smile. These differences can be observed when evaluating the smile images and the pronunciation of certain phonemes.[7] The few studies that have investigated these factors report that these methods are reliable.[1]

Studies of this nature pose difficulties owing to the labiodental characteristics, facial mobility and the complexity involved in acquiring images that represent such characteristics in each patient evaluated, with faithfulness and reproducibility, and which can be repeated at different time intervals.[2]

In this method, image capture was accomplished by filming with a digital camcorder, to ensure the recording of more accurate observations of facial dynamics during a conversation. It was used a head holder to standardize head positioning in natural and orthogonal position to the camera, in order to reduce the variation in this position, which could alter the angle of observation and thus the analysis of the arch of the smile, the gingival margin, incisors length, axial tilt, in agreement with other studies.[2,8,9]

The development of a method capable of capturing, analyzing and measuring the recorded images in a reliable and relatively simple manner, was made possible thanks to the availability of a program developed at the Multimedia Electronic Computer Center from the Federal University of Rio de Janeiro. This method made it possible to observe the images of dynamics facial in the form of a video clip, split them frame by frame and select the ones that best represent the variable being examined.

Due to the great difficulty in capturing a reproducible smile to analyze labiodental characteristics, this study used what is called a posed or social smile, which is considered more static and therefore reproducible.[10,11,3]

A standardized videography provides the clinical orthodontist a greater number of images for selection of labiodental relationship parameters. Due to likely variations in the smile of adolescents, over time, photographs are rendered inadequate for evaluating treatment effects or changes caused by aging.[7]

CONCLUSION

This method makes possible an effective recording that supports image capture during rest, speech and smile, while allowing the analysis and measurement of different variables. Information gleaned from these video clips can afford a deeper understanding of the changes in perioral soft tissues, contributing to the implementation of such knowledge in the search for more effective orthodontic treatment results.

REFERENCES

1. Van der Geld PAAM, Oosterveld P, Van Waas MAJ, Kuijpers-Jagtman AM. Digital videographic measurement of tooth display and lip position in smiling and speech: Reliability and clinical application. Am J Orthod Dentofacial Orthop. 2007 Mar;131(3):301.e1-301.e8.
2. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002 Apr;36(4):221-36.
3. Ackerman JL, Ackerman MB, Bresinger CM, Landis Jr. A morphometric analysis of the posed smile. Clin Orthod Res. 1998 Aug;1(1):2-11.
4. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 1. Evolution of the concept and dynamic records for smile capture. Am J Orthod Dentofacial Orthop. 2003 Jul; 124(1):4-12.
5. Maulik C, Nanda R. Dynamic smile analysis in young adults. Am J Orthod Dentofacial Orthop. 2007 Sep;132(3):307-315.
6. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc. 2001 Jan; 132(1):39-45.
7. Ackerman MB, Brensinger C, Landis JR. An evaluation of dynamic lip-tooth characteristics during speech and smile in adolescents. Angle Orthod. 2004 Feb;74(1):43-50.
8. Zachrisson BU. Esthetic factors involved in anterior tooth display and the smile: vertical dimension. J Clin Orthod. 1998 Sep;32(9):432-45.
9. Wong NKC, Kassim AA, Foong KWC. Analysis of esthetic smiles by using computer vision techniques. Am J Orthod Dentofacial Orthop. 2005 Sep;128(3):404-11.
10. Hulsey CM. An esthetic evaluation of lip-teeth relationship in the smile. Am J Orthod. 1970 Feb;57(2):132-144.
11. Rigsbee OH, Sperry TP, Begole EA. The influence of facial animation on smile characteristics. Int J Orthod Orthognath Surg. 1988;3(4):233-239.

Evaluation of immediate soft tissue changes after rapid maxillary expansion

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Objective: To evaluate immediate soft tissue changes following rapid maxillary expansion (RME) in growing patients, using cone beam computed tomography (CBCT).

Methods: Twenty-three consecutive patients (10 male, 13 female) treated by RME were selected. Patients were scanned using CBCT prior to placement of the rapid maxillary expander (T_0), then immediately following full activation of the appliance (T_1). Defined landmarks were then located on the pre- and post-treatment orientated images. Change in landmark position from pre- to post-treatment was then measured. In addition to landmarks, 10 direct measures were made to determine distance change without regard to direction to measure soft tissue change of the lips.

Results: Significant transverse expansion was measured on most soft tissue landmark locations. All the measures made showed significant change in the lip position with a lengthening of the vertical dimension of the upper lip, and a generalized decrease of anterior-posterior thickness of both the upper and lower lips.

Conclusions: Significant changes in the soft tissue do occur with RME treatment. There is a transverse widening of the midface, and a thinning of the lips.

Keywords: Palatal expansion technique. Cone beam computed tomography. Corrective 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

Rapid maxillary expansion (RME) has been shown to produce an increase in arch width and perimeter to allow correction of posterior crossbites and provide space to alleviate crowding of the dentition.[1,2,3] The hard tissue changes that take place have been well documented in the literature.[1,2,4-10]

Compared with the large amount of information available about the hard tissue changes associated with RME, there is a relatively small amount of information available regarding soft tissue changes. Karaman et al evaluated soft tissue changes induced by RME. They used lateral cephalograms taken on 20 patients pre- and post-RME treatment. They found that the nose tip and soft tissue A point followed the anterior movements of the maxilla and maxillary incisors.[11]

Available studies, however, largely neglect structures lateral to the midline. Studies of soft tissue change involving facial regions lateral to the midline are limited partly because these structures are not identifiable on traditional two-dimensional cephalograms.[12] Also it is somewhat difficult to identify soft tissue landmarks reliably due to the nature of these tissues.[13,14]

One attempt to measure regions lateral to the midline in RME cases was made by Berger et al.[15] They measured facial changes based on measurements made from two dimensional digital photos and found changes in several areas. Using this method they documented some changes that take place in the soft tissue when viewed from a frontal view.

With more information becoming available through the more widespread use of Cone Beam Computed Tomography (CBCT) in orthodontics, there are greater opportunities for study of the effects orthodontic treatment on the soft tissues. Progress in software development now allows for better manipulation and viewing of the CBCT images, which permits the collection of information that is reliable and precise.[16]

The purpose of this study was to evaluate the immediate soft tissue effects of RME using CBCT.

MATERIAL AND METHODS

Records of 25 patients were collected from an orthodontic private practice, which were consecutively treated with RME. All patients had been diagnosed with a skeletal transverse discrepancy, or arch length discrepancy and undergone RME treatment according to a standard protocol and performed by a single orthodontist.

Exclusion criteria consisted of patients with severe skeletal asymmetry, including those with craniofacial anomalies. Patients who had orthodontic treatment before treatment with RME were also excluded.

Because of the exclusion criteria, the final sample consisted of 23 patients (10 male, 13 female). The mean age of the patients at the time of the first CBCT image was 12.3 ± 2.6 years, with a range of 8.3 to 17.8 years. The second CBCT image was taken a mean of 22.8 days later with a range of 14 to 37 days.

Each patient had been treated with a fixed rapid maxillary expander. The expander used in all cases was manufactured by Dentaurum (Dentaurum Group, Ispringgen, Germany) and contained a 7 mm expansion jackscrew. The stainless steel appliance was soldered to orthodontic bands on the maxillary first molars, with supporting arms extending anteriorly to the premolar and canine regions (Fig 1).

The rapid palatal expander was activated two one-quarter turns (0.2 mm each quarter turn) upon delivery of the appliance, then by one one-quarter turn twice a day by the patient or parent until the required

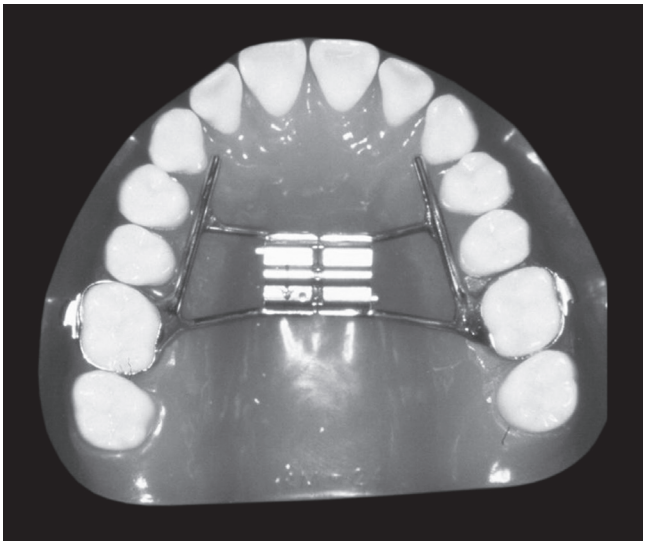

Figure 1 - Model of palatal expander used on patients in this study.

expansion was achieved. Each patient received two CBCT scans, one prior to the delivery of the appliance (T_0), and one immediately following the active expansion phase of treatment (T_1). All scans were taken by the same technician with the patient seated in a vertical position. The patients were stabilized with teeth together in centric relation, and with the Frankfort horizontal plane parallel to the floor. The Classic i-CAT CBCT scanner (Imaging Sciences International, Hatfield, PA) was used for all scans, and required 20 seconds for each scan, with voxel size set at 0.4 mm. Each data set was assigned a number to eliminate the possibility of patient identification and imported to Dolphin Imaging 10.5 software (Dolphin Imaging and Management Solution, Chatsworth, CA). The image was orientated along the mid-sagittal plane (z plane), Frankfort horizontal plane (x plane), and a coronal plane (y plane) extending through the anterior wall of the right and left external meatus. The image was orientated first to the mid-sagittal plane (determined by nasion and sella), then the horizontal plane was created perpendicular to the sagittal plane and rotated until it was parallel to and aligned with Frankfort horizontal plane. Finally the coronal plane was created perpendicular to the two already established planes, and set against the anterior wall of the right external meatus (Fig 2).

Landmark assessment

Placement of landmarks was accomplished using Dolphin Imaging software. This allows for points to be defined three-dimensionally using x, y, z Cartesian coordinate system, based on the 3 planes of orientation. A series of 20 landmarks were placed on each pre- and post-treatment scan and their three-dimensional changes were determined by their x, y, z coordinates (Fig 3). The landmark at the tip of the nose was located on only 8 patients because it was not captured in the field of view on the other 15 patients.

Most of the landmarks change noted as the result of treatment was measured in the transverse plane. To detect changes in the transverse plane, the x coordinate values were used. To measure anteroposterior change the z coordinate values were used. A list and definition of all the landmarks placed can be found on Table 1, this table also shows the plane of measurement used for each landmark.

In addition to the landmarks, 10 direct measures were made between two defined points. One direct measure was also made on the post-treatment image of the mesial and distal aspects of the rapid palatal expander to assure expansion had taken place. These measures show the change in distance between two points without regard to the direction of change. All but one of these measures was made using

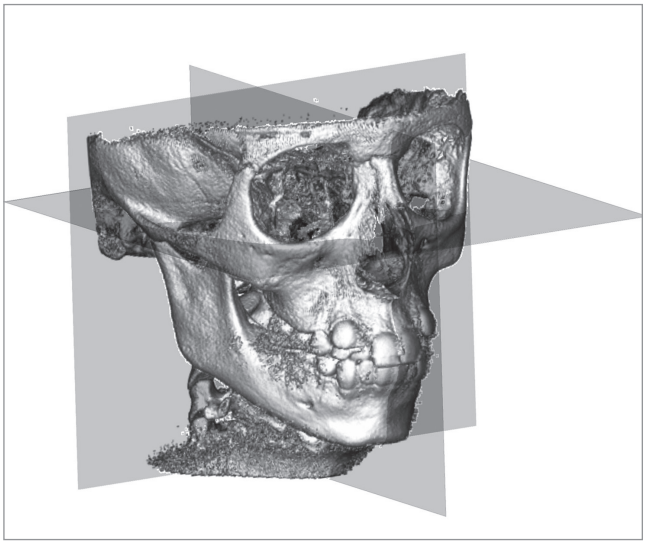

Figure 2 - Standard orientation using three-dimensional planes.

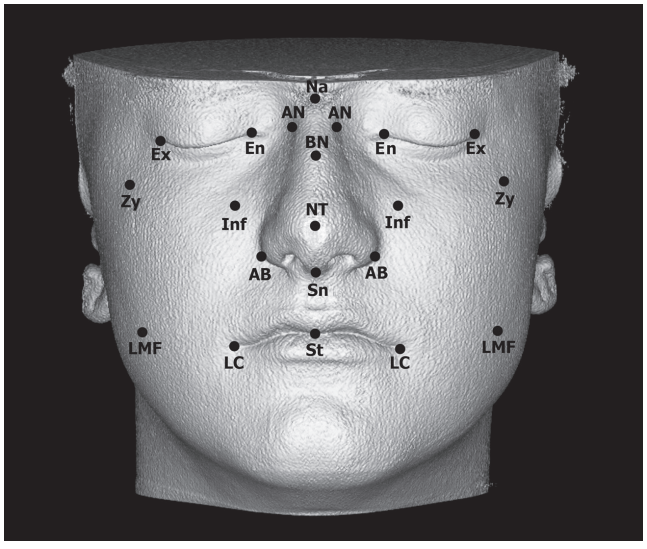

Figure 3 - Frontal view with soft tissue landmarks.

Table 1 - Definitions of anatomic landmarks.

Landmark	Definition	Measured plane
Exocanthion (Ex)	Lateral commissure of the eye recorded bilaterally	x
Endocantion (En)	Medial commissure of the eye, recorded bilaterally	x
Apex of nose (AN)	Soft tissue over the junction of the nasomaxillary suture and nasofrontal suture, recorded bilaterally	x
Soft tissue nasion (Na)	Point of intersection between the sella-nasion line and the soft tissue profile	z
Soft tissue zygion (Zy)	Soft tissue over most lateral point of the zygomatic arch, point determined from frontal view, recorded bilaterally	x
Bridge of Nose (BN)	Soft tissue on mid-sagittal plane over the tip of the nasal bone, extended parallel to FH plane	z
Soft tissue over infraorbital foramen (INF)	On frontal view located the superior anterior extent of the infraorbital foramen, landmark placed on soft tissue over that point, extended parallel to FH plane, recorded bilaterally	x, z
Alar base (AB)	Viewed frontal and inferiorly where nasal alar meets face on the inferior border of nose, recorded bilaterally	x
Nose tip (NT)	Most anterior point of the nose recorded on the mid-sagittal plane	z
Subnasale (Sn)	Point at which the nasal septum merges, in the mid-sagittal plane, with the upper lip	z
Lower midface (LMF)	Soft tissue over the center of the upper first molar crown, extending perpendicular from the mesiodistal plane of the crown, recorded bilaterally	x
Lip commissure (LC)	Point of union of the upper and lower lip, recorded bilaterally	x
Stomion (St)	Median point of the mouth when the mouth is closed	

a two-dimensional axial image generated from the three-dimensional CBCT image. These axial images were created parallel to the Frankfort horizontal plane at the level of the centers of the crowns of the incisors in the mandible and maxilla. These were used to measure changes in the thickness of the upper and lower lips. Five measures were made on the upper lip; one measure at the mid-sagittal, and one over each of the four maxillary incisors. This measurement was taken by determining the mesiodistal axis of each tooth and constructing a perpendicular bisector from the tooth outwardly to a point on the soft tissues. (Fig 4). There were four similar measures taken on the lower lip one over each mandibular incisor (Fig 5). The tenth measurement was taken on the frontal view of the three-dimensional image of the soft tissues between subnasale and stomion. This measurement was used to assess changes in the vertical length of the upper lip. All of the measures taken were recorded in millimeters. The change was then averaged for five measures on the upper lip and the four measures on the lower lip to describe the average change in the thickness of each lip.

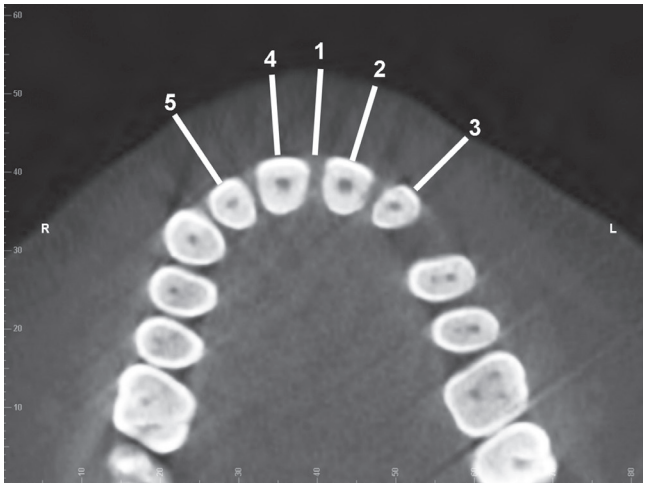

Figure 4 - Measurements of the upper lip thickness: **1**) midsagittal plane, **2**) left central incisor, **3**) left lateral incisor, **4**) right central incisor, **5**) right lateral incisor.

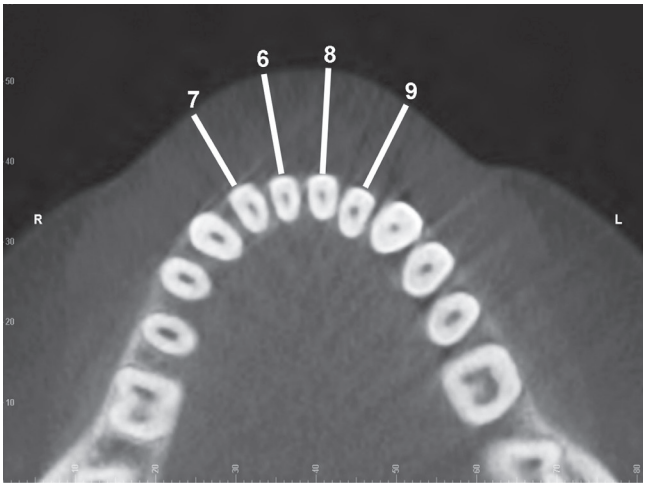

Figure 5 - Measurements of the lower lip thickness: **6**) right central incisor, **7**) right lateral incisor, **8**) left central incisor, **9**) left lateral incisor.

Statistics

For the landmark-based assessments, measurements describe the amount of change in the specific plane being investigated. Direct measures between landmarks describe the absolute amount of change between the two points independent of the direction of change. All statistics were calculated using SPSS 14.0 Statistical Software (SPSS, Inc., Chicago, IL). In order to determine the significance of described changes, a paired t-test was used. The level of significance was defined as $p<0.05$.

To asses the accuracy of landmark placement and repeated measures reliability testing was performed. Three of the twenty-three patients were randomly selected and all landmarks and measurements were duplicated. A Cronbach's alpha test was executed on repeated measures. A perfect score equals 1.00, while a Cronbach's alpha greater than or equal to 0.80 is considered an indicator for a reliable technique. Reliability testing was also used to determine the accuracy of the method of orientation. This was calculated by placing landmarks in non-changing areas of the skull, in this case on the anteriosuperior border of the right and left foramen ovale.

RESULTS

All landmarks had a Cronbach's alpha above 0.80. The intraclass correlation coefficient showed all the landmarks to be reliable. The lowest of the Cronbach's Alpha measurements reported was 0.84 for subnasale. Reliability testing of the orientation method using the Cronbach's alpha showed the x and z alignments to be reliable; the y-axis was not show to be reliably located. No measures were taken using the y-axis in this study.

The mean amount of RME in this sample was 5.2 mm with a range of 3.1 mm to 6.4 mm. The descriptive statistics for all measures are listed in Table 2. The results of the paired t-tests are shown in Table 3. The measurements for all but four of the landmarks show significant changes (Figs 6 and 7). The four landmarks that did not show significance were soft tissue nasion (Na), the left lip commissure (LC), the right apex of nose (AN), and the right soft tissue over the upper first molar (LMF). All of the measured values for the lips showed a significant change.

The average change of the upper lip was then calculated by taking the mean of the changes seen with the five measures on the upper lip. The average change in thickness of the upper lip was -0.92 mm. The same measure was made in the lower lip and change in thickness was calculated to be -1.04 mm. These demonstrated a mean decrease in upper and lower lips thickness.

Table 2 - Descriptive statistics.

Measure (mm)	n	Mean change
Right Ex	23	0.90 ± 1.18
Right En	23	1.30 ± 1.17
Left En	23	1.22 ± 1.76
Left Ex	23	1.08 ± 1.24
Right LC	23	1.20 ± 1.45
Left LC	23	0.65 ± 1.52
Right AB	23	0.86 ± 0.73
Light AB	23	0.93 ± 0.87
Na	23	0.43 ± 1.24
BN	23	0.79 ± 1.36
Sn	23	2.21 ± 1.23
Right AN	23	0.43 ± 1.25
Left AN	23	0.89 ± 1.06
Right Inf (Transverse)	23	0.85 ± 1.00
Right Inf (Anterioposterior)	23	1.21 ± 1.56
Left Inf (Transverse)	23	1.12 ± 0.97
Left Inf (Anterioposterior)	23	0.96 ± 1.27
NT	8	1.58 ± 0.68
Right LMF	23	0.78 ± 1.89
Left LMF	23	1.49 ± 1.28
Right Zy	23	0.88 ± 0.65
Left Zy	23	1.10 ± 1.28
Sn to St	23	0.92 ± 1.04
Upper Lip Midsagittal	23	-1.07 ± 0.93
Upper Lip Left Central	23	-0.68 ± 0.70
Upper Lip Left Lateral	23	-0.77 ± 0.84
Upper Lip Right Central	23	-0.93 ± 0.98
Upper Lip Right Lateral	23	-1.16 ± 1.22
Lower Lip Right Central	23	-0.99 ± 1.06
Lower Lip Right Lateral	23	-1.07 ± 1.06
Lower Lip Left Central	23	-1.19 ± 1.01
Lower Lip Left Lateral	23	-0.89 ± 1.05

Table 3 - Paired t-test results (*: significance p < 0.05).

Measure	t	Sig. (2-tailed)
Right Ex	3.66	0.001*
Right En	5.34	0.000*
Left En	3.32	0.003*
Left Ex	4.16	0.000*
Right LC	3.96	0.001*
Left LC	2.06	0.052
Right AB	5.63	0.000*
Left AB	5.19	0.000*
Na	1.66	0.111
BN	2.69	0.014*
Sn	8.63	0.000*
Right AN	1.68	0.107
Left AN	4.02	0.001*
Right Inf (Transverse)	4.08	0.000*
Right Inf (Anterioposterior)	3.73	0.001*
Left Inf (Transverse)	5.53	0.000*
Left Inf (Anterioposterior)	3.62	0.002*
Nose Tip	6.61	0.000*
Right LMF	1.99	0.060
Left LMF	5.59	0.000*
Right Zy	6.56	0.000*
Left Zy	4.12	0.000*
Sn to St	4.25	0.000*
Upper Lip Midsagittal	-5.48	0.000*
Upper Lip Left Central	-4.65	0.000*
Upper Lip Left Lateral	-4.37	0.000*
Upper Lip Right Central	-4.59	0.000*
Upper Lip Right Lateral	-4.56	0.000*
Lower Lip Right Central	-4.46	0.000*
Lower Lip Right Lateral	-4.86	0.000*
Lower Lip Left Central	-5.65	0.000*
Lower Lip Left Lateral	-3.94	0.001*

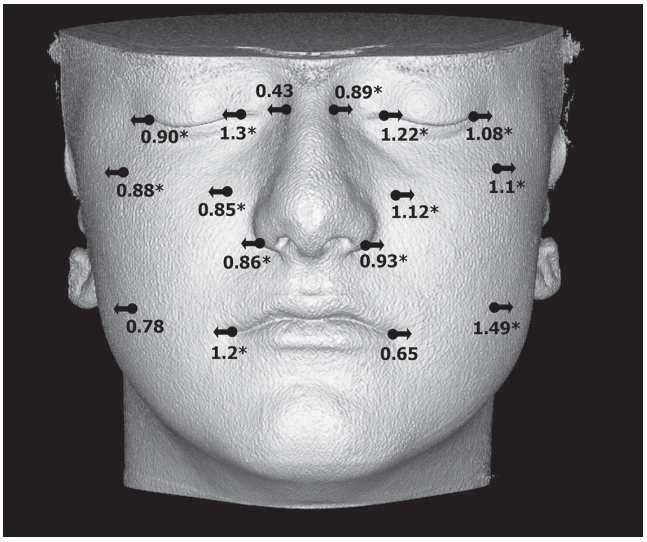

Figure 6 - Transverse change of landmarks (*significant change).

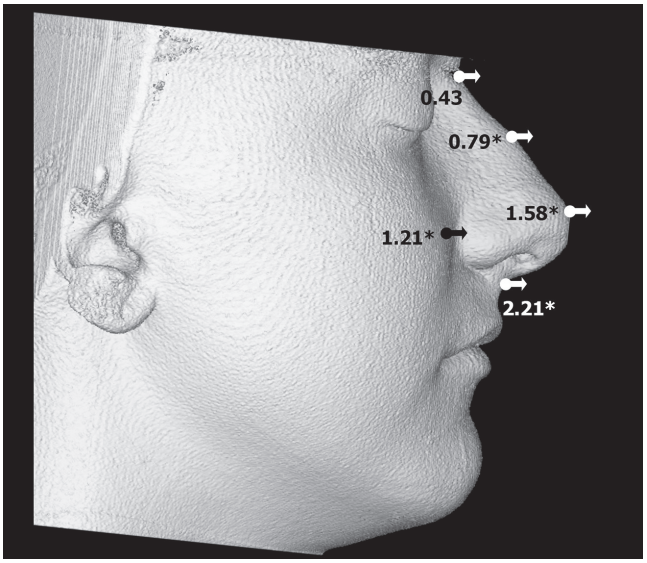

Figure 7 - Anteroposterior change (*significant change).

DISCUSSION

The changes associated with RME in hard tissue structures have been described by many authors.[1,2,4-10] It has been shown that the soft tissue does not necessarily follow the changes of the underlying hard tissue.[17] Studies on the soft tissue regions lateral to the mid-line are also limited partly because these structures are not identifiable on traditional two-dimensional cephalograms.[12] Further it is difficult to repeatedly identify soft tissue landmarks due to the nature of these tissues.[12,13]

Based on the results of this study the methods that were used to identify landmarks have shown to be reliable. Also the methods used to orientate the pre- and post-treatment CBCT scans to the same orientation have shown to be reliable. The ability to orientate the T_0 and T_1 images to the same orientation allowed changes to be measured in any plane.

This sample was unique in that the data provide information directly prior to placement of the appliance, and directly following the active

expansion phase of treatment, allowing the assessment of immediate changes, directly attributed to RME. The mean time between the scans was 22.8 days with a range of 14 to 37 days. Even though the sample represents growing children, the effects of growth are negligible because of the short time between the T_0 and T_1 scans.

Rapid maxillary expansion is designed to increase the transverse dimension of the maxilla. The forces applied act along the transverse plane. Past studies have shown that the greatest amount of change is seen in the transverse dimension.[1,2,4-10] The RME devices in this study produced a mean of 5.2 mm of expansion with a range from 3.1 mm to 6.4 mm. Many of the landmarks used in this study were chosen to measure transverse change in the soft tissue corresponding to areas of underlying hard tissues that are known to experience significant transverse changes.

Transverse change

In the upper midface transverse expansion of the soft tissue did occur. Points associated with the right eye and left eye moved away from the mid-sagittal plane representing an increase in the distance between the eyes. The width of the apex of the nose also showed an increase although the landmark movement on the right was not shown to be significant. A transverse increase was also seen in the final position of both the right and left zygions.

The width of the alar base of the nose also showed an increase. Both the right and left landmarks moved away from the mid-sagittal plane. The right side moved by an average of 0.86 mm and the left by 0.94 mm. Similar findings of transverse expansion was reported in the hard tissue nasal base using metallic implants by Krebs.[8] The soft tissue over the infraorbital foramen showed transverse increases. The lips and lower midface also showed a transverse increase, although the right lower midface landmark and left lip commissure movements were not significant ($p= 0.06$ and $p= 0.052$ respectively). Significant transverse expansion has also been noted in each of these areas in the hard tissue in previous studies.[8,10,12,18]

The soft tissue change seen in this sample did not however represent the triangular pattern of expansion that has been reported for hard tissue.[9,10] When seen from a frontal view the hard tissues show a triangular pattern of opening transversely with the apex located close to the maxillo-frontal suture. Transverse expansion in the soft tissue of this sample had a more vertically parallel pattern of expansion than that reported for the hard tissue in previous studies (Fig 6).[8,9,10]

Anteroposterior change

Some landmarks located in the mid-sagittal plane also showed significant change. Soft tissue nasion came forward an average of 0.43 mm however this measure was not significant. The p value of the soft tissue nasion of 0.111 showed that based on this study the change seen in this landmark was not consistent. It has been shown that the maxillary halves separate in the vertical plane in a triangular pattern with the apex near the maxillo-frontal suture with progressively with more skeletal separation inferiorly.[9,10] Soft tissue nasion is located near the apex of the opening where hard tissue expansion would be expected to be minimal to none at all. Soft tissue nasion was created by extending the sella-nasion line to the soft tissue. Depending on the steepness of the sella-nasion in individual patients the landmark may possibly be higher or lower than the area where expansion occurred, which would affect the consistency of recorded results.

The bridge of the nose came forward by 0.80 mm. The tip of the nose moved anteriorly by a mean of 1.59 mm however this value was only able to be measured in 8 patients because it was not captured on other scans. Subnasale moved anteriorly by a mean of 2.21 mm. These findings are in agreement with previous findings in that there is an anterior displacement of the maxilla during RME.[9,10,18,19,20]

Anterior movement was also reported in the soft tissue over the right and left infraorbital foramina. This also would agree with reported anterior displacement of the maxillary complex that has been described with RME treatment.[9,10,18,19,20]

Change in the lips

The vertical length of the upper lip also showed to have a significant increase of 0.92 mm. This finding agrees with Berger's study using two-dimensional digital photos which reported a mean

increase of 1.0 mm immediately following the activation phase of expansion.[15]

The thickness of both the upper and lower lips showed a significant decrease. The upper lip changed by a mean of -0.92 mm, while the lower lip changed by a mean of -1.04 mm. This change most likely reflects the effect of transverse expansion and stretching of the soft tissue of the mouth. Although the measure of the left lip commissure for transverse expansion was not significant (p= 0.052) the mean was 0.65 mm with one outlier showing a change of -4.6 mm which is likely affecting the significance. The right lip commissure showed a significant change of 1.20 mm, showing that there is some transverse change of the lips which could account for a thinning of the lips.

This study only looked at the immediate effects of RME treatment. Many studies suggest that the effects commonly seen with RME treatment have a high level of relapse.[3,8,9,10,15,20,21,22] Future studies on this topic may look at relapse after a period of time to determine the long term stability of the observed changes.

CONCLUSIONS

Significant changes in the soft tissue do occur with RME. There is a transverse widening of the midface, and a decrease of the thickness of the upper and lower lips.

REFERENCES

1. Gryson JA. Changes in mandibular interdental distance concurrent with rapid maxillary expansion. Angle Orthod. 1977;47:186-92.
2. Adkins MD, Nanda RS, Currier GF. Arch perimeter changes on rapid palatal expansion. Am J Orthod Dentofacial Orthop. 1990;97:194-9.
3. Geran RG, McNamara JA, Jr., Baccetti T, Franchi L, Shapiro LM. A prospective long-term study on the effects of rapid maxillary expansion in the early mixed dentition. Am J Orthod Dentofacial Orthop. 2006;129:631-40.
4. Cross DL, McDonald JP. Effect of rapid maxillary expansion on skeletal, dental, and nasal structures: A postero-anterior cephalometric study. Eur J Orthod. 2000;22:519-528.
5. Davis WM, Kronman JH. Anatomical changes induced by splitting of the midpalatal suture. Angle Orthod. 1969;39:126-32.
6. Haas A. Gross reactions to the widening if the maxillary dental arch of the pig by splitting the hard palate. Am J Orthod. 1959;45:868.
7. Haas A. Rapid expansion of the maxillary dental arch and nasal cavity by opening the midpalatal suture. Angle Orthod. 1961;31:73-90.
8. Krebs A. Midpalatal Suture Expansion Studies by the Implant Method over a Seven-Year Period. Rep Congr Eur Orthod Soc. 1964;40:131-42.
9. Wertz R, Dreskin M. Midpalatal suture opening: A normative study. Am J Orthod. 1977;71:367-81.
10. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. Am J Orthod. 1970;58:41-66.
11. Karaman A. I. FAB, I Gelgör, A Demir. Examination of soft tissue changes after rapid maxillary expansion. World J Ortho. 2002;3:217-22.
12. Grayson B, Cutting C, Bookstein FL, Kim H, McCarthy JG. The three-dimensional cephalogram: Theory, technique, and clinical application. Am J Orthod Dentofacial Orthop. 1988;94:327-37.
13. Betts NJ, Vig KW, Vig P, Spalding P, Fonseca RJ. Changes in the nasal and labial soft tissues after surgical repositioning of the maxilla. Int J Adult Orthodon Orthognath Surg. 1993;8:7-23.
14. Guest E, Berry E, Morris D. Novel methods for quantifying soft tissue changes after orthognathic surgery. Int J Oral Maxillofac Surg. 2001;30:484-9.
15. Berger JL, Pangrazio-Kulbersh V, Thomas BW, Kaczynski R. Photographic analysis of facial changes associated with maxillary expansion. Am J Orthod Dentofacial Orthop. 1999;116:563-.571.
16. Moss JP. The use of three-dimensional imaging in orthodontics. Eur J Orthod. 2006;28:416-25.
17. Park JU, Hwang YS. Evaluation of the soft and hard tissue changes after anterior segmental osteotomy on the maxilla and mandible. J Oral Maxillofac Surg. 2008;66:98-103.
18. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. Am J Orthod. 1970;57:219-55.
19. Garib DG, Henriques JF, Janson G, Freitas MR, Coelho RA. Rapid maxillary expansion--tooth tissue-borne versus tooth-borne expanders: A computed tomography evaluation of dentoskeletal effects. Angle Orthod. 2005;75:548-57.
20. Haas AJ. Long-term posttreatment evaluation of rapid palatal expansion. Angle Orthod. 1980;50:189-217.
21. Bishara SE, Staley RN. Maxillary expansion: Clinical implications. Am J Orthod Dentofacial Orthop. 1987;91:3-14.
22. Snodell SF, Nanda RS, Currier GF. A longitudinal cephalometric study of transverse and vertical craniofacial growth. Am J Orthod Dentofacial Orthop. 1993;104:471-83.

Treatment of Class II malocclusion with bialveolar protrusion by means of unusual extractions and anchorage mini-implant

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Introduction: Patients with dental Class II bialveolar protrusion are generally treated by extracting the four first premolars or two first and two second premolars, and retracting the anterior teeth. This case report describes the treatment of an adult patient with bialveolar protrusion, a Class II canine and molar relationship, and lip protrusion.

Methods: In this patient, the maxillary right second molar (1.7) had to be extracted due to extensive caries. To create sufficient space to retract the anterior teeth, the maxillary right posterior teeth were distalized with a maxillary posterior mini-implant (1.2~1.3 mm in diameter, 10 mm long), which was placed into the maxillary tuberosity area and allowed an en masse retraction of the maxillary anterior teeth.

Results: Overall, mini-implant can provide anchorage to produce a good facial profile even without additional premolar extraction in cases of dental Class II bialveolar protrusion with the hopeless second molar.

Conclusion: The total treatment period was 42 months and the results were acceptable for 34 months after debonding.

Keywords: Mini-implant. Tooth extraction. Tooth movement.

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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

Bialveolar protrusion is a condition characterized by protrusive and proclined upper and lower incisors and an increased procumbency of the lips. The goals of orthodontic treatment of bialveolar protrusion include the retraction and retroclination of maxillary and mandibular incisors with a resultant decrease in soft tissue procumbency and convexity.[1]

A common treatment approach for patients with Class II bialveolar protrusion is to extract 2 maxillary premolars or 2 maxillary and 2 mandibular premolars, and retract the anterior teeth using maximum anchorage mechanics.[2,3,4] However, the treatment plan becomes more complex and controversial when a patient has hopeless maxillary second molars that should be extracted and wants to preserve maxillary premolars.

To solve this situation, the maxillary posterior teeth should be distalized. Distal movement of the maxillary molars is often used in the correction of Class II malocclusions, and various appliances have been proposed. However, the distal movement of molars has been considered as one of the most difficult biomechanical problems to achieve treatment objectives in clinical orthodontics.

Conventional distalization mechanics either rely on considerable patient compliance or generate unwanted reciprocal movement of anchor teeth in the anterior segment. Moreover, once molar distalization has been achieved, distalization of the anterior teeth without molar anchorage loss is challenging. The side effects such as forward movement of anterior teeth during distalization of molars and forward movement of the distalized molars during anterior tooth retraction may develop resulting in a prolonged treatment time.[5]

The choice of the appropriate force system to distalize the maxillary molars efficiently and retract the anterior teeth in patients with Class II malocclusion is based mainly on the anchorage conditions required to achieve the desired treatment goals.

Absolute skeletal anchorage, available 24 hours a day, offers an alternative method for molar distalization. The use of osseointegrated implants[6], miniplates,[7] miniscrews[8,9] and microimplants[10,11] as anchorage has made distalization of the posterior teeth without anchorage loss a more realistic respect. There are few case reports involving the distalization of the maxillary posterior teeth with mini-implants (MIs) in patients with Class II bialveolar protrusion. This patient report demonstrates the use of MIs in a case of dental Class II bialveolar protrusion with the hopeless maxillary right second molar (1.7).

DIAGNOSIS

A 40 year-old woman presented with the chief complaint of lip procumbency. Facially, she exhibited a convex profile with marked protrusion of the lips, mentalis muscle strain and lip incompetence, but good vertical balance of facial proportion (middle and lower thirds) and proper maxillary incisor show on posed smile. Intrabuccally, she had a Class II canine and molar relationship except Class I molar relationship on the left side, normal overbite (2.5 mm), larger overjet (10 mm), and no significant Bolton tooth-size discrepancy. Her oral hygiene was moderate with gingival recession on several teeth, especially on the upper right canine and first premolar. There was an arch length deficiency of approximately 2 mm in the maxillary arch and 4 mm crowding in the lower arch. Dental asymmetry was present with a slight deviation of the maxillary dental midline to the left and of the mandibular dental midline to the right of the facial midline. It was just due to dental crowding and skeletal and facial asymmetry were not shown (Fig 1).

The panoramic radiograph revealed the presence of severe decay on the maxillary right second molar as well as generalized bone resorption (Fig 1). The lateral cephalogram (Fig 1) and its tracing showed dental Class II bialveolar protrusion, but Class I skeletal pattern. The skeletal pattern was normodivergent as evidenced by the FMA (Frankfort mandibular plane angle) of 29.5º and the FHI (facial height index) of 60%. The occlusal plane angle of 11.5º (Left) and 12.6º (Right) reflected the normal vertical dental pattern. The IMPA (incisor mandibular plane angle) of 98.1º reflected the proclination of lower incisors. The Z-angle of 65.6º quantified the slight facial imbalance (Table 1). There were no significant signs or symptoms of temporomandibular disorders.

TREATMENT OBJECTIVES

The treatment objectives were to (1) align and level the teeth in both arches and establish a functional

Figure 1 - Pretreatment photographs and radiographs.

Table 1 - Cephalometric measurements.

	Norm	Pretreatment	Posttreatment	Postretention
FMIA (degrees)	67	52.4	54.3	54.4
FMA (degrees)	25	29.5	28.8	28.5
IMPA (degrees)	88	98.1	96.9	97.1
SNA (degrees)	82	74.6	74.5	74.5
SNB (degrees)	80	73.2	73.5	73.8
ANB (degrees)	2	1.4	1.0	0.7
AO-BO (mm): Right / Left	2	-3.4 / -4.4	-5.5 / -6.9	-5.0 / -5.5
OP angle (degrees): Right / Left	10	11.5 / 12.6	14.0 / 15.8	13.1 / 14.5
FH a U1 (degrees)	112	126.2	103.1	103.3
Z angle (degrees)	75	65.6	74.5	76.5
FHI (%) (PFH/AFH)	69.0 (45.0/65.0)	60.0 (45.9/75.9)	61.0 (45.7/74.7)	61.0 (45.7/75.0)

FMIA indicates angle between Frankfort plane and mandibular incisor axis; FMA, angle between Frankfort plane and mandibular plane; IMPA, angle between lower incisor axis and mandibular plane; SNA, angle between SN and NA; SNB, angle between SN and NB; ANB, difference between the SNA and SNB angles; AOBO, distance between perpendiculars drawn from point A and point B onto the occlusal plane; OP angle, occlusal plane angle; FH, Frankfort horizontal plane; UI, maxillary incisor axis; FH to UI, angle between Frankfort plane and maxillary incisor axis; Z angle, angle between FH and profile line tangent to the chin and the vermilion border of both lips ; FHI, ratio of PFH to AFH; PFH, linear measurement from articulare, along a line tangent to the posterior border of the mandible, to the intersection with the mandibular plane; and AFH, linear measurement from palatal plane to mention, measured perpendicular to palatal plane.

occlusion, (2) normalize the overjet, (3) improve dental symmetry (4) obtain a balanced facial profile.

TREATMENT ALTERNATIVES

The first alternative was retraction of the maxillary and mandibular anterior teeth using maximum anchorage following four first premolar extractions, and differential tooth movement to improve dental symmetry. To reduce the patient's lip protrusion, this option would be unavoidable. But, this would require additional prosthetic treatment. The loss of pitiful tooth and adjunctive expenditure would be a burden to the patient.

The second alternative was retraction of the maxillary and mandibular anterior teeth with simultaneous distal movement of the maxillary right posterior teeth using absolute anchorage after extraction of maxillary left first premolar (2.4) and mandibular left second premolar, and group distal tooth movement of the mandibular right posterior teeth instead of extraction of mandibular right second premolar (4.5), and differential tooth movement to improve dental symmetry.

The third alternative was the same as the second alternative exception for the extraction of mandibular right second premolar (4.5) instead of group distal tooth movement of the mandibular right posterior teeth.

In the second and third alternatives, the additional prosthesis would be avoided due to the survival of the maxillary right first premolar (1.4). These options would preserve the maxillary right first premolar (14) and result in a good result without patient compliance. In the beginning, second alternative was chosen but it was insufficient to obtain a good facial profile. Therefore, in the middle of treatment, third alternative was chosen.

TREATMENT PROGRESS

The treatment began using a new protocol of Tweed-Merrifield directional force technology with MIA[12], after extracting the maxillary right second molar (1.7) and maxillary left first premolar (2.4).

After the extractions, 0.022 x 0.028-in standard edgewise appliance was placed in the maxillary arch. Leveling began with a 0.016-in nickel-titanium archwire and 0.018-in, 0.017 x 0.022-in stainless steel arch wires. The maxillary right posterior MI (1.3 ~ 1.2 mm in diameter, 10 mm in length; Absoanchor SH1312-10,

Dentos, Taegu, South Korea) was implanted into the tuberosity area distobuccal to the maxillary right second molar (1.7). The maxillary left posterior MI (1.3 ~ 1.2 mm in diameter, 8 mm in length; Absoanchor SH1312-08, Dentos) was implanted into the buccal alveolar bone between the maxillary left second premolar (25) and first molar (2.6). The mandibular right posterior MI (1.3 ~ 1.2 mm in diameter, 7 mm in length; Absoanchor SH1312-07, Dentos) was implanted into the buccal alveolar bone between the mandibular right first and second molars (4.6 and 4.7). An elastic chain force was loaded immediately after placing the MIs, from the maxillary posterior MIs to the T spring inserted into the vertical slot of the canine brackets to retract the maxillary canines to level the six anterior teeth and retract the maxillary right posterior teeth. Another elastic chain force was loaded immediately after placing the MI, from the mandibular right posterior MI to the buttons on the occlusal and buccal surface of the mandibular right second molar for buccal uprighting without extrusion (Fig 2A).

Five months into the treatment, after extracting the mandibular left second premolar (3.5), 0.022 x 0.028-in standard edgewise appliance was placed in the mandibular arch, and leveling began with a 0.014-in nickel-titanium archwire and 0.018-in, 0.018 x 0.025-in stainless steel archwires. The mandibular left posterior MI (1.3 ~ 1.2 mm in diameter, 7 mm in length; Absoanchor SH1312-07, Dentos) was implanted into the buccal alveolar bone between the mandibular left first and second molars (3.6 and 3.7). An elastic chain force was loaded immediately after placing the MI, from the mandibular left posterior MI to the mandibular left canine bracket in order to retract the mandibular left canine and first premolar to level the six anterior teeth. Another elastic chain force was loaded from the mandibular right posterior MI to the mandibular right canine bracket to distalize the mandibular right posterior teeth followed by creating space for retraction of the mandibular anterior teeth (Fig 2B).

Nine months into the treatment, 0.020 x 0.025-in stainless steel archwire with closing loops was placed in the upper arch to retract the four anterior teeth (Fig 2C). At this time, the patient wanted to correct lip protrusion more, but the posterior limit of mandibular arch did not allow for more distalization of the posterior teeth to satisfy the patient's esthetic desire. Therefore, a decision was made to extract the mandibular right second premolar (4.5).

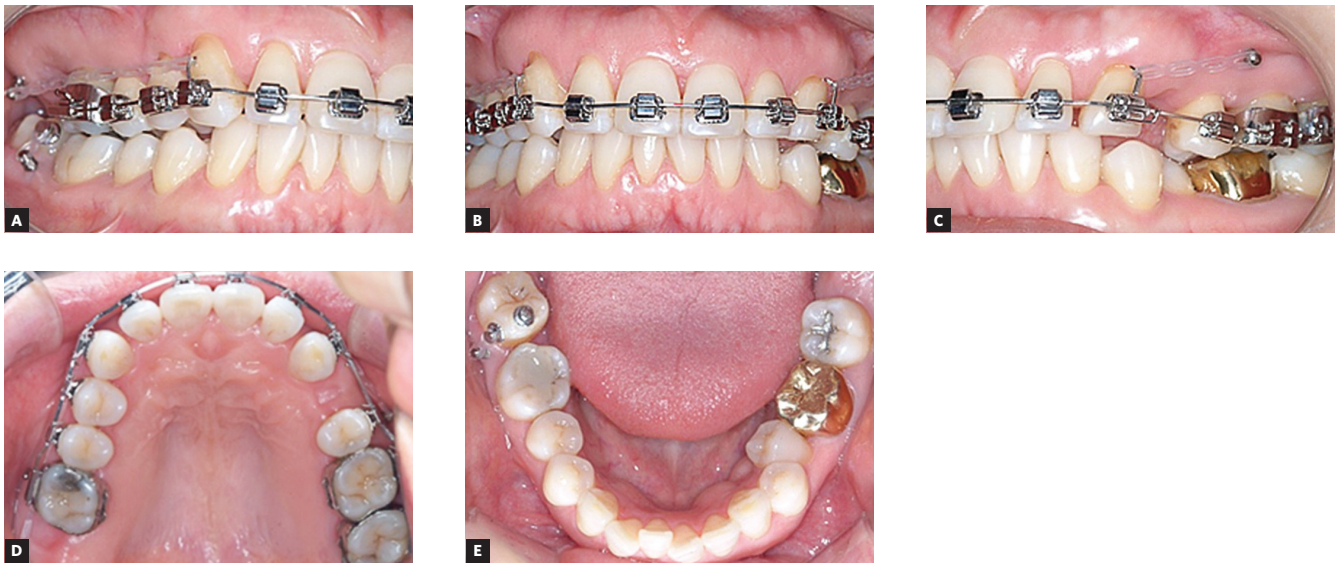

Figure 2 - Treatment progress. **A**) Maxillary right posterior mini-implant (MI) for distalization of maxillary posterior teeth, maxillary left posterior MI for canine retraction and mandibular right posterior MI, and buttons for buccal uprighting and intrusion of mandibular right second molar; **B**) After extracting the mandibular left second premolar (3.5), distalization of mandibular right posterior teeth and retraction of mandibular left canine and premolar with mandibular posterior mini-implants; **C**) En masse retraction of maxillary four anterior teeth with closing loop archwire supported by maxillary posterior mini-implants; **D**) Maxillary anterior mini-implants for intrusion and torque control, running loop for uprighting and mesial movement of mandibular molars, and retraction of mandibular anterior teeth; **E**) Mandibular right middle mini-implant for protraction of mandibular right molars and Clip on maxillary anterior mini-implants to prevent soft tissue irritation.

Figure 3 - Progress of treatment. After extraction of the second left premolar (3.5), distalization of right posterosuperior teeth and retraction of lower left canine and posterosuperior premolars with mini-implants.

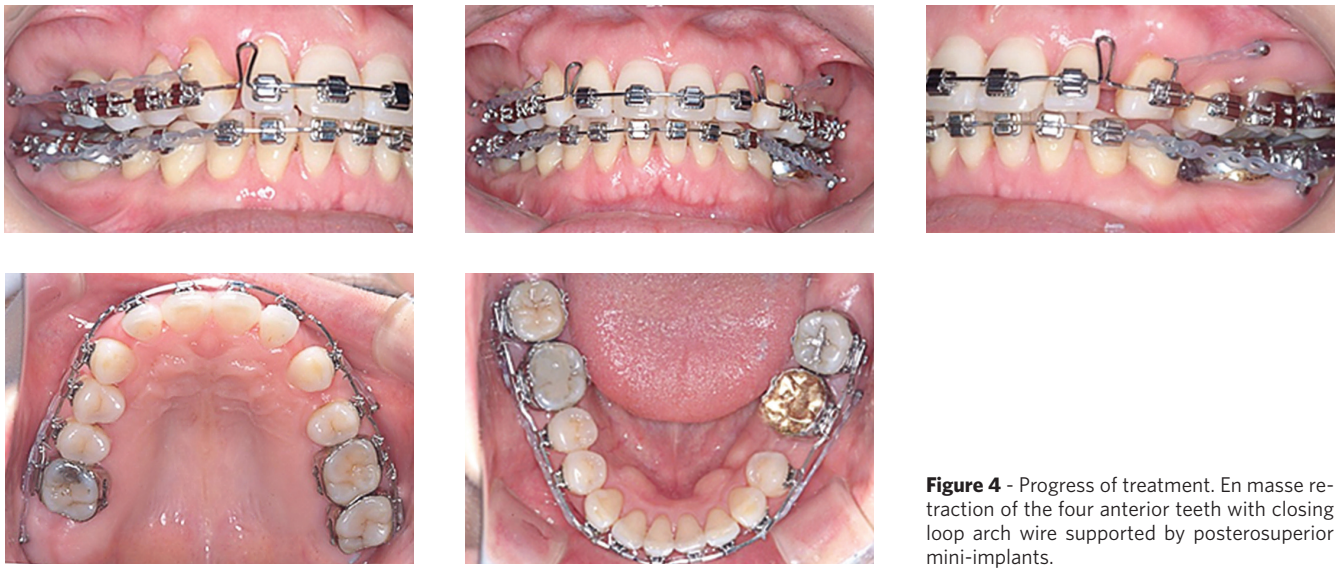

Figure 4 - Progress of treatment. En masse retraction of the four anterior teeth with closing loop arch wire supported by posterosuperior mini-implants.

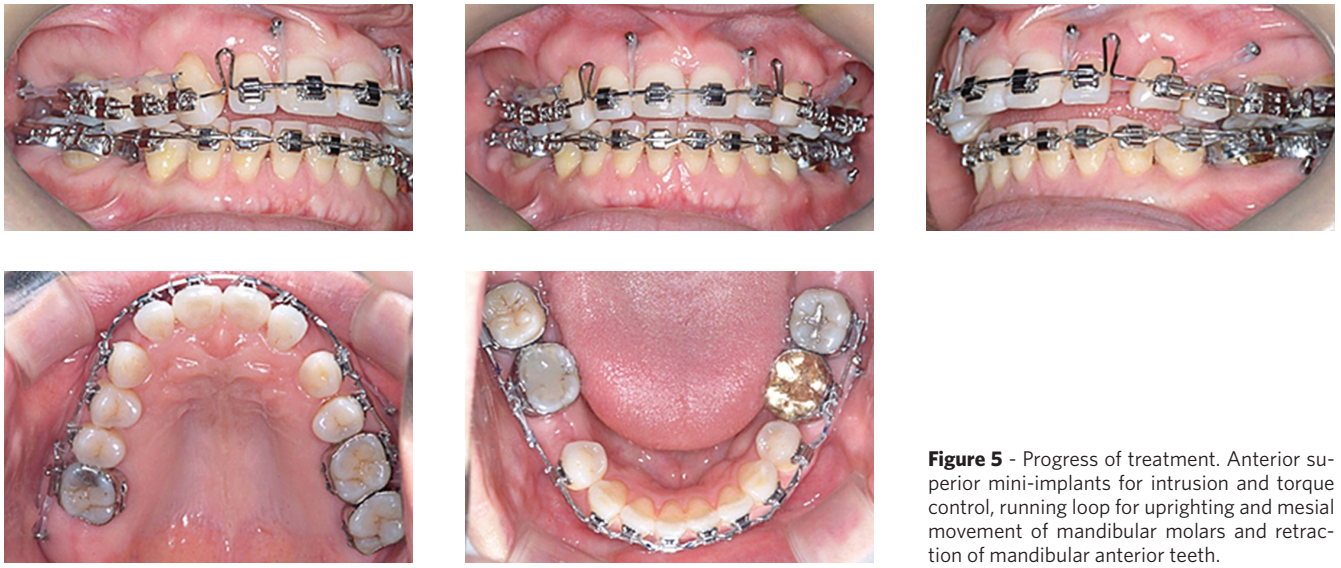

Figure 5 - Progress of treatment. Anterior superior mini-implants for intrusion and torque control, running loop for uprighting and mesial movement of mandibular molars and retraction of mandibular anterior teeth.

After the extraction, 0.018 x 0.025-in stainless steel arch wire with running loops was placed in the lower arch to retract anterior teeth and protract the posterior teeth with minimal anchorage concept. Twelve months into the treatment, the maxillary anterior MIs (1.3 ~ 1.2 mm in diameter, 7 mm in length; Absoanchor CH1312-07, Dentos) were implanted into the labial alveolar bone between the maxillary central incisors and the lateral incisors for torque control, bodily movement and intrusion of the maxillary anterior teeth (Fig 2D).

During en masse movement in the maxillary arch, a mandibular middle MI (1.3 ~ 1.2 mm in diameter, 7 mm in length; Absoanchor SH1312-07, Dentos) was implanted into the labial alveolar bone between the mandibular right canine and first premolar (4.3 and 4.4) to protract the mandibular right posterior teeth to achieve Class I dental relationship. Light curing temporary material (Clip, Voco, Germany) was applied to the upper anterior MIs to reduce the level of soft tissue irritation (Fig 2E).

The treatment was completed with ideal archwires and cusp-seating elastics. Fixed lingual retainers were bonded to the lingual sides of the six anterior teeth and circumferential clear retainers were placed on both arches, immediately before and after removing the appliances for retention, respectively. The total treatment time was 42 months.

TREATMENT RESULTS

The posttreatment facial and intraoral photographs, and dental casts revealed a nicely balanced and harmonious face by retracting the lips and showed a good interdigitation of the teeth. Several teeth presented gingival recession, but it was not worsening compared to pretreatment. The posttreatment panoramic radiograph revealed acceptable root parallelism with no significant root resorption (Fig 3). The 3.4 month retention records showed good retention without any obvious relapse (Fig 4).

As shown on the pretreatment and posttreatment cephalometric superimposition (Fig 5), the maxillary and mandibular anterior teeth were retracted with the intrusion, the right maxillary posterior teeth were distalized, the left maxillary posterior teeth were intruded, the right mandibular posterior teeth were protracted and slightly uprighted and intruded, and the left mandibular posterior teeth were slightly protracted, uprighted and extruded. The FMA was slightly decreased. The Z-angle was improved from 65.6° to 74.5° (Table 1). All these changes helped improve the facial profile (Fig 6). The post-treatment and 34-month retention cephalometric superimposition (Fig 7) showed denture recovery such as slight extrusion and labial movement of upper anterior teeth, and slight extrusion of the posterior teeth.

Figure 6 - Progress of treatment. Mini-implants to mesial movement of right mandibular molars and Clip on maxillary anterior mini-implants to prevent soft tissue irritation.

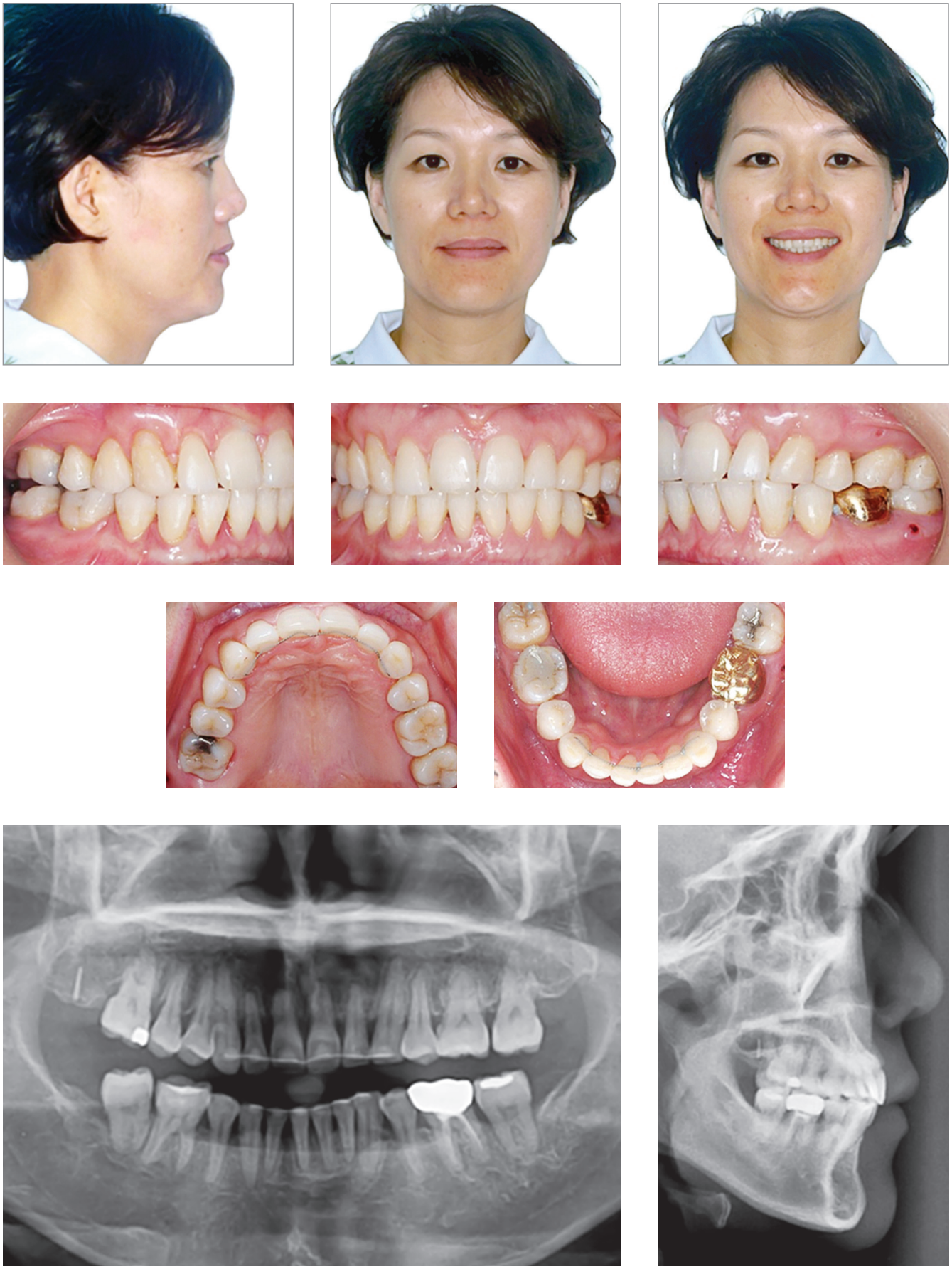

Figure 7 - Photographs and radiographs after treatment.

Figure 8 - Post-retention facial photographs, dental casts and radiographs.

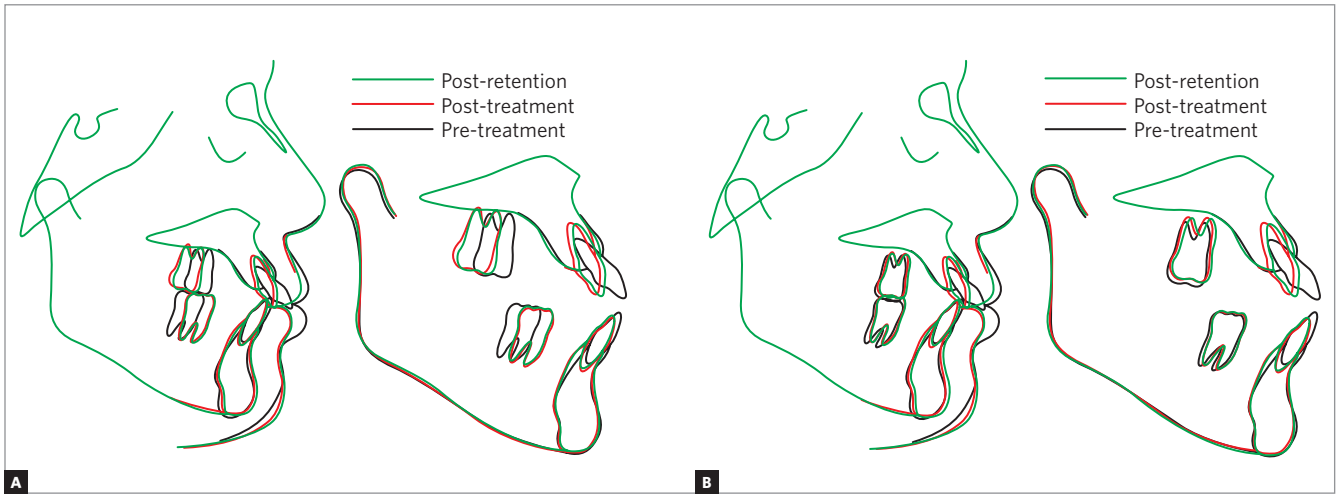

Figure 9 - Cephalometric overlays. **A**) Right side; **B**) Left side.

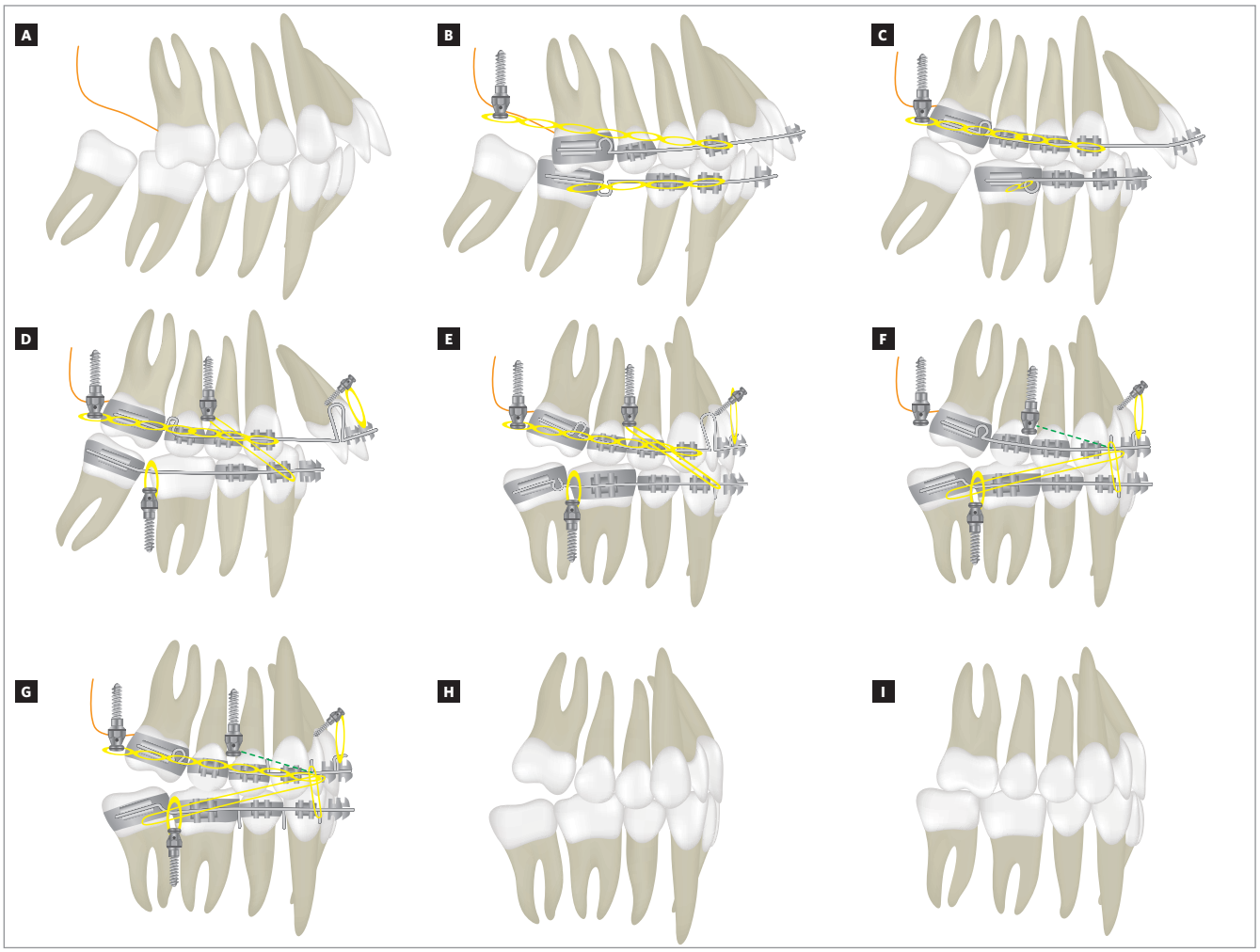

Figure 10 - Schematic diagram of the use of mini-implant anchorage (MIA) in the case of an unusual extraction in the treatment of Class II bialveolar protrusion: **A**) Before treatment; **B**) placement of mini-implant in the maxillary tuberosity area and the application of a distalizing force to the maxillary posterior teeth, running loop in the mandibular arch for leveling and en masse retraction; **C**) distalization of the maxillary posterior teeth and space closure in mandibular arch; **D**) placement of the maxillary anterior mini-implant and 0.020 x 0.025-in closing loop archwire for en masse retraction of maxillary four anterior teeth, mandibular anchorage preparation with mandibular mini-implants and Class III elastics; **E**) space closure in maxillary arch, continued mandibular anchorage preparation; **F**) directional forces; **G**) denture completion; **H**) tweed occlusion; **I**) denture recovery.

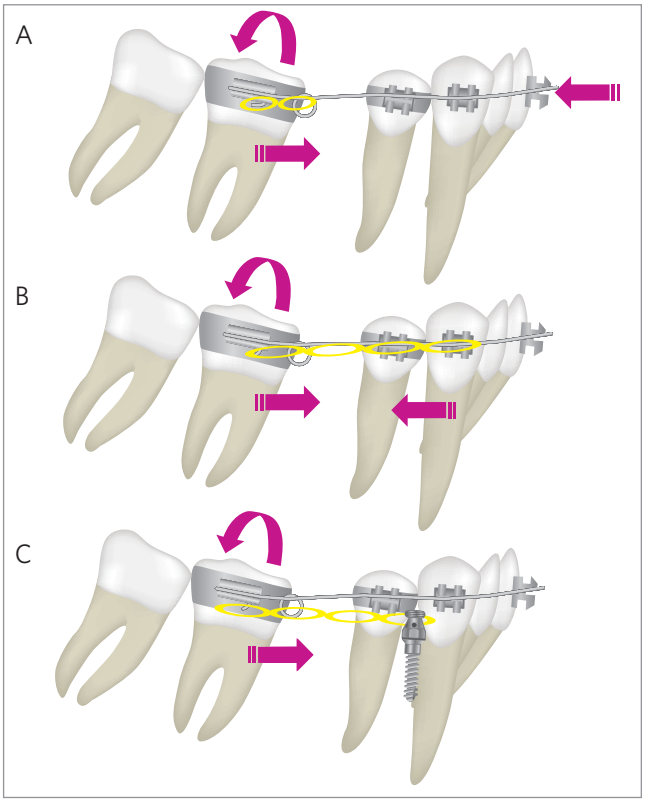

Figure 11 - Biomechanics of running loop archwire in lateral view. Uprighting and mesial movement of molars in the case of no crowding (**A**) and crowding (**B**) in the anterior teeth, and using mini-implant anchorage (**C**).

DISCUSSION

There are many clinical situations necessitating for unusual extraction of molars, including extensive caries, large restorations. A second molar extraction is indicated when (1) they are severely carious, ectopically erupted, or severely rotated, (2) mild-to-moderate arch length deficiencies exist with good facial profiles and (3) there is crowding in the posterior area with a need to facilitate first molar distal movement.[13] The patient had a severely decayed maxillary second molar on the right side (1.7). Therefore, it was removed as an alternative to an extraction of the maxillary right first premolar (1.4).

When the second molars are extracted from patients with bialveolar protrusion, group distal movement of the remaining posterior teeth and a maximum retraction of the anterior teeth are essential for preserving healthy sound premolars and achieving the treatment goal. Numerous extraoral and intraoral appliances have been proposed for distalizing the posterior teeth.[5] However, these appliances have disadvantages such as the need for patient cooperation, tipping movement, anchorage loss, and flaring of the incisors.

The clinical efficacy[12,14] and stability[15] of temporary skeletal anchorage devices have been widely described. It is a very efficient method for solving orthodontic problems that cannot be corrected using conventional methods. Several skeletal anchorage devices that are efficient in controlling anchorage have been developed to obtain anchorage control during the distalization movement.

Using MI, distalization of the maxillary right posterior teeth into the second molar extraction space followed by a maximum en masse retraction of the maxillary anterior teeth are possible without patient compliance. During retraction of the anterior teeth, MIA was used to prevent the mesial movement of the posterior teeth and intrude the upper anterior teeth (Fig 8).[12]

The vertical and horizontal component of force is determined by the vertical position of MI head. The maxillary right posterior teeth appeared to have a tendency toward distal tipping with a slight intrusion, which was appropriate in this case. Therefore, the position of MI head should be considered carefully according to the type of malocclusion, and the

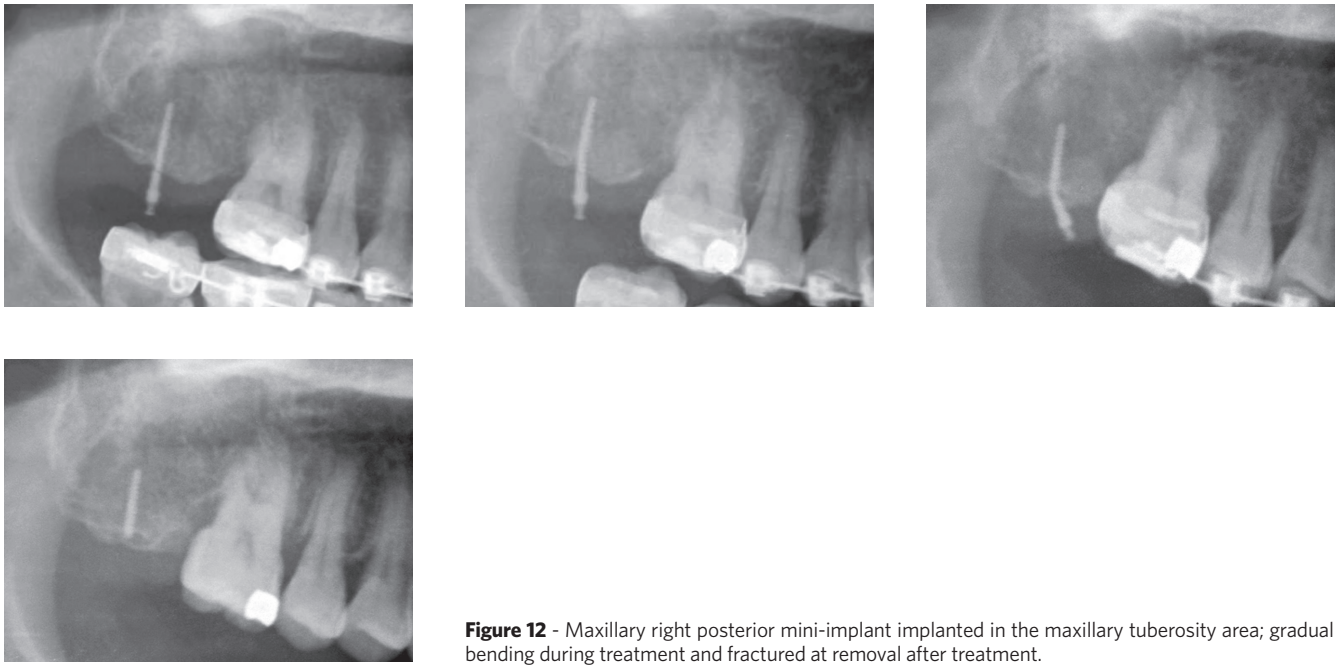

Figure 12 - Maxillary right posterior mini-implant implanted in the maxillary tuberosity area; gradual bending during treatment and fractured at removal after treatment.

amount and direction of tooth movement required.[11] In this case, a MI with a small diameter and long length was chosen to increase the success rate in the maxillary tuberosity area which is generally not suitable for screw implantation due to its limited amount of cortical bone.[16,17]

Based on the patient's chief complaint and the diagnosis of the malocclusion, an extraction of mandibular second premolars is a viable option for decreasing lip procumbency. However, at the beginning of treatment, mandibular right second premolar was not extracted for a more predictable result. An elastic chain force was loaded from the mandibular right posterior MI to the mandibular right canine bracket to distalize the mandibular right posterior teeth for an alignment of the lower anterior teeth (Fig 2B). However, the patient wanted to correct lip protrusion more and the posterior limit of mandibular arch did not allow for more distalization of the posterior teeth to satisfy the patient's esthetic desire. Therefore, the mandibular right second premolar (4.5) was removed in the middle of treatment resulting in a long treatment time.

Running loops were used in the lower arch to retract the anterior teeth and protract posterior teeth (Fig 2D). The advantages of running loops for space closure are simple wire bending, fewer changes of archwires, and shorter treatment times due to the simultaneous uprighting and mesial movement of the molars. The desired amount and direction of tooth movement can be obtained by the simple and various applications of elastic chains and MIs (Fig 7).[18] In this case, the MI was used to close the remaining space after retracting and protracting the lower anterior and posterior teeth respectively.

Clip or Fermit (Ivoclar Vivadent, clear, light-cured adhesive used for temporary restorations of inlay preparations) is useful for relieving the soft-tissue irritation from an orthodontic appliance. In this case, it was used to prevent irritation from upper anterior MIs (Fig 2E). It has many advantages comparing with conventional OrthoWax – e.g., ease of placement and removal, possible placement in most areas of the orthodontic appliance and long retention time.[19]

All MIs remained firm throughout the treatment. After treatment, they were removed by unscrewing without anesthesia. However, maxillary right posterior MI implanted in the maxillary tuberosity area had bent gradually during treatment and fractured during removal after treatment. The fractured MI was left in its position with the consent of the patient (Fig 8). Further examinations will be necessary to prevent any pathologic conditions. The screw fragment embedded

in the cortical bone can be surgically removed. A full-thickness flap is made, bone is cleared from around the fractured screw, and reverse torque is applied to the screw to remove the fragment. If the fragment encroaches on vital structures, however, it should be left in the bone, considering that orthodontic implants are made of biocompatible titanium.[20]

CONCLUSIONS

Mini-implants can simplify the treatment plan and provide absolute anchorage for the distal movement of buccal teeth in a group as well as maximum retraction of the anterior teeth in an unusual maxillary second molar extraction treatment of dental Class II bialveolar protrusion.

REFERENCES

1. Bills DA, Handelman CS, BeGole EA. Bimaxillary dentoalveolar protrusion: traits and orthodontic correction. Angle Orthod. 2005 May;75(3):333-9.
2. Janson G, Brambilla AC, Henriques JFC, Freitas MR, Neves LS. Class II treatment success rate in 2- and 4-premolar extraction protocols. Am J Orthod Dentofacial Orthop. 2004 Apr;125(4):472-9.
3. Janson G, Maria FRT, Barros SEC, Freitas MR, Henriques JFC. Orthodontic treatment time in 2- and 4-premolar-extraction protocols. Am J Orthod Dentofacial Orthop. 2006 May;129(5):666-71.
4. Janson G, Janson M, Nakamura A, de Freitas MR, Henriques JF, Pinzan A. Influence of cephalometric characteristics on the occlusal success rate of Class II malocclusions treated with 2- and 4-premolar extraction protocols. Am J Orthod Dentofacial Orthop. 2008 Jun;133(6):861-8.
5. Bondemark L, Karlsson I. Extraoral vs intraoral appliance for distal movement of maxillary first molars: a randomized controlled trial. Angle Orthod. 2005 Sep;75(5):699-706.
6. Oncaş G, Akyalçin S, Arikan F. The effectiveness of a single osseointegrated implant combined with pendulum springs for molar distalization. Am J Orthod Dentofacial Orthop. 2007 Feb;131(2):277-84.
7. Sugawara J, Kanzaki R, Takahashi I, Nagasaka H, Nanda R. Distal movement of maxillary molars in nongrowing patients with the skeletal anchorage system. Am J Orthod Dentofacial Orthop. 2006 Jun;129(6):723-33.
8. Gelgör IE, Büyükyilmaz T, Karaman AI, Dolanmaz D, Kalayci A. Intraosseous screw-supported upper molar distalization. Angle Orthod. 2004 Dec;74(6):838-50.
9. Escobar SA, Tellez PA, Moncada CA, Villegas CA, Latorre CM, Oberti G. Distalization of maxillary molars with the bone-supported pendulum: a clinical study. Am J Orthod Dentofacial Orthop. 2007 Apr;131(4):545-9.
10. Park HS, Lee SK, Kwon OW. Group distal movement of teeth using microscrew implant anchorage. Angle Orthod. 2005 Jul;75(4):510-7.
11. Chae JM. Unusual extraction treatment of Class I bialveolar protrusion using microimplant anchorage. Angle Orthod. 2007 Mar;77(2):367-76.
12. Chae JM. A new protocol of Tweed-Merrifield directional force technology with microimplant anchorage. Am J Orthod Dentofacial Orthop. 2006 Jul;130(1):100-9.
13. Bishara SE, Ortho D, Burkey PS. Second molar extractions: a review. Am J Orthod. 1986 May;89(5):415-24.
14. Park HS, Bae SM, Kyung HM, Sung JH. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. J Clin Orthod. 2001 Jul;35(7):417-22.
15. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop. 2003 Oct;124(4):373-8.
16. Kuroda S, Sugawara Y, Deguchi T, Kyung HM, Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. Am J Orthod Dentofacial Orthop. 2007 Jan;131(1):9-15.
17. Poggio PM, Incorvati C, Velo S, Carano A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod. 2006 Mar;76(20):191-7.
18. Chae J, Kim S. Running loop in unusual molar extraction treatment. Am J Orthod Dentofacial Orthop 2007 Oct;132(4):528-39.
19. Kim TK, Park SH. Relief of soft-tissue irritation from orthodontic appliances. J Clin Orthod. 2002 Sep;36(9):509.
20. Jolly TH, Chung CH. Peak torque values at fracture of orthodontic miniscrews. J Clin Orthod 2007 Jun;41(6):326-8.

Class III malocclusion with severe anteroposterior discrepancy*

Susana Maria Deon Rizzatto[1]

This study aims at reporting the clinical case of a patient with Class III skeletal malocclusion with severe maxillary deficiency, producing a reduced midface associated with severe mandibular prognathism. The pre-surgical orthodontic preparation was composed mainly by dentoalveolar expansion and repositioning of the incisors in the lower arch. Then, a combined maxillary and mandibular orthognathic surgery was performed. The treatment objectives were achieved, with significant improvement in facial esthetics and occlusion, followed by post-treatment stability. This case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics (BBO), as part of the requirements for obtaining the title of Diplomate by BBO.

Keywords: Class III malocclusion. Corrective orthodontics. Orthognathic surgery.

* Case Report, category 4, approved by the Brazilian Board of Orthodontics and Dentofacial Orthopedics (BBO).

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

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INTRODUCTION

Caucasian patient, male, 19 years and 7 months old, with accentuated Class III malocclusion and family history of Class III, being the mother the carrier. He had poor oral hygiene, caries, marginal gingivitis and good general health. His chief complaint was difficulty to chew.

DIAGNOSIS

During facial examination, a strongly concave profile was observed, with great midface deficiency and accentuated mandibular prognathism, followed by a flat malar region and deep nasolabial sulcus. The face presented symmetry, but with an increased lower third, prevailing the distance from the lower lip to the menton base. The nasolabial angle was obtuse and the mentolabial angle was almost flat, characteristic of excessive compensation by lingual inclination of lower incisors in Class III. The absence of lip volume support was evident (Fig 1). The skeletal pattern was Class III, ANB = -11 ° (SNA = 73° and SNB = 84°); the mandible was elongated with a strongly obtuse gonial angle; high GoGnSN = 45° and FMA = 38° angles, characterizing a predominance of vertical face development (Fig 4 and Table 1). From the dental point of view, patients presented Angle Class III malocclusion, with anterior and posterior crossbite and relative maxillary constriction. The upper incisors were well positioned and the lower were retroclined with moderate crowding and severe Curve of Spee (Figs 1, 2, 4).

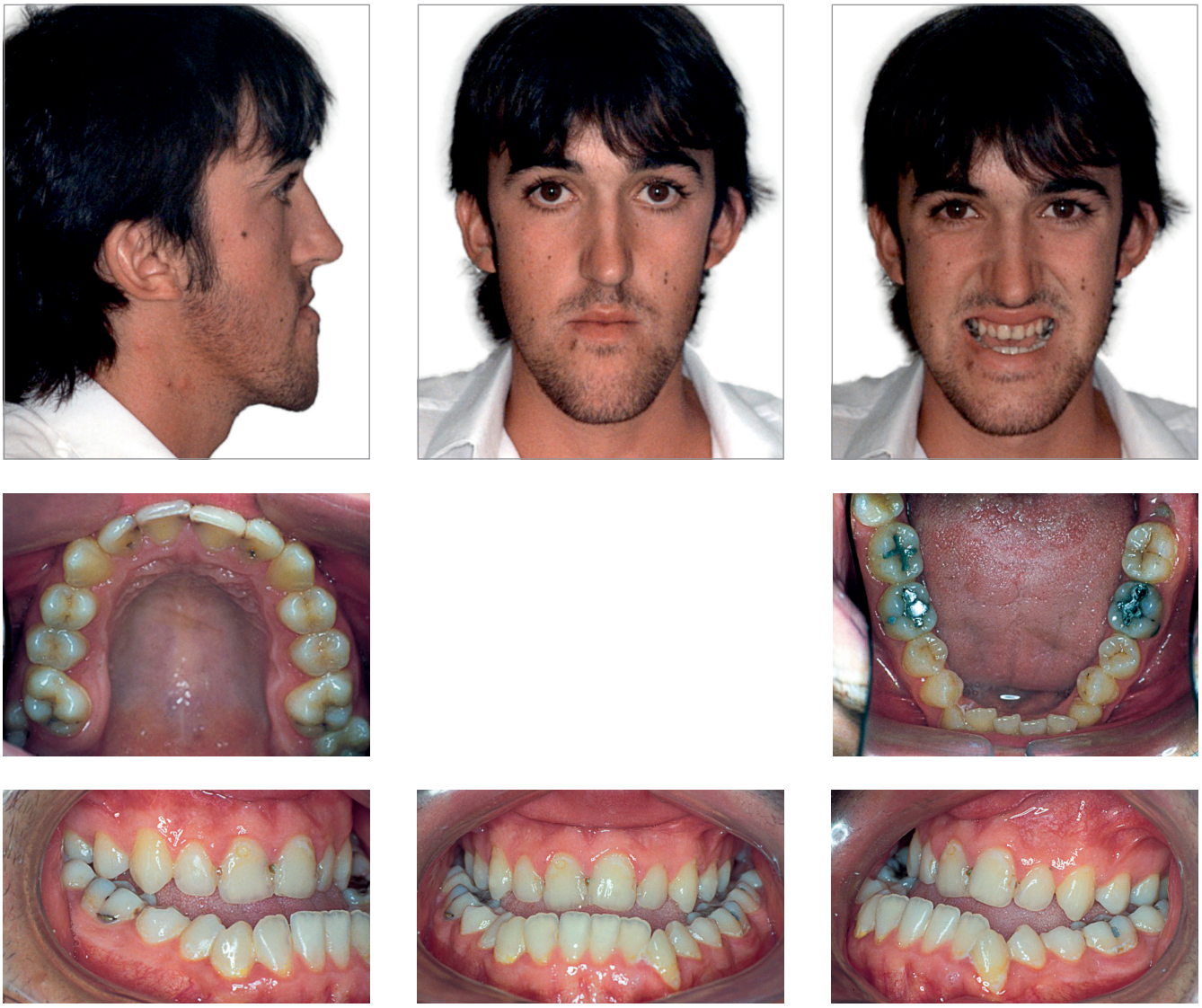

Figure 1 - Facial and intraoral initial photographs.

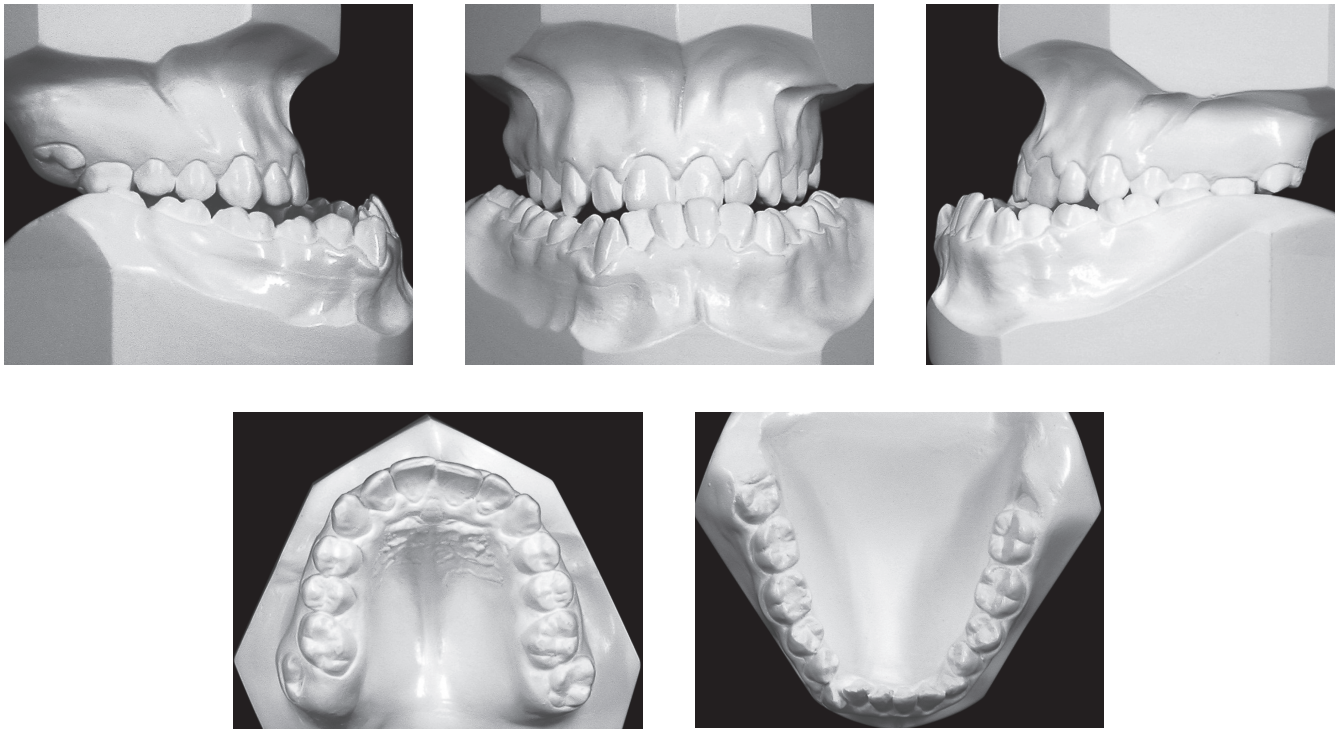

Figure 2 - Initial dental casts.

Figure 3 - Panoramic(**A**) and periapical (**B, C**) initial radiographs.

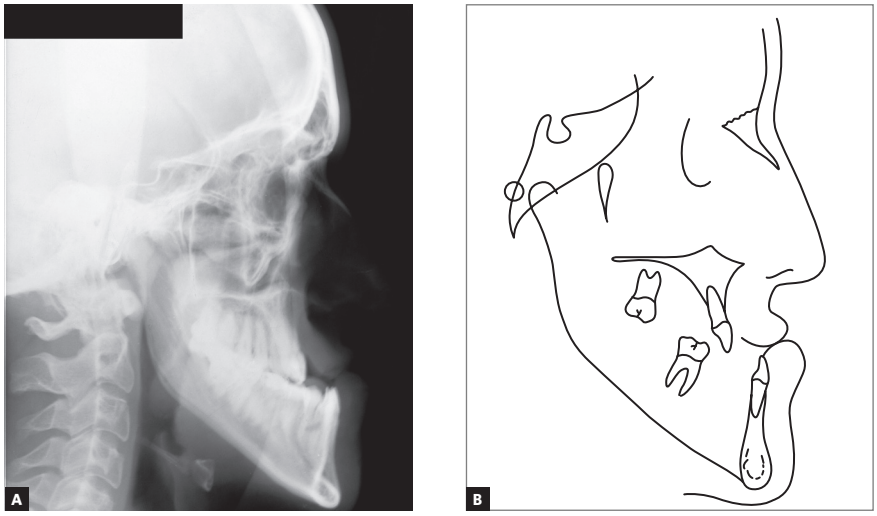

Figure 4 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

TREATMENT OBJECTIVES

The initial treatment objective was to correct the dental compensations in the maxilla and mandible through orthodontic treatment previous to the combined orthognathic surgery. In the maxilla, a dentoalveolar expansion should be performed by increasing the upper intermolar distance to adjust its transverse relation. In the mandible, the severe lingual inclination of the incisors should be corrected, leveling the curve of Spee and obtaining space for the canines and for positioning the incisors in their bone bases. The maxilomandibular sagittal and vertical will be corrected by orthognathic surgery with anterior and inferior repositioning of the maxilla and mandibular rotation and setback, aimed at obtaining the ideal occlusal relationship, function and facial harmony.

TREATMENT PLAN

The treatment plan consisted of three different steps:

First step: Refer the patient to carry out clinical review and preventive care. Following, bonding of upper and lower brackets and decompensation of the lower arch by leveling the curve of Spee and projection of the incisors. Also, placement of an upper removable plate with expanding screw to promote a mild maxillary dentoalveolar expansion and retention with the mechanics advocated by Mulligan.

Second step: At this phase to perform the combined orthognathic surgery (for maxillary advancement and mandibular setback).

Third step: A post-surgical immobilization of the jaws with rubber bands and intensive elastic physiotherapy was planned. After orthodontic treatment finishing, the appliances would be removed and the retainers would be installed.

TREATMENT PROGRESS

After clinical review and preventive care, the appliances were installed by banding first and second upper and lower molars, with double tubes in the first upper molars and installation of removable plate with the expanding screw (1/4 turn per week). The upper and lower brackets, Edgewise system (slot 0.022 x 0.028-in), were placed and alignment and leveling of the teeth were performed with initial twist-flex archwires (Dentaurum), followed by 0.016-in, 0.018-in, 0.020-in Stainless steel archwires (GAC). The decompensation of the lower arch occurred by leveling the curve of Spee and projecting the lower incisors. The retention of dentoalveolar expansion was performed with a Muligan arch in the upper arch. Impressions of the upper and lower arches were taken for dental cast manipulation, four times before the rectangular arch. Then, a rectangular 0.019 x 0.025-in archwire (GAC) was installed and on it were soldered of 0.8 mm brass

wire hooks. After this first phase, an increase on the profile's disharmony was observed due to increased sagittal dental discrepancy, mainly due to the buccal inclination of the lower incisors . However, the mentolabial angle approached normality, as well as the volume of the lower lip (Figs 5 to 8).

The patient was referred to combined orthognathic surgery, consisting of maxillary protrusion with lower replacement and mandibular retrusion with upward rotation. For the following six months, the arches were stabilized with rubber bands with Class III orientation and elastic physiotherapy was suggested. During this phase, intercuspation refining was performed, and then the appliance was removed. The lower retainer was installed, with a bonded intercanine fixed m retainer made with stainless steel 0.032-in archwire, and the upper retainer, wraparound type, was made with stainless steel 0.036-in archwire. This should be used full-time for 24 months followed by overnight use for another 12 months.

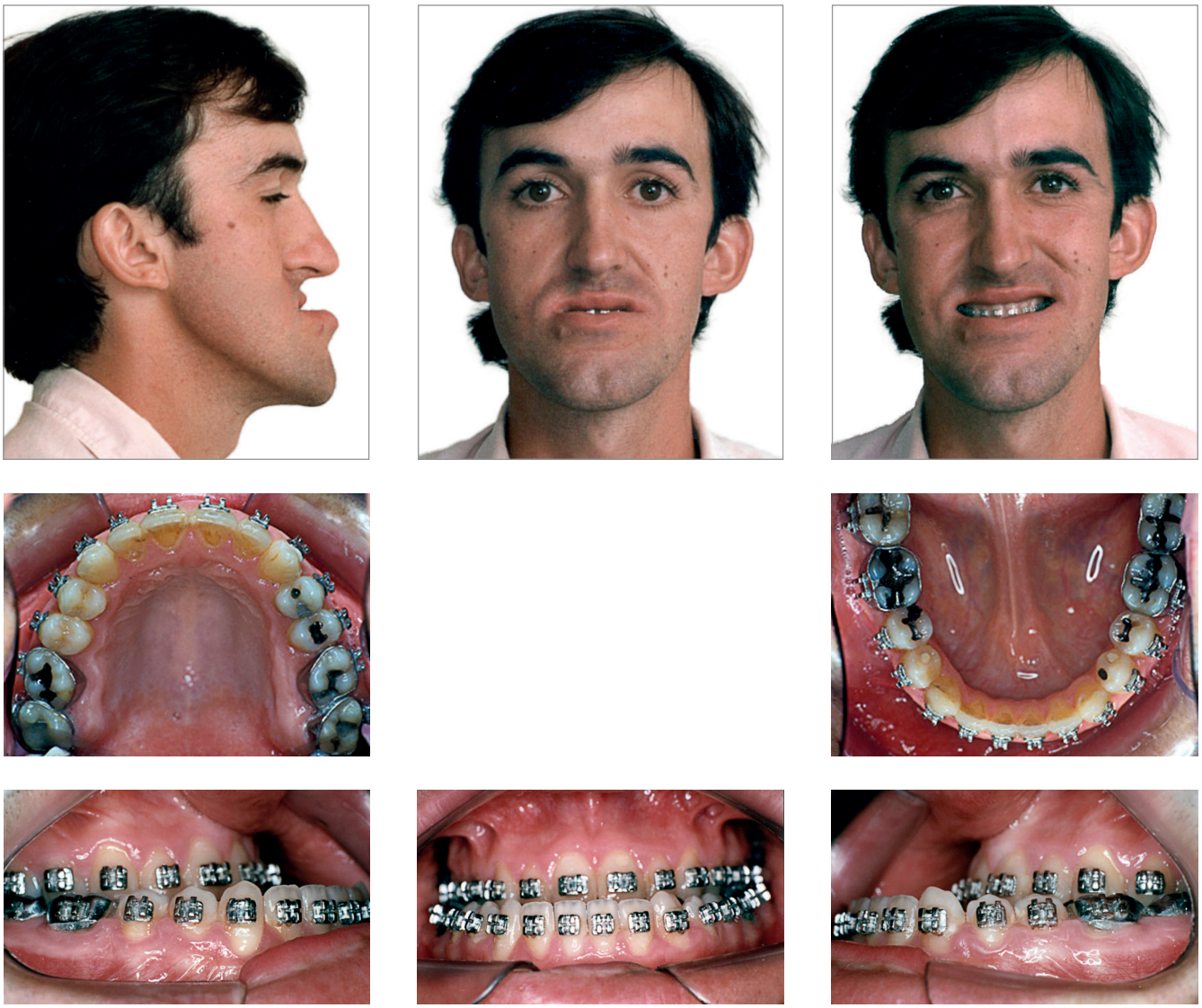

Figure 5 - Facial and intraoral pre-surgical photos.

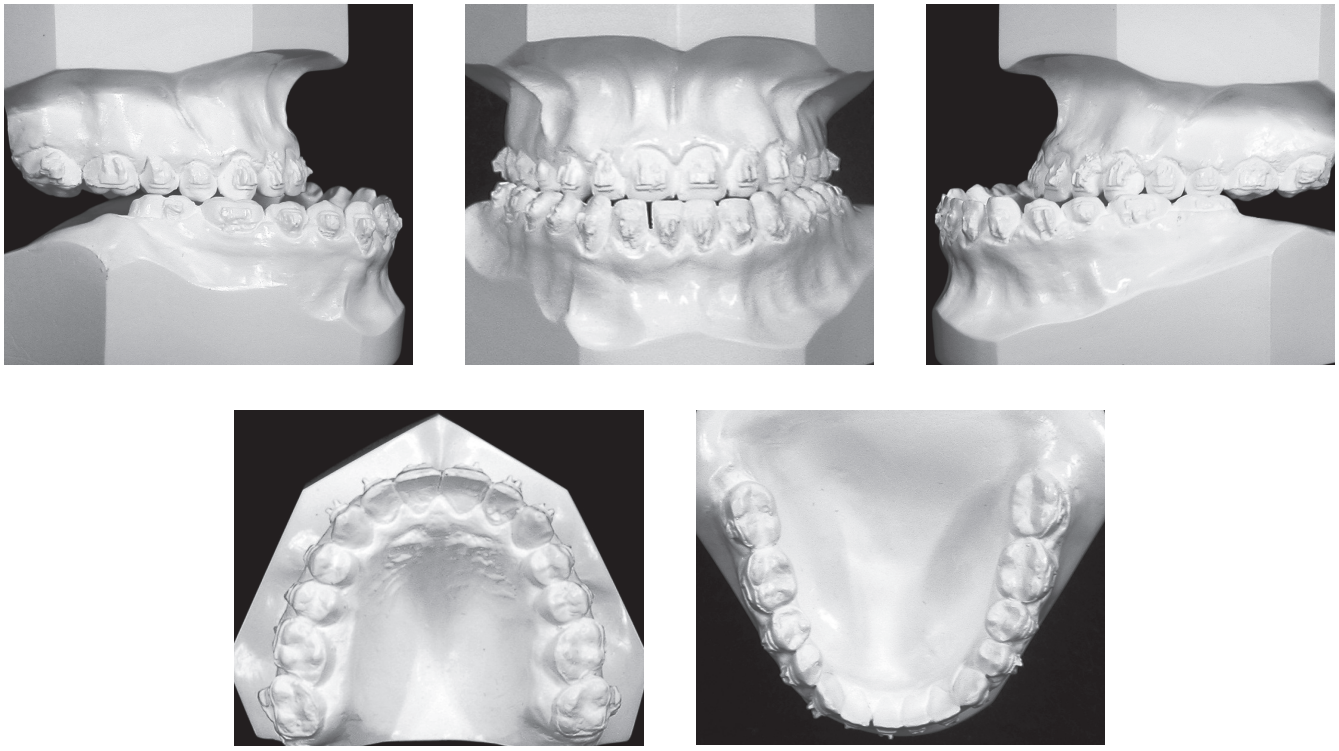

Figure 6 - Pre-surgical dental casts.

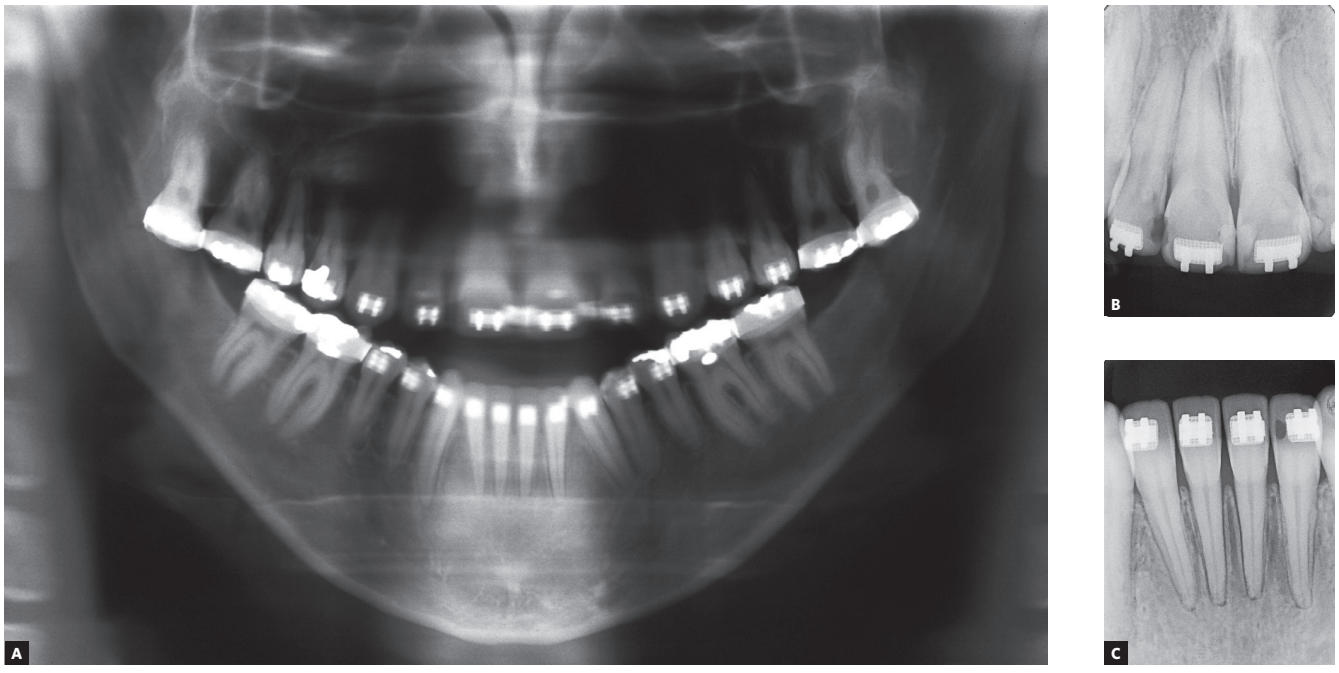

Figure 7 - Panoramic (**A**) and periapical (**B, C**) pre-surgical radiographs.

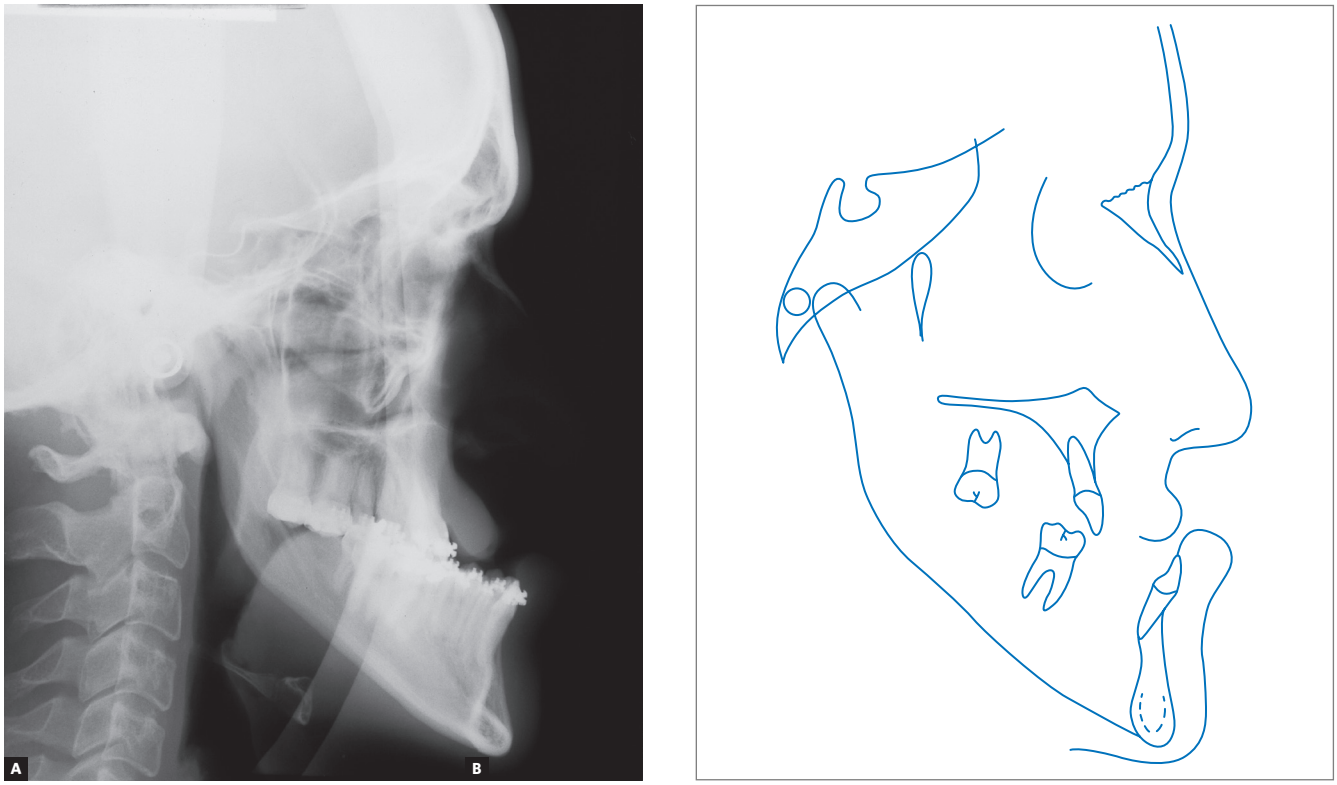

Figure 8 - Lateral cephalometric radiograph (**A**) and pre-surgical cephalometric tracing (**B**).

RESULTS

At the end of treatment, satisfactory occlusion was obtained with good dental intercuspation and presence of anterior and lateral disocclusion guides. The esthetic result was pleasing, harmonious, respecting the individual characteristics of the patient. Orthognathic surgery provided maxillary protrusion with an increase in SNA of 6º, plus lower replacement and mild dentoalveolar expansion. In the mandible, the effect was of retrusion, with the reduction in SNB of 4º in the vertical direction. The dental effects on the mandible were retroclination of incisors and increase in the intermolar distance of 7 mm. In the mandible the incisors were severely protruded, the curve of Spee was leveled, the intermolar distance increased in 3 mm and intercanine distance in 1 mm (Figs 9 to 16).

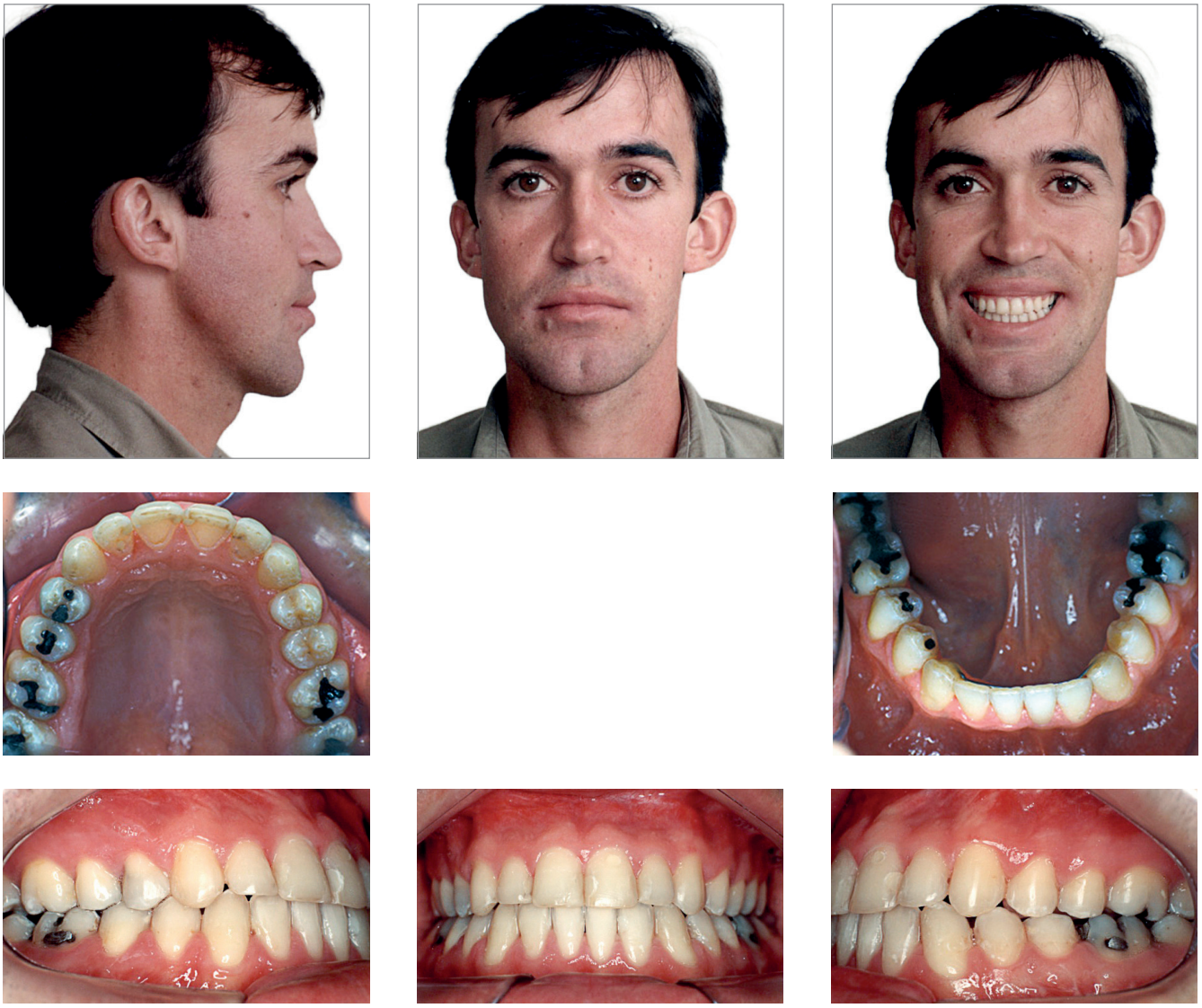

Figure 9 - Facial and intraoral final photos.

Figure 10 - Final dental casts.

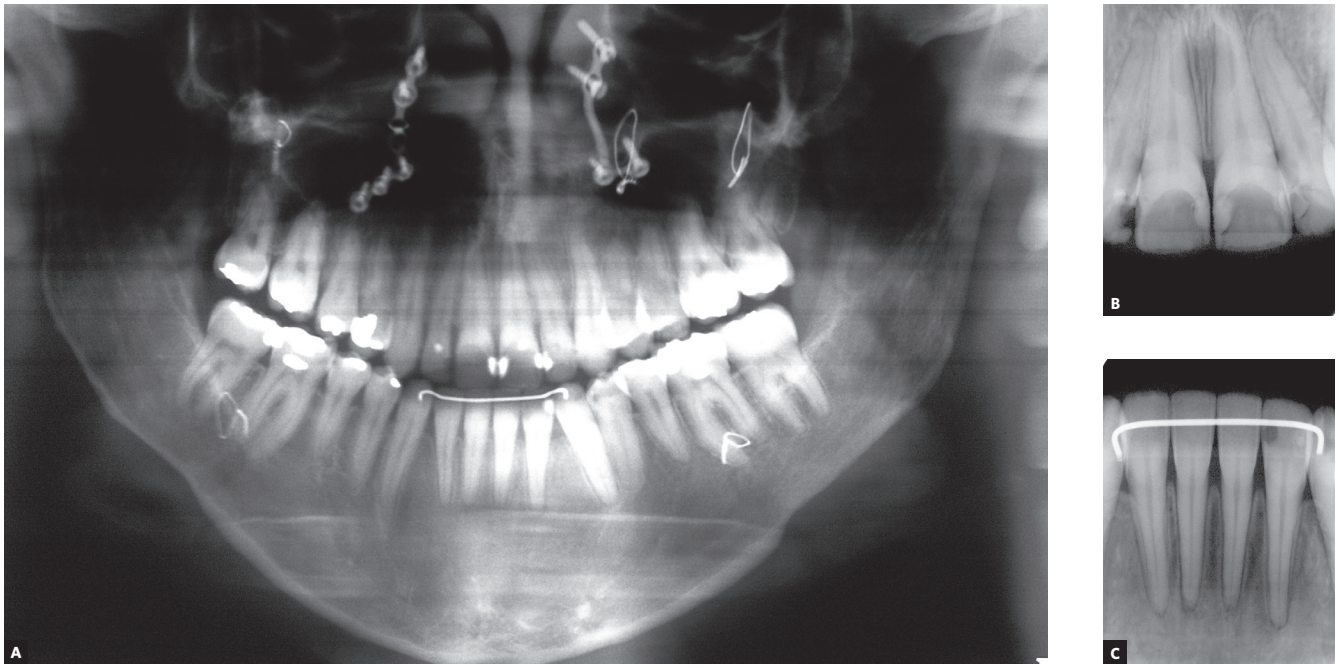

Figure 11 - Panoramic (**A**) and periapical (**B, C**) final radiographs.

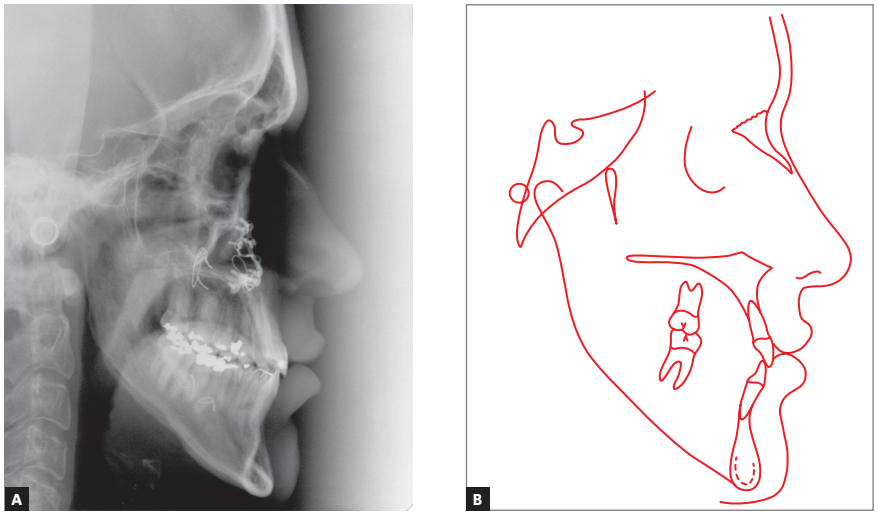

Figure 12 - Lateral cephalometric radiograph (**A**) and final cephalometric tracing (**B**).

Figure 13 - Facial and intraoral control photos, four years after retention.

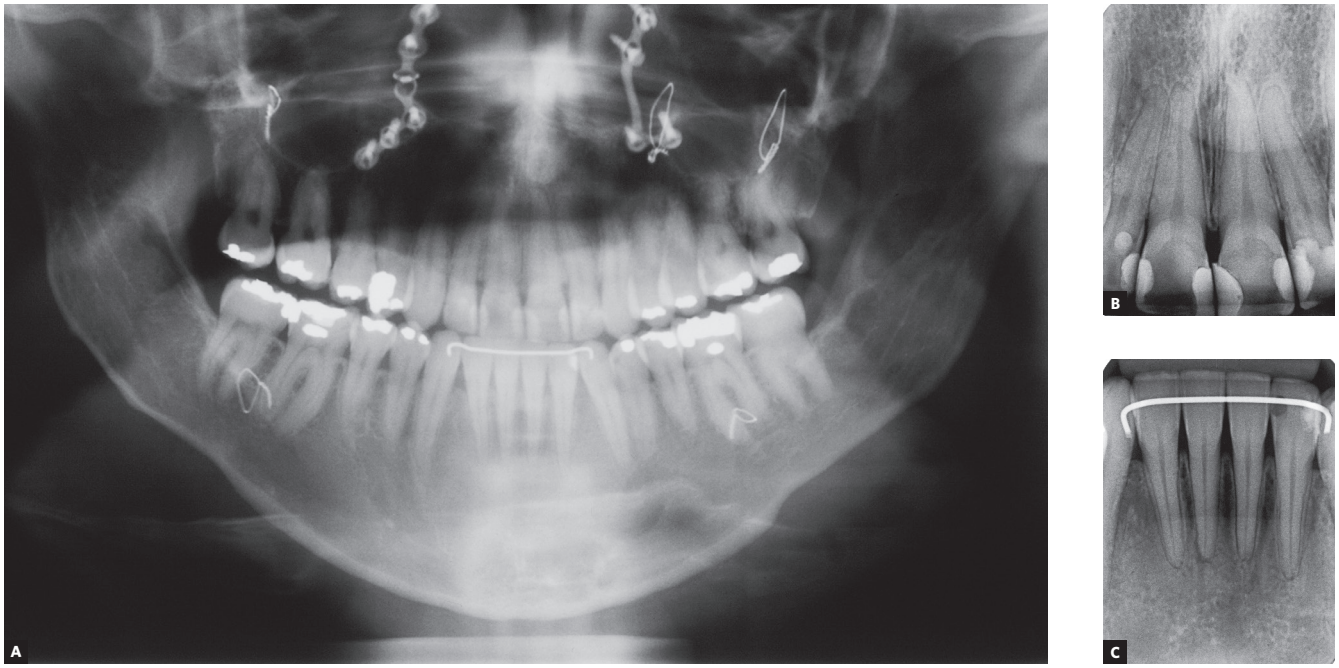

Figure 14 -Panoramic (**A**) and periapical (**B, C**) radiographs, four years after retention.

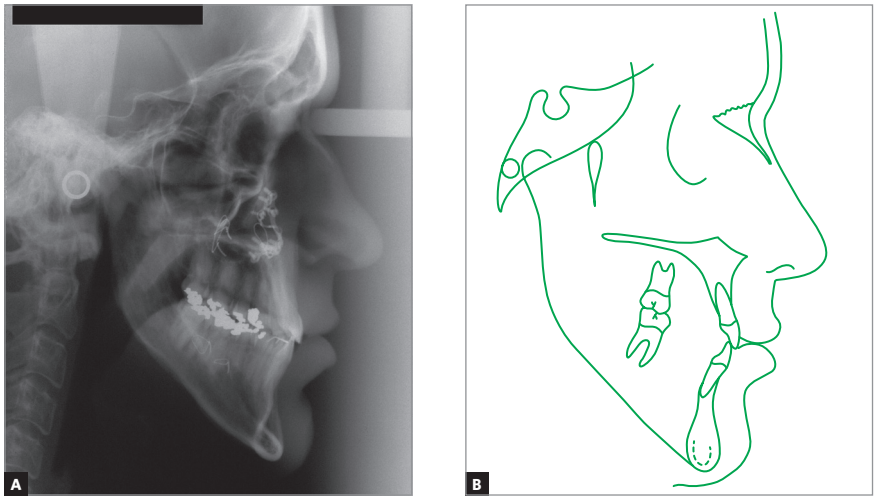

Figure 15 - Lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**), four years after retention.

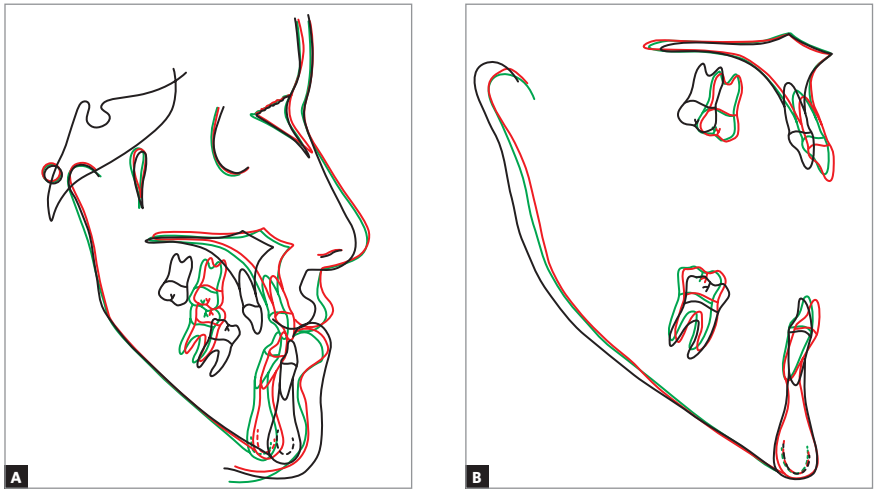

Figure 16 - Total (**A**) and partial (**B**) superimposition of the initial cephalometric tracing (black), final (red) and four years after retention (green).

Table 1 - Summary of cephalometric measurements.

	Measurements		Normal	A	P	B	C	Difference A/B
Skeletal pattern	SNA	(Steiner)	82	73	73	79	81	6
	SNB	(Steiner)	80	84	84	80	80	4
	ANB	(Steiner)	2	-11	11	-1	1	10
	Angle of convexity	(Downs)	0	-23	27	1	0	24
	Y axis	(Downs)	59	60	63	60	61	0
	Facial angle	(Downs)	87	91	90	90	90	1
	Sn-GoGn	(Steiner)	32	45	45	45	45	0
	FMA	(Tweed)	25	38	39	39	39	1
Dental pattern	IMPA	(Tweed)	90	57	77	69	70	12
	1–NA (mm)	(Steiner)	22	27	26	19	22	8
	1.NA (degrees)	(Steiner)	4	5	5	5	5	0
	$\bar{1}$–NB (mm)	(Steiner)	25	25	47	20	20	5
	$\bar{1}$.NB (degrees)	(Steiner)	4	3	6	4	4	1
	$\frac{1}{1}$ – interincisal angle	(Downs)	130	160	140	145	144	15
	$\bar{1}$–APo (mm)	(Ricketts)	1	-6	-11	3	2	9
Profile	Upper lip – S line	(Steiner)	0	-3	-6	0	-1	3
	Lower lip –S line	(Steiner)	0	4	8	1	1	3

CONCLUSION

The Class III malocclusion is considered most challenging for the orthodontist, particularly when there is skeletal involvement.[1] In this case, the diagnosis conclusion was the recommendation of orthognathic surgery due to the dominant etiologic factor - severe maxillary and mandibular malocclusion - this being the primary focus on the treatment strategy. With the surgical approach, psychosocial aspects related to the deformity can also be privileged[2] and it is important that the diagnosis and treatment plan are performed in conjunction with the maxillofacial surgeon in order to maximize results and reduce the time and complications inherent to treatment.[3,4] Combined maxillary and mandibular orthognathic surgery allowed the orthodontic treatment to be efficient, reaching its goals, with appropriate overjet and overbite relationship between canines and molars in key of occlusion. Decompensation of the lower incisor inclination, considered severe, did not cause changes that compromised the periodontal support structures. Final and control radiographs showed moderate levels of root resorption, which reveals the low biological cost of the treatment. The change in the mentolabial angle, with the positioning of the lower lip near normality, helped to reduce the subjectivity degree in the analysis of the soft tissue profile in the pre-surgical phase, enhancing the final esthetic result. The improvement in facial esthetics contributed to raising the self-esteem of the patient. The follow-up of four years post-treatment denotes stability in occlusal characteristics, morphology of the arches and facial harmony.

REFERENCES

1. Stellzig-Eisenhauer A, Lux Cj, Schuster G. Treatment decision in adult patients with Class III malocclusion: orthodontic therapy or orthognathic surgery. Am J Orthod Dentofacial Orthop. 2002;122:27-38.
2. Bilodeau JE. Correction of a severe Class III malocclusion that required orthognathic surgery: a case report. Semin Orthod. 1996;2:279-88.
3. Vig KD, Ellis E. Diagnosis and treatment planning for the surgical-orthodontic patient. Dent Clin North Am. 1990;34(2):361-84.
4. Dann JJ, Fonseca R, Bell WH. Soft tissue changes associated with total maxillary advancement: a preliminary study. J Oral Surg. 1976;34:19-23.

Gingival esthetics: An orthodontic and periodontal approach

Máyra Reis Seixas[1], Roberto Amarante Costa-Pinto[2], Telma Martins de Araújo[3]

Introduction: Currently, people's esthetic requirements and expectations have increased substantially. Therefore, dentists have been seeking ways to provide excellent treatment results which, consequently, increasingly require a well organized transdisciplinary approach. The link between orthodontics and periodontics became evident from the moment professionals began to understand the biology of tooth movement. As regards smile esthetics, however, such cooperation is now essential.

Objective: To show clinically how and when orthodontists and periodontists should work jointly to enhance smile esthetics based on the display and harmony of the gingival contour.

Keywords: Orthodontics. Smile. Esthetics. Periodontics.

INTRODUCTION

In the recent past, orthodontists placed less emphasis on periodontal health and the esthetic appearance of the gums when finishing treatment. They believed that aligning and leveling the teeth was sufficient to ensure positive results, and often overlooked the fact that smile esthetics depends on a number of factors, among which are the display and architecture of apparent gingival tissue and its contour, phenotype, zenith position and presence of interdental papilla.[1,2,3]

Furthermore, the number of adult orthodontic patients has grown considerably. Although more compliant with treatment than adolescents, adults pose a host of challenges to the orthodontist: They may have missing, worn or abraded teeth, uneven

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

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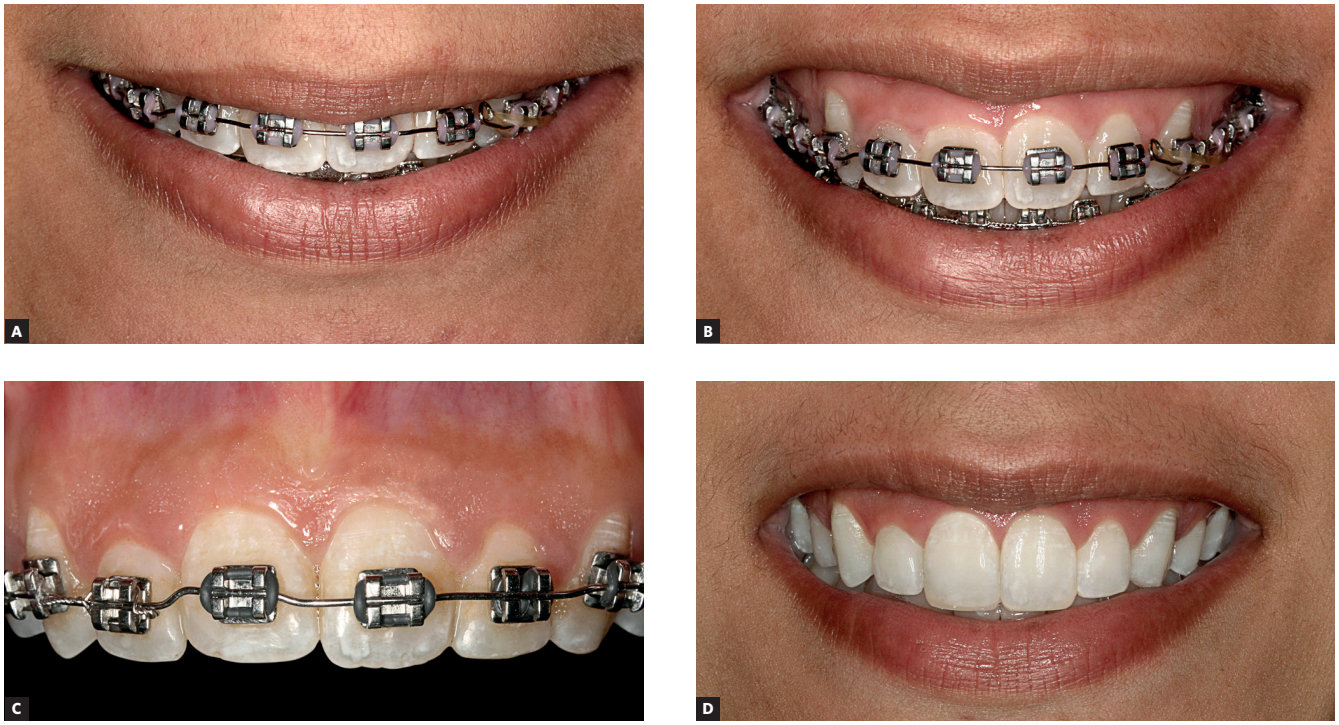

Figure 1 - **A, B**) Smile esthetics affected by disharmonious gingival contours although anterior teeth look well aligned and leveled. **C, D**) Improved gingival contour after periodontal surgery and orthodontic movement. Gingivectomies were performed on teeth #12 and 21, as well as intrusion of #11 with subsequent restoration of its incisal edge. During orthodontic intrusion, tooth #11 moved apically, carrying with it the entire periodontium, while maintaining biological distances.

gingival margins, loss of bone and interdental papillae. Finally, problems that can undermine the esthetic appearance of the teeth after debracketing. Given the complexity of these treatments, the increased choice of therapeutic resources, and increased esthetic demand by patients, a transdisciplinary approach in orthodontic treatment is now paramount, and an integration with periodontists, an absolute must[4-10] (Fig 1).

Periodontic concepts have also evolved. Recent advances in basic science in the field of periodontal biology along with clinical trials in the prevention and treatment of periodontal disease have shifted dramatically the focus of periodontal treatments. In view of a lack of direct correlation between probing depth and the presence or absence of active disease, eliminating periodontal pockets is no longer the only goal of periodontal therapy. The indiscriminate use of resective procedures common until the mid-1980s generated undesirable sequelae in tissue architecture, such as gingival margin recession and potential loss of interdental papillae[10,11] (Fig 2). Additionally, the search for better and more effective alternatives to rebuild tissue loss during disease progression and after resective procedures[2,3] represented a great leap for periodontics in the pursuit of "red esthetics" and quality of life for patients.

This realization underscores the increasing need for exchange of information and scientific knowledge between orthodontists and periodontists. It is therefore necessary that the theoretical and practical training of these professionals converge.

IDEAL GINGIVAL ESTHETIC CONTOUR

The appearance of the gingival contour follows the underlying bone architecture and is influenced primarily by factors such as tooth position, type of periodontium, tooth form, and design of the CEJ. In a clinically healthy periodontium, the gingival contour forms and invests the CEJ.[2,3,13]

The contour of the gingival margins of the six maxillary anterior teeth plays an important role in smile esthetics and is determined by the


Figure 2 - Undesirable sequelae in a female patient's periodontium treated by resective surgical procedures.

Figure 3 - Differences between the heights of the apical gingival margins of anterior teeth, determining the ideal gingival contour for the region.

following features: Firstly, the gingival margins of the central incisors should be on the same level, furthermore, they should position themselves more apically to the margins of the lateral incisors and remain on the same level of the margins of the canines. The contour of the gingival margins must coincide with the CEJs of the teeth, and each tooth must have a gingival papilla that occupies the interdental embrasure (Fig 3).

According to a study published by Kokich,[14] the closer to the midline gingival contour asymmetries are located, the more easily these asymmetries will be identified as less esthetic by orthodontists, GPs and laypersons alike. Therefore, there may be variations in the patterns described above when these are located in different quadrants of the same patient, but contour symmetry between central incisors is always necessary. One might add that when the height of the gingival margin of the lateral incisors is positioned more than 2 mm above the gingival margin of the central incisors and canines, smile esthetics is said to be compromised (as shown in the description of Fig 9). Kokich also suggests that patients with gingival contour discrepancies and low smile line require no correction as this condition is not seen as esthetically relevant.[6-10]

Interdental papillae form the gingival tissue that fills the space between adjacent teeth. These papillae are influenced by the distance and inclination between teeth, alveolar bone height and anatomical form of clinical crowns, with the latter determining interproximal contact point height[2,3] (Fig 4).

Papillae can be observed in regions at a distance of less than or equal to 5 mm between the alveolar bone crest and the contact point. When this value is increased to 6 mm or 7 mm, the ability to observe the papilla is hindered, while measurements above 7 mm often mean that the papilla is not present[15] (Fig 5).

Distances of less than 0.3 mm between roots result in a reduction of the proximal bone, a condition often accompanied by an absence of interdental papilla. Moreover, large interradicular spaces, e.g., diastemas, are usually associated with short, flattened papillae.[16]

The loss of the papillae as a sequela of periodontal disease or iatrogenic dental procedures causes

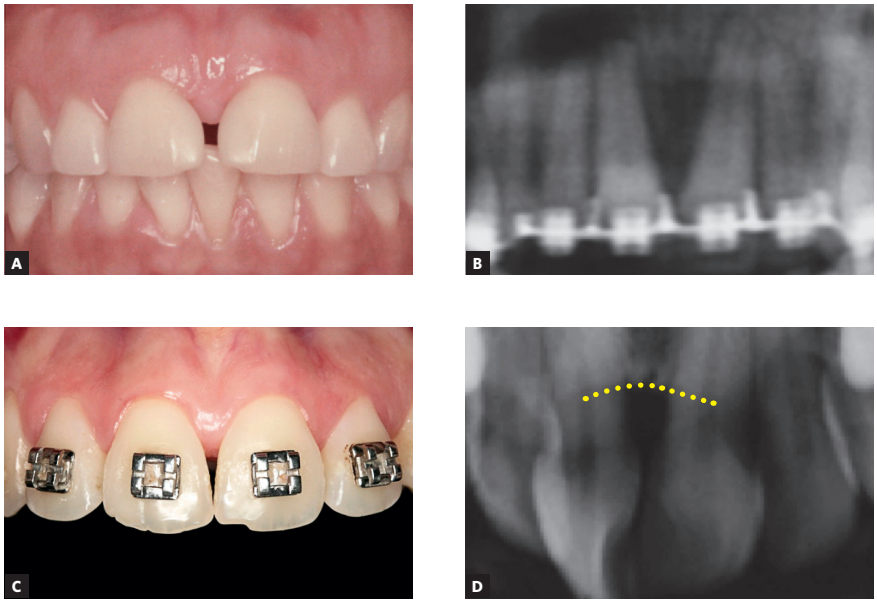

Figure 4 - Factors determining the presence and form of the papillae: **A, B**) Distance and inclination between the teeth; (**D**) triangular form of the clinical crown, (**C**) alveolar bone crest height.

Figure 5 - Relationship between the presence of interdental papillae, and the distance between the alveolar bone crest and the contact point of the teeth.

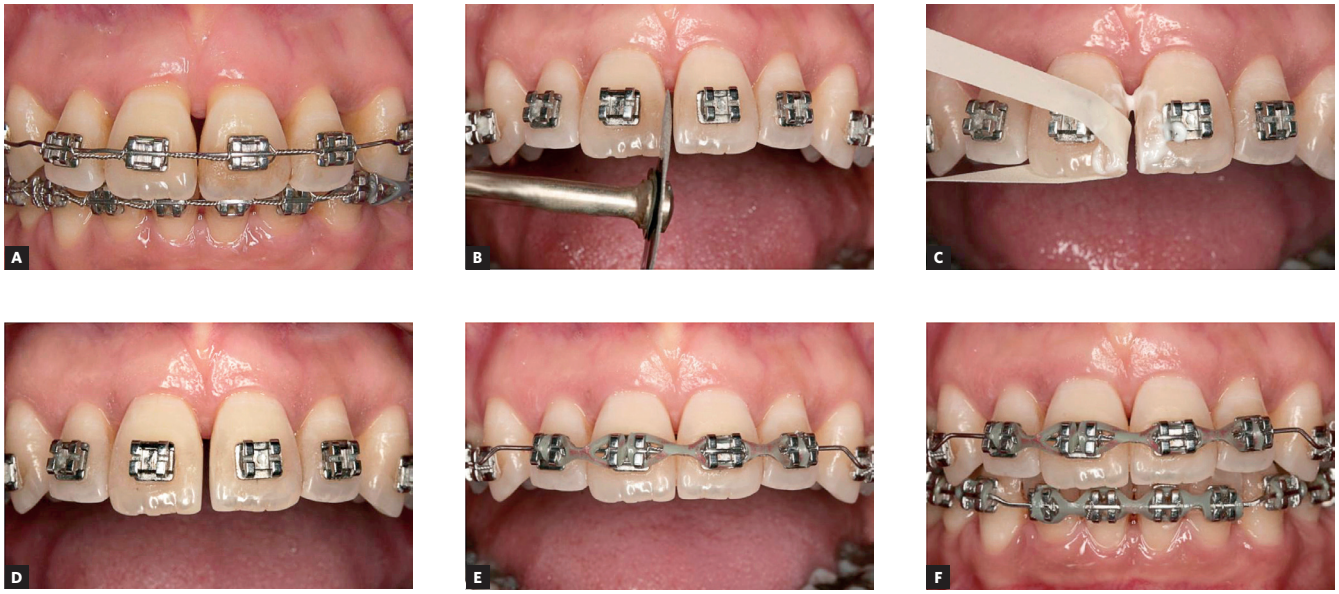

Figure 6 - **A**) Median dark space caused by alveolar bone crest loss **B**) Interproximal stripping performed with diamond steel disk at low rotation; **C**) polishing of the stripped surfaces with flexible strips of sandpaper and whiting **D**) space created between incisors; **E, F**) bringing teeth closer together with elastomeric chains, showing improvement in papillary esthetics.

the formation of "dark spaces" that interfere negatively in the perception of smile esthetics. The small size of interdental papillae combined with a purely capillary nutrition render their reconstruction a periodontal procedure whose outcome is hard to predict, further strengthening the idea that papillae should be carefully preserved.[2,3] Orthodontists treat this condition by combining interproximal stripping with tooth movements, and positioning more apically the contact point between the teeth (Fig 6). Soft tissue grafts can improve tissue volume, but in most cases results only give a misleading impression that the dark space has been reduced or closed since the height of the papillae is not completely restored.[2,3]

DISCREPANCIES IN GINGIVAL ESTHETIC CONTOURS

Changes in gingival contour may be located either coronally or apically relative to CEJ, and can be addressed in various manners, by:

- Orthodontic movement, intruding or extruding the teeth involved[1,7,8,9]
- Resective gingival surgery to lengthen the clinical crown (gingivectomy or gingivoplasty)
- Resective bone surgery to lengthen the clinical crown

Planning and selecting the best option to correct the problem depends on several factors: Sulcus depth on probing, location of CEJ relative to the bone level, crown-root relationship between the teeth involved, root form,[1,2,3] and degree of gingival display on smiling.[18]

The conditions listed below adversely affect the harmony of the gingival contour and their respective treatment options.

Compensatory dental extrusion

Compensatory dental extrusion is one of the conditions that alter the gingival contour. It tends to occur as a result of wear and/or fracture of the incisal edge of anterior teeth, which extrude and carry with them the entire periodontal tissues. It affects adult patients who usually present with poor horizontal and vertical relationship between the dental arches. In these cases, the anterior teeth extrude and carry with them the periodontal tissues. Clinical examination disclosed incisors with normal probing depths and worn incisal edges, causing an esthetically inadequate width/height ratio, which is usually these patients' chief complaint.[7-10]

There are two treatment options which should be discussed with the patient:

1) Clinical crown lengthening surgery with osteotomy. The main objective of this procedure is to restore clinical crown height lost at the expense of marginal periodontal tissue by means of resective techniques and apical repositioning. The main disadvantage of this approach is a reduction in dental implantation due to a decrease in the root/crown ratio, given root surface exposure and the need for additional restorative treatment.[2,3] Moreover, since roots have a tapered form, satisfactory interproximal esthetics cannot be ensured, and it is not uncommon to find poor sealing of the embrasures and the emergence of "dark spaces" postoperatively. Filling these gaps with restorative materials creates the appearance of wide, "square" teeth in addition to an irregular emergence profile with an exceedingly convex tooth/restoration interface, which hampers biofilm control and can compromise the health of the periodontium.
2) Orthodontic leveling of the gingival margins and subsequent restoration of the incisal portion of the teeth: The key purpose of this approach is to level the CEJ. This procedure is more conservative and biological but requires the use of a fixed orthodontic appliance and longer treatment and retention times (Fig 7).

Currently, the placement of a fixed appliance in patients whose anterior teeth have their incisal edges worn and/or fractured should be performed by taking as reference the gingival margin positioned more apically[7-10] (Fig 8).

Given that the primary objective of the approach in these cases is to level the gingival contour, the clinical and radiographic evaluation of the patient prior to treatment should be implemented to verify periodontal health, shallow levels of gingival sulci, and particularly, similar values (Figs 9 and 10).

Figure 7 - **A**) Case finished with harmonious gingival contour; **B**) minimal, similar probing depths, and uneven incisal silhouette due to incisal edge wear of tooth #11; **C**, **D**) restoration of incisal edge of #11 with composite resin; **E**) properly balanced incisal guidance.

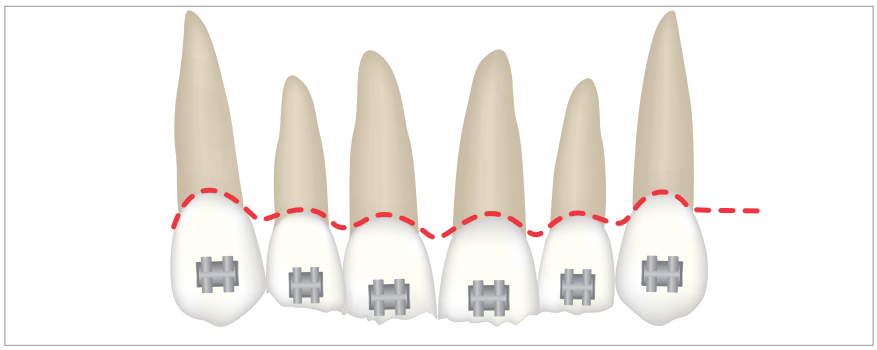

Figure 8 - Orthodontic appliance placed on anterior teeth with irregular incisal edges due to wear and/or fracture: In the event that gingival contours are found to be uneven, and the depth of gingival sulci are minimal and similar, bonding of orthodontic brackets should use as reference the apical height of the gingival margin, which constitutes the CEJ of the teeth.

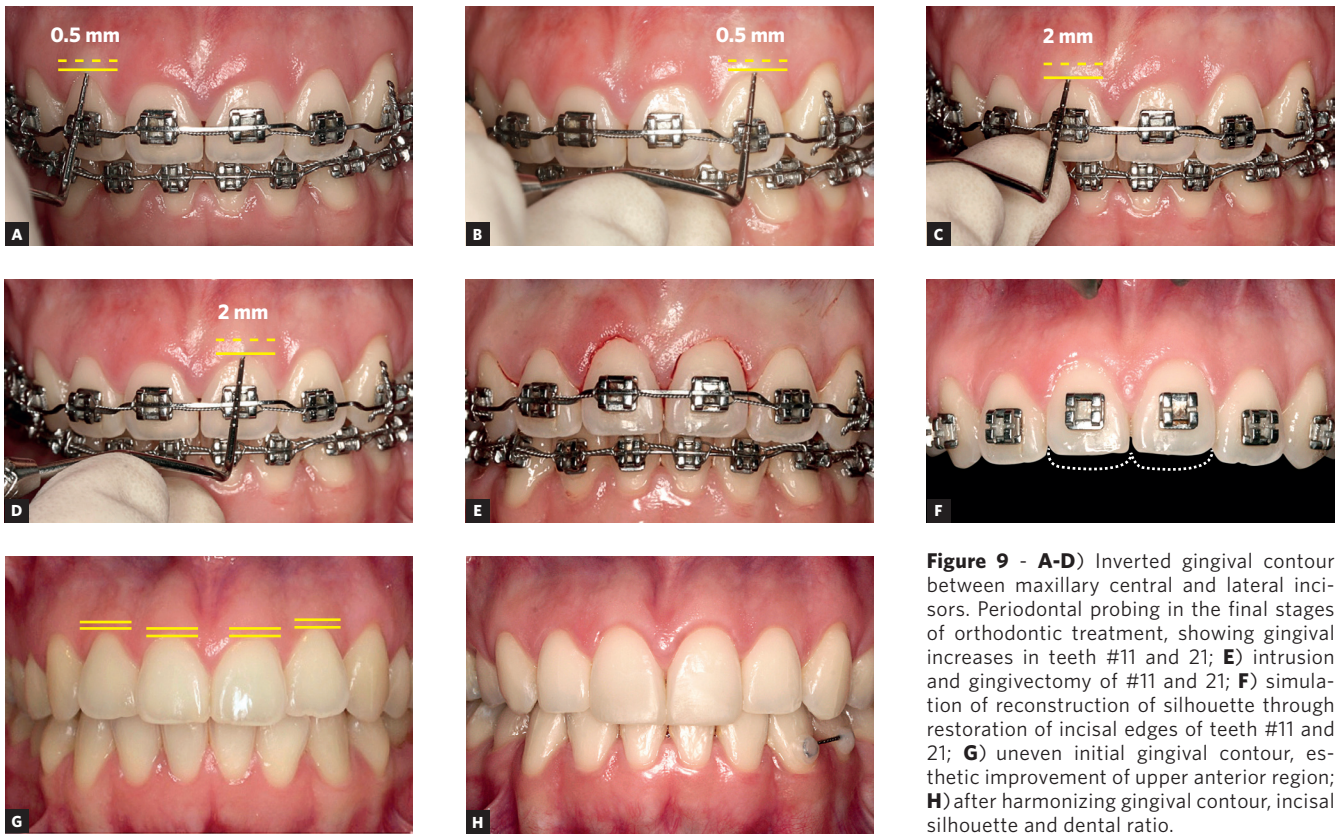

Figure 9 - **A-D**) Inverted gingival contour between maxillary central and lateral incisors. Periodontal probing in the final stages of orthodontic treatment, showing gingival increases in teeth #11 and 21; **E**) intrusion and gingivectomy of #11 and 21; **F**) simulation of reconstruction of silhouette through restoration of incisal edges of teeth #11 and 21; **G**) uneven initial gingival contour, esthetic improvement of upper anterior region; **H**) after harmonizing gingival contour, incisal silhouette and dental ratio.

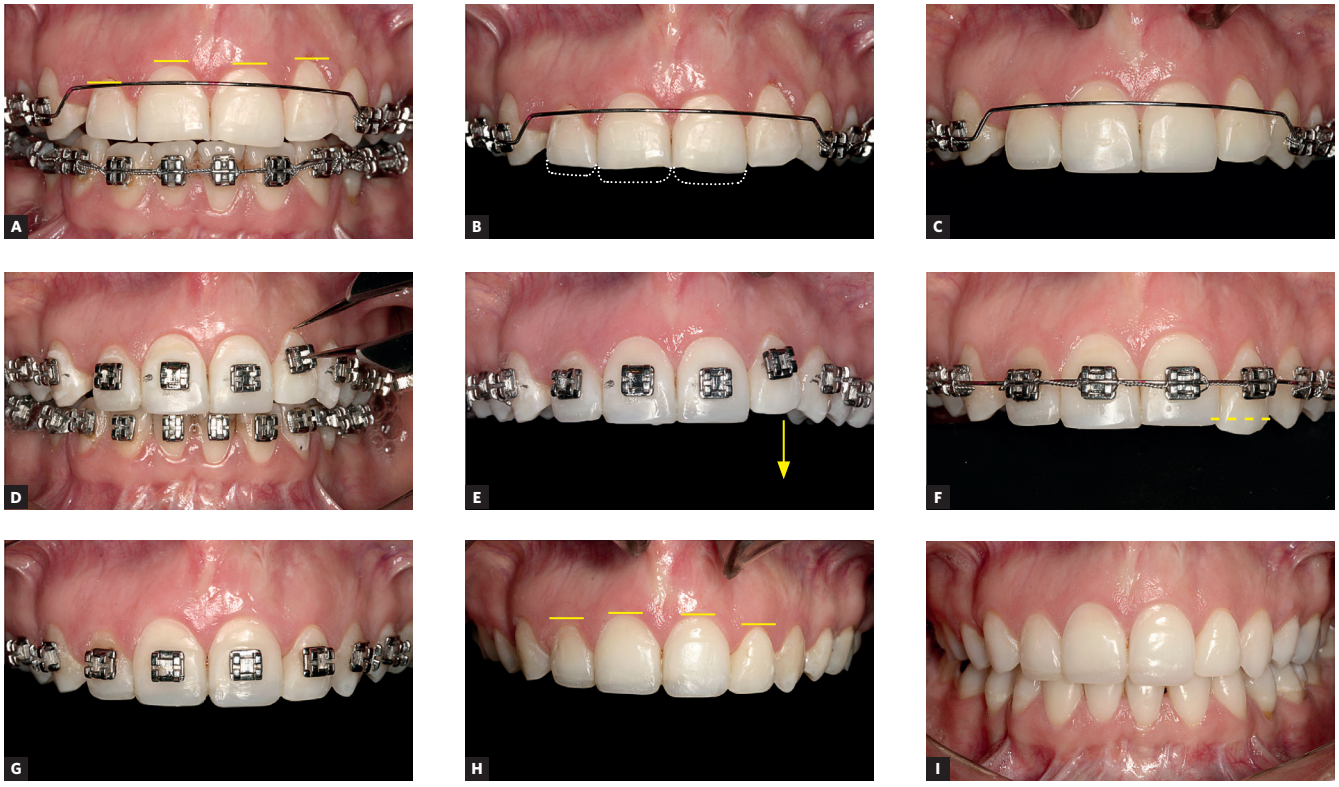

Figure 10 - **A, B**) Patient nearing completion of orthodontic treatment, showing uneven gingival contour in upper anterior region, and wear of incisal edges of teeth #12, 11 and 21; **C**) provisional composite resin restorations established a new incisal silhouette and new anatomical proportions for these teeth; **D**) rebonding of brackets taking as reference the apical gingival margin of incisors; **E, F**) leveling of gingival margins of upper anterior region by extrusion and ameloplasty of tooth #22; **G, H, I**) final esthetic appearance after dentogingival leveling of the case.

Altered passive eruption

The normal tooth eruption process is considered complete when the teeth reach the occlusal plane and go into function. The soft tissues, in turn, follow this movement and ultimately the gingival margin migrates apically almost as far as the CEJ. When this does not happen and the gingiva continues to invest part of the dental clinical crown, it is named altered passive eruption (APE).[2,13]

APE cases usually involve young patients presenting with intact anterior incisal edges and undesirable width/height dimensions. The orthodontist is responsible for properly diagnosing this condition and treatment planning should invariably involve cooperation by a periodontist to ensure gingival esthetics[17] (Fig 11).

According to Garber and Salama,[17] APE can be classified based on the amount of keratinized gingiva: Type 1: Wide band of keratinized gingiva; Type 2: Narrow band of keratinized gingiva, and also subclassified according to the relationship between the CEJ and alveolar bone crest:

» **Subgroup A:** The distance between the alveolar bone crest and the CEJ is greater than or equal to 1 mm, therefore sufficient for the connective tissue attachment. In this subgroup, in type I cases, gingivectomy can solve the problem, while in Type II cases, a flap displaced apically is indicated.

» **Subgroup B:** The distance between the alveolar bone crest and the CEJ is less than 1 mm, therefore insufficient for the connective tissue attachment. In these cases, osteotomy is necessary to establish correct biological distances. Therefore, the distance from the alveolar bone crest to the CEJ determines whether or not there it is necessary to displace the flap in order to remodel the bone, ensuring sufficient space to accommodate the connective tissue attachment.

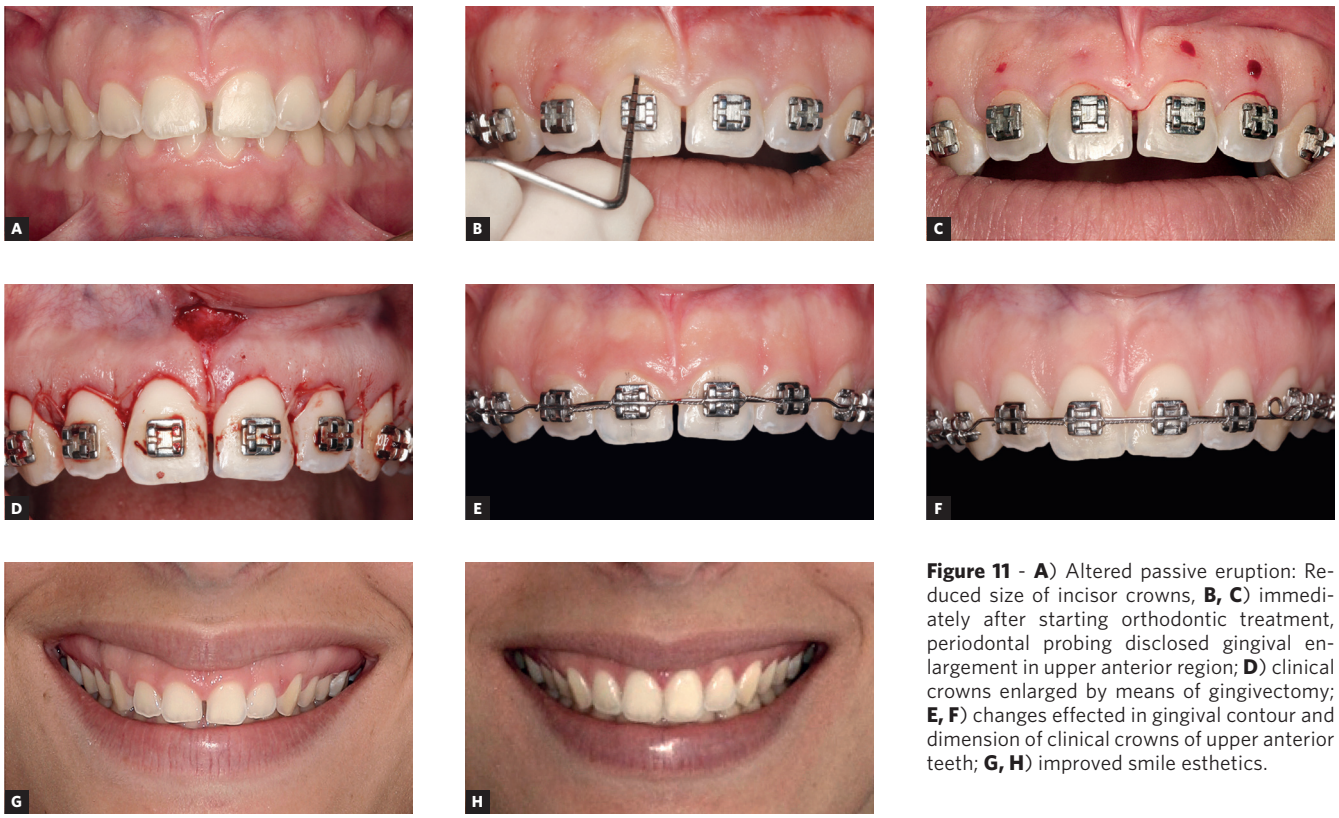

Figure 11 - **A**) Altered passive eruption: Reduced size of incisor crowns, **B, C**) immediately after starting orthodontic treatment, periodontal probing disclosed gingival enlargement in upper anterior region; **D**) clinical crowns enlarged by means of gingivectomy; **E, F**) changes effected in gingival contour and dimension of clinical crowns of upper anterior teeth; **G, H**) improved smile esthetics.

This classification is important when choosing the periodontal therapy to be employed in each case specifically.

Many patients present with APE in all anterior teeth and their chief complaint is excessive gingival display on smiling, which characterizes "gummy smile." When there is a combination of vertical maxillary excess in its etiology - which would require ortho-surgical treatment – these issues can be fully addressed with periodontal surgery (clinical crown lengthening), with a considerable impact on smile esthetics and on patient satisfaction with the treatment outcome[18] (Fig 11).

Many patients often find it difficult to maintain proper oral hygiene during the course of orthodontic treatment. Moreover, given the presence of orthodontic brackets, a reduction occurs in the self-cleaning process effected by the lips and cheeks, also contributing to the emergence of gingival inflammation, with isolated or widespread increases in probing depths. Regardless of how satisfactorily one succeeds in leveling and aligning the teeth, and in achieving functional occlusion, smile esthetics is never entirely satisfactory after removal of the orthodontic appliance.

Often, however, one can restore oral hygiene to optimum levels after appliance removal, thereby reducing gingival enlargement in these cases. Thirty to sixty days after removal of the orthodontic appliance, should gingival enlargement persist in some regions, the periodontist should intervene surgically to correct these pseudo pockets.

Gingival recession

Gingival recession is defined as the apical migration of the gingival margin toward the CEJ. It can affect individual teeth or groups of adjacent teeth. It can also be associated with other factors such as: Noncarious cervical lesions, cervical dentinal hypersensitivity, abfraction, and increased

biofilm accumulation. This condition is a frequent complaint among patients, and adversely affects gingival contour esthetics by rendering it less attractive.[2,13]

The negative correlation between orthodontic tooth movement and loss of gingival attachment has been extensively reported.[2,12,19-23] Often, even prior to orthodontic treatment patients present with a compromised periodontium, and bone dehiscence is usually already present, especially in areas of incisors and canines. This anatomical condition can only be diagnosed and evaluated more accurately by CT scans of these regions. In these cases, orthodontic movement can be performed as usual, but greater care should be exercised regarding biofilm control, in addition to implementing a correct, non-traumatic brushing technique.[24]

When tooth movements are made toward the cortical bone, bone dehiscences may result.[19-23] This does not mean that in such cases orthodontic movement inevitably entails a loss of attachment, but does indicate that this is more likely to happen in the presence of etiologic factors of gingival recession, i.e.,inflammation caused by biofilm and/or tooth brushing trauma.

Classical studies in animals[14-18] showed bone formation in areas of bone dehiscence after tooth movement in medullary directions. According to Lindhe,[12] in some cases areas of gum recession can also be masked by coronal migration of the soft tissue margin, reflected by increased gingival height (Fig 12).

What is known, however, is that moving teeth in medullary directions often induces bone formation in areas of dehiscence. Tooth movement in these cases appears to be beneficial to periodontal health as it improves the morphology of alveolar bone and decreases anatomical predisposition to tissue attachment loss (Figs 13 and 14).[19-23]

In view of the above, the existence of gingival recession prior to the start of orthodontic treatment will require periodontal surgery for root coverage before starting to move teeth that present with gingival recession, especially if these teeth are moved toward the

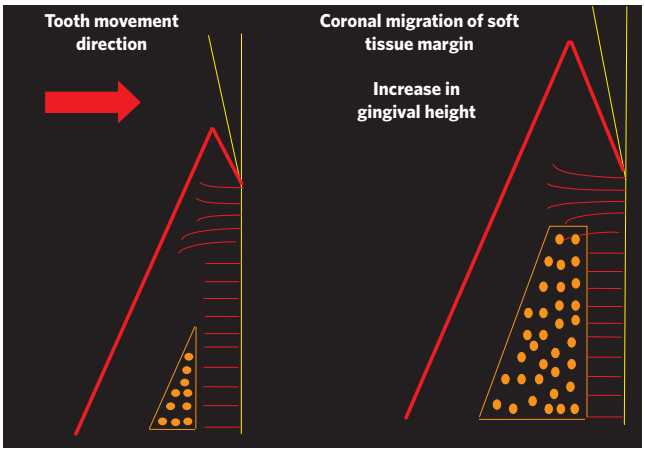

Figure 12 - Changes that occur in marginal periodontal tissues after moving lingually teeth with bone dehiscence positioned labially in the dental arch: Increases in bone and gingival height can be observed, as well as coronal migration of soft tissue margin after movement (Adapted from: Kokich, Kokich, Spear[10]).

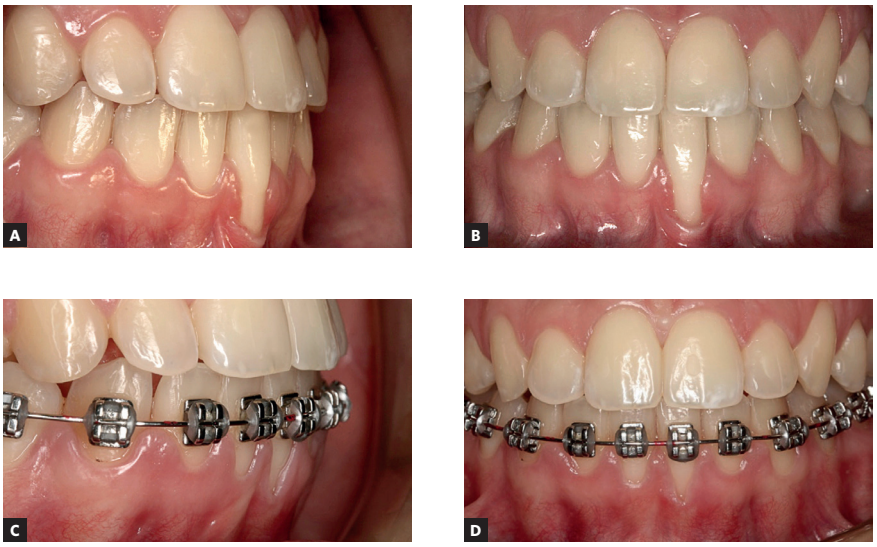

Figure 13 - Gingival recession and buccal positioning of tooth #32's root (**A, B**); reduced recession after orthodontically moving root to correct position in alveolar bone (**C, D**).

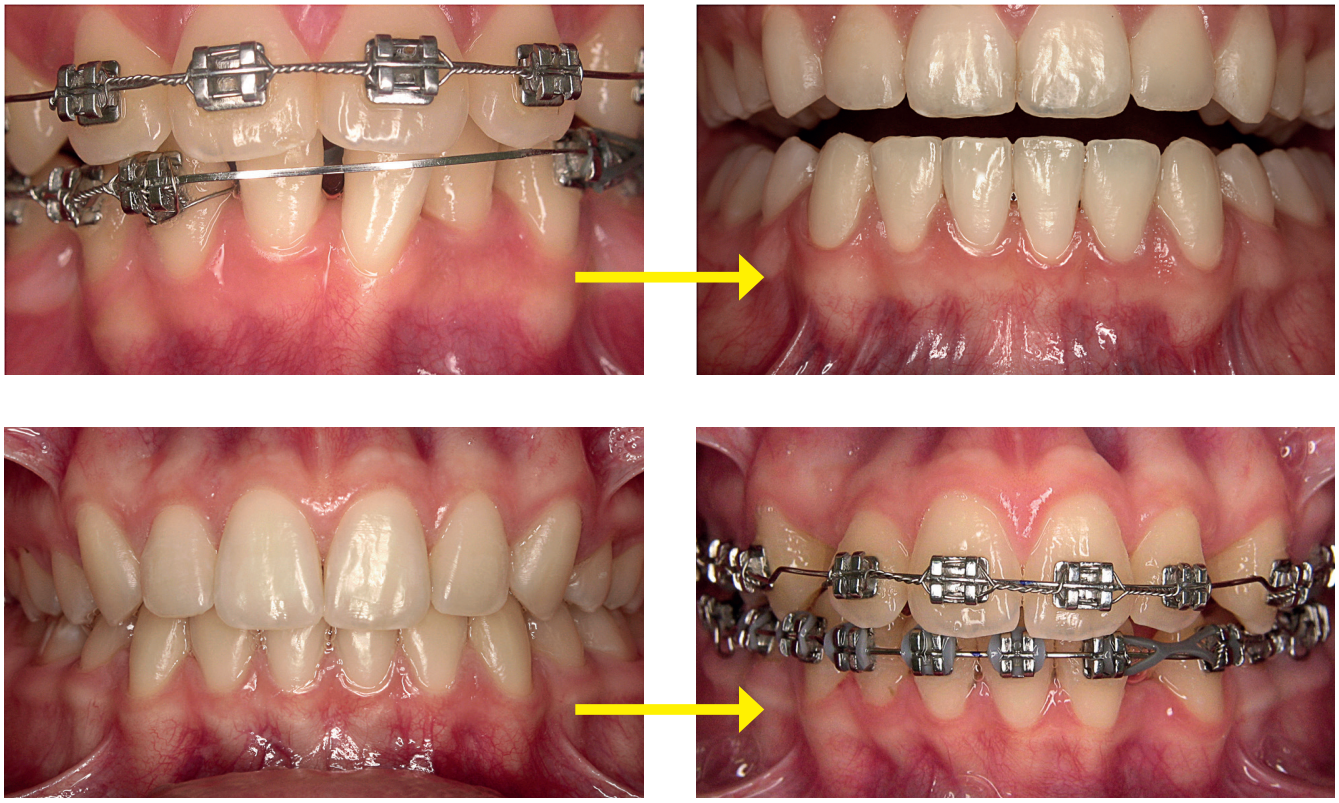

Figure 14 - Patients with unfavorable periodontal phenotypes treated with first premolar extraction and incisor retraction. Changes in alveolar bone morphology can be observed as teeth have taken on a less cortical position. Gingival aspect appeared less distended and slender, and possibly less susceptible to potential trauma and/or inflammatory diseases.

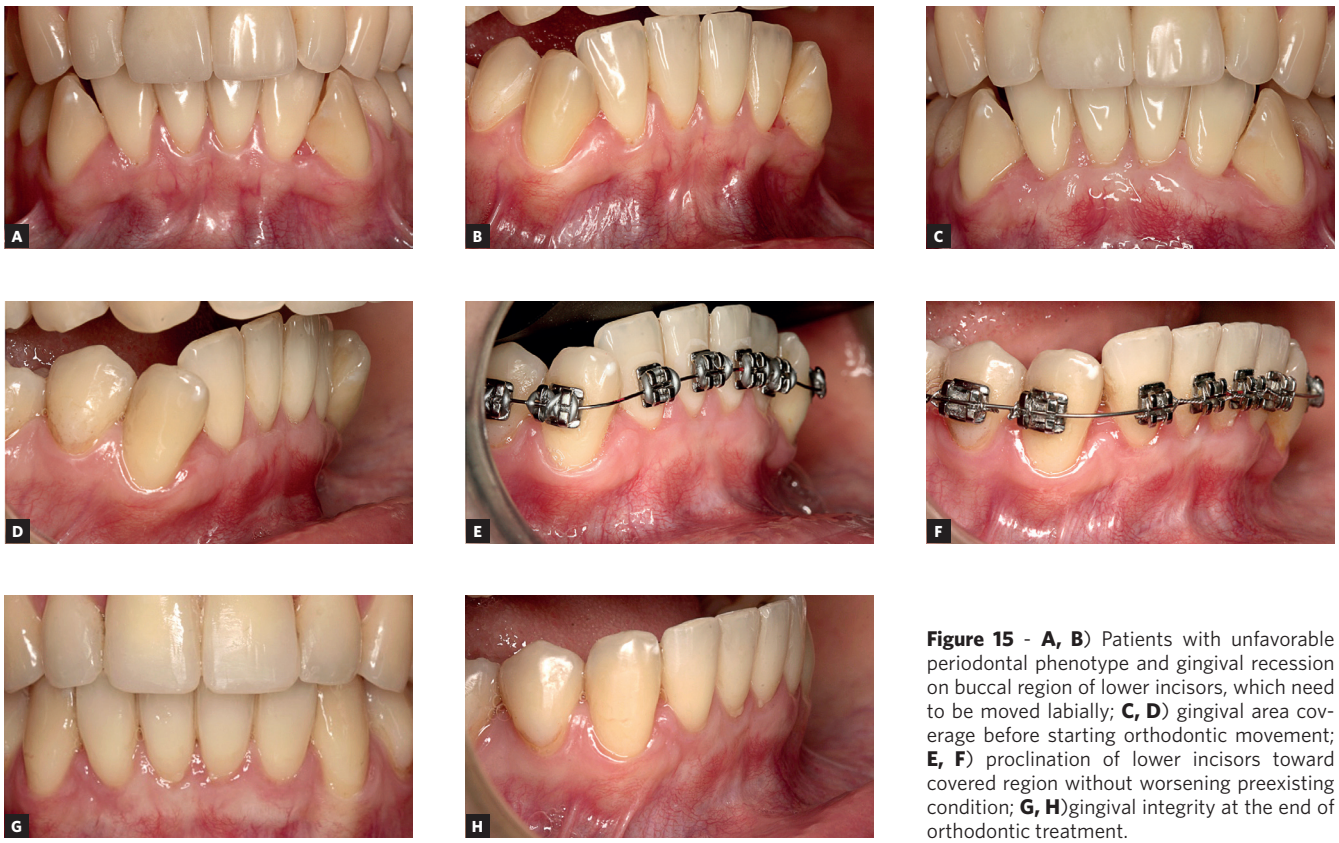

Figure 15 - **A, B**) Patients with unfavorable periodontal phenotype and gingival recession on buccal region of lower incisors, which need to be moved labially; **C, D**) gingival area coverage before starting orthodontic movement; **E, F**) proclination of lower incisors toward covered region without worsening preexisting condition; **G, H**)gingival integrity at the end of orthodontic treatment.

Figure 16 - Patient with history of periodontal disease, bone loss and gingival recession in upper incisor region (**A, B**). Reduced areas of gingival recession after retraction of upper anterior teeth (**C, D**).

periodontal attachment loss area (Fig 15). If these teeth are moved toward more medullary regions, the recession is more likely to improve as a result.[2,4,13] In this case, the need for root coverage surgery can be determined after completion of the orthodontic treatment (Fig 16).

CONCLUSIONS

Success in definitively improving the esthetics of gingival contours requires orthodontic and periodontal procedures. In orthodontics, placement of corrective appliances must take into account the apical heights of the gingiva of maxillary anterior teeth. To this end, it is recommended to probe and record, for diagnostic purposes, the gingival levels prior to bonding the brackets. Knowledge of clinical periodontics should be constantly reviewed and updated to ensure that treatment is properly performed and esthetic outcomes optimized.

REFERENCES

1. Zanetti GR, Brandão RCB, Zanetti LS, Castro GC, Borges Filho FF. Integração orto-perio-prótese para correção de assimetria gengival: relato de caso. R Dental Press Estet. 2007 Out-Dez;4(4):50-60.
2. Borghetti A. Cirurgia plástica periodontal. Porto Alegre (RS): Artmed; 2002.
3. Joly JC, Silva RC, Carvalho PFM. Reconstrução tecidual estética: procedimentos plásticos e regenerativos periodontais e peri-implantares. São Paulo: Artes Medicas; 2010.
4. Cohen M. Interdisciplinary treatment planning: principles, design, implementation. Seattle: Quintessence; 2008.
5. Zachrisson BU. Orthodontics and periodontlcs. In: Lindh J, Karring T, Lang NP, Editors. Clinical periodontology and implant dentistry. 3rd ed. Copenhague (DK): Munksgaard; 1998. p. 741-93.
6. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.
7. Kokich VG. Enhancing restorative, esthetic and periodontal results with orthodontic therapy. In: Schlunger S, Youdelis R, Page R, Johnson R. Editors. Periodontal Therapy. Philadelphia (PA): Lea and Febiger; 1990. p. 433-52.
8. Kokich VG, Nappen DL, Shapiro PA. Gingival contour and clinical crown length: their effect on the esthetic appearance of maxillary anterior teeth. Am J Orthod. 1984 Aug;86(2):89-94.
9. Kokich V. Esthetics and anterior tooth position: an orthodontic perspective, part II: vertical position. J Esthet Dent. 1993 Jul-Aug;5(4):174-8.
10. Kokich VG, Kokich VO, Spear F. Maximizing anterior esthetics: an interdisciplinary approach. In: McNamara JA, Kelly K Jr, editors. Frontiers in Dental and Facial Esthetics. Ann Arbor (MI): Needham; 2001.
11. Ramfjord SP. Changing Concepts in Periodontics. J Prosthet Dent. 1984 Dec;52(6):781-6.
12. Ramfjord SP, Morrison EC, Burgett FG, Nissle RR, Shick RA, Zann GJ, et al. Oral hygiene and maintenance of periodontal support. J Periodontol. 1982 Jan;53(1):26-30.
13. Lindhe J. Tratado de Periodontia Clínica e Implantologia Oral. 5a ed. Rio de Janeiro: Guanabara Koogan; 2010.
14. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11(6):311-24.
15. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact pointto the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol. 1992 Dec;63(12):995-6.
16. Fradeani M. Estethic analysis: A systematic approach to prosthetic treatment. Chicago (IL): Quintessence Books; 2004.
17. Garber DA, Salama MA. The aesthetic smile: diagnosis and treatment. Periodontol 2000. 1996 Jun;11:18-28.
18. Seixas MR, Costa-Pinto RA, Araujo TM. Checklist dos aspectos estéticos a serem considerados no diagnóstico e tratamento do sorriso gengival. Dental Press J Orthod. 2011 mar-abr;16(2):131-57.
19. Ericsson I, Thilander B, Lindhe J. Periodontal condition after orthodontic tooth movements in the dog. Angle Orthod. 1978 Jul;48(3):210-8.
20. Wennström JL, Lindhe J, Sinclair F, Thilander B. Some periodontal tissue reactions to orthodontic tooth movement in monkeys. J Clin Periodontol. 1987 Mar;14(3):121-9.
21. Engelking G, Zachrisson BU. Effects of incisor repositioning on monkey periodontium after expansion through the cortical plate. Am J Orthod. 1982 Jul;82(1):23-32.
22. Karring T, Nyman S, Thilander B, Magnusson I. Bone regenerations in orthodontically produced alveolar bone dehiscence's. J Periodontal Res. 1982 May;17(3):309-15.
23. Wennström JL. Lack of association between width of attached gingival and development of gingival recessions. A 5-year longitudinal study. J Clin Periodontol. 1987 Mar;14(3):181-4.
24. Claffey N. Decision making in periodontal therapy: the reevaluation. J Clin Periodontal. 1991;18:384-9.

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Book chapter

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Oliveira DD, Oliveira BF, Soares RV. Alveolar corticotomies in orthodontics: Indications and effects on tooth movement. Dental Press J Orthod. 2010 Jul-Aug;15(4):144-57. [Access 2008 Jun 12]. Available from: www.scielo.br/pdf/dpjo/v15n4/en_19.pdf

1. Registration of clinical trials

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

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

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

2. Portal for promoting and registering clinical trials

With the purpose of providing greater visibility to validated Clinical Trial Registers, WHO launched its Clinical Trial Search Portal (http://www.who.int/ictrp/network/en/index.html), an interface that allows simultaneous searches in a number of databases. Searches on this portal can be carried out by entering words, clinical trial titles or identification number. The results show all the existing clinical trials at different stages of implementation with links to their full description in the respective Primary Clinical Trials Register.

The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

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

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

- Primary Registers: Comply with the minimum requirements and contribute to the portal;
- Partner Registers: Comply with the minimum requirements but forward their data to the Portal only through a partnership with one of the Primary Registers;
- Potential Registers: Currently under validation by the Portal's Secretariat; do not as yet contribute to the Portal.

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/faq.pdf. The identification number must be informed at the end of the abstract.

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

Yours sincerely,

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