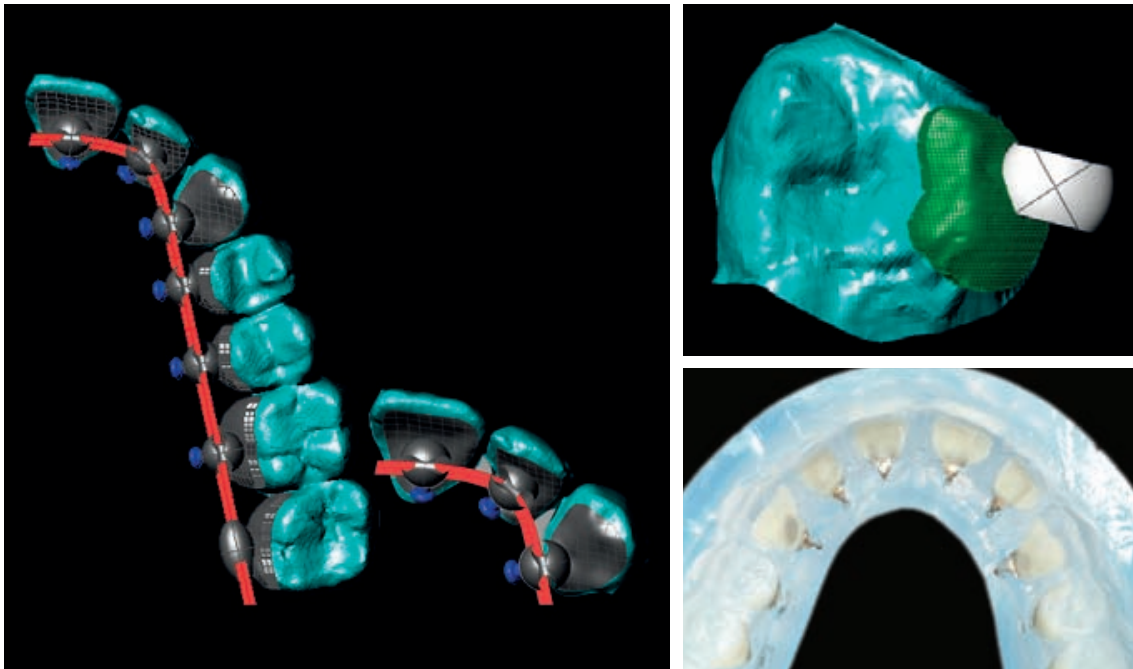


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Volume 16, Number 2, March / April 2011



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v. 16, no. 2

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Revista Dental Press de Ortodontia e
Ortopedia Facial (ISSN 1415-5419).

Dental Press Journal of Orthodontics

(ISSN 2176-9451) is a bimonthly publication of Dental Press International Av. Euclides da Cunha, 1.718 - Zona 5 - ZIP code: 87.015-180 - Maringá / PR, Brazil - Phone: (55 044) 3031-9818 - www.dentalpress.com.br - artigos@dentalpress.com.br.

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1. Ortodontia - Periódicos. I. Dental Press International.

CDD 617.643005



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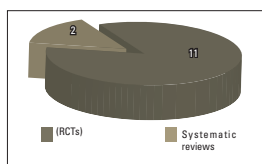


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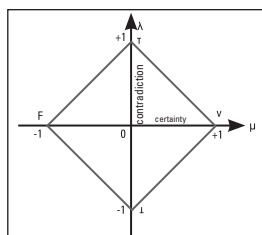
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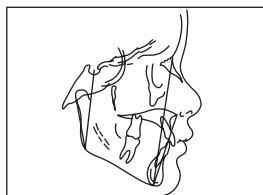
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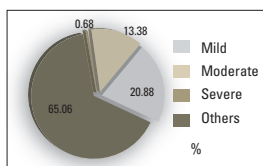
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In 2015, Brazil will become the main knowledge producer in dentistry in the world

Economic analysts, World Bank staff and academics in this area agree that Brazil will assume the position of the fifth largest economy in the world in a relatively short time. Those into science may even be surprised by economic growth, but not with the way of investigating and projecting the country's position. Regression statistical models, which in the research area language is synonymous with "forecast", are used for this purpose. The historical series are analyzed and future scenarios are estimated.

In fact, this is a recurring tool in different studies published in the pages of DPJO. In science, in some cases it is crucial to analyze data to develop predictive models. These models are used as parameters to predict outcomes, to classify cases and understand the difficulty of certain treatments.

The statistics are also used to evaluate the quantity and quality of scientific production of countries and specialties. One of the databases available for consultation to this end is the SCOPUS¹, and, recently I did an analysis of the information provided by it. This exercise included evaluating descriptive statistics of scientific production from major country producers of knowledge in dentistry. I evaluated two aspects: the production of all areas and orthodontics alone.

In 1996, the first year in this database, Brazil

was in 17th place in ranking of number of articles produced in dentistry. However, when we evaluate the total production between 1996 and 2009, Brazil jumped to fourth place. The year of 2009 is the last with a SCOPUS list. However, the most interesting is what happens when we detail this research a little more. If only the year 2009 is submitted for consideration, our country is in second place in number of produced articles, being only behind of the USA.

When evaluating the specialty of orthodontics in isolation, the data are even more motivating. Throughout all the period of 1996-2009, our country is in second place in the ranking of publications in the area. But when only the years 2008 and 2009 are analyzed, we are—shocker—1st in the number of articles, and a factor H higher than the U.S. (the H factor measures the amount weighted by the quality of work and that is being measured by the number of citations).

The fact of being the first country in the world in publications on orthodontics is not everything. The data matrix does not incorporate the Dental Press Journal of Orthodontics published in English. It means that our number of citations will increase exponentially in the near future. The journal, published with the name "Revista Dental Press de Ortodontia e Ortopedia Facial", had a rapid growth in recent years, as can be witnessed

at the SCOPUS site. In certain configurations of search, our journal is in 3rd place in the international arena. But this is just the beginning.

Impressed with the growth of Brazilian publication in dentistry, I was puzzled over the future scene. Maintaining current growth rates of the publishing countries how will we be in 5 years? To understand the future scenario, I searched the number of articles published by the major nations over a decade, and performed linear regression models—read "prediction"—to foresee their ranking in 2016. Figure 1 includes all the countries reviewed and have, in the yellow area, the future. Brazil will become in 2015 the main producer of knowledge in dentistry in the world, overtaking the USA. Note our rising curve.

The change of scientific polarity will have a strong impact in our country. Our schools will have to adapt to receive foreign students speaking English. Do not be dismayed. Americans and Europeans will become regulars in our universities, reversing the migration route established in the twentieth century. Such cooperation will be very beneficial for everyone.

Course coordinators in Brazil, get ready for this scenario. You will get these students and play often the role of leading international research groups.

Jorge Faber
Editor-in-chief
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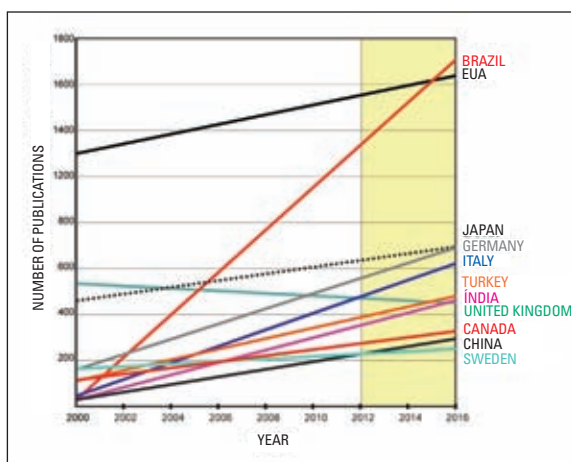


FIGURE 1 - The scientific production in dentistry was analyzed by regression predictive models. Notice in the chart the growth pattern of various countries. Brazil stands out and becomes, in 2015, the main producer of knowledge in dentistry in the world, overtaking the USA.

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1. SCImago. (2007). SJR — SCImago Journal & Country Rank. Retrieved March 23, 2011, from <http://www.scimagojr.com>.

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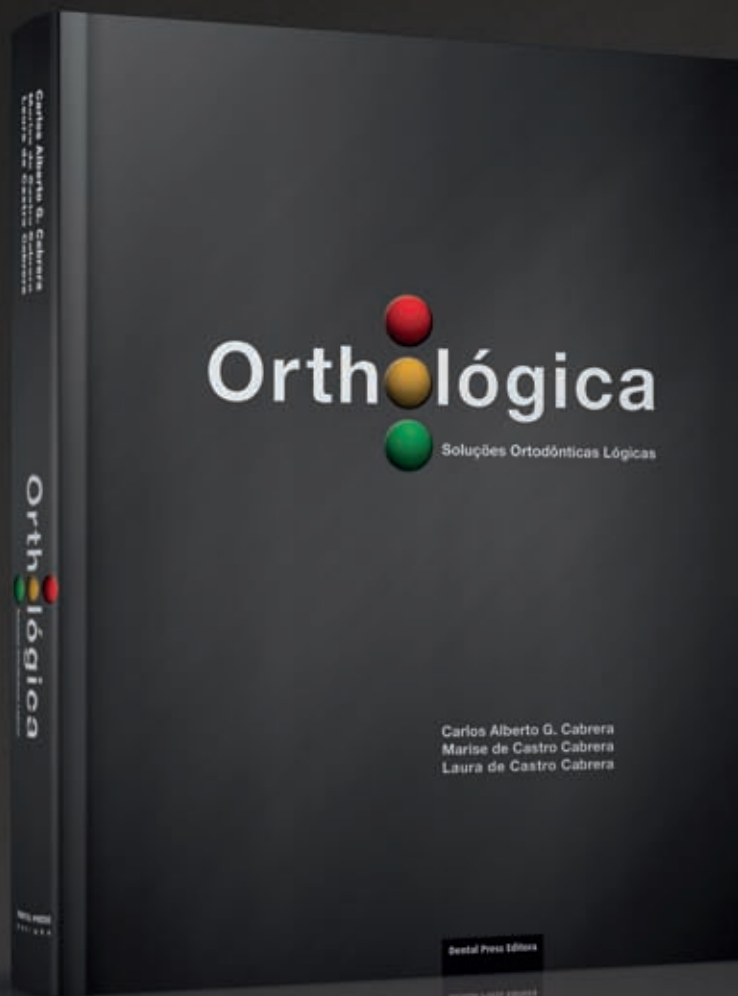
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"Logic is a science based on universal knowledge, which adopts principles and systems to distinguish right from wrong."

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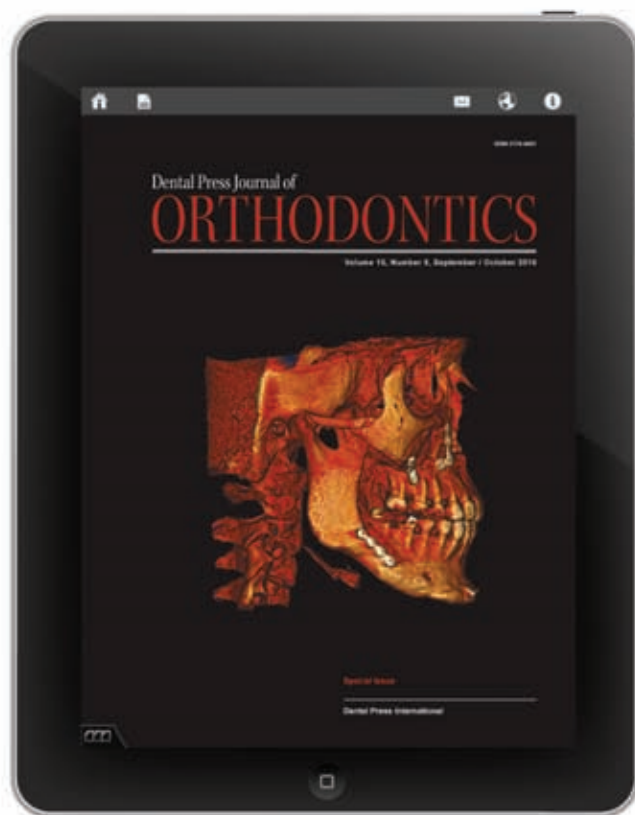
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This move aimed to achieve the standards required by appraiser and indexer organs (CAPES), regarding the visibility, impact factor and citation index of journals. It is believed that by being available in both languages, these indicators are positively influenced.

All those changes, as a demand from the scientific community, represented by such appraiser organs, aims the direct benefit of authors, researchers and organizations for promoting the research and science. Thus, it is intended to provide greater visibility and relevance to the literary production contained within this Journal.



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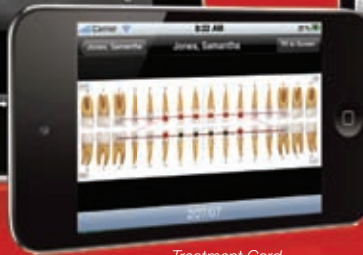
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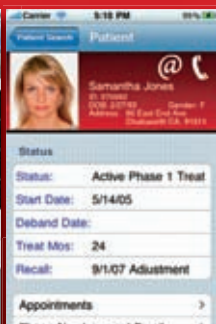
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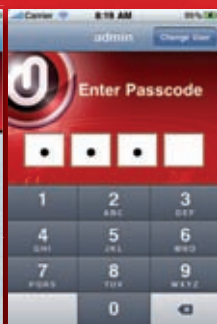
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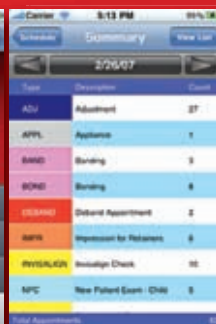
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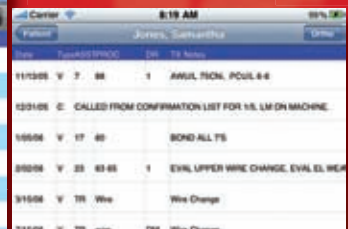
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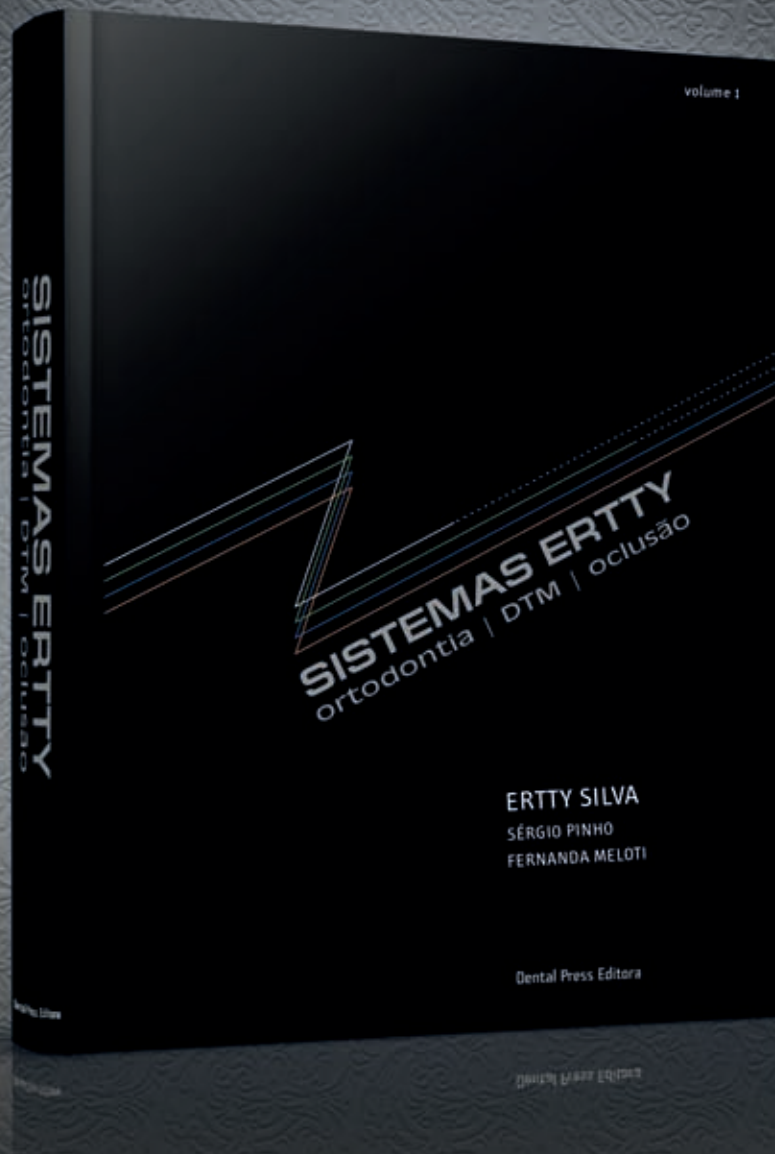
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What's new?

- A critical and personal approach of the news and the new directions of Orthodontics.

27/05/2011 - Friday

Prof. Dr. Jesus Maués Pinheiro Júnior

- Morphological considerations of short face pattern individuals.

Prof. Dr. Laurindo Furquim

- Long-term evaluation, using cone beam tomography, of the cortical bone and the radicular apex of the premolars in the role of canines.

Prof. Dr. José Valladares Neto

- Obstructive Sleep Apnea X Orthodontics: reality, dream or nightmare?

Prof. Sérgio Azevedo

- Orthodontics of the Future: Monitoring of Dentistry to the 3D images.

28/05/2011 - Saturday

Prof^ª. Dr^ª. Silvia Braga Reis

- The concept of Standard and its implications for contemporary practice of orthodontics.

Prof. Dr. David Normando

- The Orthodontic Retreatment in an Adult Patient - limits for compensation.



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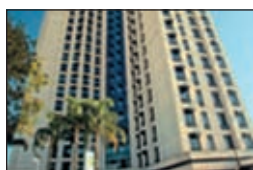
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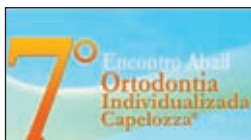
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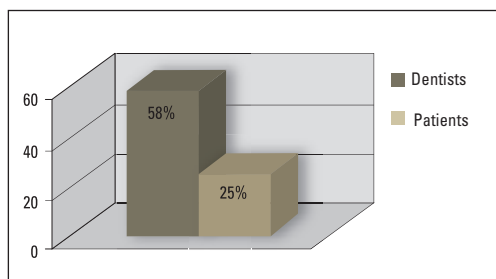


FIGURE 5 - Identification of changes in Gingival Plane height: Dentists vs. Patients.

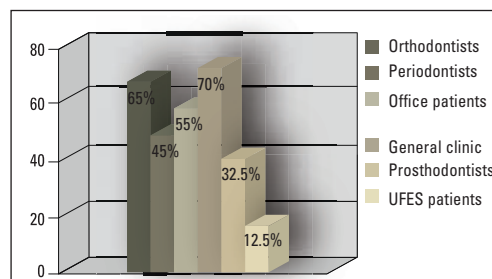


FIGURE 6 - Identification of changes in Gingival Plane height: Evaluation of the groups of Patients and Dentists.

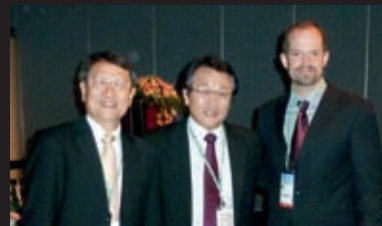
The correct Figures 5 and 6—that should have been published in previous edition of DPJO in the article titled “Perception of changes in the gingival plane affecting smile aesthetics,” from the authors Daniela Feu, Fabíola Bof de Andrade, Ana Paula Camata Nascimento, José Augusto Mendes Miguel, Antonio Augusto Gomes, Jonas Capelli Jr. (Dental Press J Orthod. 2011 Jan-Feb;16(1):68-74)—are those contained in the above images.

WIOC Congress (Taiwan)

The editor-in-chief of DPJO, Jorge Faber, participated at the end of the year, of the WIOC (World Implant Orthodontic Conference) in Taiwan. His participation was highlighted, with many people from all over the world, asking to take pictures with the speaker.



Jorge Faber, Eric Liou (president of the WIOC congress), Giuliano Maino (president of the next World Congress, in Verona, Italy) and Hideo Suzuki (Brazil), also lecturer in the congress.



The section coordinators, John Lin and Junji Sugawara, and Jorge Faber, after his lecture.

In memoriam: Stélio Ribeiro da Silva (1934 – 2011)

Mr. Stélio Ribeiro passed away on February 4th, at 76 years of age, after complications due to a heart surgery. Mr. Stélio worked for more than 50 years in the orthodontic material trade. It is important to state, however, that Mr. Stélio was more than a salesman, he was always a great enthusiast of Orthodontics, sponsoring courses and lectures in Rio de Janeiro state and all over Brazil, helping Orthodontic Graduate courses in Rio de Janeiro and in special, aiding the newly-graduates in acquiring their equipment. Stélio leaves Solange Ribeiro, his wife, two sons and one daughter and three grandchildren. As he liked to say: "I'm easy to be acquainted, but difficult to be forgotten". Our sincere condolences.



Master thesis

Dr. Laura Cabrera, Faculty of Dentistry of Bauru - FOB-USP, presented the study on *The cephalometric effects produced by the use of Carrière distalizer after molar distalization.*

Prof. José Fernando Castanha Henriques, Dr. Laura Cabrera, Prof. Célia Pinzan-Vercelino, and Prof. Daniela Gamba Garib Carrera.

International Dental Congress APCD Centennial



Altair A. Del Bel Cury and Renata Cury.



Regina D. Pinto.



Dental Press was present at the International Dental Congress - APCD Centennial, which had the theme "Congregate to grow".



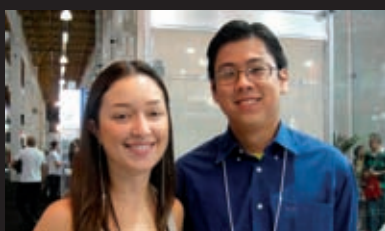
Juliana Vieira.



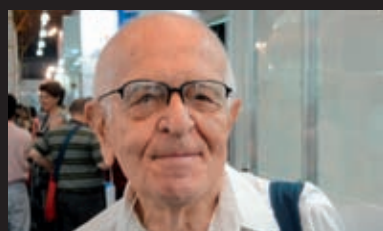
Carlos Estrela and Carlos Elias.



Juliana Nakamura, Luciana Perkowitsch and Teresa Furquim.



Rachel Furquim and Bruno S. Hirata.



Sergio Luz e Silva.



Gilson Sydney, Ana C. Pereira and Carlos Estrela.



Raquel Morelato and Jessica Carvalho.



Clari Bordignon, Adilson Ferraresi and Fernando Marson.



Thiago Donizete da Silva, Gabriela Fatureto Marques and Antonio Batista.

Digital technologies and CAD/CAM systems applied to lingual orthodontics: The future is already a reality

Carla Maria Melleiro Gimenez*

Lingual orthodontics has been gaining space around the world due to its particularity to offer a discreet treatment option, “invisible”, in “secret” for the correction of malocclusion, combining biomechanical efficiency and enhancement of the smile during treatment.

As the brackets are on the lingual surface, the point of force application is closer to the center of resistance, maximizing the potential of induced tooth movement, which results in faster clinical achievements and significant control over the mechanics.

A landmark study was published in 2001, by Dr. Scuzzo and Dr. Takemoto,⁹ which gave new perspective to lingual orthodontics describing the possibility of permanently eliminating compensating bends, with a Straight-Wire system, based on differential bracket positioning, placed more to the cervical region of the tooth. Within this context, the PSWb⁶ (Prieto Straight-Wire brackets), a Brazilian bracket that is now in its third generation, was developed based on three principles: more cervical bonding (base without gingival extension beyond the slot, higher gingival wing far from the gums), anterior bracket profile slightly increased (compensation for the Straight-Wire technique can be possible); distal offset in the canine bracket, the second premolar bracket with its profile slightly higher than the first premolar bracket. It is important to mention that this

bracket enables the simplified indirect bonding technique as a routine in orthodontics practice, facilitating bonding, mechanics during treatment and finishing (Fig 1).

The development of new technologies in image scanning and digital programs enabled the emergence of systems based on an ideal digital setup as reference for bracket positioning with remarkable accuracy by eliminating laboratory steps and, therefore, the chances of errors in them.

The Orapix® system represents a major advance and was the result of a partnership between a company in South Korea and Dr. Fillion,² allowing the use of the Straight-Wire technique in lingual orthodontics, with any kind of brackets,



FIGURE 1 - PSWb, Brazilian bracket that allows working with Straight-Wire.

* MSc and PhD in Orthodontics, FOA-UNESP.

and with high precision for their positioning. By scanning the malocclusion models (CAD/CAM) and image capturing by 3TXer software, an ideal virtual numeric setup is built from the data of the orthodontic planning (Fig 2). There is the possibility for the orthodontist to check the virtual setup, or build his/her own setup if he/she prefers (Fig 3). At this stage, the selected brackets are arranged in groups on the digital setup and approximated



FIGURE 2 - A) Initial scanned model and B) virtual setup of the Orapix System.

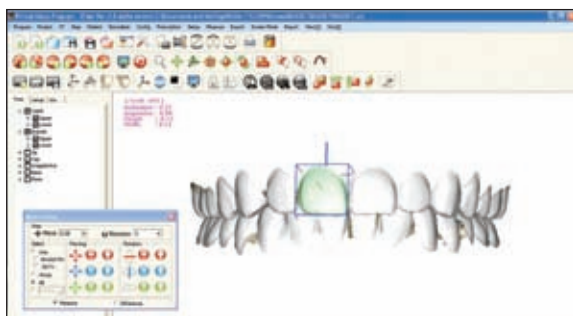


FIGURE 3 - Virtual setup checking.

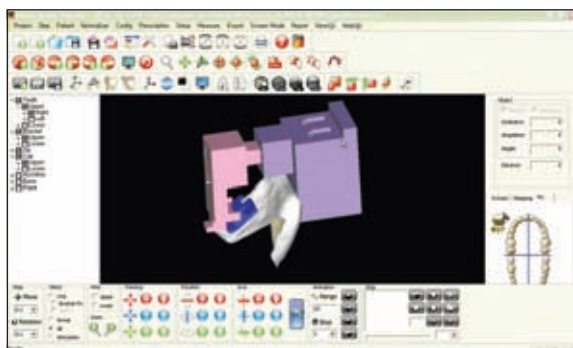


FIGURE 5 - Virtual transfer jig.

as much as possible to the lingual aspect (Fig 4). Then, each bracket is checked individually with necessary corrections made in three dimensions. From this point on, the virtual data will be transferred to real malocclusion models by transfer jigs previously arranged on the virtual bracket by the 3TXer software (Fig 5) and lately prototyped in resin. There are two parts in these jigs: one that is attached to the bracket slot and one that fits the buccal surface. Therefore, placing the brackets in these jigs and taking them to the malocclusion model, they adjust in a very reliable way and the space left between the bracket and the lingual surface of the model is filled with resin, forming the pads (Fig 6). Usually, the extension is made of resin, copying the lingual surface and forming the KommonBase⁵, which ensures great adjustment, appreciably reducing debonding events. With the Memosil (Heraeus Kulzer) forming partial trays or with resin custom trays, the indirect bonding is made in the patient's mouth (Fig 8).

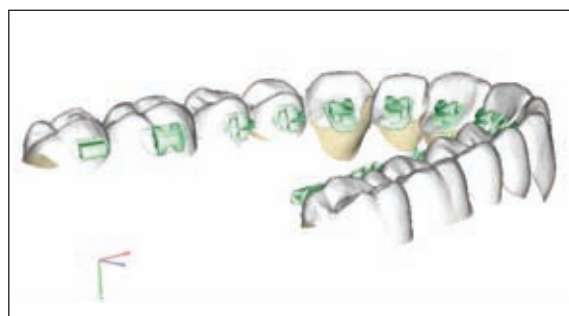


FIGURE 4 - Brackets arranged together for the Straight-Wire technique.



FIGURE 6 - Real transfer jig.

In this system, the orthodontist has the responsibility of taking impressions of the patient, sending the dental cast made of special plaster to an Orapix® center, as well as the planning forms filled in detail (describing approach, strategies, type of brackets, sequence of wire and type of anchorage). Planning is important in directing the setup, which is what allows individualization and excellence in the results. After receiving the mounted case, indirect bonding is done and mechanics starts. Finishing is significantly streamlined, and everything once planned on the setup is now obtained as clinical outcome (Fig 9).

Another interesting system is the Incognito®, currently distributed by 3M. This system, designed by Dr. Wiechmann, is also based on a setup, however, this is done in a conventional way, with great quality control. Nevertheless, the orthodontist does not have access to its checking. Later, the setup is scanned (Fig 10) and the image is captured by a specific software on which accessories

are designed by copying the lingual surfaces of the teeth (Fig 11). These “custom brackets” are made of a metal alloy which contains gold in its composition and require the same casting process of the prosthetic parts (Fig 12). As gold is a noble metal, it allows low-friction, easier sliding of the wires, polishing associated with this sliding, which theoretically provides a favorable biomechanical system. Yet, it is a system that prioritizes the compensation of the anatomical differences of lingual aspects based on compensating bends, with no possibility of working with straight wires. These bends are performed by robots, with excellent precision, and are difficult to be reproduced by the orthodontist (Fig 13). The orthodontist takes impressions of the patient with elastomeric material, sends the impression and the detailed planning to the company, and subsequently he/she will receive the custom appliance ready for bonding, as well as the sequence of wires. This is one of the most widely spread systems around the world.



FIGURE 7 - Resin extension – Kommon Base.



FIGURE 8 - Transfer tray in Memosil.



FIGURE 9 - Precise setup (A) in relation to the final result (B).



FIGURE 10 - Setup being scanned for the Incognito system.

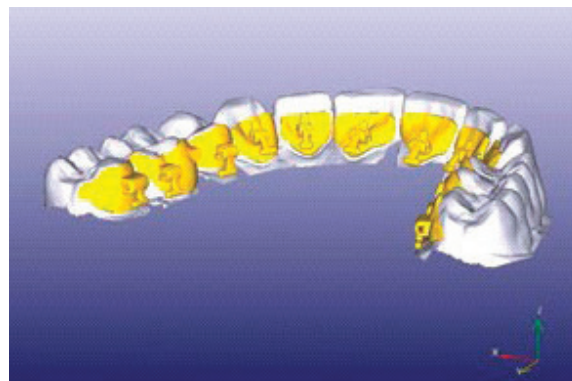


FIGURE 11 - Custom accessories: copy of the lingual surface.



FIGURE 12 - Casting process of brackets.

The Lingual Jet® system—developed in association with Dr. Gualano and Dr. Baron¹, by the same Korean company that developed the Orapix® (in association with Dr. Fillion)—represents a mid-point between the two systems described previously, mixing their main characteristics. The aspects in common with the Orapix system is the fact that they are based on an ideal virtual numeric setup, and display accessories in such a way

to allow the use of straight wires for orthodontic mechanics (Fig 14), and the orthodontist has access to the setup.

Regarding the Incognito® system, the common characteristics are the use of custom metal accessories, use of gold alloy to manufacture them (although the possibility of using alternative materials such as titanium or zirconia is being studied; options that may be interesting concerning

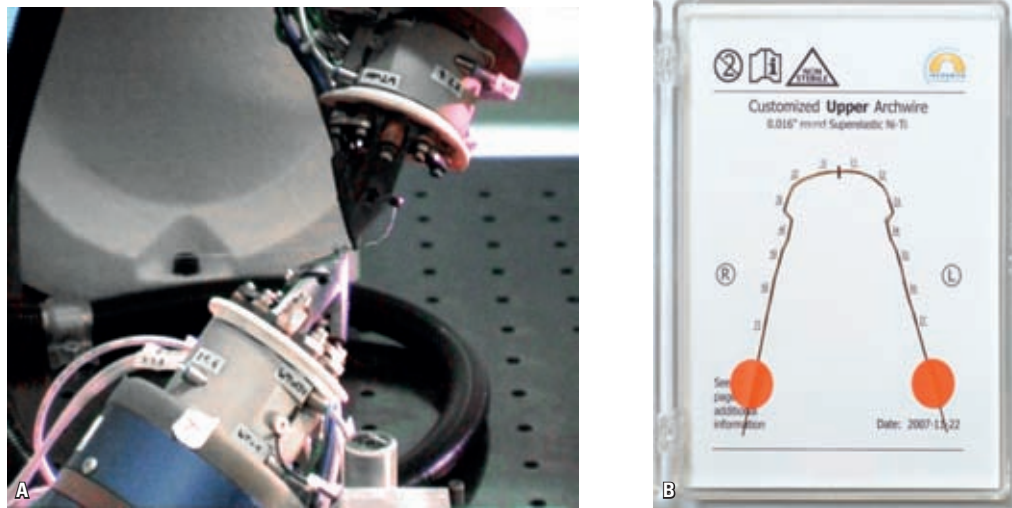


FIGURE 13 - A) Robots bending the wires and B) individualized archwire.

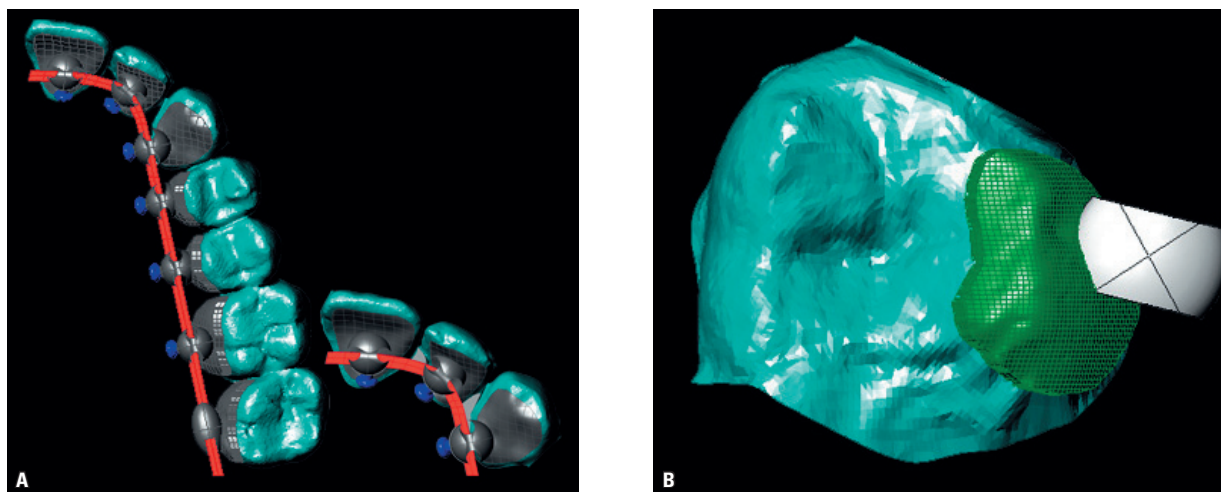


FIGURE 14 - A) Lingualjet System enabling work with straight wire. B) Lingualjet System with custom brackets.

allergies, aesthetics and biomechanics). The dispatch process is the same, the orthodontist has to send the patient's models together with the detailed and sequential planning, and then the custom appliance will be sent for bonding and sequence of straight wires.

It is very important to emphasize that the diagnosis is paramount in any system, as well as establishing an individualized plan according to the characteristics and needs of each case, in order to achieve the satisfactory completion with excellent results.

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Tooth whitening products in toothpastes and mouthwashes may act as co-carcinogens in the oral mucosa

How to advise orthodontic patients and how to avoid undesirable effects

Alberto Consolaro*, Leda A. Francischone**, Renata Bianco Consolaro***

At the conclusion of clinical orthodontic treatments, patients very often ask about the need or possibility of tooth whitening. During treatment, patients sometimes ask about the use of toothpastes or mouthwashes with whitening products. In several situations, they may ask direct questions, such as:

- » Is bleaching good or bad for my health?
- » Does it cause cancer?
- » Are you in favor or against it?

We discuss tooth whitening in this article as a way to help orthodontists to define indications and establish guidelines for their patients.

Since the old Egyptian civilization, human beings have expressed their desire to have bright, white teeth.^{12,41} According to historical references,²² the pioneering external tooth whitening procedure should be assigned to Atkinson, who, in 1893, described the use of a 3% hydrogen peroxide solution as a mouthwash for children to reduce caries and whiten their teeth. He found that at a 5% concentration, whitening was greater, and much greater

when concentration was 25%, but the risk of lesions to soft tissues increased substantially due to the caustic effect of the whitening product. Tooth whitening has been described in the scientific literature since the beginning of modern times.^{6,15,20,48}

External tooth whitening became popular in 1989, after Haywood and Heymann²³ published a study that received media attention in the form of articles and commercials. Internal and external whitening products are similar and all have hydrogen peroxide in their composition. They may receive different names according to their composition and presentation: urea peroxide, percarbamide, carbamide, sodium perborate and others. Some of them release or change into hydrogen peroxide only when applied to teeth.

In the search for esthetic results and white, vital teeth, which have a strong commercial and advertising appeal, whitening products have been added to the composition of mouthwashes and toothpastes.^{19,29,31,37,39,40} Hydrogen peroxide has often been incorporated into products whose

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primary function is antiseptic.^{2,49} Recently, dyes have been added to toothpastes for a passive process of tooth whitening with visible, transient but immediate results.

Products classified as cosmetics should not have any therapeutic function and are not supposed to affect body physiology. In 1991, the Food and Drug Administration (FDA) removed whitening products from the list of cosmetic products and reclassified them as drugs or medicine. In 1994, the American Dental Association (ADA) established criteria and recommendations for their use to ensure efficacy and patient safety.^{1,10}

According to the ADA, products with hydrogen peroxide for home use are divided into three groups:

- a) Antiseptic products with hydrogen peroxide, whose contents should be known by dentists and patients and which should be used only for short periods of time.
- b) Whitening products containing 3% hydrogen peroxide or carbamide peroxide, prescribed by dentists that, together with their patients, should be familiar with their contents.
- c) Tooth pastes, that should have low concentrations of hydrogen peroxide or calcium peroxide.

Toothpastes and antiseptic products should be prescribed by healthcare workers, who are primarily responsible for their patients' choices because these products are different from those that patients choose to buy voluntarily, even when they know their risks, such as tobacco and alcoholic beverages.

Hydrogen peroxide is also found in other products, such as coffee, and is present in industrial processes to produce foods, such as fruit juices, because of its antibacterial and antiviral properties.²⁹ The human metabolism also produces hydrogen peroxide and, for example, stores it in cytoplasmic granules to fight bacteria that the cells, particularly neutrophils, destroy by phagocytosis.

The undesirable effects of whitening products

With a few exceptions, all treatments using drugs might have undesirable effects, and this is also true with whitening products. When directly applied to the dentin, they produce demineralization that results in the enlargement of dentinal tubules because of their acidity when acting upon the dentin. In the cemento-enamel junction, they enlarge exposed dentin gaps found in all human teeth, even primary teeth.^{9,13,14,16,17,32}

In general, whitening products are composed of hydrogen peroxide when they act on the tooth surface, although they may be composed of and called something different, such as carbamide peroxide, urea peroxide and sodium perborate. When applied externally, whitening products act as acid solutions and may increase superficial enamel porosity, promote the separation and infiltration of composite restorations, and induce discrete subclinical pulp reactions or dentin hypersensitivity.^{9,13,14,16,17,32} However, of all undesirable effects, the ones that stand out are the effects on soft tissues:

1. They "burn" or necrotize soft tissues due to the caustic effect of hydrogen peroxide.
2. They participate as promoters, or co-carcinogens, in chemical carcinogenesis, potentializing the effects initially induced by carcinogenic initiating agents,^{3,4,7,8,10,11,18,28,29,33,35,36,38,39,42-47} including those in other points of the gastrointestinal mucosa.

The action of carcinogenic agents on tissues has a cumulative effect along life, and malignant tumors are often found after the fourth decade of life. Along life, the effect of a carcinogenic agent is irregular and unpredictable in most cases, and its actions are invariably added to that of other agents and environmental factors or inherent characteristics of each individual. This is the reason why there are no accurate estimates about the biological and clinical risks for an individual that accumulates exposure to the sun, smokes or consumes alcohol, for example.

The frequency of tooth whitening in current clinical practice and the addition of chemical whitening products to mouthwashes and toothpastes indicate that we should know in detail how they act and what consequence their action has on the oral mucosa. Teeth are brushed several times a day, and knowing what has been added to and used for oral hygiene may help to preserve the oral health of the population and define preventive attitudes.

The effect of tooth whitening products on oral carcinogenesis: promoters but not initiators

A study^{33,34} about the carcinogenic effects of whitening products was conducted using a universally accepted and knowingly effective experimental model in which the products were applied to the oral mucosa of hamsters for 22 weeks and the carcinogen 9,10-dimethyl-1,2-benzanthracene (DMBA) was the positive control (Figs 1 and 2). They found that, when applied separately, whitening products were not carcinogenic, that is, they did not initiate oral cancer when acting individually. In other words, hydrogen peroxide does not induce a normal cell to undergo mutations that progress into a malignant tumor. When a chemical substance induces such mutations, it is classified as an initiator.

During the same trial, hydrogen peroxide was applied to the oral mucosa of other hamsters alternating with DMBA applications every other day during the same length of time. There was a considerable increase in the number of animals with oral cancer and in the size of the lesions, much greater than in the group of hamsters without DMBA. These results showed that hydrogen peroxide does not initiate, but stimulates the already induced cell proliferation and promotes the morphological appearance of cancer. Any chemical product that has such properties is called a promoter. Hydrogen peroxide is characterized as a promoter, but the term co-carcinogen has also been used. In the mouth, the oral mucosa and its cells are affected by several co-carcinogens: tobacco products, alcohol, sun rays, viruses and innumerable environmental chemical products, such as bicarbonate and herbicides and pesticides contained in foods. An oral promoter may very likely act and collaborate in the formation of a malignant tumor.

Using the same experimental model, Camargo⁵ was mentored, as part of a PhD Program, to test once more the carcinogenic effect of 27% hydrogen peroxide and a specific whitening product containing 10% carbamide peroxide. At the same time, the effects of toothpastes with hydrogen peroxide in their composition were investigated.



FIGURE 1 - Normal lateral tongue margin and mouth floor in golden Syrian hamsters.

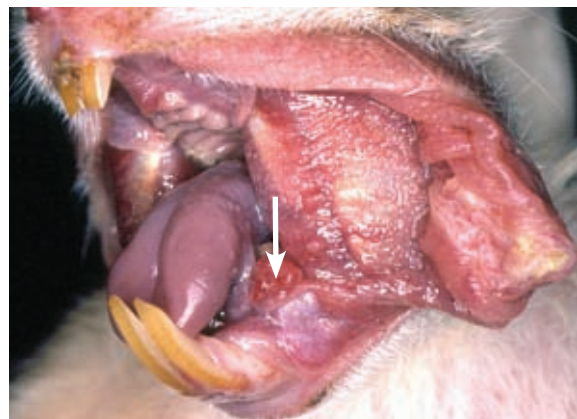


FIGURE 2 - DMBA-induced squamous cell carcinoma in lateral tongue margin and floor of the mouth of golden Syrian hamster after drug application on alternate days for 22 weeks.

First, 30 commercial brands of toothpaste were evaluated to detect hydrogen peroxide; 29 had it, although most did not inform about its presence on their labels. Toothpastes for children also had hydrogen peroxide.

The results found by Camargo⁵ revealed that, in the composition of tooth whitening products or as part of toothpastes, hydrogen peroxide was a promoter of chemical oral carcinogenesis; that is, it was a co-carcinogen. These results confirm previous findings.

Figure 3 schematically shows the synergism that might exist between an initiator and a promoter. The promoter, which may be a whitening product, is graphically represented by drops,

whereas the initiator, represented by the switch, may be tobacco products or alcoholic beverages. The schematic diagram suggests that tooth whitening in a smoker—for example, often performed by the dentist using a protective resin dam once a year—may represent the promoter that acts after the initiator, at alternate time points, which corresponds to the 6th situation (Fig 3).

Clinical, social and commercial implications of these results

The first implication of these recent findings is the need to inform the population about the benefits and risks of tooth whitening to promote a culture of open communication rather than a

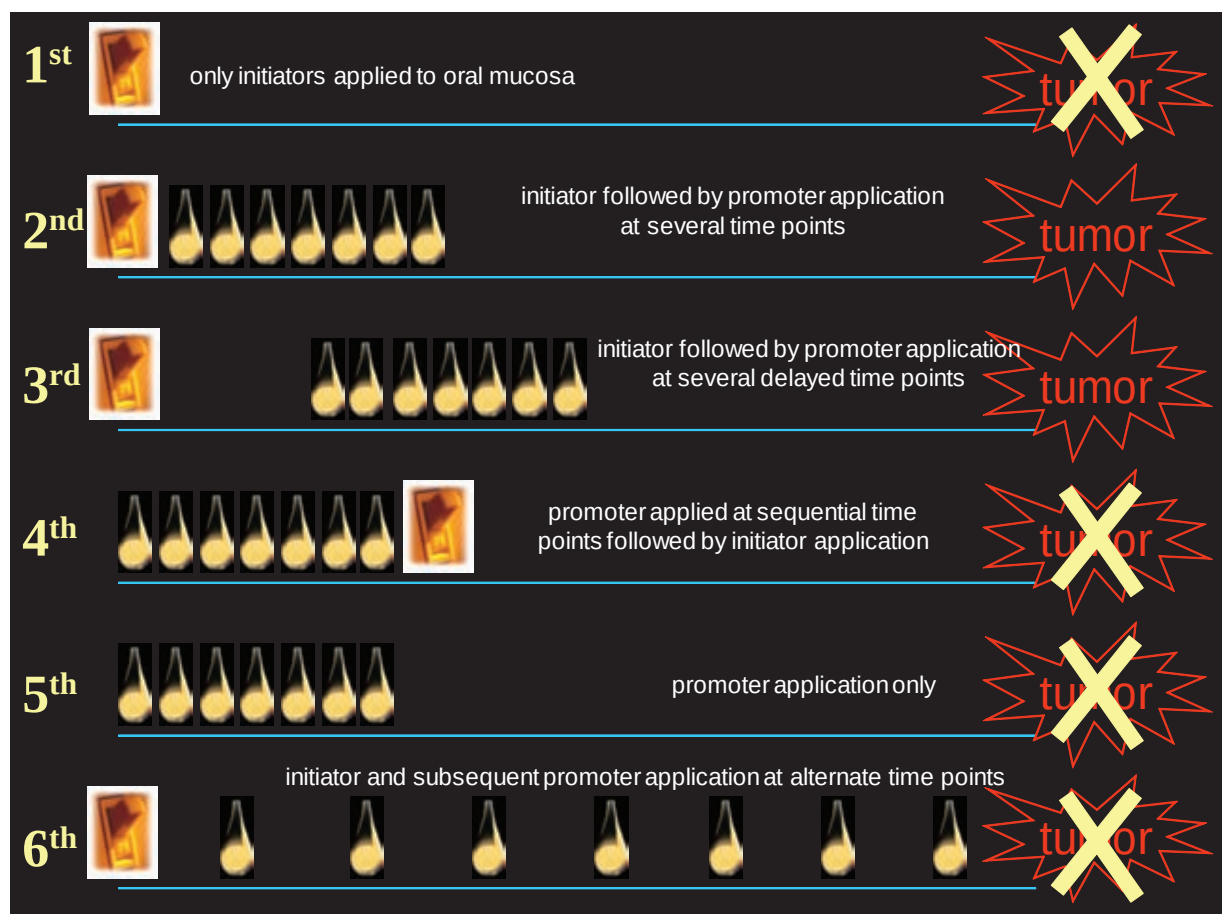


FIGURE 3 - Schematic drawing of six different situations of effectiveness of carcinogenesis promoting agents according to action time and frequency before or after use of initiating agent. According to tests using the experimental DMBA-induction model in oral mucosa, tooth whitening products act as chemical carcinogenesis promoters (switch represents initiator, and drop, promoter).

culture of fear. Undoubtedly, tooth whitening products are part of our current culture, but we should develop techniques and technologies to reduce and eliminate their undesirable effects. Tooth whitening is a personal opportunity, and the market should make it available to those that are interested in it. However, it should be safe, and the conscious choice of those that decide not to do it should be respected. Toothpastes and mouthwashes free of hydrogen peroxide should be offered to the population in general, and their composition should be described on their labels, as it is already the case with cigarettes, alcoholic beverages and oral antiseptic products.

The carcinogenic effects of hydrogen peroxide as a promoter are not limited to the oral mucosa, and extend to the oropharynx, esophagus and bowel²⁴⁻²⁷ if ingested by the patient. Consumers should be warned not to ingest hydrogen peroxide during tooth brushing and oral hygiene, performed several times a day. Once again, consumers should be given the option to choose products with or without hydrogen peroxide.

People should be told that the carcinogenic effect of tooth whitening products is very mild, but its relevance is associated with the frequency at which hydrogen peroxide is in contact with the oral mucosa: every day, several times every 24 hours. They should also be warned about the fact that initiating factors, such as tobacco, alcohol, oncogenic viruses and products ingested with foods and breathed in the environment, are the most important causes of oral cancer. In carcinogenesis, whitening products are one of the several contributing factors, but are not capable of inducing cancer if used alone and exclusively, as schematically demonstrated in Figure 3.

Healthcare professionals, consumers, manufacturers and agencies should harmoniously get together to discuss what is best for society: to classify whitening agents as cosmetic products or as medical drugs. Cosmetic products, by definition, do not have a therapeutic action and cannot affect

body physiology; however, tooth whitening products change dentin structures and have antiseptic effects. Should they not be, therefore, classified as medical drugs?

Another question should be raised: how about tooth whitening performed by the dentist in the dental office? Would it have the same carcinogenic effect? No, because tooth whitening performed by the dentist has undergone technical and technological improvements in the last 15 years. Tooth whitening applied in the office by the trained and prepared dentist includes the isolation of teeth, which may be achieved by using different techniques, such as cervical and gingival light-cured resin dams, which prevent the direct contact between the mucosa and the tooth whitening product (Fig 4).

At the same time, isolation of the gingiva and the cervical region protects the cemento-enamel junction and its dentin exposure gaps from the direct contact with the whitening products, whose action might enlarge the gaps and the diameter of exposed dentinal tubules and increase dentinal hypersensitivity.

After the conclusion of the whitening procedure in the dental office, and before water is used and the cervical and gingival resin dam is removed, maximal suction should be applied to remove the whitening product. After that, water jets can be used, but only when almost all whitening product has been removed using as much suction as possible, and after the resin dam has been removed, because some of the product, though not much, may remain in the dam's structure. This procedure will ensure that the amount of whitening products that is in direct contact with the oral mucosa and cemento-enamel junction is very little, particularly if we consider that this procedure is performed only a few times and not everyday, differently from tooth brushing and oral hygiene with mouthwashes.

Another question should be raised in this analysis of clinical and social implications of the can-



FIGURE 4 - Protective resin dam applied to cervical region; it drastically reduces or prevents contact of whitening product with gingival mucosa and cemento-enamel junction.

cer promoting effects of tooth whitening products: Are the risks greater when tooth whitening is applied at home and prepared by the patient with or without professional supervision?

No matter how clear the information received from the dentist was, how well the nightguard fits the teeth, or how skillful the patient is, the whitening product will, unfortunately, spread on the oral mucosa, dissolve in the oral cavity and be carried away by saliva. The widespread and prolonged contact with the oral mucosa and the oropharynx will be inevitable. As product ingestion may also be unavoidable, the product will get in contact with other points of the gastrointestinal mucosa, which may have undesirable consequences. Whitening products have an extensive and unrestricted effect on the cemento-enamel junction.

In addition to these concerns resulting from the limitations of control when using at-home tooth whitening, two other important aspects should be mentioned:

1. The risks of self-medication or self-indication when the patient buys the product without first seeing a dentist or receiving any professional advice and applies it at home irregularly and not adopting any special care.
2. The lack of control over time and frequency at which the patient performs the

procedure at home, which might enhance whitening results, but biologically affects the mucosa and teeth and does not compensate for the non-measurable and non-detectable risks in the future.

Final orthodontic considerations

External tooth whitening is a very important option to improve and enhance the appearance of teeth and the face after the conclusion of orthodontic treatment. Bracket bonding, accumulation of bacterial plaque, white spots and staining of lamellae, cracks and other cavities on the tooth surfaces may affect the esthetic results of the orthodontic treatment. External tooth whitening may standardize tooth color and remove stains from recesses. Together with restorations, drilling and other procedures, external tooth whitening may be a procedure to achieve part of the patient's final goal when undergoing orthodontic treatment: to give the mouth and teeth a normal and healthy appearance and, consequently, to improve personal relations and self-esteem.

Patients may ask for advice, and orthodontists may or may not indicate external tooth whitening. They should keep in mind that it is a technical procedure to be performed by a trained dentist aware of the possible biological effects of the chemical product used (hydrogen peroxide). This procedure should be restricted to the office, where carefully performed techniques and professional responsibility are part of the service paid by the patient. Tooth whitening performed at home will never have the technical accuracy and biological safety necessary and provided by the dentist: whitening products may spread over the teeth, cemento-enamel junctions and oral mucosa, and some of it will be swallowed.

Patients may also ask for recommendations about the use of toothpastes or mouthwashes. Products with tooth whitening agents, particularly toothpastes and mouthwashes, should bring that specific information on their packaging, where it

should read whether or not it contains hydrogen peroxide.

The effect of tooth whitening on teeth and oral mucosa are not measurable in time because of superposed factors that act in the oral cavity, particularly those that may cause oral cancer. Patients should receive information about the carcinogenic effect of whitening products, which is low. However, healthcare workers that prescribe them have much greater responsibilities and should also advise

patients about preventive procedures and safety.

Health agencies, dentists, consumers and manufacturers, that is, society as a whole should harmoniously promote tooth whitening products to the category of medical drugs and restrict their use to dentists, who are duly trained and qualified to perform the highly technical tooth whitening procedures. Recommendations to use or purchase and requests to fill prescriptions should only be made by dentists.

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An interview with Jason Cope

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It was with great pleasure that I accepted the invitation to coordinate the interview with Dr. Cope, whom I admire greatly, especially because of the excellent clinical and scientific work he develops. He obtained great highlight on the international scene for his brilliant performance with the use of orthodontic miniscrews. Recently, in the last Congress of the Brazilian Association of Orthodontists, he presented a well attended course on the subject.

Dr. Jason B. Cope was born in Dallas (USA), first son of Dr. Donald D. Cope, an orthodontist in love with the profession, which exerted a strong influence on his career. He was introduced to the intricacies of orthodontics, when he was just a teenager with 13 years old, because he usually read, with great interest, the American Journal of Orthodontics, journal subscribed by his father. Perhaps because of this he decided to study dentistry, graduating in 1995. He completed his postgraduate studies in orthodontics in 1997 and was invited to join the faculty of the same institution as assistant clinical professor. Simultaneously, for another two years, he did a post-doctoral fellow in craniofacial biology. In his young career, Dr. Cope has published several articles in leading international journals, 35 book chapters and an important treatise on distraction osteogenesis, plus an excellent book on temporary anchorage devices (OrthoTADs, The Clinical Guide and Atlas), published in 2007. He was also honored with several awards for his research on bone biology, including the Award of Special Merit Thomas M. Graber, awarded by the American Association of Orthodontics. Natural born researcher, developed the IMTEC orthodontic implant and some other products designed to orthodontics, having won a patent, along with three others still pending.

He has a clinical private practice in Dallas, and sees patients three days a week. On other days, he is divided between presenting conferences, publishing, travelling and inventing. He is currently developing a website, in which he intends to offer lectures given by him, case reports and technical videos. His dedication to orthodontics is evident. In 2002, with the goal of proving the clinical excellence of his work, he underwent the examination of the American Board of Orthodontics, when it then became a graduate. In 2004, he presented a scientific paper to become a member of the Edward H. Angle Society of Orthodontists, and in 2005, he was awarded a prize by the Baylor College of Dentistry Alumni Association. All this makes Dr. Cope more than worthy of great success. We shall know more of the details of this excellent professional work through this interview that we tried to edit with great care and affection. We hope everyone enjoys the reading.

Marcos Alan Vieira Bittencourt

1) Do you consider the temporary anchorage devices (TADs) the new paradigm in orthodontics? Why?

Carlos Alberto Estevanell Tavares

I believe TADs are one of several new paradigms in orthodontics. Others include soft tissue lasers and Cone-Beam Computed Tomography (CBCT). Although I use all three clinically, I think TADs are the most important because they benefit a larger number of patients. For example, CBCT is beneficial for impacted canines and several other less common situations. Soft tissue lasers are great for uncovering teeth, gingivectomies, frenectomies, and the like. But, these are all procedures that can be performed by a periodontist. Our limitations with controlling anchorage, however, are significant and cannot be referred to another person to handle. There are several cases in which TADs are the only way to ideally control anchorage: A) protraction of posterior teeth to eliminate the need for restoring congenitally missing teeth (Fig 1); B) preprosthetic tooth movement in mutilated dentitions; C) intrusion of supererupted teeth; D) distalization of full step Class II or Class III malocclusions; and E) skeletal open bites in patients unable or unwilling to undergo surgical treatment.

2) Which methods do you use to assure a safe placement of the TADs?

Carlos Alberto Estevanell Tavares

Several methods have been advocated to pro-

vide safety for TAD placement. One is to use radiographic templates and guides. There are several limitations with this technique. First, the Buccal Object Rule must be used, which predicates multiple radiographs and wasted clinical time. Moreover, few orthodontists have the ability to take periapical radiographs. Finally, it is completely inaccurate, and only accounts for the insertion point and not the final location of the TAD. This technique does not improve the safety of TADs for patients.

The second is to use infiltration of local anesthetic. This is advocated by those who don't want patients to feel anything. Although, it would be nice for patients to feel nothing, the limitation with this technique is that it profoundly anesthetizes the soft tissue, periodontal ligament (PDL), and pulp, which then completely eliminates the ability for the patient to give feedback if they do feel something.

The third option is to use topical anesthetic only. I developed the first topical anesthetic only protocol back in 2004. To explain, I saw great resistance of orthodontists to place miniscrews due to the "surgical" appearance of the procedure and need for local anesthetic injections. It became readily apparent that in order to motivate orthodontists to engage the process, the technique would have to be relatively fast, simple, and "nonsurgical". Therefore, I developed an alternative technique to avoid local anesthetic injections.

Much like extracting a tooth, the placement of a miniscrew implant (MSI) involves two po-



FIGURE 1 - Protraction of posterior teeth to eliminate the need for restoring congenitally missing teeth. **A)** Mandibular occlusal at TAD placement; **B)** Buccal at TAD placement; **C)** Mandibular occlusal at posttreatment.

tential sensations felt by patients – pressure and pain. Pressure is felt by patients because bone is viscoelastic and responds to internal pressure (either via tooth removal or miniscrew insertion) by expanding. This expansion causes fluid flow through the bony canaliculi, which patients perceive as pressure. Pain is felt if the sensory, or afferent, nerves are triggered. For bone, the internal anatomy is not innervated, only the external surface is innervated. The nerve supply comes from the periosteum, which is richly innervated by sensory periosteal nerves. This is why breaking a bone is painful, i.e., tearing of the periosteal membrane. The gingiva, mucosa, teeth, and PDL receive sensory (afferent) innervation from the Trigeminal Nerve, which when activated, stimulates pain. Considering the foregoing, if the soft tissues and periosteum can be anesthetized without anesthetizing the tooth root and PDL, then a patient can be completely pain-free, while at the same time being sensate and able to detect the proximity of the miniscrew during insertion, but before contact is ever made with the tooth root. It is important to recall that bony expansion during miniscrew insertion will cause patients to experience pressure. Therefore, it is incumbent upon the clinician to make sure the patient understands the difference between pressure and pain.

Using this biologic rationale, I began to develop an atraumatic, topical anesthetic miniscrew placement protocol in 2004 with Oraqix (Dentsply Pharmaceutical, York, PA), a high strength periodontal topical anesthetic. After the success of the initial clinical trials, we formally introduced this as the Cope Placement Protocol™ in 2005. A year later, I switched to a more potent high strength topical anesthetic, DepBlu (Steven's Pharmacy, Costa Mesa, CA), which provides profound soft tissue and periosteal anesthesia with limited anesthetic effect on tooth roots and PDL. There are several benefits: the procedure is much simpler because local infiltration by

injections is unnecessary and there is little risk of anesthetizing the tooth root, so the potential of hitting the tooth root is almost impossible.

In about 15% of cases, the soft tissue is thicker than about 2 mm so I will use the Madajet (MADA International, Carlstadt, NJ) needle free pneumatic syringe. Importantly, this still anesthetizes only the soft tissues and periosteum.

3) Even using computed-tomography to evaluate the interradicular space to prevent root damage during treatment, what do you do when you detect contact between miniscrews and roots, or it does not happen at all? José Nelson Mucha

Using the above Cope Placement Protocol™, it is almost impossible to hit a tooth. And, although I have a CBCT machine, I believe that the routine use of CBCT for TAD placement is unnecessary. A panoramic radiograph is all that is routinely necessary.

4) Some papers describe advantages in installing miniscrews tipped in relation to cortical bone. The most cited advantages are improvement of the contact surface with the cortical bone and reduction of the risk of root damage. Why do you suggest the use of a perpendicular position in your placement protocol? Carlo Marassi/Marcos Alan Vieira Bittencourt

The “angled” concept is usually advanced by clinicians using small diameter MSIs – 1.2-1.5 mm in diameter. The rationale for angling an MSI is threefold: A) it places the apex of the MSI between the apices of the roots where there is usually more bone; B) it places the head of the MSI closer to the keratinized tissue; and C) it increases the surface area of the MSI in contact with bone (bone-implant contact).

Although these sound logical, I disagree with them. From a biomechanical standpoint, TADs are designed to control anchorage, and therefore

should usually be placed at the center of resistance, which is not at the apices of the teeth. TADs should be placed where they are needed, not at some irrational location based on fear of hitting a tooth root. Clinically, I have not seen an increase of soft tissue irritation or infection when the MSI head is in alveolar mucosa. Lastly, small diameter MSIs have less bone-implant contact, which increased their chance to fail.

My MSI is 1.8 mm in diameter, which automatically gives it greater bone-implant contact without the need to angle it. To calculate the surface area of the implant component in cortical bone, the following formula is used: $(2) \times (\pi) \times (\text{radius}) \times (\text{height})$. Therefore, a 1.2 mm, 1.5 mm, and 1.8 mm MSI would have the following surface areas assuming they were all placed at the same depth in 1.5 mm thick cortical bone:

- » 1.2 mm = 5.65 mm² surface area;
- » 1.5 mm = 7.07 mm² surface area, or 125% of the 1.2 mm MSI;
- » 1.8 mm = 8.48 mm² surface area, or 150% of the 1.2 mm MSI.

Finally, are dental implants angled? No, because they have their greatest strength when loaded parallel and perpendicular to their long axes, and not oblique to their long axes. Therefore, I believe that MSIs should be placed perpendicular to the bone surface.

5) Do you usually apply distalization mechanics in dentoalveolar Class II patients? If so, are there any criteria that differentiate the choice between an adolescent and an adult? José Nelson Mucha/Marcos Janson

Yes, I distalize in Class II cases. I don't see a big difference between adolescents and adults in this respect. The criteria that I usually use are: What does the face look like? If the mandible is retrognathic and the patient desires facial change, then I will use a Forsus appliance (3M Unitek, Monrovia, CA) on an adolescent or mandibular advancement on an adult.

On the other hand, if the maxillary dentition is protrusive and the mandible is normal, then I will either distalize the upper or extract premolars. I base this decision on the severity of the Class II and the overjet, how much alveolar bone is distal to the upper second molars, and the estimated treatment duration. The larger the overjet and less posterior alveolar bone, then more I will tend to extract. It usually also takes longer to distalize a full step Class II than to retract anterior teeth after extraction, so I will have the patient and/or parents give feedback on the decision as long as it would not lead to deleterious treatment results.

6) How do you proceed in cases where the entire maxillary dentition must be distalized? Carlo Marassi/Carlos Alberto Estevanell Tavares

I have done this several ways: A) placed MSIs in the posterior palate to pull everything back; B) placed MSIs in the anterior palate to push everything back; C) placed MSIs in the posterior maxilla on the facial to pull everything back; and D) placed MSIs in the anterior maxilla on the facial to push everything back. I have found that regardless of whether the MSI is on the facial or palatal, it is most beneficial to place the force on the facial, because it locates the line of force facial to the center of resistance and helps with Class II to Class I molar rotation.

To this point, I have had good success with two specific techniques. The first is to place the MSI between the upper lateral incisor and canine and attach a Forsus appliance (3M Unitek, Monrovia, CA) from the MSI to the upper first molar to distalize the molar, then allow retraction of the canines to Class I, followed by retraction of the anterior teeth after MSI removal (Fig 2). The second is to place the MSI in the palate about the level of the first premolar and about 2-3 mm parasagittally (due to the unfused midpalatal suture in growing patients). Then I attach a prefabricated

transpalatal arch (TPA) from the MSI to the first premolars or canines and use open coil spring on the facial to distalize the molars. Once the molars are Class I, I attach the same TPA from the molars to the MSI to retract that anterior teeth. This is usually better because it only requires one MSI and uses traditional mechanics (Fig 3).

7) When distalizing the mandibular dentition with miniscrews, the most important consideration is its position. How do you determine the exact placement site? José Nelson Mucha

For these cases, I place the MSI in the retromolar area. This region is relatively horizontal with good bone. I have used the external oblique ridge, however, in this location, the cheek usually folds over the head of the MSI and becomes traumatized by the upper buccal cusps in maximum intercuspation or lateral excursive movements.

Another benefit of the retromolar area is that the MSI can be centered buccolingually there and forces attached from the MSI to both the buccal and lingual of the teeth so that the teeth feel a pure posterior force. If desired, the force can be attached only the buccal or lingual of the teeth, which would provide great control if narrowing or expansion were desirable, respectively. Rotation control is also possible with this location (Fig 4).

8) Open bites in adult patients are always a challenge. Do you usually work with posterior intrusion in these cases? How do you select the patients that fit better in this approach? Marcos Janson

I have been using TADs for openbite closure in adults since 2003. For skeletal openbites, the literature suggests that closing an openbite by extruding the anterior teeth with anterior box elastics and/or indiscriminately leveling the occlusal plane



FIGURE 2 - Distalization of maxillary teeth using TAD-Forsus combination. **A)** Buccal at TAD placement; **B)** Buccal after molar distalization; **C)** Buccal at posttreatment.



FIGURE 3 - Distalization of maxillary teeth using TAD-TPA combination. **A)** Maxillary occlusal at TAD placement; **B)** Maxillary occlusal after molar distalization; **C)** Maxillary occlusal after anterior retraction and TAD removal.

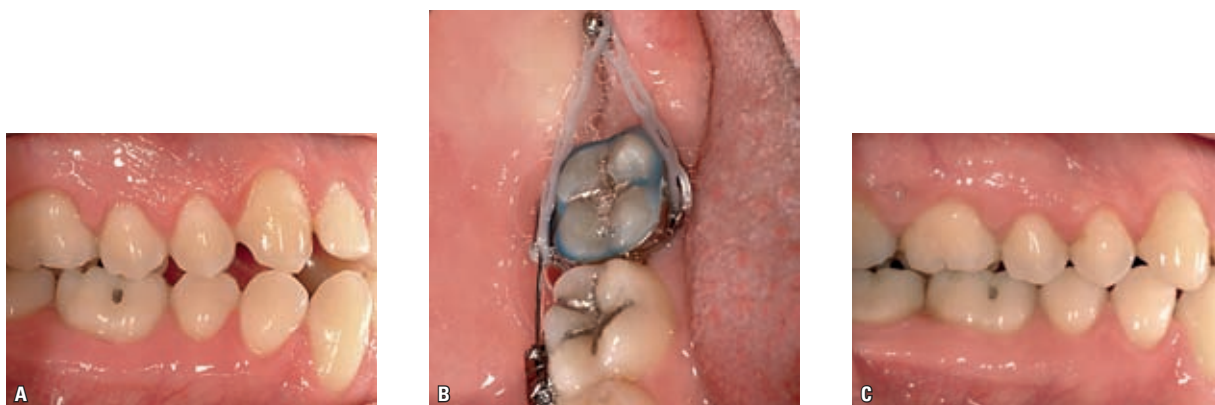


FIGURE 4 - Distalization of mandibular teeth using retromolar MSIs. **A)** Buccal at pretreatment; **B)** Mandibular occlusal at TAD placement; **C)** Buccal at posttreatment.

increases the tendency for incisors to relapse or display root resorption.

Understanding this, I have designed my mechanics to avoid anterior extrusion and maximize posterior intrusion. I start with an initial round NiTi archwire with a step in the archwire at the step in the occlusal plane, which is usually between either the lateral incisor and canine or canine and first premolar. This prevents extrusion of the anterior teeth. Next I work up to a full size rectangular archwire, also with a step in it. Then I take a panoramic radiograph and reposition any non-ideally placed brackets. Next, I section the archwire at the step, so that the anterior teeth are no longer tied to the posterior teeth. I place an MSI as deep in the palate horizontally between the first and second molars with an expanded TPA (the TPA is expanded about 3 mm per side to counter the narrowing effect of intrusion from the palatal side only). The force is applied from the MSI to the TPA to deliver a pure intrusive force to the upper posterior. The upper anteriors do not move. The palate is the ideal location in this situation

because there is better soft tissue apically. Also, the force is palatal to the center of resistance. This helps to seat the lingual cusps, which are usually hanging down in open bite cases (Fig 5).

To date, I have had no problem closing any adult openbite. I have patients 3-4 years in retention and show no relapse.

9) How much do you believe it is possible to intrude a tooth using miniscrews, considering the shortening of the clinical crown?

Carlos Alberto Estevanell Tavares

I don't think there is a limit to how much a tooth can be intruded. I believe there is a distinction, however, on the underlying etiology of the extruded tooth. If it is a supererupted tooth, then biologically there is no reason to believe that intrusion to its pre-extruded position should be difficult. I have intruded supererupted molars as much as 7 mm (Fig 6).

I also have a case with a gummy smile and vertical maxillary excess in which the entire maxilla was intruded about 5 mm. The main criteria is based more on diagnosis and treatment planning than actually intruding the teeth (Fig 7).

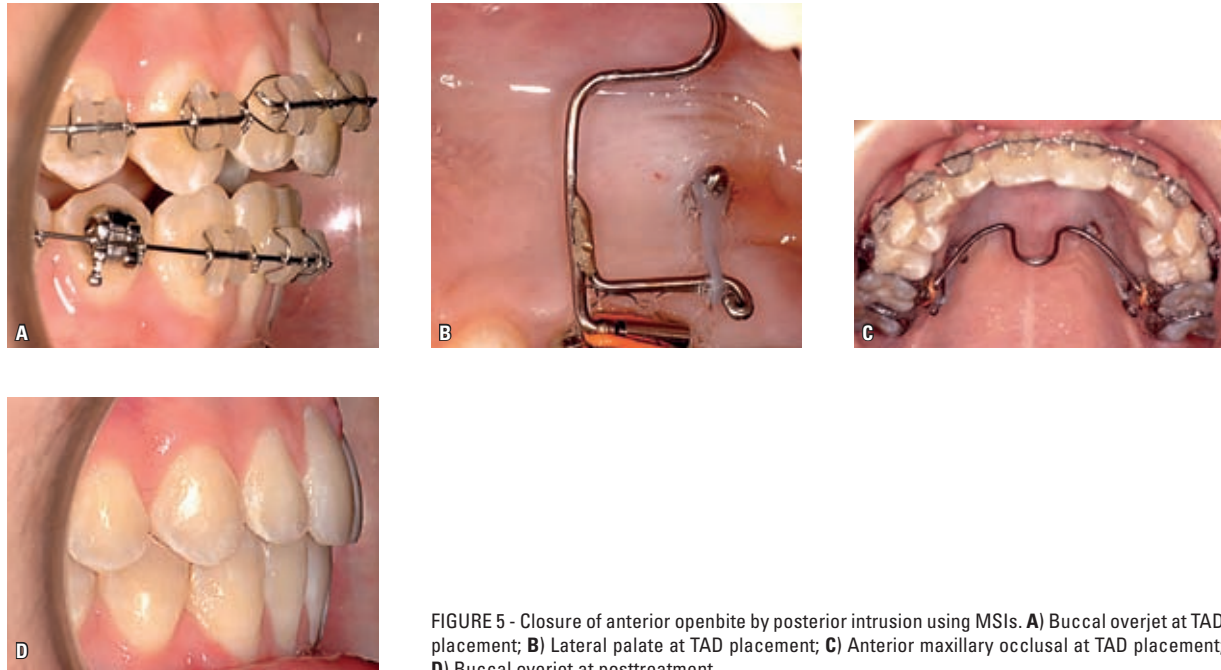


FIGURE 5 - Closure of anterior openbite by posterior intrusion using MSIs. **A)** Buccal overjet at TAD placement; **B)** Lateral palate at TAD placement; **C)** Anterior maxillary occlusal at TAD placement; **D)** Buccal overjet at posttreatment.

10) What is your experience in using mini-screws as anchorage to rapid maxillary expansion? Carlo Marassi

I have used MSIs to correct unilateral crossbites using unilateral palatal expanders. In both cases, I placed two MSIs in the palate on the normal side and fixed the expander from the MSIs to the teeth on the crossbite side. Expansion proceeded normally with significant crossbite correction on the affected side (Fig 8).

11) In what situations do you use elastics instead of NiTi coil springs associated to miniscrews? Carlos Alberto Estevanell Tavares

On all cases, I used power chain initially. The force level is no more than 50-75 g. The literature indicates that 70-80% of all failures occur within

the first 8-12 weeks of MSI placement and loading. I believe this occurs for several reasons. First, the placement protocol is paramount. I think the MSI should be placed drill-free (without a pilot hole), and very slowly/carefully without any wobble, which leads to over enlargement of the implant hole. Second, the initial loading force should be light, not heavy. The first 6-8 weeks, to me, are for stabilizing the MSI and not to move teeth. Therefore, I use elastic force for the first 6-8 weeks, and then move to a coil spring force thereafter as I increase the force level. However, my total force range is usually not more than 100-250 g. The only location I routinely use elastic force for the entire tooth movement is in the anterior region. This is because coil springs tend to irritate the lips in this area.

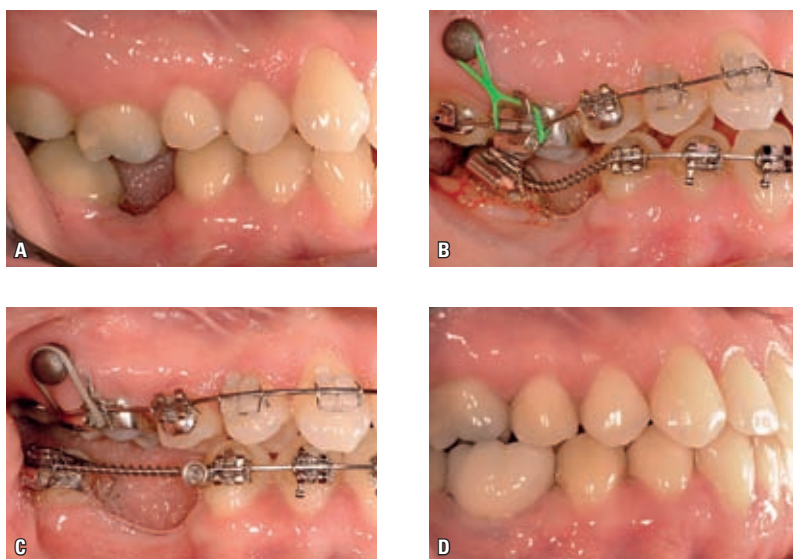


FIGURE 6 - Intrusion of supererupted molars using MSIs. **A)** Buccal at pretreatment; **B)** Buccal at TAD placement; **C)** Buccal at TAD removal; **D)** Buccal at posttreatment.



FIGURE 7 - Intrusion of maxillary arch for gummy smile correction using 4 MSIs. **A)** Anterior at TAD placement; **B)** Maxillary occlusal at TAD placement; **C)** Anterior at TAD removal. Note intrusion relative to MSIs.



FIGURE 8 - Unilateral palatal expansion using MSIs. **A)** Anterior at TAD placement; **B)** Maxillary occlusal at TAD placement; **C)** Anterior after crossbite correction.

12) Scientific evidences have shown that cortical bone is the main point of failure. Does this mean that miniscrews can be shorter? Maria Tereza Scardua

I agree that the cortical bone, compared to cancellous bone, is more important. My own clinical research indicates a higher success rate with 6 mm, as opposed to 8 mm and 10 mm MSIs. I don't however think we can use MSIs shorter than about 6 mm. The extra length is not needed for bone, but rather for the increased soft tissue thickness in certain regions. For example, I use the 10 mm in the retromolar area and in the lateral palatal wall, where the soft tissue thickness averages 4 mm.

13) Do you follow a protocol to adjust the force you apply at the miniscrew in accordance to each different clinical situation?

Marcos Alan Vieira Bittencourt

I determine my force level primarily based on the number of teeth that I will attach to the MSI. In general I try to stay at a level so that each individual tooth has a force of no more than about 50-75 g applied to it.

14) Publications have shown controversy regarding the increase in success rate of miniscrews with surface treatment. What is your experience with surface treated miniscrews? Carlo Marassi/Maria Tereza Scardua

I have not used any MSI with surface treatment. The rationale with surface treatment—whether additive (surface coating with hydroxyapatite) or subtractive (sandblasting with aluminum oxide)—is to roughen the surface, thereby increasing the chance of osseointegration. I do not see this as a significant benefit, because we eventually want to be able to remove the MSIs. Osseointegrated MSIs are significantly harder to remove than non-integrated MSIs, often requiring the MSI to be trephined out of the bone. Moreover, my total success rate is at 90%. I don't see the potential

increase of several percentage points by using surface treated MSIs neither a significant enough benefit to justify the additional surgical procedure to remove an integrated MSI.

15) What is your clinical procedure in case of miniscrew mobility? Carlo Marassi

As I mentioned, my failure rate is relatively low. So I do not see this situation often. If a MSI has a subtle mobility, meaning I can push on it and see that it has a subtle "give" to it, I will leave it in. In almost all of these cases, I have used the MSI to complete tooth movement as originally intended. If, on the other hand, the MSI is mobile enough that I could remove it with my fingers, then I will remove it. If I still need to use a MSI for anchorage, I will either replace it in another location, or if that is not an option, I will leave the MSI out for 8-10 weeks until the bone has filled in the hole substantially, then replace the MSI in its previous position.

16) You developed an orthodontic implant for Unitek (Unitek Temporary Anchorage Device System). What are the main differences between it and the other miniscrews?

Marcos Alan Vieira Bittencourt

The main benefit of the Unitek Temporary Anchorage Device System (3M Unitek, Monrovia, CA) is that there is only one diameter and three lengths (Fig 9A). We chose a 1.8 mm diameter because it provides greater strength and has been shown to be much more resistance to fracture than smaller diameter implants. Contrary to popular opinion, our 1.8 mm MSI does not have a greater risk of hitting tooth roots. Actually, because of its unique hybrid design, our 1.8 mm MSI has less chance of hitting tooth roots than most 1.5 mm diameter MSIs (Fig 9B).

To explain, the Unitek TAD has a conical component and a cylindrical component. The conical component begins at the apex at 0.35 mm in diameter and gradually increases to the full

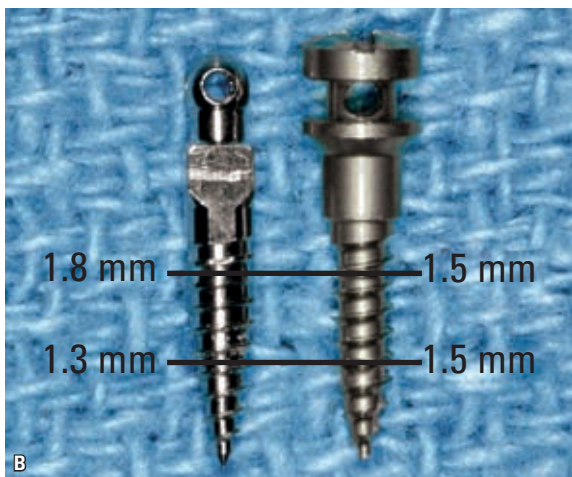
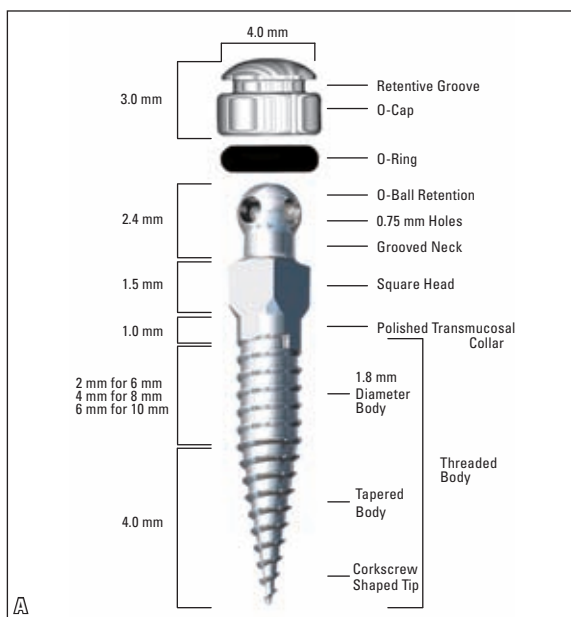


FIGURE 9 - An Unitek TAD. **A)** Major design features; **B)** Comparison of Unitek TAD (silver) and KLS TAD (gold).

1.8 mm cylindrical diameter 4 mm up from the apex. This is the part that makes the MSI sharp and capable of perforating the cortex. This is also the component that resides within the cancellous bone between the tooth roots—so there is less chance of hitting tooth roots. The cylindrical component is designed to reside within the cortical bone, thereby increasing the surface area and bone-implant contact. Therefore, it has the best of both worlds—a smaller diameter between tooth roots, and a larger diameter in cortical bone where there is no risk of hitting tooth roots.

17) Do you have any experience in using miniscrews as provisional teeth in cases of congenital absence, in growing patients, who have to wait for osseointegrated implant? If so, what is the bone response around it? Does it maintain horizontal thickness and allow vertical growth? Marcos Janson

Yes, I have a case where I have used a MSI as a temporary lateral. She has had the temporary implant for 5 years now and the implant has not submerged, the horizontal and vertical bone levels look better than they did initially (Fig 10).

Obviously, we need to look at this on a larger scale with prospective clinical trials, but the initial results are promising. For those interested in this case, I have it full documented on my continuing education website, www.CopestheticCE.com,



FIGURE 10 - Temporary lateral incisor replacement. **A)** Anterior at TAD placement. **B)** Anterior at 5 year retention. **C)** Periapal radiograph at 5 year retention.

where I have listed the protocol and products necessary for temporary restoration of a congenitally missing lateral incisor. In addition, much of the information covered in the interview can be

found in greater detail on the website.

All photos were reprinted with permission from www.CopestheticCE.com.

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Influence of inter-root septum width on mini-implant stability

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Abstract

Objective: The purpose of this study was to evaluate the influence of the inter-radicular septum width in the insertion site of self-drilling mini-implants on the stability degree of these anchorage devices. **Methods:** The sample consisted of 40 mini-implants inserted in the inter-radicular septum between maxillary second premolars and first molars in 21 patients to provide skeletal anchorage for anterior retraction. The post-surgical radiographs were used to measure the septum width in the insertion site (ISW). In this regard, the mini-implants were divided in two groups: group 1 (critical areas, $ISW \leq 3$ mm) and group 2 (non-critical areas, $ISW > 3$ mm). The degree of mobility (DM) was monthly quantified to determine mini-implant stability, and the success rate of these devices was calculated. This study also evaluated the sensitivity degree during miniscrew load, amount of plaque around the miniscrew, insertion height, and total evaluation period. **Results:** The results showed no significant difference in mobility degree and success rate between groups 1 and 2. The total success rate found was 90% and no variable was associated with the miniscrew failure. Nevertheless, the results showed that greater patient sensitivity degree was associated to the mini-implant mobility and the failure of these anchorage devices happened in a short time after their insertion. **Conclusion:** Septum width in the insertion site did not influence the self-drilling mini-implant stability evaluated in this study.

Keywords: Orthodontic anchorage procedures. Dental implants. Dental radiography. Tooth root.

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Editor's summary

Mini-implants feature a considerable clinical failure rate due to early or late instability. Thus, research has been searching for the risk factors associated with failure in the stability of skeletal anchorage devices. This study aimed to compare the stability and success rate of self-tapping mini-implants placed in inter-radicular septa with critical and non-critical mesiodistal dimensions, i.e., septa with width equal to or smaller than 3 mm and greater than 3 mm, respectively.

Twenty-one patients were selected who were undergoing orthodontic treatment and needed anchorage for anterior retraction, totaling 40 mini-implants. The devices were inserted in the inter-radicular septum between maxillary second premolars and first molars. The sample was divided into two groups: Group 1 (critical areas) and group 2 (non-critical areas), and septum

width at the insertion site was measured on post-operative radiographs. Mini-implant stability was evaluated monthly by assessing the degree of mobility by means of a very specific and sensitive methodology.

The results revealed that the mini-implants in Groups 1 and 2 had a similar degree of mobility. No association was noted between mini-implant success rate and septum width at the insertion site. As yet, the literature has not reached consensus on the minimum distance required between mini-implants and tooth roots. Most studies merely speculate on the ideal "safety margin," but fail to show accurate values for such distance. It is speculated that this lack of correlation between septum width and mini-implant success rate is directly linked to the use of three-dimensional radiographic-surgical guides, which enable highly accurate and safe mini-implant insertion.

Questions to the authors

1) How can orthodontists ensure that a mini-implant is successfully inserted in a region of narrow interdental bone septum?

Despite the high success rate of mini-implants, even when installed in narrow septa, and although the installation procedure is apparently simple, orthodontists should strive to be as thorough as possible since this procedure is extremely technique-sensitive. The keys to success when inserting mini-implants in critical areas are: Accurate diagnosis by means of standardized bitewing radiographs or CT scans so that selection of insertion site and mini-implant diameter are carefully defined, use of a three-dimensional surgical guide, particularly for orthodontists who are new to mini-implants and, finally, professionals should not underestimate any surgical technique detail as these are essential for success in the use of mini-implants.

2) Are the rates of accidents and complications higher in regions of narrow bone septum?

Yes. These insertion areas are considered critical due to a higher rate of accidents and complications since the chance of tooth root contact or perforation increases considerably. Damage to tooth roots is mainly due to incorrect determination of the site and/or angle of insertion of the mini-implant in the bone tissue, and when faced with a narrow bone septum any deviation from this insertion angle, however small, can lead to contact between mini-implant and tooth root, and even to tooth loss. Besides, one must consider that close proximity of the mini-implant to the tooth root in narrow septa also renders more frequent the encroachment of periodontal ligament space during the insertion procedure, which may affect the stability of this anchorage device. Therefore, the use of surgical guides is mandatory

for accurate insertion of mini-implants in critical areas. Moreover, selection of mini-implant diameter in narrow septa should be thorough and take into account, when measuring septum width on bitewing radiographs or CT scan sections, the periodontal ligament space of adjacent tooth roots (approximately 0.25 mm each). As a result, the rates of accidents and complications in septa with critical width can be reduced.

3) Research in the area of mini-implants has intensified in recent years. What issues still need further clarification as regards mini-implant stability?

The number of scientific works involving orthodontic mini-implants is indeed experiencing continuous growth. However, there are important methodological difficulties to be overcome by scientific studies that focus on this topic. Actually, the variables that influence mini-implant stability are numerous, and therefore difficult to study in isolation because they involve issues related to the patient, the clinician and the mini-implant features. To further complicate matters, most of these studies are not prospective, and as a consequence samples are poorly standardized, with strict selection criteria,

and the fact that a large number of variables are included yields sharply conflicting results in the literature. Thus, studies are inconclusive or show widely divergent conclusions regarding the definition of variables that determine the stability or loss of these anchorage devices. The number of histological studies in animals has been growing and as a result some important factors have been brought to light concerning the understanding of peri-implant bone remodeling, the presence of osseointegration and extension of the bone/metal contact surface, but small sample sizes preclude the extrapolation of results. Many findings, therefore, are still mere speculation. It should also be noted that the results achieved in these animal studies cannot be fully extrapolated to humans because differences between these organisms do not reproduce the same biological events. In summary, the theme of “mini-implant stability” still comprises an untold number of issues to be addressed and explained. It is essential that further studies be conducted with well defined methodologies and purposes to progressively enhance the understanding of variables that need to be controlled by clinicians if these devices are to provide excellent stability and success in orthodontic treatment.

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Demystifying self-ligating brackets

Renata Sathler**, Renata Gonçalves Silva***, Guilherme Janson****, Nuria Cabral Castelo Branco*****, Marcelo Zanda*****

Abstract

Currently self-ligating brackets have been associated to faster and more efficient treatments, which arouse the curiosity to compare them to the conventional system. Unlike traditional appliances, self-ligating brackets do not require elastomeric or metal ligatures. The literature is abundant in concluding that this feature decreases, ostensibly, the friction resistance during sliding mechanics. Moreover, there are reports on minimizing the need of extractions and maxillary expansion using these accessories. Therefore, the purpose of this literature review was to seek the newest studies about self-ligating brackets currently used in orthodontic treatments, confirming or correcting current speculations.

Keywords: Orthodontic brackets. Friction. Treatment outcome.

Editor's summary

Self-ligating brackets have been associated with faster and more efficient treatments, which raises the issue of comparing them to conventional systems. Contrary to conventional devices, self-ligating brackets do not require ligatures, and some authors have argued that this characteristic clearly reduces friction and resistance to sliding. Moreover, treatments that use these brackets seem to be more conservative. The purpose of this review of the literature was to evaluate the scientific evidence about the effect of these devices on orthodontic treatments according to the most recent studies about self-ligating brackets currently available in the market.

Some facts about the use of self-ligating brackets are unquestionable. They actually do not promote greater root resorption than conventional brackets, and their use does not require ligatures, which results in less plaque accumulation in both the appliance and the enamel around the bracket. Other aspects have not been defined yet, and results suggest that their application demands less chair time, reduces friction during sliding and shortens total treatment time. Moreover, as their slot closing mechanism is more effective than the one found in conventional devices, some authors suggest that intervals between visits may be longer.

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However, evidence of the excellent performance of self-ligating brackets has been obtained mostly from in vitro studies. Clinical trials have yielded less encouraging results, and studies that evaluated friction are a good example of it. When crowding is taken into consideration, the levels of friction seem to be similar to those found when using conventional brackets. The arguments that support the possibility of adopting a more conservative treatment are assumptions that disregard the individual needs of each patient. Indiscriminate expansion may lead to poor esthetic results,

compromise periodontal structures and increase the chances of recurrence. Moreover, expansion mechanics is more closely associated with the shape of the CuNiTi arch wire than with the use of self-ligating brackets. When making decisions about self-ligating brackets, dental healthcare workers should not confuse orthodontic appliances with treatment philosophy. The promise of treating all using the same mechanical and systematic approach seems to ignore the individuality of each case and distort treatment goals that should aim at excellence in orthodontics.

Questions to the authors

1) What are the advantages of the clinical use of self-ligating brackets? And the disadvantages?

The advantages are less plaque around the device and full insertion of the wire in the slot, which provides more effective torque control when using arch wires of a larger size. The disadvantages are the lower rotation correction rate in the first stages of alignment and the consequent increase in pain when the second wire is inserted, as well as the high cost of these devices when compared to conventional brackets.

2) Would the authors suggest that further studies should be conducted to investigate the effect of self-ligating brackets on orthodontic treatment outcomes?

Clinical studies should compare cases with the same type of malocclusion and similar severity based on occlusal indices and divided into groups with conventional or self-ligating brackets. Comparisons should be made of the

number of device breaks, pain during treatment, treatment time and final occlusal results. Also, studies should evaluate stability in the long term.

3) Are self-ligating brackets the future of orthodontics?

Self-ligating brackets do not warrant the development of faster treatments or better treatment plans than the ones made when using conventional brackets. They are just an option and should be chosen according to each dentist's skills and experience, rather than on the promises of better or more efficient outcomes.

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Use of orthodontic records in human identification*

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Abstract

Objective: This study describes a forensic case of incinerated remains that were identified using information found in his orthodontic records. **Method:** Incinerated remains of a man were found inside a car. After forensic crime scene investigation and postmortem and radiographic exams in the Forensic Department, forensic experts found that the victim had a fixed orthodontic appliance, supernumerary teeth in all quadrants, partially erupted third molars and amalgam restorations in some surfaces of several teeth. As the individual's soft tissues were substantially destroyed, identification using fingerprints was not the ideal choice. After orthodontic records were handed in by the family, his clinical chart, radiographs, intra- and extraoral photographs and impressions were analyzed, and these data were compared with previously collected information. **Results and Conclusions:** Forensic dentistry examination revealed 20 concordant points in specimen examination and orthodontic records, which enabled the establishment of a positive correlation between the cadaver under examination and the missing person and eliminated the need for further analyses (DNA tests) to identify the victim.

Keywords: Forensic anthropology. Forensic dentistry. Orthodontics.

INTRODUCTION

Orthodontics is the specialization whose purpose is the prevention, supervision and guidance of the development of the masticatory system, the correction of dentofacial structures, including the conditions that require tooth movement for their treatment, and the establishment of esthetic harmony of the maxillary and mandibular structures of the face.

Because of the complexity of cases and the considerable time spent working with orthodontic patients, orthodontists produce several dental records, fundamental for the planning and performance of this type of treatment. These records usually include dental charts, which may be defined as the comprehensive document that contains all data about patient identification and history, answers to

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a health questionnaire, findings of general physical examinations and extra- and intraoral exams, treatment plan chosen and authorized by the patient and treatment outcomes. Patient records are also used as a file to store complementary tests required by the orthodontic treatment, such as radiographs, plaster impressions, photographs, tracings, and other specific documents.

In Brazil, dentists are required to adequately store and keep all dental documents produced during the treatment of their patients, as established in Paragraph 5 of the Brazilian Code of Ethics in Dentistry. The storage of dental records enables the orthodontist to follow the clinical development of treatments under way and those already completed at any time. In Forensic Dentistry, the importance of these stored materials is associated with both issues of professional defense, in cases of lawsuits against dentists,⁸ and the identification of skeletonized, putrefied or incinerated cadavers.^{11,12}

Considering the responsibility of orthodontists in the practice of their profession and the richness of information found in orthodontic records, this study describes a forensic case of an individual whose remains were incinerated and whose identity was positively established using information from a panoramic radiograph and intraoral photographs taken due to an orthodontic treatment.

CASE REPORT

In August 2006, the incinerated remains of a man were found inside a car. After the forensic crime scene investigation, remains were taken to the Forensic Department of the region for routine postmortem examination, such as the determination of cause of death, identification of instrument or means of death and, if possible, establishment of the victim's identity.

The friability of remaining hard tissues, exacerbated by incineration, led us to resect the mandible and maxilla so that the characteristics of the dental arches could be better evaluated. Although

care was taken during postmortem examination, part of the structures in the anterior mandible did not resist tissue manipulation and partially lost their integrity. Postmortem and radiographic examination of these specimens revealed the presence of several dental events of great forensic importance, such as the use of a fixed orthodontic appliance (Fig 1), supernumerary teeth in the four quadrants, partially erupted third molars and amalgam restorations in several tooth surfaces (Figs 2 and 3).

Concurrent to the examination of remains, police investigations advanced and found information about the probable victim, who had anthropological characteristics compatible with those found in the cadaver under study. As soft tissues were severely destroyed, identification according to fingerprints was not the ideal choice. Therefore, relatives of this missing person were asked to search for any type of medical or dental records or photographs that might support identification.

The result of their search brought the information that the missing individual was undergoing orthodontic treatment, and all clinical records were requested. The records handed in for examination were a clinical chart, a panoramic radiograph (Fig 4), a lateral radiograph, 05 intraoral photographs (Fig 5), 03 extraoral photographs, a request for the extraction of supernumerary teeth,



FIGURE 1 - Incinerated anterior teeth with missing brackets, lost with buccal enamel, and orthodontic wire.

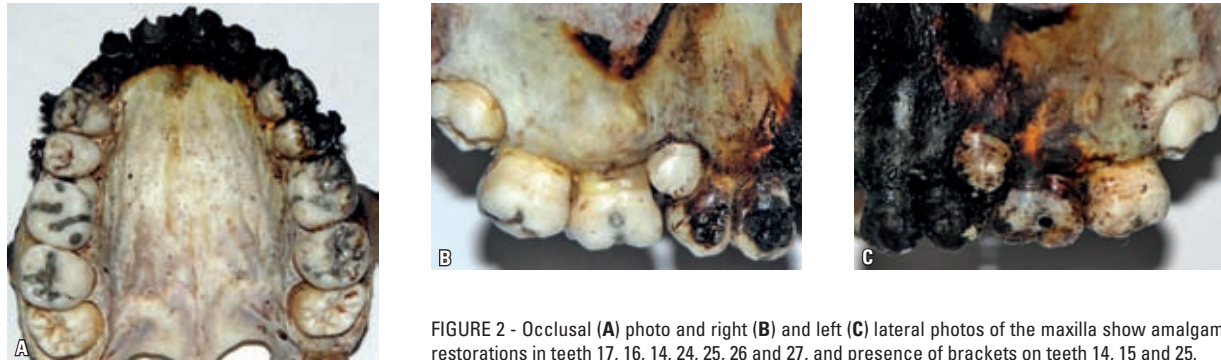


FIGURE 2 - Occlusal (A) photo and right (B) and left (C) lateral photos of the maxilla show amalgam restorations in teeth 17, 16, 14, 24, 25, 26 and 27, and presence of brackets on teeth 14, 15 and 25.

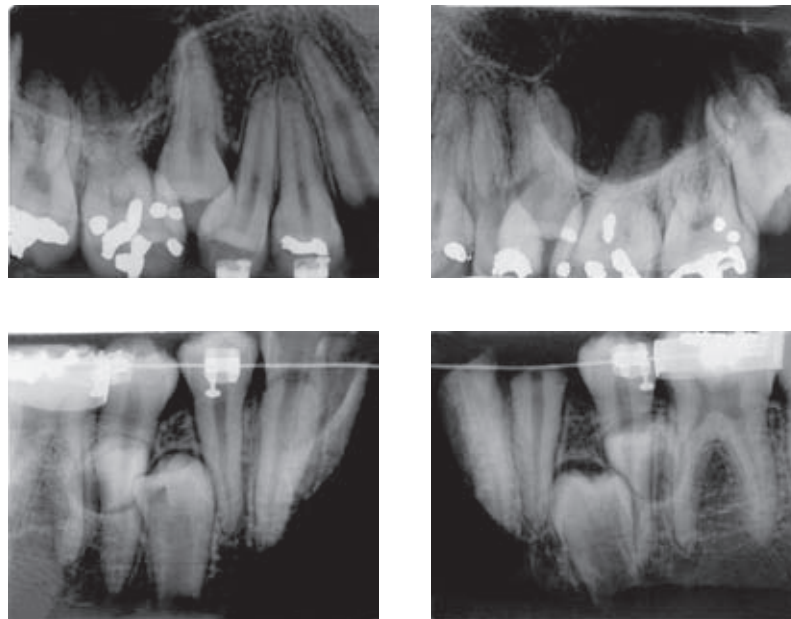


FIGURE 3 - Postmortem radiographs show supernumerary teeth in maxillary and mandibular arches, as well as brackets and bands in mandibular molars.

a radiographic interpretation report and a pair of plaster impressions. The date of these documents was of 2005. All dental information and characteristics in the orthodontic records were grouped in a single dental diagram.

DISCUSSION

Forensic literature has several case reports of incinerated, skeletonized or decomposing remains that were identified by analysis of dental characteristics,^{5,6} a technique that may be associ-



FIGURE 4 - Panoramic radiograph used in orthodontic treatment (2005).



FIGURE 5 - Intraoral photographs taken for orthodontic treatment (2005).

ated with other human identification methods.² The good results obtained with the use of this technique may be assigned to the considerable resistance to fire of teeth and dental materials,⁷ as well as to the information found in documents produced during dental care, such as dental charts, radiographs and photographs.

Forensic dental identification may be classified as a comparative method to determine an individual's identity. For didactic purposes, it may be divided into three phases: (1) exam of the cadaver's dental arches; (2) exam of dental records; (3) and forensic dental comparisons.⁹ In the first phase, all the particular characteristics found in the cadaver's dental arches are recorded and associated with present or missing teeth, restorations (surfaces and materials), prosthesis, endodontic treatments, pathologies, anomalies, and other features. During the exam of dental records, experts collect all data about treatments performed or planned that were recorded by the dentist in the dental charts, associated with the information produced by complementary tests, such as radiographs, photographs and impressions. During the last phase, the data obtained in the first two phases are compared using the same reference points (surface,

tooth, quadrant) and a qualitative and quantitative analysis of the particular dental characteristics (Fig 6).

In the case described here, forensic dentistry comparisons revealed that a total of 20 relevant comparison points were identified, associated with the presence of supernumerary teeth between teeth # 15/16, 25/26, 34/35 and 44/45 (Teeth are described using the FDI numbering system), in addition to shape and site of amalgam restorations in most of the posterior teeth. These concordant comparative points showed a positive correlation between the cadaver under examination and the identity of the missing person and eliminated the need to perform other exams (DNA tests) to establish the victim's identity. Genetic testing provides extremely reliable results, but falls short of the usefulness of forensic dental examinations when cost, time and structure necessary to use the technique are taken into consideration.¹⁰

Positive identification was possible after we obtained the missing person's orthodontic treatment documentation. The panoramic radiograph and the photographs used in orthodontic planning were obtained by using correct techniques

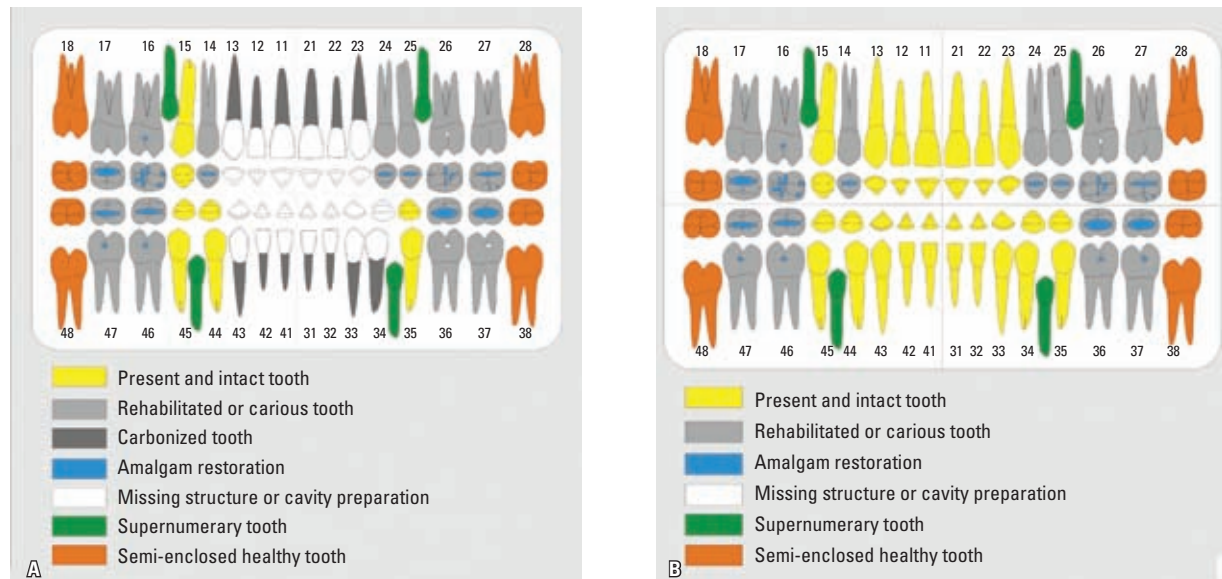


FIGURE 6 - Dental diagram built according to postmortem and radiographic examination of remains (A), and dental diagram with data collected from orthodontic records (B).

and had no distortions or poor sharpness, which made it possible to evaluate qualitative features. This is the reason why no minimum number of points should be established for the positive identification of an individual using the forensic dental technique, because the number of concordant points may vary according to each case.¹

CONCLUSION

Dentists should be aware of the importance of accurately completing dental charts and producing and storing data and material that are part of a patient's dental documentation because, in addition to their clinical importance, these records may produce relevant information to courts.

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Submitted: April 2007

Revised and accepted: February 2009

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Sleep bruxism: Therapeutic possibilities based in evidences

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Abstract

Introduction: Sleep bruxism (SB) is defined as a stereotyped and periodic movement disorder, characterized by tooth grinding and/or clenching occurring during sleep, associated with rhythmic masticatory muscle activity. This condition isn't a disease, but when exacerbated may cause an unbalance and changing of orofacial structures. Thus, it is necessary to obtain effective and safe treatments for the control and management of the bruxist patient. The treatment alternatives range from oral devices, pharmacological therapies to cognitive-behavioral techniques. **Objective:** This study, a systematic literature review having as research bases MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs and BBO, between the years of 1990 and 2008, with focus in randomized and quasi-randomized clinical trials, systematic reviews and meta-analysis, had as objective to analyze and discuss possibilities of treatment for sleep bruxism. **Results:** According to the literature analysis there is a lot of treatment options for the SB, but many of the therapies have no scientific support. Thus, the choice therapy should be based on scientific evidences and in clinical common sense, for an improvement in quality of life of the bruxist patient.

Keywords: Sleep bruxism. Treatment. Oral devices. Drugs. Behavior-cognitive.

INTRODUCTION

Sleep Bruxism (SB) is considered a movement disorder related to sleep.¹ This parafunction is characterized by non-functional teeth contact, which can occur in a conscious or unconscious way, manifested by grinding or clenching of teeth. This condition is not a disease, but when exacerbated may cause a pathophysiological unbalance

of the stomatognathic system. Several therapeutic modalities have been suggested, but there is no consensus on the most efficient.²⁰

Due to its prevalence and injuries caused to the patients, the correct diagnosis shows great value to the development of appropriate treatment protocols, which include therapeutics using devices and oral therapies, pharmacological

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measures and cognitive-behavioral treatments (CBT). Thus, the objective of this systematic literature review is to discuss, based on scientific evidence, treatment alternatives for the control and management of SB.

MATERIAL AND METHODS

A computerized search in MEDLINE, Cochrane, EMBASE, PubMed, Lilacs and BBO was performed. The research descriptors used were “sleep bruxism”, “treatment”, “drugs”, “medications” and “oral devices”, which were crossed in search engines. The initial list of articles was submitted to review by two reviewers, who applied inclusion criteria to determine the final sample of articles.

Inclusion criteria for the selecting articles were:

- » Articles published from January 1990 until July 2008.
- » Within a context of an evidence-based Dentistry, only randomized clinical trials (RCTs) and quasi-randomized trials, systematic reviews and meta-analysis were included. Pilot studies were not included.
- » Studies should include therapies for the treatment of SB involving orodental, pharmacological and/or cognitive-behavioral therapies.
- » Studies written in English, Spanish or Portuguese.

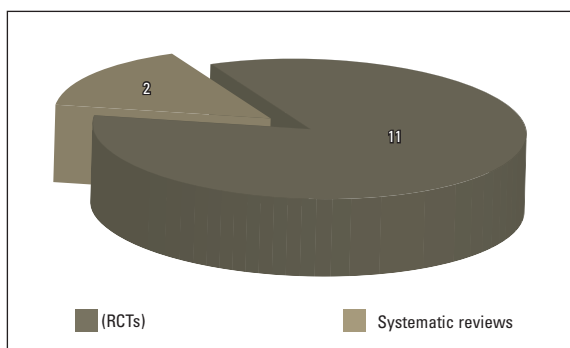


FIGURE 1 - Design of included studies.

RESULTS

After applying the inclusion criteria 13 studies were selected and the Kappa index of agreement between reviewers was 1.00. Thus, these studies were grouped according to the therapeutic modalities: orodental, pharmacological or cognitive-behavioral (Figs 1 and 2).

EVIDENCE-BASED DENTISTRY - SYSTEMATIC REVIEW

Orodoental treatments: oral appliances and occlusal rehabilitations

In a systematic review, Tsukiyama et al²¹ evaluated the effects of occlusal adjustment as a treatment for bruxism, temporomandibular disorders (TMD), headaches and chronic cervical pain. Eleven studies met the inclusion criteria and three of these studies evaluated occlusal adjustment as a therapy for bruxism. The literature analysis concluded that there are no clinical studies showing that occlusal adjustment is superior to non-invasive therapies for the SB and TMD.

Dubé et al,² in a controlled, double-blind and crossover RCT assessed the efficacy and safety of an occlusal splint and a palatal splint in the reduction of the muscle activity and teeth clenching in a sample of nine patients with SB. The patients, randomly, used an occlusal splint or a palatal splint for a period of two weeks, and then the treatments

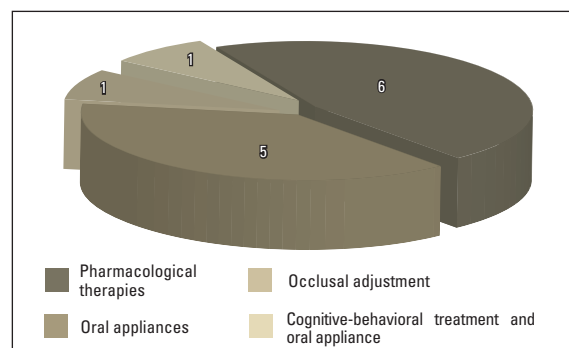


FIGURE 2 - Types of therapies for SB.

were swapped and the use was followed by another two weeks. The therapies were evaluated by polysomnographic examinations. The authors found that there was a statistically significant reduction in the number of episodes of SB with the use of both treatments, with no differences due to the design of the devices.

In a controlled, double-blind and parallel RCT, Van der Zaag et al²² compared the effects of occlusal and palatal splints in the management of SB. A sample of 21 patients were divided randomly between the occlusal splint ($n = 11$) and the palatal splint ($n = 10$) groups. In these individuals two polysomnographic evaluations were performed, one conducted before the beginning of therapy and another after a treatment period of four weeks. The study results showed that neither the occlusal splint, nor the palatal splint had an influence on the SB or in relation to patient sleep.

Harada et al,⁵ in a controlled and crossover RCT, compared the effects of a stabilization splint and a palatal splint in the management of SB. The sample consisted of 16 patients with bruxism who were divided randomly into two groups ($n = 8$) according to the splint used, and muscle activity was evaluated by an electromyographic portable device. After a period of use of the splint by six weeks, followed by two months without using any splint, the individuals were swapped between groups and started using the splint that had not yet been used for another six weeks. The results of this study showed that both the occlusal splint and the palatal splint reduced the masseter muscle activity during the night immediately after appliance installation. However, no effects were observed after 2, 4 and 6 weeks of use, and no differences were noted due to the splints designs.

Landry et al⁹ performed a RCT controlled and crossover comparing the effects of two therapies in the management of SB: in one patients received a mandibular advancement device (MAD), which involved two arches; and in the other therapy pa-

tients received a traditional occlusal splint. The sample consisted of 13 participants who underwent polysomnographic examination, with diagnosis of SB. Based on these results, the authors concluded that short-term temporary use of the MAD is associated with a notable reduction in motor activity of SB, and to a lesser order the occlusal splint also found a reduction of SB. However, the use of MAD in eight patients caused adverse effects, such as pain and discomfort.

In a systematic review published in Cochrane, Macedo et al,¹² evaluated the effectiveness of occlusal splints as an alternative treatment for the SB. The authors conducted a computerized search, from 1966 to May 2007, including only randomized or quasi-randomized trials. The final sample of articles consisted of five RCTs. Occlusal splint therapy was compared to: palatal splint, mandibular advancement device, transcutaneous electrical neural stimulation (TENS) and no treatment. The authors concluded that there is not enough evidence to affirm that the occlusal splint is effective in the treatment of SB.

Pharmacological treatments

Etzel et al³ evaluated the effects of L-tryptophan on the SB in a double-blind RCT. Using a portable electromyography device, a sample of eight patients identified as nocturnal bruxists, received tryptophan (50 mg/kg) or placebo for 8 days, followed by further 8 days with the drugs inverted. Diet and alimentary habits were monitored during the experimental period. The study results showed no significant differences between therapies, suggesting that supplementation with L-tryptophan is ineffective in the treatment of SB.

In a double-blind randomized clinical trial, Mohamed et al¹³ evaluated 10 patients with SB, which received 25 mg of amitriptyline and 25 mg of placebo for one week each. The results showed that neither the intensity nor location of pain, and electromyographic activity of the masseter muscle were significantly affected by the tricyclic

antidepressant therapy. Based on this study, low doses of amitriptyline are not recommended for the control of sleep bruxism, or for the discomforts associated with this sleep disorder.

In another double-blind RCT involving amitriptyline, Raigrodski et al¹⁷ assessed the effects of this antidepressant on nocturnal activity of the masseter muscle and in duration of sleep in patients with bruxism. The sample consisted of 10 women who received active treatment (amitriptyline 25 mg/night) and inactive (placebo, 25 mg/night) for a period of four weeks each. To assess the activity of masseter muscle a portable electromyography device was used. The results showed that administration of amitriptyline did not significantly decrease the activity of the masseter muscle, neither significantly increase sleep duration.

The role of the dopaminergic system in the SB was studied by Lobbezoo et al,¹¹ in a controlled, double-blind and crossover RCT. A sample of 10 patients with SB received low doses of L-dopa associated with benserazide and was evaluated in a sleep laboratory. After the first night of adaptation, the second and third nights the patients received two doses (100 mg) of L-dopa or placebo, in a crossed design, with a dose one hour before bedtime and another four hours after the first. It was found that the use of L-dopa resulted in a decrease in the average number of bruxism episodes per hour of sleep, but this reduction proved to be modest, being only of the order of 26%.

Lavigne et al,¹⁰ in a controlled, double-blind and crossover RCT, evaluated the effects of bromocriptine on the SB. The study sample consisted of seven patients with SB, evaluated by polysomnography. These patients underwent two weeks of active treatment or placebo and then remained a week with no treatment, after the treatments were crossed in the sample. The doses of bromocriptine ranged from 1.25 mg to 7.5 mg (six days) up to 7.5 mg dose (8 days). Examining the results, bromocriptine did not reduce the frequen-

cy of episodes of bruxism during the night or the amplitude of contractions of the masseter muscle.

Assessing the effects of clonidine (0.3 mg) and propranolol (120 mg) on the SB, Huynh et al⁶ conducted a controlled, double-blind and crossover RCT comparing these drugs to placebo. A sample of 25 patients with a history and diagnosis of SB, was divided randomly into the groups, participating in this study and were monitored by polysomnographic examination. The results showed that propranolol (n = 10) did not affect the SB, whereas clonidine (n = 16) decreased sympathetic tone in the minute preceding the onset of SB, reducing the SB by preventing activation of the sequence of autonomic and motor events characteristics of the same. Hypotension was also observed in the morning in 19% of the studied patients.

A study not selected by the inclusion criteria, as it was not randomized, but with interesting findings, was of Saletu et al,¹⁸ in which a blind and controlled study investigated the acute effects of clonazepam on the SB. The sample consisted of 10 patients who received prior treatment with occlusal splint. Polysomnography and psychometry were used to evaluate the patients who received placebo or clonazepam. The administration of 1 mg of clonazepam significantly improved the index of SB and also the quality of sleep, with a good tolerability to drug.

Cognitive-behavioral treatments

Ommerborn et al¹⁵ conducted a RCT comparing the occlusal splint (n = 29) to a cognitive-behavioral therapy (CBT) (n = 28) in the management of the SB. The CBT consisted of measures such as problem solving, progressive muscle relaxation, nocturnal biofeedback and recreation training. Treatment for both groups lasted 12 weeks, and patients were examined pre and post-treatment and 6 months after conclusion of the study. The findings showed a significant reduction in activity of the SB in the two groups, but the effects were small. Moreover, the CBT group had a

tendency to return to baseline of the study when compared to occlusal splint.

DISCUSSION

Considerations about the subject should always be performed through a critical reading of the methodology used by different authors. The use of the basic research principles allows the researchers to try to control as best as possible the biases of the study, generating higher levels of evidence. Thus, methodological criteria such as sample size calculation, randomization, blinding, control of involved factors and calibration intra and inter-examinators, become important tools to qualify the level of the generated scientific evidence.¹⁹

Within this context, of an evidence-based dentistry, it appears that the most common types of studies published in Brazilian journals correspond to studies of low potential for direct clinical application: *in vitro* studies (25%), narrative reviews (24%) and case reports (20%). The low number of studies with greater strength of evidence shows the necessity to increase knowledge of evidence-based methods among Brazilian researchers.¹⁴

According to the systematic literature review, it appears when evaluating therapeutic modalities for the control and management of the SB, that the selected studies presented in this article showed, for the most part, short samples and a short follow-up time. Thus, with small and unrepresentative samples, it is difficult to extrapolate the results to the general population. Moreover, many of the selected studies had a relatively short follow-up time, demonstrating the necessity for a larger longitudinal follow-up time to evaluate the real efficacy and safety of proposed treatments, whether orodental, pharmacological or cognitive-behavioral therapies. This becomes important because many drugs can cause tolerance and dependence effects in patients when used for long periods.

When analysing oral appliances as a treatment for the SB, it appears that there is no significant

scientific evidences that the occlusal splint treats the SB, but benefits as the reduction in tooth wear are observed.^{12,22} Only two studies found a reduction in episodes of SB and in the masseter electromyographic condition with the use of splints, but one of these studies had a follow-up time of just two weeks, while the other only found an improvement immediately after installing the appliance, being that in subsequent evaluations improvements have not been observed.^{2,5} Still, when comparing the occlusal splint to palatal splint (without occlusal covering) there is similarity in results between the two treatment modalities.^{2,5}

On the other hand, the mandibular advancement device, similar to appliances used for treatment of snoring and obstructive sleep apnea syndrome (OSAS), showed a greater reduction in episodes of SB when compared to occlusal splint. However, the exact mechanism that explains this reduction continues to be investigated. The hypotheses are focused on the size and configuration of the device, presence of pain, reduction in freedom of movement or change in upper airway patency.⁹

In patients with Sleep Bruxism the treatment option for minimally invasive and reversible therapies should be first choice in treatment protocols. Already the option for irreversible treatments, such as occlusal adjustment, have no scientific basis to support it, as there is no scientific evidence that occlusal adjustment treats or prevents Sleep Bruxism and TMD.^{8,21}

Regarding to the pharmacological treatments, clonidine has a major role, but is associated with secondary adverse effects, demonstrating the necessity for further controlled RCTs with longer follow-up time to verify its real efficacy and safety.⁶ Thus, clonazepam becomes a safer alternative and with satisfactory results in the short term.^{7,18} It is important to mention here that the clonazepam, like other benzodiazepine drugs, may exacerbate OSAS. In other words, if the patient has a diagnosis of bruxism and OSAS, the clonazepam may

be contraindicated. Another drug that also shows good results in the control and management of SB is L-dopa.¹¹ In relation to amitriptyline, there is no scientific evidence to justify its use in patients with SB,^{13,17} same fact occurs with propranolol,⁶ tryptophan³ and bromocriptine.¹⁰

Target of many current studies in the Orofacial Pain investigations, due to its analgesic and antinociceptive properties, botulinum toxin has yet no RCTs analyzing its role in the treatment of SB. What is observed in the literature are studies evaluating botulinum toxin in situations associated with bruxism, such as muscle hyperactivity and myofascial pain,⁴ or studies without significant levels of evidence. In the future, with the performance of controlled RCTs, with representative samples and long follow-up time, botulinum toxin can be assessed as to its real effectiveness and safety for the treatment of SB.

Alternative cognitive-behavioral treatments may act in combination with other therapies, proceeding as an adjunct in the management of the SB. The awareness and patient education about their situation and the importance of changing habits that may be influencing and perpetuating their condition is important. Measures such as problem solving, muscle relaxation, nocturnal biofeedback, sleep hygiene and recreation, in other words, alternatives that reduce anxiety and stress, become tools for optimal results in situations of SB.^{15,16}

CONCLUSIONS

- » The occlusal splint seems to be an acceptable and safe treatment alternative in the short and medium terms, while the clonazepam, among pharmacological treatments, stood out as a therapeutic option in the short term, because in the long term it can cause dependence.
- » The results of this systematic literature review seems to indicate that the mandibular advancement device and clonidine are the most promising experimental treatments for the SB, however both are associated with secondary adverse effects.
- » There is need for further randomized clinical trials, based on representative samples and long follow-up time, to assess the effectiveness and safety of proposed treatments for the control and management of the SB.
- » Cognitive-behavioral therapies such as psychotherapy, biofeedback, physical exercise and lifestyle changes, which are aimed at stress reduction, may be auxiliary in the treatment of SB.
- » The SB continues to be a condition of complex etiology, associated with numerous treatments with often undefined prognosis. Thus, conservative treatments, minimally invasive and safe should be first choice, with the patient assisted by a multidisciplinary team, aiming at restoring quality of life.

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Submitted: August 2008
Revised and accepted: March 2009

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Longitudinal evaluation of dental arches individualized by the WALA ridge method

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Abstract

Introduction: The mandibular arch form is considered one of the main references among the diagnostic tools because the maintenance of this arch form and dimension is an important factor for stability of orthodontic treatment. **Objectives:** to evaluate the changes in mandibular intercanine and intermolar widths during orthodontic treatment and 3 years of post treatment, in which the WALA ridge was used for individualization of the mandibular arch form. **Methods:** The sample comprised 20 patients (12 women and 8 men), with a mean age of 20.88 years. The dental casts of the initial, final and post-treatment evaluations were used for measurement of the intercanine and intermolar distances in the center of the facial surface of the clinical crown and in the width of the WALA ridge. Data were analyzed by means of ANOVA test followed by Tukey test ($p < 0.05$). **Results:** There was a statistically significant difference in intercanine and intermolar distances among the three stages evaluated. These distances increased significantly with treatment, and presented a reduction in the post-treatment period, however not reaching the initial values. **Conclusions:** the WALA ridge method used in this study for construction of the individualized diagrams and for measurement of the intercanine and intermolar distances was shown to be valuable, allowing the individualization of the dental arches and favoring the post-treatment stability.

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

INTRODUCTION AND LITERATURE REVIEW

The purpose of orthodontics is to correct malocclusions, and place the teeth in their ideal positions and in equilibrium with their bony bases. Esthetics and function is enhanced provided that the periodontal tissues and support structures

remain healthy. Furthermore, the long term success and stability will depend on precise diagnosis and planning and well used mechanics. During preparation of the treatment plan it is important to observe the morphology of the dental arch of each patient, since respect for its individuality

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will avoid periodontal problems, such as gingival retractions, instability and deficiencies in the esthetic results.¹¹ The form of the mandibular dental arch is considered one of the main references during treatment, as its maintenance is an important factor for the stability of orthodontic treatment.²⁰

In an ideal occlusion, the teeth are positioned in the greatest possible degree of harmony with their bony bases and with the surrounding tissues. Thus, preservation of the form and dimensions of the dental arches must be one of the first objects of orthodontic treatment. Various factors may influence the morphology of the dental arches, such as the facial type, genetics, type of occlusion, musculature and ethnicity. The mandibular canines and molars are considered determinant factors in the arch width and movements of incisors in the buccal direction should be avoided.¹⁸

Dental arch form studies began in 1889 with Bonwill,⁶ who developed the first diagram which was used in orthodontics by other researchers. On the basis of his postulations, Hawley¹³ constructed a diagram denominated Bonwill-Hawley, for orthodontic purposes. From then onwards, various diagrams were drawn with the aim of helping in the construction of metal arches used during treatment. In addition to form, the dimension of the dental arch was also a reason for concern.^{8,11,16} It is known that when alterations are made in the distance between the canines and molars during treatment, there is a great tendency towards relapse.^{19,25}

Andrews and Andrews² suggested the use of an anatomic reference such as a parameter with the object of centralizing the roots of teeth in the basal bone, which they denominated the WALA ridge, of which the initials mean Will Andrews + Lawrence Andrews. The WALA ridge is the strip of soft tissue immediately above the mucogingival junction of the mandible, at the level of the line that passes through the centers of rotation of the teeth or close to it, and is exclusive to the mandible. The mandibular dental arch will present this

requirement and will be with the ideal form when the midpoint of the vertical axes of the facial surfaces ("FA" points) of the central and lateral incisors, canines, 1st premolars, 2nd premolars, 1st and 2nd molars are 0.1 mm; 0.3 mm; 0.6 mm; 0.8 mm; 1.3 mm; 2.0 mm and 2.2 mm, respectively, from the WALA ridge. In the authors' perception, after eruption the crowns of the permanent teeth are subject to alterations as a result of "environmental" forces. These forces may tip the teeth around their centers of rotation. Hypothetically, when this occurs, the centers of rotation of the mandibular teeth, which remain in the center of the basal bone, do not alter, however, the crowns and root apices may be altered. Therefore, the center line of rotation (hypothetical line that passes through the horizontal center of rotation of each tooth) would be the line that best conserves the original and supposedly ideal form of the dental arch. Thus, the ideal form of the maxillary and mandibular dental arches would be dictated by the form of the basal bone of the mandible. When the form of the mandibular dental arch is correct, the wire that unites the bracket slots of "straight-wire" brackets should have the same shape as that of the WALA ridge.¹⁷

By means of the "Six Elements of Facial Harmony", defined as a classification of the objectives and goals of orthodontic treatment, Andrews and Andrews³ determined that Element 1 referred to the form and length of the dental arches. Based on the premise that the form and length of the dental arches should be individual for each patient, the goals established for a correct dental arch would be: The root apex of the long axis of each tooth should be centralized on the basal bone and the crown should present the correct inclination; the distance from point FA to the WALA ridge, within the nominative values; the central line of the dental arch is equal to the sum of the mesiodistal diameters of the crowns at the contact points and the depth of the central line of the mandibular arch should be between 0 and 2.5 mm.

The WALA ridge concept would keep a close relationship with the "Six Keys of Perfect Occlusion"¹ and was consolidated as a real and true reference for determining the individual morphology of the dental arches.

PROPOSITION

To perform a longitudinal evaluation of dental casts of patients submitted to orthodontic treatment, who had their dental arches individualized by the WALA ridge method with regard to the following aspects:

- alterations in the mandibular intercanine distance and between the mandibular molars;
- transversal alterations in the WALA ridge, in the region contiguous to the mandibular intercanine and intermolar distances;
- reliability of the method for the individualization of dental arches.

MATERIAL AND METHODS

Material

The materials were used in accordance with the regulations of the National Council of Health, No. 196/1996, Ministry of Health, and this study was approved by the Research Ethics Committee of UNIARARAS Protocol No. 219/2007.

The sample was obtained from the files of patients who received orthodontic treatment at a private clinic in Curitiba/ PR, Brazil. It was composed of 20 plaster models, obtained from the same clinic, taken at the stages of pre-treatment (T1), post-treatment (T2) and 3 years after the end of treatment (T3) of patients ranging between the ages of 13 years and 11 months and 39 years and 1 month, among whom 8 were men and 12 women.

For selecting the T1 sample, the following factors were evaluated:

- Presence of complete permanent dentition, except third molars.
- Class I malocclusion, determined by the relationship of the first molars and premolars.

- Absence of diastemas.
- Teeth and alveolar ridge visible in plaster models, the latter being compatible and checked against the morphology of the WALA ridge clinically presented by the patient.
- Slight mandibular crowding (-1 mm to -4 mm). For selecting the T2 sample, the following factors were evaluated:
 - Class I, determined by the relationship of the canines, premolars and first molars; correct intercuspation provided by the first molar cusp-sulcus relationship and premolar cusp imbrasure relationship, evaluated from the lingual perspective.
 - Overjet of 0 to 2 mm and overbite of 1 to 2 mm.
 - Angulation and inclination of the crowns according to Andrews method of Keys II and III, respectively.¹
 - Absence of diastemas.
 - Curve of Spee depth of 0 to 2.5 mm.
 - Teeth and alveolar ridge visible in plaster models, the latter being compatible and checked against the morphology of the WALA ridge clinically presented by the patient.

The corrective orthodontic treatment was performed according to the following protocol: without extractions; finishing objectives in accordance with Andrews' six keys method;¹ straight-wire technique, Andrews standard prescription ("A" Company, California, USA) with slot 0.022 x 0.028-in; wire contour individualization for leveling and alignment defined by the WALA ridge form, observed from the occlusal perspective of the mandibular plaster model and adapted to a diagram recommended by Andrews and Andrews.²

The notes made on the clinical charts about the clinical procedures were analyzed, showing that 8 cases were submitted to rapid maxillary expansion before orthodontic treatment; 5 used Class II intermaxillary elastics with an upper reverse curve; 7 used Class III intermaxillary elastics; 7 were submitted to interproximal wear of the mandibular

incisors, as 3 cases presented Bolton's discrepancy due to excess maxillary tooth size.

Plaster models of patients that presented the following anomalies were excluded from the sample: Dental agenesis; supernumerary and extraneous teeth; teeth with alterations in shape, dental mutilations and bony bases compromised in the sagittal direction.

Methods

To mark the axes, points and reference ridges and to obtain dimensions on the plaster models, the following equipment was used: Black pencil (model t5.5v Regent 1250 6B, Faber Castell, SP) and a digital caliper with a resolution of 0.01 mm and exactness of approximately 0.02 mm (Mitutoyo Sul Americana Ltda., Brazil). The measurements were made exclusively by the researcher.

Axis, WALA ridge, points and their demarcations

A single examiner, using a pencil, marked the axes, points and WALA ridge on the maxillary plaster models for T1, T2 and T3, by the visual method, according to the following description:

- a) Facial-Axis of the Clinical Crown (FACC): The most prominent portion of the central lobe of the facial surface of all teeth crowns, except for the molars, which corresponds to the sulcus that separates the two large facial cusps. Demarcation was done with a graphite on the crowns of mandibular canine and first molar teeth.

- b) WALA Ridge: Soft tissue ridge located below the gingival margins of mandibular tooth crowns and immediately above the mucogingival junction.
- c) Facial-Axis Point (FA point): Point on FACC that separates the gingival half of the clinical crown from the occlusal half. Demarcation was done with a graphite tip on the crowns of mandibular canine and first molar teeth (Fig 1).
- d) WALA Ridge Point (point WR): Demarcation of the WALA ridge was made with the graphite surface (Fig 2); the most prominent point on the curve of the WALA ridge adjacent to each tooth was denominated Point WR (Fig 3). Demarcation was done with a graphite tip contiguous to the mandibular canine and first molar teeth.

Measurement of the linear variables (mm)

These were made with the use of a digital caliper directly on the mandibular plaster models and noted on a specific chart.

- a) Mandibular intercanine distance (IC): distance between the mandibular right and left canines, on the respective FA points (Fig 4).
- b) Mandibular intermolar distance (IM): distance between the mandibular right and left canines, on the respective FA points (Fig 4).
- c) Intercanine distance at the width of the WALA ridge (IC WR): transversal dimension between the points of the WALA ridge of the mandibular canines (Fig 6).



FIGURE 1 - Delimitation of Points FA with a graphite tip.



FIGURE 2 - Demarcation of the WALA ridge made with a graphite surface.



FIGURE 3 - Delimitation of Points WR with a graphite tip.

- d) Intermolar distance at the width of the WALA ridge (IM WR): transversal dimension between the points of the WALA ridge of the mandibular molars (Fig 7).

After every measurement taken, the caliper was reset in the initial position (zero), in order to avoid an erroneous readout. The caliper was placed on the reference points, using the tips of the measurement probes, taking care to keep it parallel to the occlusal plane during each measurement to ensure the recordings were made only in the horizontal direction.

Statistical Analysis

Method Error

To calculate the intra-examiner error, 7 pairs of models for each evaluated stage (T_1 , T_2 and T_3) were randomly selected, for a second demarcation of the points and linear variable measurements, totaling 21 pairs of plaster models. The approximate interval between the first and second measurement was 15 days.

The formula proposed by Dahlberg⁹ ($Se^2 = \sum d^2 / 2n$) was applied to estimate the order of variables of the casual errors, while the



FIGURE 4 - IC distance at the respective FA points.

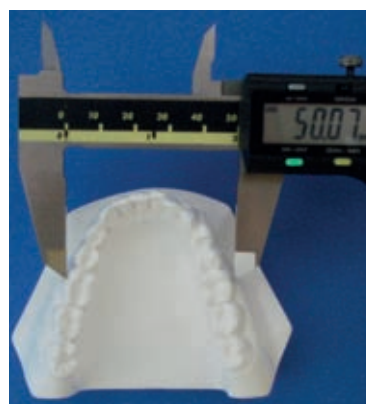


FIGURE 5 - IM distance at the respective FA points.



FIGURE 6 - IC WR distance at the respective WR points.



FIGURE 7 - IM WR distance at the respective WR points.

systematic errors were analyzed by the application of the paired “t” test, according to Houston¹⁴. The level of significance was established at 5% ($p < 0.05$).

Statistical Method

Descriptive statistics were performed of all the data obtained from the sample: age at the beginning of treatment (T1); treatment time (T2-T1); post-treatment evaluation time (T3-T2), as well as for the studied variables (IC, IM, IC WR and IM WR), in all the stages and periods studied: T₁, T₂, T₃, T₂-T₁, T₃-T₂ and T₃-T₁.

The dependent ANOVA test was used, and when there was a significant result, the Tukey test was performed to observe whether there

was significant alteration in the studied variables between the initial, final and post-treatment stages. The level of significance was established at 5% ($p < 0.05$).

RESULTS

Table 1 presents the descriptive statistics (mean, standard deviation, minimum and maximum) initial age, treatment time and post-treatment evaluation time.

Table 2 presents the results of the systematic and casual error evaluations by means of the paired t test and the Dahlberg formula,⁹ applied to the studied variables. There were no systematic errors and the casual errors were considered acceptable, and it could be affirmed that the WALA ridge method was an easily reproducible method, since there was no difference between the two measurements of the variables IC WR and IM WR performed by the same examiner at two different times.

The results of the descriptive statistical analysis for the variables IC, IM, IC WR and IM WR are shown in Tables 3, 4, 5 and 6, respectively, in all the studied times: T₁, T₂, T₃, T₂-T₁, T₃-T₂ and total

TABLE 1 - Descriptive statistics of initial age, time of treatment and post-treatment evaluation time (mm).

Variables	Mean	s.d.	Minimum	Maximum
Initial age	20.88	7.86	13.91	39.08
Time of treatment	2.47	0.57	1.36	3.17
Post-treatment evaluation time	3.20	0.32	3.05	4.17

TABLE 2 - Results of the estimate of systematic and casual errors applied to the variables IC, IM, IC WR and IM WR.

Variables	1st Measurement		2nd Measurement		N	Dahlberg	P
	Mean	s.d.	Mean	s.d.			
IC	28.95	1.59	28.90	1.60	21	0.09	0.059
IM	49.50	1.65	49.54	1.65	21	0.10	0.134
IC WR	30.65	2.55	30.10	2.58	21	1.21	0.138
IM WR	54.44	2.37	54.47	2.33	21	0.11	0.339

TABLE 3 - Descriptive statistics of the variable IC (mm).

Variables	Mean	s.d.	Minimum	Maximum
IC T1	29.29	1.62	25.70	31.80
IC T2	30.42	1.57	27.60	33.30
IC T3	29.79	1.68	26.10	32.50
IC T2-T1	1.12	1.06	-0.70	3.10
IC T3-T2	-0.62	0.69	-2.30	0.20
IC T3-T1	0.50	0.65	-0.70	1.80

TABLE 4 - Descriptive statistics of the variable IM (mm).

Variables	Mean	s.d.	Minimum	Maximum
IM T1	48.07	2.14	44.00	52.20
IM T2	50.30	1.77	47.20	53.70
IM T3	49.30	2.08	44.00	52.90
IM T2-T1	2.22	1.73	-0.90	5.30
IM T3-T2	-0.99	1.15	-4.60	0.60
IM T3-T1	1.23	1.13	-0.50	3.50

TABLE 5 - Descriptive statistics of the variable IC WR (mm).

Variables	Mean	s.d.	Minimum	Maximum
IC WR T1	30.06	2.23	25.30	33.20
IC WR T2	30.82	1.60	26.90	33.40
IC WR T3	30.39	1.88	26.00	33.30
IC WR T2-1	0.76	0.90	-1.60	1.90
IC WR T3-2	-0.43	0.52	-1.60	0.50
IC WR T3-1	0.33	0.56	-1.10	1.70

TABLE 6 - Descriptive statistics of the variable IM WR (mm).

Variables	Mean	s.d.	Minimum	Maximum
IM WR T1	54.18	1.94	50.50	57.30
IM WR T2	54.79	1.97	51.10	58.40
IM WR T3	54.51	1.90	50.70	57.50
IM WR T2-1	0.61	1.08	-2.40	2.50
IM WR T3-2	-0.28	0.75	-1.50	2.50
IM WR T3-1	0.32	0.72	-1.50	2.10

TABLE 7 - Results of the ANOVA test and Tukey test for the variables IC, IM, IC WR and IM WR, among the 3 evaluation times T1, T2 and T3.

Variables	Initial (T1)	Final (T2)	Post-treatment (T3)	P
	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	
IC	29.29 (1.62) ^A	30.42 (1.57) ^B	29.79 (1.68) ^C	0.000*
IM	48.07 (2.14) ^A	50.30 (1.77) ^B	49.30 (2.08) ^C	0.000*
IC WR	30.06 (2.23) ^A	30.82 (1.60) ^B	30.39 (1.88) ^A	0.004*
IM WR	54.18 (1.94) ^A	54.79 (1.97) ^A	54.51 (1.90) ^A	0.074

Different letters indicate statistically significant differences ($p < 0.05$).

alteration between the initial stage and the post-treatment evaluation stage (T_3-T_1).

Table 7 demonstrates the results of the dependent ANOVA test and Tukey test for the variables IC, IM, IC WR and IM WR, among the 3 evaluation times.

The results of the dependent ANOVA test for the variables IC and IM indicated that there was statistically significant difference among the three studied stages. This demonstrates that these variables increased significantly with the treatment (T_2-T_1), and presented a reduction in the post-treatment period (T_3-T_2); that is, a return to the pre-treatment values, however, not attaining the initial values.

The variable IC WR presented an increase during treatment, and also presented a significant relapse post-treatment, returning to the initial values. The variable IM WR did not change significantly with the treatment or during the post-treatment period.

DISCUSSION

According to Houston,¹⁴ in order for the precision of a methodology to be adequately

analyzed, a minimum of 20-30% of the sample must be re-evaluated. Therefore, for the intra-examiner error evaluation, new measurements of the four studied variables were taken in 7 randomly selected study models, totaling 21 pairs of models, measured about 15 days after the first measurements were taken. The results of the two measurements were then submitted to the formula proposed by Dahlberg,⁹ to obtain the casual errors. To obtain the systematic errors the paired t test was applied. Some degree of judgment and subjectivity on the part of the examiner may occur during measurement of the plaster models,²⁴ which emphasizes the importance of the methodological error analysis in the case of measurements taken from plaster models.

The results demonstrated the absence of systematic errors, and the casual errors were minimal and acceptable (Table 2). The major casual error occurred in the measurement IC WR, with a value of 1.21. The absence of significant systematic errors and the reduced values of the casual errors observed in this study may have occurred both from the standardization and precision of the measurements, as well as from the simplicity

and objectivity of the measurements of the study models, making the WALA ridge diagram method extremely reliable and easily reproducible.

Of the evaluated sample, 17 patients presented an increase in IC during the treatment and 3 presented a slight reduction. On an average, the increase was 1.12 ± 1.06 mm (Table 3). IC showed a slight but statistically significant increase during treatment, perhaps due to the fact that 8 patients were treated by having rapid maxillary expansion performed. The change in the post-treatment period—that is, between the final and the post-treatment evaluation stages—also referred to as relapse, was slight, but statistically significant (Table 7). This change in IC in the post-treatment period occurred in the direction of the initial position occupied by the canines; that is, there was a reduction of -0.62 ± 0.69 mm in this distance after the conclusion of treatment (Table 3). This reduction was shown to be significant, however, it did not attain the values obtained at the beginning of treatment (Table 7).

These results may support the concept of maintenance of the original intercanine distance in orthodontic treatment, as it tends to return to the initial values, as has been described in the literature^{9,19}. Some authors^{17,21,26} have also concluded that the increase in IC could lead to a deficiency in the results. However, it is difficult to distinguish between what is relapse or what is a natural reduction in this distance as the years pass.^{4,5,22,23}

As regards IC WR, this presented a significant alteration during treatment, as well as a significant relapse in the post-retention period (Tables 5 and 7). Nevertheless, these alterations were well reduced, representing an increase of 0.76 ± 0.90 mm during treatment and a reduction of only -0.43 ± 0.52 mm in the post-treatment period (Table 5). Clinically, these alterations may be considered insignificant. Moreover, these alterations in IC WR were shown to be smaller than the alterations of IC measured at the FA points; that is, in the center of the facial surface of the clinical crown of the mandibular canines.

There was a slight increase in IM during the treatment stage, and a relapse tending to a reduction in this distance in the post-treatment period. Only 2 patients presented a reduction in IM during the treatment. The mean increase during treatment was 2.22 ± 1.73 mm. The relapse was small, a mean of -0.99 ± 1.15 mm, however, it was significant since the alteration in the treatment was also shown to be significant, and it occurred in the direction of the initial position occupied by the mandibular molars but did not attain the pre-treatment values (Tables 4 and 7). The variable IM presented greater differences between the beginning and end of treatment than between the final and post-treatment evaluation stages, which demonstrated that this dimension presented a relative longitudinal stability.^{22,23} The relapse found in the post-retention stage for the intermolar distance was small, similar to that found in some studies.^{12,21}

The variable IM WR presented no significant alteration during treatment and in the post-treatment period (Tables 6 and 7). Due to the non-significant results, one could consider that IM WR was not altered during the treatment and remained stable during the post-retention period. The alterations in IM WR were shown to be more stable than the alterations in the intermolar distance measured in the FA points.

Before examining the models of dental arches with the objective of evaluating their form, specifically for determining the diagram, it is necessary to have a diagnosis and the general treatment goal defined. On this point, the dental arches had probably been examined and influenced the diagnosis and treatment plan. Only after this is it possible to have parameters for judging the mandibular arch, and evaluating its form.^{7,11}

The major concern of researchers has always been to obtain a simplified method that would allow an analysis of the position of the teeth in the dental arches that could be performed by the clinician in a simple and objective manner. The

other question would be the standardization of the method of evaluating the position of the teeth in the dental arch.

During orthodontic treatment, the intercanine distance can be increased,¹⁵ but many authors have observed that any alteration in the mandibular intercanine width was unstable.^{19,25} Therefore, the original width needs to be maintained to increase the long term stability. According to the results obtained, it can be affirmed that the WALA ridge method^{2,10} was shown to be valid and allowed the individualization of dental arches in order to favor post-treatment stability.

Consequently, evaluating the form of dental arches with the object of defining the form of the arches to be used in dental treatment in an individualized manner is a mandatory procedure. This study, therefore, supports the affirmation that there is true individualization only when it allows treatment intentions, interacting with the anatomic characteristics, to define the form of the arches.⁷

CONCLUSIONS

It was concluded that:

- » IC and IM increased with treatment and underwent a statistically significant reduction in the post-treatment period, although they did not return to the initial values. The alterations were small and clinically insignificant.
- » IC WR increased with treatment and underwent a reduction in the post-treatment period, although the alterations were clinically insignificant. IM WR were not altered during treatment and remained stable during the post-retention period.
- » Clinically, the WALA ridge method used in this study for making the individualized diagrams and for measuring the intercanine and intermolar distances was shown to be valid, allowing individualization of the dental arches and favoring post-treatment stability.

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Submitted: October 2008
Revised and accepted: November 2008

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Electronic cephalometric diagnosis: Contextualized cephalometric variables

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Abstract

Introduction: Classical parametric assessments and isolated cephalometric variables may not provide the best information in craniofacial morphology. Rather, contextualized cephalometrics can be more promising, since it allows for integration among weighty cephalometric variables. **Objective:** The main purpose of this manuscript is to present the application of a non-trivial mathematical model in cephalometrics, providing data mining by filtering certainty and contradiction in each network “node”. **Methods:** In the proposed “neural network”, each “cell” is connected to others “cells” by “synapses”. Such decision-making system is an artificial intelligence tool tailored to potentially increase the meaning of assessed data. **Results:** The comparison between the final diagnosis provided by the paraconsistent neural network with the opinions of three examiners was heterogeneous. Kappa agreement was fair for anteroposterior discrepancies, substantial or fair for vertical discrepancies and moderate for dental discrepancies. For the bimaxillary dental protrusion, the agreement was almost perfect. Similarly, the agreement among the three examiners, without any software aid, was just moderate for skeletal and dental discrepancies. An exception was dental protrusion, which agreement was almost perfect. **Conclusions:** In conclusion, the analysis of performance of the developed technology supports that the presented electronic tool might match human decisions in the most of the events. As an expected limitation, such mathematical-computational tool was less effective for skeletal discrepancies than for dental discrepancies.

Keywords: Cephalometric diagnosis. Non-trivial logics. Artificial intelligence.

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INTRODUCTION

In orthodontics, as in any other medical or dental specialty, it is possible to apply mathematical parameters to biological systems. Before the premises are set, the evidences may be considered as coincidences or as “truth”, although “truth” may hold significant uncertainty or contradiction.

Routinely, cephalometric data have been extensively described in the orthodontic literature. With no doubt, the most of such data is expressed by means and standard deviations. Central tendency measurements are frequently criticized because they present just a general view of a specific problem, far less than the desired individualized information.

Therefore, with clear limitation, means and standard deviations force the orthodontist to allocate each variable in certain pre-determined classes, many times academically well accepted, however, not always biologically proofed. The values can be interpreted with a “flexible” allocation, allowing that a value refers to two sequential classes, with certain degree of pertinence to each one of them. In this case, the application of mathematical values to the understanding of natural phenomena is probably better.

With such support, the theory of the fuzzy logic^{1,2} was presented. According to such theory, values are pertinent to more than a pre-determined class, what means that a specific value may refer to two sequential classes, with certain degree of pertinence to each one. The fuzzy logic was applied in orthodontics to select types of headgears³, to evaluate the visual subjective judgment of the anteroposterior relationship between maxilla and mandible^{4,5} and to establish non-surgical treatment plans.⁶ However, a mathematical model based upon fuzzy and paraconsistent logic in order to contextualized cephalometric data has not been presented.

In general, cephalometric is limited because cephalometric variables hold important degrees of imprecision when individually analyzed. Without the “whole picture”, there is no clear “*gestalt*”

about the craniofacial architecture of each person, what means that there is no trustable screening of a possible discrepancy and its degree of severity. Such limitations make the clinical application of cephalometry less effective than what is expected by clinical orthodontists.

A better scenario would be to setup specific software that could quantify how much “noise” is carried by each cephalometric variable, weighing its relative contribution to a general index of discrepancy. Such approach would offer a significant progress in regard to the current cephalometric comparisons, which are simple measurements of central tendency, as means and standard deviations.

Furthermore, the application of paraconsistent logic⁷⁻¹⁰ allows the mathematical modeling of imprecise and inconsistent data. Therefore, it is possible to detect and control contradictions, targeting to provide more and better answers to old problems. In this study, the paraconsistent logic was applied to contextualize selected cephalometric variables, throughout neural networks, which considered the degrees of certainty and contradiction in each one of its “cells”.

PROPOSITION

The goals of this project are:

1. To present a mathematical-computational model to process interactions among cephalometric values.
2. To validate the performance of such artificial intelligence tool, comparing to the opinions of three specialists in orthodontics, even not having a golden standard for such approach.
3. To classify in a ranking the degree of agreement between the opinion of the examiners and the electronic cephalometric diagnosis, in specific parts or dimension of the craniofacial complex.

MATERIAL AND METHODS

The following cephalometric landmarks (Fig 1) were selected:

1. Basion (Ba): the most inferior posterior point on the posterior margin of the foramen magnum.
2. Sella (S): the center of the pituitary fossa of the sphenoid bone.
3. Nasion (N): the junction of the frontal and nasal bones, at the fronto-nasal suture.
4. Pterygo-maxillary fissure (PtgI): the most inferior point of the pterygo-maxillary fissure.
5. Posterior nasal spine (PNS): the most posterior point on the bony hard palate.
6. Anterior nasal spine (ANS): the tip of the median anterior bony process of the maxilla.
7. Upper molar: the most inferior point of the mesial cuspid tip of the first upper molar, posterior reference for the occlusal plane.
8. Anterior reference of the occlusal plane: established by bisecting the overbite or openbite of the incisors, considering the incisal edges of the upper and lower incisors.
9. Gonion (Go): the most postero-inferior point of the angle of the mandible.
10. Menton (Me): the most inferior point on the mandibular symphysis.
11. Gnathion (Gn): the most anterior and inferior point on the contour of the symphysis. Determined by bisecting the angle formed by the mandibular plane (Go-Me) and the Nasion-Pogonion line.
12. A Point: the most posterior point on the anterior curvature of the maxilla.
13. B Point: the most posterior point on the anterior curvature of the mandibular symphysis.
14. Pogonion (Pg): the most anterior point on the contour of the bony chin.
15. Upper incisor edge: the incisal tip of the maxillary central incisor.
16. Upper incisor apex: the root tip of the maxillary central incisor.
17. Lower incisor edge: the incisal tip of the mandibular central incisor.
18. Lower incisor apex: the root tip of the mandibular central incisor.

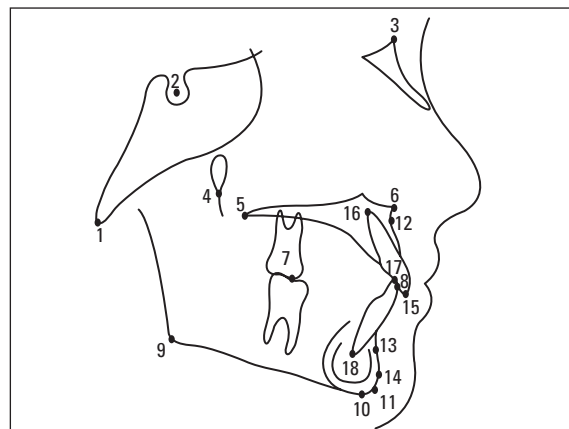


FIGURE 1 - Selected cephalometric variables.

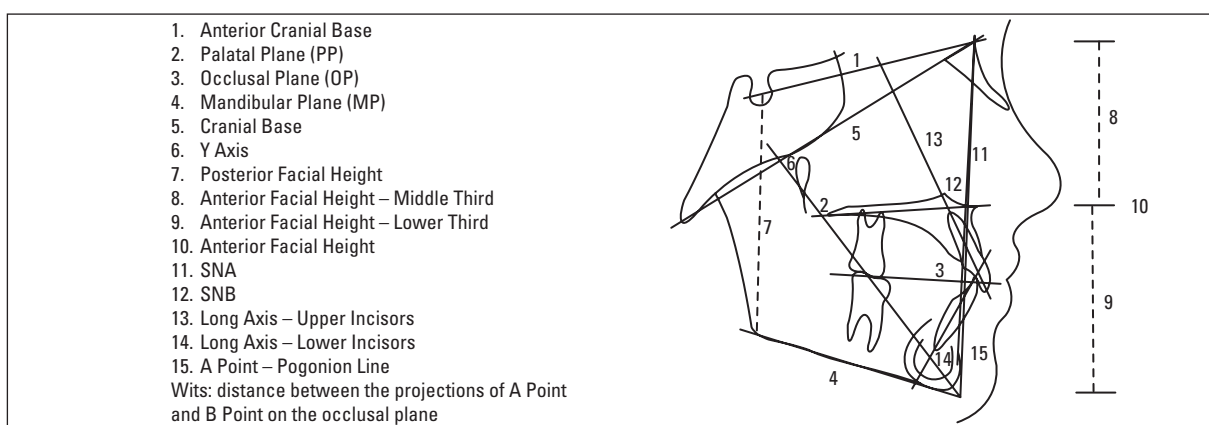


FIGURE 2 - Cephalometric analysis.

The means and standard deviations of the described cephalometric measurements (Fig 2) were provided by a Brazilian cephalometric atlas.¹¹ The values were allocated by age and gender and the means and standard deviation were z-scored, before the mathematical modeling.

The selected cephalometric variables were divided in three units:

» Unit I: related to the anteroposterior discrepancy. Variables: divided into two levels of information (level 1 prioritized to level 2). The level 1 included the variables ANB and Wits. In the level 2, there was a composition of the results of level 1 with the variables SNA and SNB.

» Unit II: related to the vertical skeletal discrepancy.¹² Variables: 1) S-Go/N-Me Proportion; 3) Y Axis angle and; 3) SN/PP, SN/OP and SN/MP angles.

» Unit III: related to the dental discrepancies. Variables: divided into three different levels (without priority): 1) Upper incisors: U1.PP angle, U1.SN angle and the linear measurement U1-NA, taking in account the SNA angle (from Unit I); 2) Lower incisors: L1.APg angle, L1.NB angle, L1.GoMe angle and the linear measurements L1-APg and L1-NB, taking in account the SNB angle (from the unit 1); 3) Relationship between the upper and lower incisors: U1.L1 angle.

LIMITATIONS OF THE CONVENTIONAL CEPHALOMETRIC ASSESSMENT

Considering that the average of the ANB angle for a young adult (18 year-old male) is 2° (Skeletal Class I) and the orthodontist wants to evaluate the anteroposterior relationship using such cephalometric reference, even assuming that significant limitation is involved, let us describe such conventional cephalometric diagnostic process.

It is well known that the use of cephalometric variables assumes landmark location, tracing reproducibility, clinical significance errors and others. To exemplify some of them, in such particular case, the ANB value may incorporate errors such as the position of the Nasion (due to the length and/or inclination of the anterior cranial base), the limited identification of A point and the vertical facial features of the assessed patient. Observe that such errors may be due to the limitations of the cephalometric method or due to the geometrical camouflage. Geometrical camouflage is, for instance, the ANB angle be smaller than the actual discrepancy because of a long or steep anterior cranial base.

Independent of the nature of the limitation, methodological or geometrical, the possible use of the ANB angle takes to the next question: "In this specific case, which value for the ANB angle

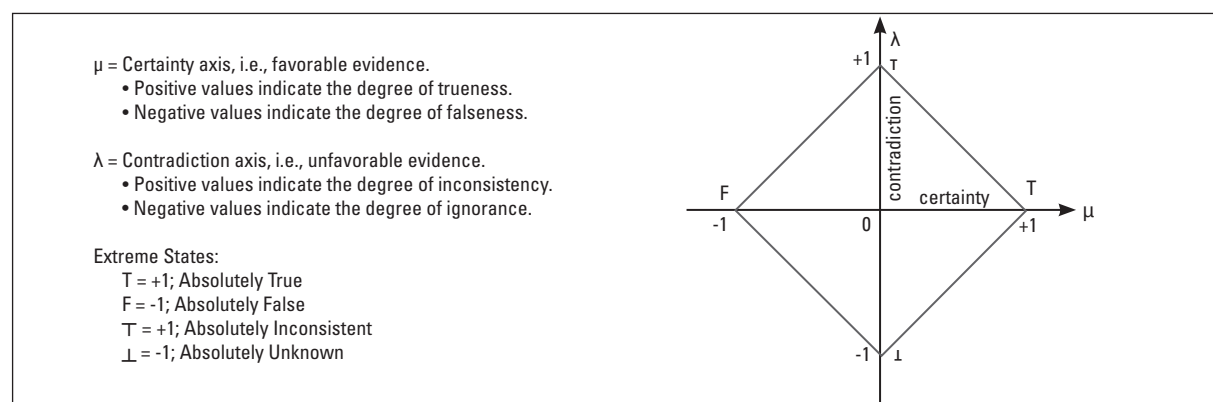


FIGURE 3 - Description and graphic illustration of the "basal cell" of the paraconsistent logics.

would be coherent with an actual scenario of skeletal Class II or Class III?" In the most of the cases, the answer is not clear. Other cephalometric information as Wits, SNA, SNB (and many others) could be elected to help to answer such question.

NEURAL NETWORK AND PARAconsistent LOGIC

The model of "artificial intelligence" applied in the current project, targeting to enhance the meaning of conventional cephalometric data, makes decisions in each one of the "nodes" of the proposed neural network, filtering degrees of certainty and contradiction. As a result, in each assessed case, degrees of evidence of abnormality

quantify the favorable and unfavorable evidences for each attribute of interest, for each region or dimension considered by the program.

CONTEXTUALIZING CEPHALOMETRIC VARIABLES

The statement can be formulated under a different view: "In this case, how high or low/negative is necessary for the value of ANB to allow certainty that it is a skeletal Class II (or Class III)?" Such quantification is represented by the axis $[\mu]$ (Certainty Axis, Fig 3). An extremely high ANB value, which clearly indicates a skeletal Class II, could be, for instance, 10° (Fig 4). It can be affirmed that, if ANB is equal or higher than 10° ,

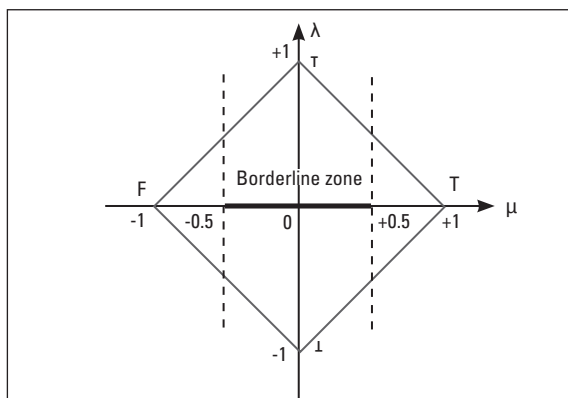


FIGURE 4 - Borderline zone.

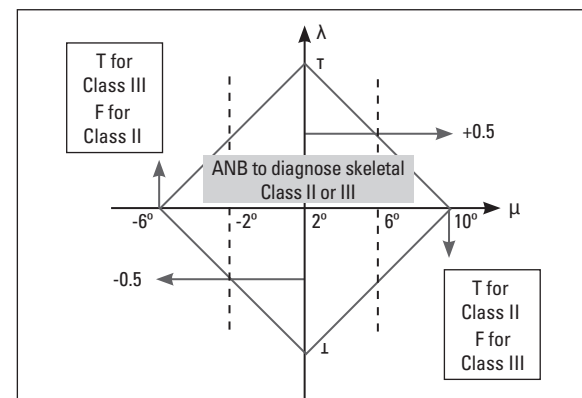


FIGURE 5 - Examples of ANB angles.

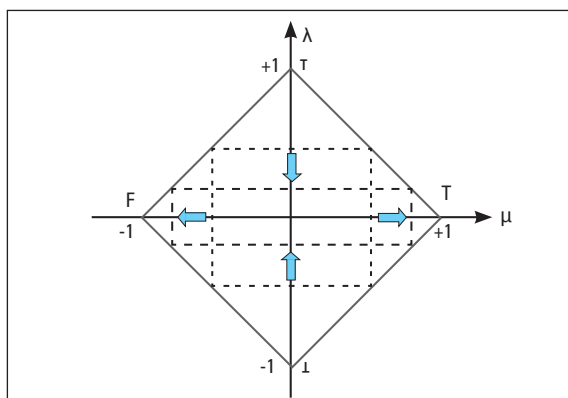


FIGURE 6 - The $[\mu]$ values distant from the norm correspond to the decrease of the $[\lambda]$ values.

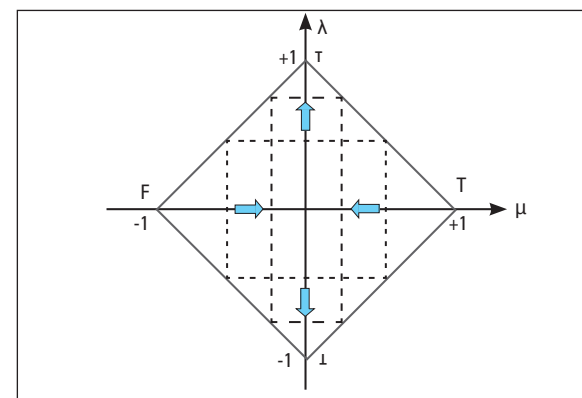


FIGURE 7 - The $[\mu]$ values near to the norm correspond to the increase of the $[\lambda]$ values.

$T = +1$ and the individual clearly presents a skeletal Class II. In the same manner, an extremely low value for skeletal Class III could be, for instance, -6° (Fig 5). If ANB is equal to or lower (negative) than -6° , $F = -1$, and the individual clearly does not present a skeletal Class II. Degrees of trueness (T) and falseness (F) are represented with a “mirror image” (Fig 5) in order to show the possibility of the discrepancy to be a scenario of skeletal Class II or skeletal Class III.

The intermediary values, in between the extreme states already mentioned, are located in the borderline zone $0.5 \leq \mu \leq 0.5$ (Fig 4); that means that the graphic shows ANB values, that in this case, cannot guarantee trueness or falseness of the occurrence of events like skeletal Class II or Class III.

Over the $[\mu]$ axis, as far as the ANB value is distant from the norm, the degree of contradiction showed in the $[\lambda]$ decreases, for skeletal Class II or III, since such ANB angle reflects with lesser uncertainty a skeletal discrepancy (see arrows, Fig 6).

When the ANB angle is close to the norm (or is the norm), the scenario of a skeletal discrepancy only occurs if the information “ANB angle” is significantly inconsistent or unknown (see arrows, Fig 7). If $[\lambda]$ is the extreme value $\top = +1$, means that is absolutely inconsistent with the scenario of a skeletal Class II or Class III and if $[\lambda]$ is the extreme value $\perp = -1$, means that the value is absolutely unknown to identify such scenario.

SAMPLE FOR VALIDATION OF THE PROPOSED MODEL

The sample for validation consisted of 120 cephalometric tracings, retrospectively analyzed, of Caucasian individuals which sought for orthodontic treatment in a private office, which radiographs were consecutively selected from the files of the author. Such sample included 53 males and 67 females, from 06 to 53 year-old. Twenty two patients (18.3%) were older than 18 year-old and were considered adults. The inclu-

sion criteria for this specific sample were: 1) To be Caucasian (to match the data of the atlas¹¹) and; 2) To have a lateral radiograph taken in the same cephalostat (Lúmina Radiologia, São Paulo, SP, Brazil). The exclusion criteria were: 1) To present any craniofacial deformity or syndrome and; 2) Radiographs with bad quality (head positioning or processing).

DATA COLLECTION

The lateral radiographs were traced by an orthodontist-operator and digitalized by other operator. A 0.03 mm mechanical pencil and orthodontic acetate paper were used for the orthodontic tracing. The tracings were digitalized in the Summasketch III table (Summagraphics Corporation, Scottsdale, AZ, USA) and collected by software developed to operate the cephalometric electronic system (Iris Informática, São Paulo, SP, Brazil).

SYSTEMATIC AND METHOD ERRORS

In order to calculate the systematic and method errors (Dahlberg¹³ formula), a sub-sample of 15 radiographs, chose by random selection (one in every five radiographs, starting with the 20th case of the sample) was re-traced and re-digitalized, in a 4 week interval. Taking into consideration both operators, there was no statistically significant systematic error for any assessed cephalometric variable. Taking into consideration both operators again, the method error varied from 0.46 mm (S-Go variable) to 0.94 mm (N-ANS) and from 0.33° (Y axis variable) to 0.94° (SN-OP variable).

MATHEMATICAL-COMPUTATIONAL MODELING

The system was developed considering eighteen cephalometric landmarks, modeled by 223 Boolean inference rules, which resulted in 405 possible categories. The software code-sources for both, mainframe and feeder, are described in ap-

proximately 10 thousand lines of Delphi language (Release 8.0, Borland Inc., Austin, TX, USA) and compatible the Oracle platform (Oracle Corp., CA, USA) by the company Iris Informática (São Paulo, SP, Brazil).

EXAMINERS SELECTION

The tracings and cephalometric values were submitted to three examiners, selected according to their academic education and clinical experience. Inclusion criteria: 1) To hold a PhD degree and; 2) To be involved in research projects and a recognized university and also practice clinical orthodontics. The exclusion criteria were: 1) To know the project by contact with the author and; 2) To demonstrate preference or rejection biases for any cephalometric variable or cephalometric analysis.

STATISTICAL TOOLS

The validation sample (120 cases) was submitted to four assessments: three examiners assessments (subjective and qualitative) and electronic cephalometric analysis (objective and quantitative). The data from all the collections (examiners and software) were pooled and computed by the SPSS statistical package (Release 10.0; Chicago, IL, USA).

RESULTS

The developed neural network contextualized cephalometric data throughout its “synapses”, connecting the values $[\mu]$ and $[\lambda]$ of the cells.

The performance of the software was assessed by Kappa agreement indexes,¹⁴ which pa-

rameters are presented in the Table 1. The opinions of the three examiners (E1, E2, E3) were tested against the performance of the software, besides the indexes of agreement between the examiners without the software (Table 2).

The Kappa index of agreement was fair for anteroposterior discrepancies, substantial or fair for vertical discrepancies and mainly moderate for dental discrepancies. For the bimaxillary protrusion, the agreement was almost perfect. Furthermore, the agreement among the opinions of the three examiners was moderate for skeletal and dental discrepancies and almost perfect for the bimaxillary protrusion.

DISCUSSION

Neural artificial networks can be described as computational systems which allow the connection among “cells”. As biological neurons, the “artificial neurons” are united by “synapses”, which connections might be “excitatory or inhibitory”.

TABLE 1 - Meaning of the Kappa indexes of agreement.¹⁴

Kappa Index	Meaning
0.00	No agreement
0.00-0.19	Poor agreement (P)
0.20-0.39	Fair agreement (F)
0.40-0.59	Moderate agreement (M)
0.60-0.79	Substantial agreement (S)
0.80-1.00	Almost perfect agreement (AP)

TABLE 2 - Kappa indexes between the examiners and the software, and also among the examiners.

Attribute of Interest	E1 X Software	E2 X Software	E3 X Software	E1 X E2 X E3
Anteroposterior discrepancy	0.34 – (F)	0.29 – (F)	0.37 – (F)	0.49 – (M)
Vertical discrepancy	0.75 – (S)	0.37 – (F)	0.67 – (S)	0.53 – (M)
Upper incisors positioning	0.44 – (M)	0.22 – (F)	0.45 – (M)	0.47 – (M)
Lower incisors positioning	0.45 – (M)	0.08 – (P)	0.46 – (M)	0.42 – (M)
Upper and lower incisors	0.92 – (AP)	0.85 – (AP)	0.89 – (AP)	0.84 – (AP)

The advantage of the use of neural artificial networks in regard to the conventional computational programming is its ability to solve problems that do not have direct algorithm solutions or the solutions are very complex, as the cases of predictions and pattern recognition, and therefore would demand intense computational processing.

The present model of artificial intelligence was formatted to prevent inefficient cycles of data processing, since it makes partial and progressive decisions in which one of its “synapses”, simultaneously modeling certainty and contradiction, before providing a final decision. Such strategy increases its capacity of data mining throughout the decision tree.

Sophisticated mathematical models have been developed in various areas of Medicine for drug development,¹⁵ for clinical diagnosis,¹⁶ and for image diagnosis interpretation.¹⁷ In all these situations, the neural networks allows for the recognition of hidden patterns and, as logical and direct consequence, better predictions.

In our model of neural network and paraconsistent logic, in which we visualized the contextualization of cephalometric variables, the “artificial thinking” was presented considerably alike the “human being thinking”. It is interesting to highlight the fact that the agreement among the three examiners, in regard to the skeletal and dental discrepancies and without any interference of any electronic diagnosis tool, was just moderate. Such fact exposes an important degree of controversy among subjective opinions, even those given by specialists paired by academic education and clinical experience. In the other hand, in regard to the bimaxillary dental projection, measured by the relationship between the upper and lower incisors, the agreement is almost perfect, indicating that the examiners can well recognize a pattern of dental protrusion or dental retroclination with better homogeneity than to identify skeletal discrepan-

cies or individual dental discrepancies in each one of the jaws, maxilla or mandible.

It is also important to point out that the exclusion criteria for sample selection was not to include an individual that was not Caucasian. If it was the case, its values comparison with the reference atlas¹¹ would not be correct. The examiners were warned about such bias and they have given their opinion, considering the bimaxillary dental projection case-to-case, for Caucasian individuals. If other ethnicities were also considered, for instance afro-Americans, probably the opinions of the examiners about the bimaxillary dental positioning would not be so homogeneous.

In the daily practice, usually borderline scenarios provoke different opinions among diverse specialists. Therefore, in the case of controversial and subjective opinions, to expect substantial or almost perfect agreement for borderline scenarios would be incoherent. In support of that expectation, our results suggest that the given opinions and the electronic measurement of the software converge in most of the cases.

It is important to highlight that subjective comparisons, as is the case of the opinions given by the examiners, do not hold a golden standard of answer. There is no right or wrong. Therefore, it can be stated that the software is not better or worse than the specialists in orthodontics in order to detect cephalometric discrepancies. The “machine” diagnosed as it were “one other specialist”.

Without a defined golden standard, lack of a better agreement might be interpreted in two different ways, equally relevant: 1) there is certain difficulty for the software to contextualize cephalometric variables and electronically diagnose an orthodontic case and/or; 2) there is certain difficulty for the orthodontists to interpret cephalometric information and sum them up in a final cephalometric consensus. There is no way to know if both situations occurred and if one

was more relevant than the other. Theoretically, therefore, the comparison is relative or, if conservatively interpreted, immeasurable.

However, in certain aspects, as systematization and time consuming, there is clear advantage in the use of an electronic diagnostic system. Because its processing, which is mathematical-computational, is absolutely constant, standardized and clearly quicker, since it does not depend upon subjective and, up to certain point, random human opinions.

The project had also as proposal to know the ranking of difficulty to diagnose different types of discrepancies, skeletal or dental. This is the ranking: the software was less effective for the anteroposterior relationships than for the vertical and dental discrepancies, as happened with the examiners as well. In the bimaxillary relationships between upper and lower incisors, both the electronic diagnosis, as the opinions of the examiners, were expressively homogeneous.

Another characteristic to be discussed is the nominal allocation. For the anteroposterior discrepancy (unit I), 5 classes were determined. For the vertical discrepancy (Unit II) and dental discrepancy (Unit III), only 3 classes were established. Naturally, in terms of probability, a better agreement is expected as less options are given to the software or to the examiners. Therefore, the ranking must be understood by the reader with such bias: in the study design the probabilities were not matched before the assessment. Realistically, the nominal classes were established according to the usual classi-

fication given by clinical orthodontists in each one of the described scenarios.

In sum, in general view, the opinions of the examiners were qualitative and subjective, therefore, up to certain point, non-equalized and vulnerable, besides the fact that they demanded long time to be obtained. On the other hand, the software offered quantitative and objective answers, better equalized and that were obtained significantly faster than the agreement between specialists.

CONCLUSION

A mathematical-computational model was developed in order to extract hidden cephalometric patterns from conventional cephalometric data, throughout the quantification of its imprecision and conflicts. The mathematical modeling refined and contextualized cephalometric values, allowing a sound “electronic thinking”, comparable to the opinions of specialists in orthodontics.

Therefore, our results support that, in general, the “electronic opinions” presented by the software are comparable to the human opinions. As an expected limitation, since for malocclusion the electronic perception could not be better than the human perception, the sensibility of the described electronic tool was, as the human, lower for skeletal discrepancies than for anteroposterior dental projections.

ACKNOWLEDGMENTS

We thank the orthodontists Dr. Selaimen and Dr. Brandão for their opinions as examiners.

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Submitted: October 2008
Revised and accepted: February 2009

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Comparative study of facial proportions between Afro-Brazilian and white Brazilian children from 8 to 10 years of age*

Cassio Rocha Sobreira**, Gisele Naback Lemes Vilani**, Vania Célia Vieira de Siqueira***

Abstract

Objective: To evaluate the vertical facial proportions of Afro-Brazilian and white Brazilian female children, aged 8-10 year-old, and to evaluate differences between the race groups.

Methods: The authors evaluated 70 cephalometric radiographs, in lateral norm, equally divided into the two groups, 22 at 8-year-old, 18 at 9-year-old, and 30 at 10-year-old. All the patients showed harmonious facial esthetics, normal occlusion and none of them were subjected to previous orthodontic treatment. The following proportions were evaluated: LAFH/TAFH (ANS-Me/N-Me), TPFH/TAFH (S-Go/N-Me), LPFH/TPFH (Ar-Go/S-Go), LPFH/LAFH (Ar-Go/ANS-Me). Data were analyzed by descriptive statistics and Student's t-test in order to compare the differences between the race groups, ANOVA with Bonferroni's test for comparison between the ages and Pearson's correlation coefficient to examine the level of association between facial proportions. Statistical analysis was performed at the 0.05 level of significance. **Results:** The findings showed no statistically significant differences between the groups and between the ages for each group, for all variables. **Conclusion:** There were no significant differences in facial proportions between Afro-Brazilian and white Brazilian female children. The facial proportions remained constant from 8 to 10 years of age, regardless the racial group.

Keywords: Cephalometrics. Facial proportions. Afro-Brazilian children. White Brazilian children.

INTRODUCTION AND LITERATURE REVIEW

Nowadays, many researches^{9,18,19,23,29} are increasingly trying to improve scientific knowledge of cephalometry, especially those related to the vertical dimensions of the face, since many experienced clinicians agree that the malocclusion with

marked facial vertical imbalance generally are more difficult to treat and have less stability than those with severe anteroposterior discrepancy.²⁵ The control of the vertical dimension of the face represents a point of fundamental importance to the success of orthodontic treatment.^{13,25,29}

* This article is based on research submitted by the first author in partial fulfillment of the requirements for the Master of Science in Dentistry (Orthodontics) degree, Department of Orthodontics, Pontifical Catholic University of Minas Gerais - PUC/Minas.

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The lack of attention from the orthodontist's side in this regard would help a retrusive positioning of the chin^{13,25,26,29} due to clockwise mandibular rotation, worsening facial esthetics.

Aiming at finding a normal pattern in the vertical proportions of the face, several authors^{4,5,6,14,17,18,20,30} have established mean values considered normal for these proportions, noting that patients with such measures or who were close to them, had more balanced and harmonious faces.

Although there are several studies^{4,5,7,12,14,17,18,20,21,22,27,30} evaluating facial proportions, few of them have set out to check these proportions in young black individuals^{19,23}. Knowing that this group has some craniofacial characteristics that are different from the white individuals,^{1,2,10,11,15,16} on which the routinely used data are based for diagnosing and planning the orthodontic treatment, one sees the need for further studies concerning the black subjects.

In a comparative study between white and black subjects, it is important to clearly distinguish from an anthropological point of view, so that no subjective aspects guide the indication of what individual belongs to which racial type. Skin color, hair type, and nasal and labial morphology are characteristics of utmost importance in determining the racial type,³ since the white individuals present fair skin, straight or wavy hair, high and thin nose and thin lips, while the black individuals exhibit dark skin, coiled hair, low and flat nose and bulky lips. The term "race" seems more appropriate for anthropological studies, since it expresses biological characteristics of the population studied, as opposed to "ethnicity", which indicates socio-cultural aspects.²⁴

While comparatively studying cephalometric characteristics between the races Afro-Brazilian and white Brazilian, according to Downs and Sassouni's analysis, we observed higher absolute values, as well as dental and labial double-protrusion in the Afro-Brazilian group². The mandibular plane

was more inclined, the maxilla was more anteriorly positioned and the dental double-protrusion was more prevalent in the black children when compared to the white ones¹⁰. The dental double-protrusion in Afro-Brazilians is the result of a wider mandibular ramus in this racial group,¹¹ and the lip double-protrusion is a normal feature indicating that the normal values of the facial profile, recommended in Ricketts's, Steiner's, and Holdaway's analysis, cannot be applied to that group.²⁸

For females, most of the craniofacial growth occurs before menarche, in most cases occurring early in the second decade of life.⁸ Thus, it becomes imperative to know the normal standards of young women in pre-menarche so that the diagnosis and treatment can be applied in time to obtain satisfactory results.

The aim of this study is to assess and quantify the facial proportions observed in cephalometric radiographs obtained in lateral norm, from Afro and white Brazilian females, from 8 to 10 years of age, searching for differences in proportions between races and ages, within each racial group. Also, we intend to verify the presence of a correlation between different facial proportions.

MATERIAL AND METHODS

The development of this research was initiated only after submission and approval of the Ethics Committee in Research at PUC Minas, under the number 135/2004.

The sample for this retrospective cross-sectional study consisted of 70 cephalometric radiographs, taken in lateral norm, from 70 young Brazilian females, 35 white and 35 black, ages 8, 9 and 10 years. The sample was evenly distributed among the racial groups according to age groups, being 11 8-year-old children, 9 9-year-old children, and 15 10-year-old children for each racial group.

The classification of the children as Afro or white Brazilian followed the anthropological characteristics such as skin color, hair type, nose and lip morphology described by Ávila.³

The inclusion criteria adopted for the sample selection were based on Siqueira and Prates's²⁶ work and included: chronological age of 8, 9 and 10 years; Brazilian nationality; radiographic images with adequate sharpness and contrast, without distortion; general good health; harmonious facial profile with passive lip seal; absence of facial asymmetries; profile tending to straight in white, and bimaxillary protrusion of mild to moderate intensity in the Afro-Brazilians; normal occlusion; no previous orthodontic treatment; and black and white racial types with descent of the same racial type.

The development of the cephalograms was based in Bishara's,⁴ Jarabak and Fizzel's,¹⁷ Nanda's²¹, Nanda and Rowe,²² and Schendel et al's²⁵ postulates, identifying the dentoskeletal and tegumental profile structures that allowed the demarcation of the following points and lines (Fig 1):

- 1) N-Me - distance between points N and Me. Represents the total anterior facial height (TAFH).
- 2) ANS-Me - distance between points ANS and Me. Represents the lower anterior facial height (LAFH).
- 3) S-Go - distance between points S and Go. Represents the total posterior facial height (TPFH).
- 4) Ar-Go - distance between points Ar and Go. Represents the lower posterior facial height (LPFH).

According to the works of Bishara and Jakobsen,⁵ Horn,¹⁴ Jarabak and Fizzel¹⁷ and Wylie and Johnson,³⁰ we used the following measurements for evaluation of vertical craniofacial proportions:

- 1) ANS-Me/N-Me - Proportion between LAFH and TAFH.
- 2) S-Go/N-Me - Proportion between TPFH and TAFH.
- 3) Ar-Go/S-Go - Proportion between LPFH and TPFH.
- 4) Ar-Go/ANS-Me - Proportion between LPFH and LAFH.

Statistical methodology

All tracings and measurements were performed twice, at random, with an interval of approximately 30 days, by the same investigator and checked by a second, obtaining two measures, knowing that the mean values were used for statistical analysis. For verification of random error between the first and second measurements, we used Dalhberg's formula.

The descriptive analysis consisted in demonstrating the values of the variables and in the calculation of the synthesis (mean) and variability (standard deviation) measures, besides the minimum and maximum values. For comparison of means between groups of young white and Afro-Brazilians we used the Student's t-test. In the intraracial assessment between the ages of 8, 9 and 10 years, we used the ANOVA (Analysis of Variance) with Bonferroni's test indicating where the differ-

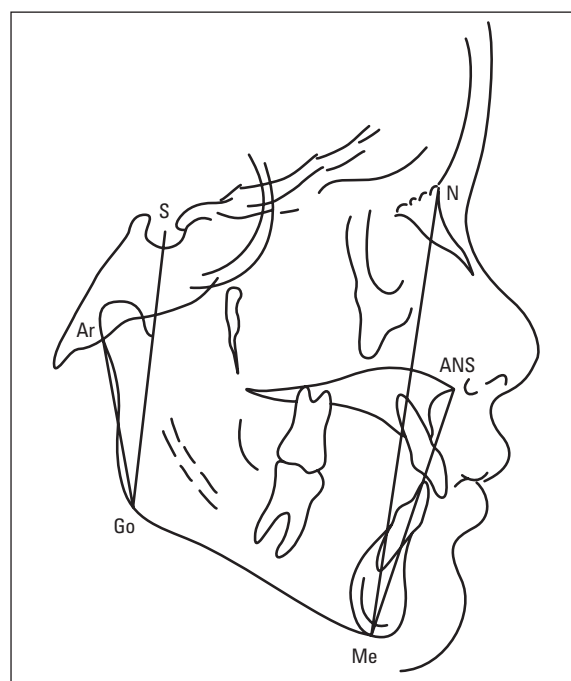


FIGURE 1 - Landmarks and lines that were used in this study.

ence occurred. To determine the degree of association between the different proportions, we used Pearson's correlation coefficient. The level of significance previously defined for this study was 5%.

RESULTS

The verification of random error between the first and second measurements did not show any significant errors in any variable mea-

sured, indicating the reliability of the cephalometric values obtained (Table 1).

Table 2 shows the mean values, standard deviations and Student's t-test results for proportions LAFH/TAFH, TPFH/TAFH, LPFH/TPFH and LPFH/LAFH for the white and Afro-Brazilian groups. According to the results, no statistically significant differences were found between the groups.

The ANOVA results for the proportions LAFH/TAFH, TPFH/TAFH, respectively, showed no statistically significant differences, considering the groups separately and the total sample, but pointed to the existence of statistically significant differences for the proportions LPFH/TPFH and LPFH/LAFH, considering the total sample (Table 3).

Thus, we performed Bonferroni's test in order to identify at what point was the difference

TABLE 1 - Random error for measurements according to Dahlberg's formula.

Measurements	Values
Total Anterior Facial Height (TAFH)	0.77
Lower Anterior Facial Height (LAFH)	0.64
Total Posterior Facial Height (TPFH)	0.65
Lower Posterior Facial Height (LPFH)	0.92

TABLE 2 - Mean values, standard deviations, and values for Student's t-test for the proportions LAFH/TAFH; TPFH/TAFH; LPFH/TPFH and LPFH/LAFH, according to the racial group, age and total sample.

Proportion	Mean values and s.d. for White children at 8, 9, and 10 years of age and for the total sample				Mean values and s.d. for the black children at 8, 9, and 10 years of age and for the total sample				p values			
LAFH/TAFH	0.55 (±0.02)	0.57 (±0.01)	0.55 (±0.01)	0.55 (±0.01)	0.56 (±0.02)	0.56 (±0.01)	0.55 (±0.02)	0.56 (±0.02)	0.063 ^{NS}	0.778 ^{NS}	0.771 ^{NS}	0.218 ^{NS}
TPFH/TAFH	0.63 (±0.03)	0.63 (±0.03)	0.64 (±0.04)	0.63 (±0.03)	0.64 (±0.02)	0.62 (±0.02)	0.61 (±0.04)	0.62 (±0.03)	0.387 ^{NS}	0.734 ^{NS}	0.167 ^{NS}	0.371 ^{NS}
LPFH/TPFH	0.61 (±0.03)	0.59 (±0.02)	0.60 (±0.01)	0.60 (±0.02)	0.61 (±0.03)	0.58 (±0.02)	0.59 (±0.03)	0.60 (±0.03)	0.807 ^{NS}	0.406 ^{NS}	0.527 ^{NS}	0.587 ^{NS}
LPFH/LAFH	0.71 (±0.07)	0.66 (±0.05)	0.69 (±0.04)	0.69 (±0.06)	0.70 (±0.07)	0.64 (±0.04)	0.66 (±0.07)	0.67 (±0.06)	0.846 ^{NS}	0.559 ^{NS}	0.169 ^{NS}	0.221 ^{NS}

NS = non-significant, p>0.05.

TABLE 3 - Analysis of Variance (ANOVA) results for the proportions LAFH/TAFH; TPFH/TAFH; LPFH/TPFH and LPFH/LAFH for age, in each racial group, and for age and race, in the total sample studied.

Proportions	F and p values > F for white children	F and p values > F for black children	F and p values > F for the total sample
LAFH/TAFH	3.13 / 0.057 ^{NS}	0.86 / 0.433 ^{NS}	1.92 / 0.154 ^{NS}
TPFH/TAFH	0.21 / 0.811 ^{NS}	1.79 / 0.183 ^{NS}	0.43 / 0.654 ^{NS}
LPFH/TPFH	1.10 / 0.345 ^{NS}	2.57 / 0.091 ^{NS}	3.72 / 0.029*
LPFH/LAFH	1.69 / 0.200 ^{NS}	1.85 / 0.174 ^{NS}	3.32 / 0.042*

* Significant (p<0.05); NS = Non-significant.

TABLE 4 - Bonferroni's test for comparing the variance of the proportion LPFH/TPFH according to age.

AGE	8	9
9	- 0.026 0.026*	
10	- 0.014 0.276	- 0.011 0.627

* Significant (p<0.05).

for the proportion LPFH/TPFH (Table 4).

The value found has a negative sign, indicating that the mean observed at 9 years was smaller than the mean observed at 8 years of age. The value in bold indicates that the significant difference occurred between 8 and 9 years of age.

We also performed Bonferroni's test in order to identify at what point was the difference in the proportion LPFH/LAFH (Table 5).

The value found has a negative sign, indicating that the mean observed at 9 years was lower than the mean observed at 8 years of age. The value in bold indicates that the significant difference occurred between 8 and 9-year-old.

To verify the degree of association between the proportions, we used Pearson's correlation coefficient, where the observed values for both variables in a single observational unit are compared and the quantification of the correlation

is given by Pearson's coefficient "r". It is the mean product of standard deviations of variables "x" and "y". If its value is negative, it indicates that when the value of a variable (x) increases, the value of another variable (y) decreases or vice versa. In case of a positive value, it means that the two variables have changing values in the same direction. Two variables have a perfect correlation when the value of "r" is equal to 1.00; and there is total lack of correlation when "r" takes the value zero. Values equal to or greater than 0.90 indicate the presence of a strong correlation, between 0.50 and 0.90, of moderate correlation. Values below 0.50 indicate a weak correlation.

According to Table 6, the results indicated the presence of a mild correlation between the variables under evaluation. Positive and significant correlations were observed between LPFH/LAFH with TPFH/TAFH and with LPFH/TPFH; negative and significant correlation was observed between LPFH/LAFH with LAFH/TAFH. All these correlations can be classified as moderate. The other correlations are weak and non significant.

The results among black Brazilian children were very similar to those among the white children, in relation to the statistical significance of correlations, observing the positive correlations between LPFH/LAFH with TPFH/TAFH and with LPFH/TPFH, but with slightly higher intensity than the white children (Table 7).

TABLE 5 - Bonferroni's test for comparing the variance of the proportion LPFH/LAFH according to the age.

AGE	8	9
9	- 0.052 0.037*	
10	- 0.025 0.467	- 0.026 0.508

* Significant, $p < 0.05$.

TABLE 6 - Pearson's correlation coefficient among the variables LAFH/TAFH; TPFH/TAFH; LPFH/TPFH and LPFH/LAFH in white children (n=35).

Variable	LAFH/ TAFH	TPFH/ TAFH	LPFH/ TPFH	LPFH/ LAFH
LAFH/TAFH				
TPFH/TAFH	-0.065 0.710			
LPFH/TPFH	-0.282 0.100	-0.057 0.742		
LPFH/LAFH	-0.583 0.000	0.663 0.000	0.608 0.000	

TABLE 7 - Pearson's correlation coefficient among the variables LAFH/TAFH; TPFH/TAFH; LPFH/TPFH and LPFH/LAFH in Afro-Brazilian children (n=35).

Variable	LAFH/ TAFH	TPFH/ TAFH	LPFH/ TPFH	LPFH/ LAFH
LAFH/TAFH				
TPFH/TAFH	-0.041 0.812			
LPFH/TPFH	-0.275 0.109	0.249 0.148		
LPFH/LAFH	-0.528 0.001	0.676 0.000	0.802 0.000	

DISCUSSION

Considering that the pattern of facial and skeletal malocclusions are early determined,^{5,8,21} the diagnosis of an imbalance before the maximum period of craniofacial growth would allow a greater usage of this in favor of orthodontic treatment, making it more biological and personal.

The orthodontic literature, referring to cephalometric standards, is highly concentrated in the evaluation of white individuals.^{1,2,10,11,15,16,19,23,24,28} However, studies show differences in the cranio-dento-facial complex between the groups of white and black people, justifying the execution of comparative research, minimizing the use of information that may exert negative influences on the diagnosis and, consequently, on the results of the orthodontic treatment. Features such as greater maxillo-mandibular cephalometric linear measurements,^{1,2,11,15} greater buccal inclination of the incisors,^{1,2,10,11} differences in mandibular plane¹⁰ inclination, more protrusive facial profile,^{2,10,28} and more anteriorly placed maxilla and/or jaw,^{1,10,16} were found in black children when compared to the white ones. Few studies^{19,23} aimed at evaluating the vertical facial proportions in black individuals and in age groups different from the present study.

The proportion LAFH/TAFH reports on the proportional relationships of the anterior region of the face. The higher the LAFH value, the higher the proportion, which indicates a tendency to an open bite. The opposite is true for a pattern of deep bite.^{7,9,12,13,14,20,25,30} In this study, in the groups of white and Afro-Brazilian children, the proportion LAFH/TAFH was at 0.55 and 0.56, respectively, and no statistically significant differences were found between ages or groups. Lopes,¹⁹ assessing white and black children from 4 to 6 years of age with normal primary dentition, found higher values of LAFH for blacks, being 0.60 at 4 and 0.59 at 6 years old and, consequently, higher values from the

proportion LAFH/TAFH.

Among the white children, the results of this study were proved according to Wylie and Johnson,³⁰ where the LAFH represented 0.55 of the TAFH in patients with a good facial standard. Nahoum,²⁰ evaluating patients with normal occlusion and good facial profile, found the value 0.55, without specifying age. In young Brazilians with Angle Class I, between 8 and 11 years-old, Locks et al¹⁸ found a value of 0.58 for LAFH.

The proportion TPFH/TAFH, also called facial height ratio,¹⁷ informs the proportional relationships of the posterior region of the face with the anterior region. The lower the value of TPFH and/or higher the value of TAFH, the lower the proportion, indicating a tendency to an open bite. The opposite is true for a pattern of deep bite.^{9,17,28}

In this study, in the white and Afro-Brazilian group, this proportion was 0.63 and 0.62, respectively, and was not found statistically significant differences among ages or groups. These values are close to those observed by Lopes,¹⁹ who obtained 0.62 at 4 years and 0.61 at 6 years old for white, and 0.60 at 4 years and 0.61 at 6 years old for black children with no statistically significant differences between races and ages.

Among white subjects, Jarabak and Fizzel,¹⁷ in a study of 200 patients of both sexes aged between 17 and 20 years and Bishara,⁴ studying female patients from 4.5 to 12-years-old, affirmed that this proportion should be 0.65, being the mean of the present study compatible with the value previously recommended by the authors.

The proportion LPFH/TPFH reports the proportional relationships of the posterior region of the face. The lower the value of the SPFH (S-Ar), the lower is the value of TPFH, indicating a tendency to an open bite. This trend will be even worse if the LPFH is also reduced. The opposite is true for a pattern of deep bite.¹⁷ According to Jarabak and Fizzel,¹⁷ the ideal proportion of SPFH/LPFH at the age

of 11 would be 3:4, or 0.75; i.e., the proportion LPFH/TPFH would be 4:7, or 0.57. However, one must consider the sum of the sella (N.S.Ar), articular (S.Ar.Go) and gonial (Ar.Go.Me) angles, which, in patients with balanced faces, is $396 \pm 6^\circ$.

In this study, in the white and Afro-Brazilian group, this ratio was 0.60 and 0.60, respectively, and statistically significant differences between the races were not found. Evaluating the total sample and considering the age group, this proportion was significantly higher at 8 years of age (0.61) than at 9 (0.59). These results occurred due to a higher mean of the TPFH and lower of the LPFH at the age of 9 in both races, indicating a changing pattern of these measures among the children within one year.

The absence of statistically significant differences between the races and ages studied for the values of the proportion LPFH/TPFH was also observed by Lopes¹⁹ when evaluating the normal deciduous dentition in white and black children, since the author obtained values of 0.58 for 4-year-old and 0.58 for 6-year-old for white, and 0.58 for 4-year-old and 0.57 for 6-year-old for black children.

In white individuals, Bishara, Peterson and Bishara⁶ found that in female patients, age 10, with clinically acceptable occlusion, this proportion was 0.64; against 0.60 in the present study, this difference occurred due to a higher mean value of the LPFH in the first work. According to Bishara and Jakobsen,⁵ this proportion does not vary significantly in patients with balanced facial pattern from 10 to 26-year-old.

The proportion LPFH/LAFH, also called the facial height index,¹⁴ informs the proportional relationships of the lower, posterior, and anterior regions of the face. The lower the LPFH value and/or higher the LAFH value, the lower the proportion, indicating a tendency to a skeletal open bite. The opposite is true for a pattern of deep bite.^{13,14,18,20,29}

In this study, in the white and Afro-Brazilian group, this ratio was 0.69 and 0.67, respectively, with no statistically significant differences between the races. Considering the total sample and the age group, this proportion was significantly higher at 8 (0.70) than at 9-year-old (0.64). These results were mainly due to a higher mean of the LAFH for 9-year-old in both groups.

Evaluating white patients with an average age of 11 years, Horn¹⁴ found a mean number of 0.70, similar to that found in this study. According to this author, cases with values below 0.55 and above 0.85 should be considered for surgical treatment.¹⁴ Studying white Brazilian children of both sexes, 8-11 year-old, Locks et al¹⁸ found the value of 0.66.

Lopes¹⁹ assessed the proportion LPFH/LAFH in white and black children with normal deciduous dentition, from 4 to 6-year-old, and found 0.61 and 0.61 for the white and 0.58 and 0.59 for the black children at 4 and 6 years old, respectively, which indicates a lower value of LAFH in these ages. Nouer²³ evaluating young females with excellent occlusion, from 10 to 14-year-old, found the value of 0.69, similar to that found in this study. This could suggest a pattern of maintenance of this ratio in Afro-Brazilian females with normal occlusion, from 8 to 14-year-old.

According to the results obtained in this study, no variable showed a strong correlation value, either positive or negative, with any other, indicating no solid interaction pattern between them.

The behavior between the racial groups was very similar. Positive correlations were observed between LPFH/LAFH with TPFH/TAFH and LPFH/TPFH. A negative correlation was observed between LPFH/LAFH with LAFH/TAFH. All these correlations were significant and classified as moderate. The other correlations proved weak and non-significant.

CONCLUSIONS

According to the methodology used and the results obtained, we concluded that:

- 1) Comparing the groups Afro and white Brazilians, no significant differences between them were identified in any of the measured facial proportions.
- 2) There were moderate correlations between LPFH/LAFH with TPFH/TAFH and LPFH/

LAFH with LPFH/TPFH in the white children group.

- 3) There were moderate correlations between LPFH/LAFH with TPFH/TAFH and a stronger correlation between LPFH/LAFH with LPFH/TPFH in the black children group. These correlations were slightly higher than those presented by the white children group.

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Submitted: August 2007
 Revised and accepted: February 2010

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Evaluation of the shear bond strength of two composites bonded to conditioned surface with self-etching primer

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Abstract

Aim: The aim of this study was to evaluate the shear bond strength and the Adhesive Remnant Index (ARI) between the composites Eagle Bond and Orthobond bonded to an enamel surface conditioned with Transbond Plus Self-Etching Primer. **Methods:** Seventy-five bovine permanent mandibular incisors, divided into five groups (n=15) were used. In Groups 1, 2 and 4, the bonds were performed with Transbond XT, Orthobond and Eagle Bond respectively, in accordance with the manufacturers' recommendations. In Groups 3 and 4, before bonding with Orthobond and Eagle Bond, respectively, the tooth surface was conditioned with the acid primer Transbond Plus Self-Etching Primer. After bonding the shear test was performed of all samples at a speed of 0.5 mm per minute in an Instron mechanical test machine. **Results:** The results (MPa) showed that there were no statistically significant differences among Groups 1, 2, 3 and 5 ($p>0.05$). However, these groups were statistically superior to Group 4 ($p<0.05$). The ARI (Adhesive Remnant Index) results showed a higher number of fractures at the bracket/composite interface in Groups 1, 2, 3 and 5.

Keywords: Composite resins. Shear bond strength. Orthodontic brackets.

INTRODUCTION

Until the 1960s, an orthodontic appliance was assembled by fabricating bands on all the teeth. This procedure was extremely work-intensive, with a long chair time, discomfort for the patient, difficult to clean, esthetically unfavorable and after the appliance was removed, spaces remaining between the teeth were observed.²

Replacement of the banding system by accessories bonded directly to the tooth enamel was an advancement achieved in orthodontics that benefited not only the patient, but the professional as well. This was only possible due to the classic work of Buonocore,⁶ who observed that acid etching the enamel increased the adhesion of acrylic resin to the tooth surface. As from this discovery,

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various materials for attaching accessories to teeth have appeared.¹⁰ With this development, it became quicker and easier to assemble the appliance, contributing greatly to the popularization of orthodontics.

Although it is simple, the bonding technique requires steps that must be followed in an ordered and careful manner, in order not to compromise accessory bonding to the tooth enamel.⁵ The clinical procedures necessary for adequate bonding with conventional systems are prophylaxis, enamel etching, primer application, composite placement at the bracket base, and bonding itself.^{3,4,5,7}

The bracket bonding technique has been modified and improved over the years. New materials and items of equipment regularly appear, with the purpose of simplifying the procedure and making it faster, however, without losing the quality necessary for attaching the accessory to the tooth, and enabling it to resist the masticatory forces as well as those of orthodontic mechanics.

In view of the wide range of bonding materials at the orthodontist's disposal, it is necessary to know their properties, in addition to testing them, to prove their efficacy. The aim of the present article was to evaluate the shear bond strength and Adhesive Remnant Index (ARI) of orthodontic brackets bonded with the composites Orthobond and Eagle Bond to surfaces etched with phosphoric acid and with a self-etching agent Transbond Plus Self Etching Primer (TPSEP).

MATERIAL AND METHODS

In this *in vitro* study, 75 bovine permanent mandibular incisors were used. They were cleaned, stored in a 10% formaldehyde solution and kept in a refrigerator at an approximate temperature of 6°C.

The teeth were embedded in PVC reduction sleeves (Tigre, Joinville, Brazil) with acrylic resin (Clássico, São Paulo, Brazil), so that only their crowns were exposed. When they were embedded, the buccal surfaces of these crowns

were placed perpendicular to the base of the die with the aid of a 90° set square made of glass, with the purpose of enabling correct mechanical testing. After polishing the resin, all the sets were stored in distilled water and again placed in the refrigerator.

Before bonding, the buccal surfaces of the teeth received rubber cup prophylaxis (Viking, KG Sorensen, Barueri, Brazil), with extra-fine pumice stone (S.S.White, Juiz de Fora, Brazil) and water for 15 seconds. After this they were washed with air/water spray for 15 seconds and dried with an oil- and humidity-free jet of air for the same length of time. After every five prophylaxes, the rubber cup was replaced to standardize the procedure.

After prophylaxis, the test specimens were randomly divided into five groups (n=15) and maxillary central incisor brackets (Abzil Lancer, São José do Rio Preto, Brazil) with a base area of 13.8 mm² were selected to be bonded to the specimens.

» Group 1 (control): Enamel conditioning with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of XT primer, bracket bonding with Transbond XT, removal of excesses using an exploratory probe (Duflex, Juiz de Fora, Brazil), light curing for 40 seconds, being 10 seconds on each surface (mesial, distal, incisal and gingival) at a distance of 1 mm from the bracket, using a XL 1500 appliance (3M, Dental Products, Monrovia, USA) with light intensity of 450 mw/cm², regularly checked with a radiometer (Demetron, Danbury, CT, USA).

» Group 2: Enamel etching with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of Orthoprimer (Morelli, Sorocaba, São Paulo, Brazil) on the etched surface, placement of the composite Orthobond (Morelli) at the base of the bracket, placing it in position and removing the excesses.

» Group 3: Application of TPSEP (3M Unitek,

Monrovia, USA), rubbing on the enamel for 3 seconds, light air jet to spread the material, placing the composite Orthobond (Morelli, Sorocaba, São Paulo, Brazil) at the base of the bracket, placing it in position and removing the excesses.

» Group 4: Enamel etching with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of Eagle Bond primer (American Orthodontic, Sheboygon, USA) on the etched surface, light curing the primer for 15 seconds, placement of the composite Eagle Bond (American Orthodontic, Sheboygon, USA) at the base of the bracket, placing it in position and removing the excesses.

» Group 5: Application of TPSEP (3M Unitek, Monrovia, USA), rubbing on the enamel for 3 seconds, light air jet to spread the material, placing the composite Eagle Bond (American Orthodontic, Sheboygon, USA) at the base of the bracket, placing it in position and removing the excesses.

After bonding the test specimens were stored in distilled water and kept in an oven at a tem-

perature of 37°C for 24 hours.

To perform the mechanical test a device was fabricated to keep the specimen stable during the test (Fig 1). The specimens were submitted to the shear test in an Emic DL 10.000 universal test machine (São José dos Pinhais, Brazil) operating at a speed of 0.5 mm/min, by means of a chisel-shaped active tip/rod (Fig 2). The shear bond strength results were obtained in Kgf, transformed into N and divided by the bracket base area to provide results in MPa.

After performing the test, the buccal surface of each test specimen was evaluated under a stereoscope (Carl Zeiss, Göttingen, Germany) at 8X magnification in order to quantify the Adhesive Remnant Index (ARI) as recommended by Artun and Bergland:¹ 0= no quantity of composite adhered to the enamel; 1= less than half of the composite adhered to the enamel; 2= over half of the composite adhered to the enamel; 3= all of the composite adhered to the enamel.

The shear bond strength test results were sub-

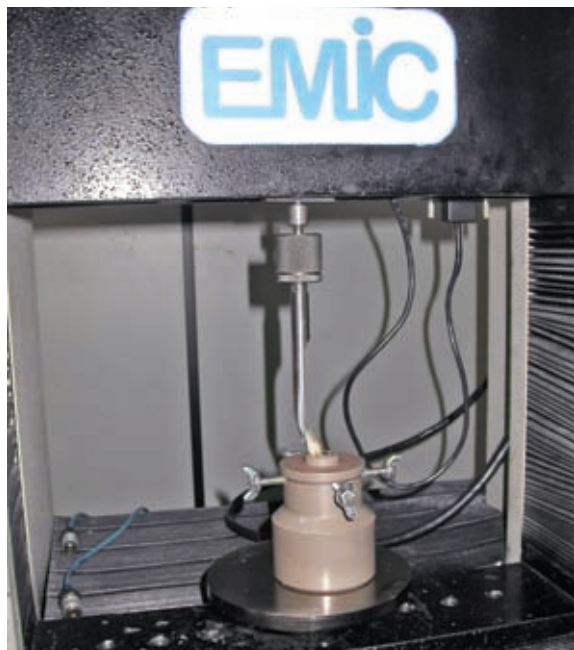


FIGURE 1 - Device fabricated to maintain the specimen stable during the test.



FIGURE 2 - Mechanical test being performed in the EMIC test machine

mitted to the analysis of variance (ANOVA) and afterwards to the Tukey test in order to compare the control with the other treatments. To evaluate the ARI scores, the Kruskal-Wallis test was used.

RESULTS

In the comparison of the shear bond strength values (Table 1) no statistically significant differences were found among between Groups 1 (Conventional Transbond XT), 2 (Conventional Orthobond), 3 (Orthobond to enamel conditioned with Transbond Plus Self Etching Prime), and 5 (Eagle Bond to enamel conditioned with Transbond Plus Self Etching Prime). Statistical differences were found between Groups 1 and 4 (Eagle Bond conventional), which presented the lowest shear bond strength, as shown in Table 1 and Figure 3.

In the evaluation of the Adhesive Remnant Index (ARI), the scores were observed within each group, as shown in Table 2.

Between Groups 1 and 2 ($p=0.178$); 1 and 3 ($p=0.107$); 2 and 3 ($p=0.467$); 1 and 5 ($p=0.103$); 2 and 5 ($p=0.121$) and 3 and 5 ($p=0.165$) no statistically significant differences were found in the evaluation of ARI. However, statistically significant differences were observed between Groups 1 and 4 ($p=0.000$); 2 and 4 ($p=0.000$); 3 and 4 ($p=0.000$), and 4 and 5 ($p=0.002$).

DISCUSSION

In an endeavor to diminish the number of procedures in the conventional bonding technique and the patient's chair time, Self-Etching Primers (SEP) have been developed. These systems are formed by a primer and acid in a single solution, capable of etching the tooth surface, promoting the action of the primer and do not require washing and drying after they have been applied.⁹ Few studies in the literature have evaluated to effectiveness of these new SEPs in terms of bond strength when used with the various composites available on the market. Therefore, the purpose of the present study was to

TABLE 1 - Mean shear bond strength values and standard deviation.

Groups	Mean (MPa)
1	10.62 (3.64)
2	7.28 (3.06)
3	7.85 (2.31)
4	6.89 (4.6)
5	9.22 (2.38)

TABLE 2 - Scores and mean post of the Adhesive Remnant Index (ARI) presented by the groups.

Groups	ARI Scores				Mean Post
	0	1	2	3	
1	4	4	2	5	33.43
2	1	3	4	7	44.70
3	0	0	8	7	50.97
4	4	9	2	0	18.93
5	2	1	7	5	41.97

0 = No quantity of adhesive adhered to the enamel.
 1 = Less than half of the adhesive adhered to the enamel.
 2 = Over half of the adhesive adhered to the enamel.
 3 = All of the adhesive adhered to the enamel.

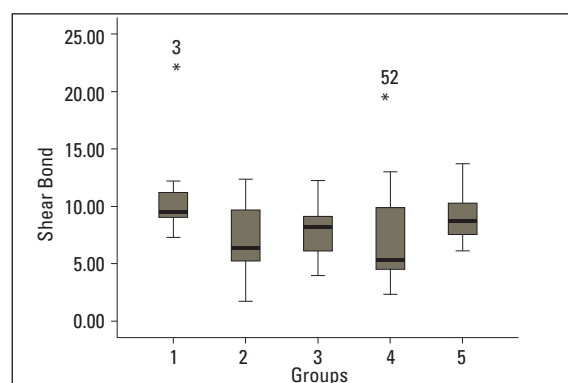


FIGURE 3 - Box Plot demonstrating the shear bond strength values among the evaluated groups.

evaluate the shear bond strength and the Adhesive Remnant Index when the surface was prepared with TPSEP.

As control, bonding was performed with the use of Transbond XT, an exhaustively tested material with proven characteristics of resistance to masticatory forces.^{8,11}

In addition to the control group, bonding was performed with the materials Orthobond and Eagle Bond in accordance with the manufacturers' instructions. These groups served as a standard for the comparison of the real influence of TPSEP in bonding procedures.

In the comparison of the shear bond strength values, no statistically significant differences were found among the groups in which conventional Transbond XT (1), conventional Orthobond (2), Orthobond to enamel conditioned with TPSEP (3), and Eagle Bond to enamel conditioned with TPSEP (5) were used. The application of TPSEP associated with the composites Orthobond and Eagle, facilitated bonding by eliminating steps, and did not alter bonding, but indeed improved it, as was the case in Group 5, which presented the best results when compared with Group 4, which was bonded in accordance with the manufacturer's technique.

Statistical differences were found between the Control and the group in which conventional Eagle Bond was used, with the latter showing the lowest mean shear bond strength in comparison with the other groups.

When comparing the shear bond strength means presented by the five groups with the values suggest-

ed by Reynolds and Franhofer¹³ as being adequate for the majority of procedures performed in orthodontics, (between 5.9 and 7.8 MPa), one finds that the values obtained for the groups were compatible with clinical requirements. This finding is of clinical interest, since the use of TPSEP makes the bonding procedure 65% faster, according to Whyte.¹²

In the evaluation of the Adhesive Remnant Index (ARI), no statistically significant differences were found between Groups 1 and 2; 1 and 3; 1 and 5; 2 and 3; 2 and 5; and 3 and 5. Statistically significant differences were observed between Groups 1 and 4; 2 and 4; 3 and 4; and 4 and 5. These differences were a result of the lower ARI values for Group 4, in which Eagle Bond was used in accordance with the manufacturer's technique. The adhesion to the tooth provided by the association of TPSEP, favored higher means (bond strength) and consequently, protection of the enamel during bracket debonding, since the largest quantity of composite remained adhered to the tooth enamel.

CONCLUSION

It could be concluded that TPSEP is an important aid when quicker work is required during bracket bonding with the use of composites Orthobond and Eagle Bond.

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Submitted: February 2007

Revised and accepted: December 2007

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Chemical and morphological analysis of the human dental enamel treated with argon laser during orthodontic bonding

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Abstract

Introduction: The main utilities of the argon laser in orthodontics are the high speed curing process in orthodontic bonding and the caries resistance promotion of the tooth enamel. **Objective:** To evaluate the chemical and morphological changes in the tooth enamel treated with the argon laser in the orthodontic bonding parameters. **Methods:** Fifteen sound human first premolars, removed for orthodontic reason, were selected and sectioned across the long axis in two equal segments. One section of each tooth was treated and the other remained untreated. A total of thirty samples was analyzed, creating the laser (n =15) and the control groups (n =15). The treatment was done with 250 mW argon laser beam for 5 seconds, with energy density of 8 J/cm². **Results:** The X-ray analysis demonstrated two different phases in both groups, the apatite and the monetite phases. The reduction of the monetite phase was significant following laser treatment, suggesting higher crystallinity. The EDS analysis showed an increase in the calcium-phosphorus ratio in the laser group, linked with the decrease of the monetite phase. The surface morphology was smoother after the laser exposure. **Conclusion:** The results of high crystallinity and superficial enamel smoothness in the laser group are suggestive of the caries resistance increase of the tooth enamel.

Keywords: Argon laser. Tooth enamel. Orthodontic bonding.

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INTRODUCTION

The laser-tissue interaction is controlled by the irradiation parameters and optical properties of the tissue. When the laser energy strikes the tissue, it may be absorbed by the tissue, transmitted through it, scattered on it or reflected.^{18,22,33} Based on these interactions, the argon laser has five main utilities in dentistry: early caries detection by fluorescence,⁷ soft tissue cutting,^{21,27} bleaching agent activator,²⁷ laser curing of dental materials,^{2,6} and promotion of tooth enamel resistance against demineralization.^{9,10}

High-speed polymerization and enamel resistance promotion are the most significant clinical properties in orthodontic treatment that justifies laser application. In 1999, Blankeau et al⁵ showed that 5 seconds of argon laser exposure created a composite with higher compressive strength than 20 seconds of visible light curing. Losche¹⁶ reported a greater conversion rate of canphoroquinone with the argon laser when compared with visible light. Many authors tested the different properties of dental materials cured with argon laser or visible light. Better or equal results in argon laser polymerization were found in these studies.^{3,12,21} Pulpal histology from “in vivo” tests confirm that the argon laser used at the energy levels used in restorative dentistry creates neither short-term nor long-term pulpal pathology.²¹

Sedivy et al²⁴ tested the argon laser in the bonding of orthodontic metallic brackets. They concluded that with 1 W power, the argon laser took 87% less time to obtain similar bond strength than conventional light cure. In a similar study, Lalani et al¹³ confirmed that 5 seconds polymerization using argon laser produced bond failure loads comparable to 40 seconds of conventional light cure. Weinberger et al²⁹ investigated the bonding of ceramic brackets and showed that it can be done with 231 mW power for 10 seconds of argon laser.

Another important effect of the laser on human enamel is related to a prevention characteristic.

Hicks et al^{9,10} concluded that the human dental enamel became more resistant to dental caries after a single exposure to argon laser radiation of 250 mW for 10 seconds. The same group associated the use of the argon laser with fluoride treatment and found better results in terms of caries resistance. In a clinical study, Anderson et al¹ demonstrated that argon laser radiation with 325 mW for 60 seconds reduced in 90% the depth and the area of caries lesion.

Using the argon laser in the orthodontic bracket bonding, the enamel around the bracket is modified. The effects of the argon laser therapy in tooth enamel vary with the several combinations of power and time curing described, although most of them are for the caries resistance treatment. Nevertheless, the power and the curing time for bonding and for resistance promotion are different.

The purpose of the present study was to investigate the chemical and morphological effects of argon laser irradiation on human enamel treated in a protocol of high speed curing of orthodontic brackets.

MATERIAL AND METHODS

Fifteen human first premolars extracted for orthodontic purposes were selected for this “in vitro” study. Following the extractions, the soft tissues were removed and the teeth were evaluated using a halogen light,³² only sound elements were selected (Fig 1).

The dental elements were stored in a 0.1% thymol waterish solution and kept in a temperature of 361°C.^{4,8} All the teeth underwent prophylaxis, using pumice, water, and brush in low speed for 10 seconds.²³ It was followed by washing with water for 10 seconds and drying with a hair dryer for 15 seconds, so the surface became free from oil contamination.¹⁷ In order to produce uniform abrasion on the enamel surface on the entire sample, a new brush was used for each tooth, and just one operator prepared the sample.

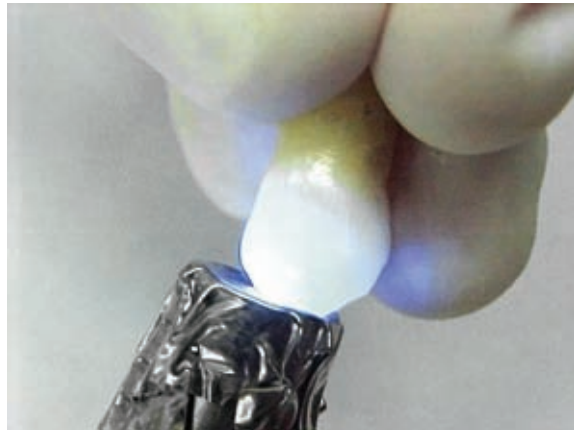


FIGURE 1 - Enamel quality evaluation by halogen light evaluation.

The dental elements were sectioned in two equal segments, cut across the long axis with a carborundum disc in low rotation and water refrigeration. Each tooth had one half treated and the other half remained untreated, thereby creating a laser group ($n = 15$) and a control group ($n = 15$).

The treatment was done with an argon laser (Accucure 3000®, Laser Med, Salt Lake City, USA) with 250 mW power for 5 seconds during each cycle, delivering an energy density of 8 J/cm^2 (Fig 2). The laser power was checked with a calibration meter built into the laser before its use on each sample.

Energy Dispersive Spectroscopic analysis (EDS)

The EDS analysis was done in a $4000 \text{ } \mu\text{m}^2$ enamel area of the buccal surface (Jeol 5800 LV®, Tokyo, Japan). The relative calcium-phosphorus ratio was compared in both the treated and untreated samples, using the technique of least squares fit.

Descriptive statistics were performed on the data to obtain means and standard deviations for each group and the groups were analyzed for significant differences using a paired-sample T test, at 5% significance (SPSS for Windows Release



FIGURE 2 - Argon laser treatment with 250 mW power continuously delivered during 5 seconds.

11.0 SPSS software Corp., Munich, Germany).

Following this analysis, the sample was divided and 10 pairs were submitted to X-ray diffraction analysis and the other 5 pairs were submitted to scanning electron microscopy (SEM).

X-ray diffraction analysis

The sample was laid out with the buccal enamel surface tangent to the diffraction plane and analyzed using an X-ray diffractometer (Rigaku, Dmax 2200, Osaka, Japan) with monochromatized $\text{CuK}\alpha$ radiation (wavelength $\lambda = 1.540 \text{ } \text{\AA}$) at 40 kV and 40 mA. The diffractograms were collected in the angular interval of $5^\circ \leq 2\theta \leq 80^\circ$ using 0.05° steps. The fixed time was two seconds per step and the diffractogram of each group was obtained by mean peaks.

The phase identification was done by a matching process using the International Center for Diffraction Data (ICDD) database. The cell refinement report and the crystallinity evaluation were done with the Materials Data Inc Jade® program, version 5.0, California, USA.

Scanning electron microscopy analysis

Five pairs of the sample received a gold layer for 3 minutes in the coater (Pollaron SC 500®, Sputter, VG, Microtec) at 20 mA current and

TABLE 1 - Calcium and phosphorus relative ratio in control and laser groups compared by paired sample test.

Groups	N	Mean	Std. Deviation	Std. Error Mean	Pairs	df	Sig.
Control Ca	15	0.6961	0.0205	0.0053	Pair 1	14	0.002
Laser Ca	15	0.7394	0.0319	0.0082			
Control P	15	0.2361	0.0120	0.0031	Pair 2	14	0.000
Laser P	15	0.1872	0.0341	0.0088			

200 mTorr vacuum. The enamel surfaces were evaluated by secondary electron detection (Jeol 5800 LV®, Tokyo, Japan) at 500X, 1000X and 1500X original magnification.

RESULTS

Energy Dispersive Spectroscopic Analysis

The paired-sample T test showed significant differences between the relative calcium and phosphorus ratio after the treatment with the argon laser ($p < 0.05$). The results indicated higher relative calcium rate and lower relative phosphorous rate after the laser exposure (Table 1).

X-ray diffraction analysis

The phase identification showed a principal and a secondary phase in both groups. The principal phase was the apatite (database card # 09-0432) and the secondary phase was the monetite (database card # 09-0080). The original diffractogram of the control group showed a broad peak between 20° and 35°, which is characteristic phase of amorphous materials (Fig 3).

No new peaks were observed in the laser group when compared with the control group. Nevertheless, the diffractogram of the laser group showed narrower peaks and reduction of the amorphous phase. Furthermore, the monetite phase was significantly decreased, indicating higher crystallinity of the treated enamel surface (Fig 3).

In the cell refinement analysis, both a- and c-axis of the apatite structure showed significant differences between the control and laser groups. After the laser treatment, the a-axis showed a contraction of 0.064 Å and the c-axis an expansion of 0.016 Å.

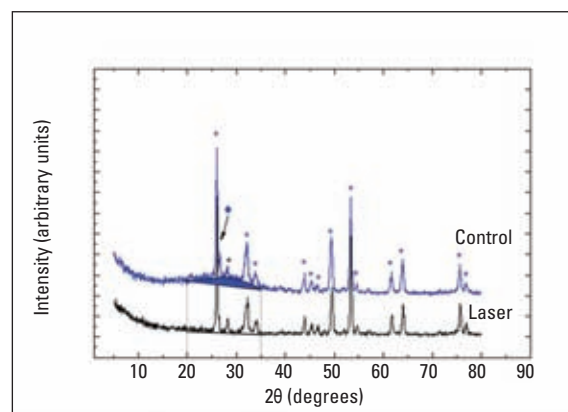


FIGURE 3 - Diffractogram of control and laser groups. (*) Apatite phase peaks, (●) monetite phase peaks. Reduction of amorphous phase (blue area above the diffractogram).

TABLE 2 - Values of experimental and hydroxyapatite cell parameters (database card #09-0432).

Groups	Axis	Mean	Std deviation
Control	a-axis	9.530 Å	0.003 Å
	c-axis	6.861 Å	0.006 Å
Laser	a-axis	9.466 Å	0.006 Å
	c-axis	6.877 Å	0.002 Å
Hydroxyapatite	a-axis	9.418 Å	--
	c-axis	6.884 Å	--

These values obtained from the laser group came close to hydroxyapatite values (Table 2).

Scanning Electron Microscopic analysis (SEM)

Untreated enamel surfaces from the control group showed voids and microvoids, representing the normal enamel prism end markings (Fig 4). In contrast, following argon laser irradiation, the surface morphology was substantially changed, becoming smoother (Fig 5).

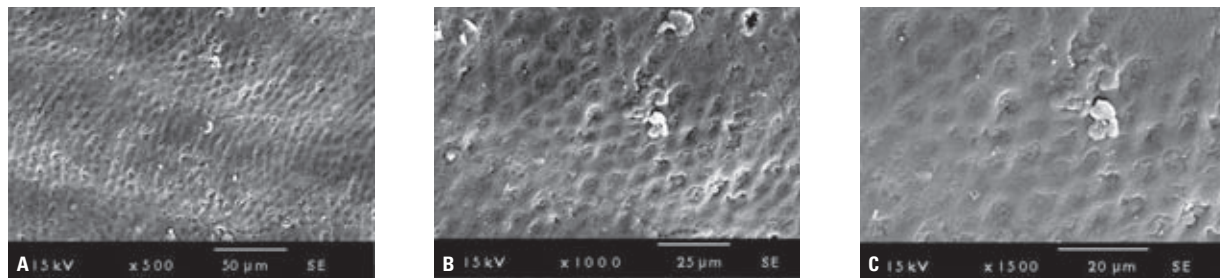


FIGURE 4 - Enamel surface morphology in control group: **A)** SEM at 500X original magnification; **B)** SEM at 1000X original magnification; **C)** SEM at 1500X original magnification (SE detection).

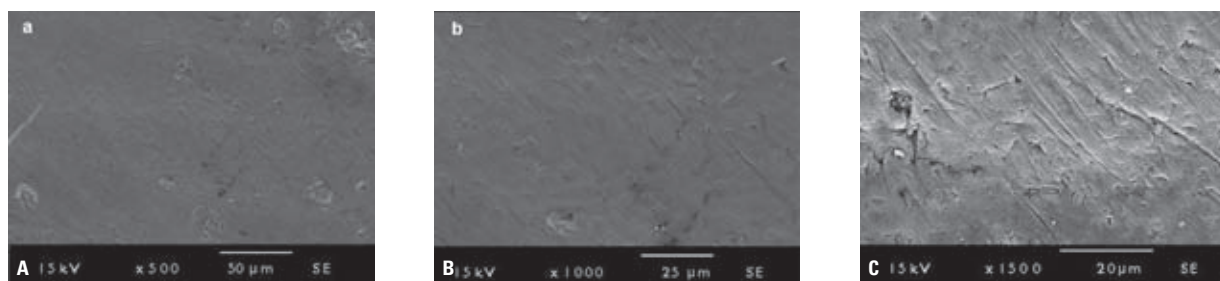


FIGURE 5 - Enamel surface morphology in laser group: **A)** SEM at 500X original magnification; **B)** SEM at 1000X original magnification; **C)** SEM at 1500X original magnification (SE detection).

DISCUSSION

The first laser application in dentistry was done with a ruby laser, which increased enamel resistance to decalcification.²⁶ Since then, some authors reported this same effect after the enamel treatment with different types of lasers.

The main explanation for the acid resistance of the enamel tissue is less permeability and reduction of carbonate content,^{19,20} water and organic substances in the treated enamel²⁰.

Blankaneau et al⁵ reported “in vivo” argon laser radiation effects on human enamel resistance against decalcification. This study described reduction of 29.1% on average lesion depth in a laser treatment with a 250 mW beam for 10 seconds. Anderson et al,¹ using a 325 mW beam for 60 seconds, found reduction of 91.6%. In this way, we could expect similar result on the enamel around the brackets during the ortho-

odontic bonding. Although, the time exposure and the laser power for that are different (250 mW beam for 5 seconds).^{13,25,28}

The energy density (ED) could be calculated by the division of the energy (E) by the spot area (S). The energy is expressed by the product of the power (P) and the exposure time⁶ (t) (Equation 1).

$$ED = \frac{E}{S} = \frac{P \times t}{S}$$

Nelson et al¹⁹ investigated the effects of pulsed, infrared laser radiation on human dental enamel with an energy density varying between 10 to 50 J/cm². They concluded that the laser radiation resulted in a melted surface and the heat delivery was limited to 10-20 µm depth. A new phase of tetracalcium diphosphate monoxide was identified in the treated surface with a

reduction of the carbonate content.

In our study, the argon laser treatment was done with 250 mW power for 5 seconds, delivering an energy density of approximately 8 J/cm². No new phase was found in the treated enamel surface. In agreement, Oho and Morioka²⁰ did not find any new phases in the argon laser treatment with 67 J/cm².

The difference among these studies can be attributed to the effect of infrared¹⁹ and the argon laser²⁰ radiation on enamel surfaces. The higher energy absorption of the infrared spectrum by the enamel results in higher thermal energy conversion⁷ and more significant changes in comparison with the argon laser changes.

An interesting finding of this work was the correlation between the EDS and X-ray diffraction results. The EDS analysis showed the increase of the calcium-phosphorus ratio in the laser group. This result was brought into relation with the decrease of the monetite phase found in the x-ray diffraction analysis. In the diffractograms of the control and laser groups, the main phases observed were the apatite and the monetite phase. The apatite phase (Ca₁₀(PO₄)₆(OH)₂) had a calcium-phosphorus ratio of 1.67 and the monetite phase (CaPO₃(OH)) had a ratio of 1.0. Hence, the decrease of the monetite phase in the laser group, in theory, this should result in an increase of the calcium-phosphorus rate. Actually, the increase of the calcium-phosphorus ratio following the laser treatment was observed, sustaining the change in the enamel surface.

The diffractogram analysis showed the decrease of the amorphous phase after the laser treatment. This result added up to the reduction of the monetite phase and to the narrower apatite peaks in the laser group indicated higher crystallinity in the treated enamel. These results are supported by Oho and Morioka²⁰ and Nelson et al¹⁹ findings, where a best arrangement of ions in the crystal lattice of the laser

treated enamel tissue was found. This feature was related to the higher resistance against enamel acid demineralization^{1,9,10}. In addition, the reduction of water, carbonate and organic substances^{1,5,19} can also explain the acid resistance of the enamel exposed to laser. So, additional studies are needed to determine the influence of these factors in the orthodontic bonding protocol.

The changes in the apatite structure arrangement were analyzed by the cell refinement of the X-ray analysis. The most significant change found in the present work was the apatite a-axis contraction of 0.064 Å. Based on previous studies, reductions of water and carbonate in the apatite phase^{11,15} affected the length of the a-axis of the apatite enamel crystal. The argon laser treatment with energy density of either 11.5 or 100 J/cm² induced a contraction of the a-axis of apatite and this result was linked with the reduction of lesion depth and the caries resistance increase of the enamel^{9,10,30,31}. In this manner, due to the fact that the argon laser treatment with energy density of 8 J/cm² induces an a-axis contraction of 0.064 Å. It is possible that a similar resistance mechanism occurs in the parameters of this study. In such case, it could be suggested that this contraction indicates reduction of water and carbonate, resulting in enamel resistance. However, additional studies are needed to prove this mechanism.

In the SEM analysis, the laser group showed a significantly smoother surface morphology than the control group. The end prism marks observed in the control group were erased after argon laser treatment. This smooth feature is compatible with best arrangement of ions in the crystal lattice of the enamel surface and with the higher crystallinity. Furthermore, a smooth enamel surface reduces the plaque adherence tendency and could be considered by itself as preventive characteristic.

CONCLUSIONS

1. Argon laser treatment with 250 mW for 5 seconds modified the enamel surface resulting in the increase of the enamel crystallin-

ity, suggesting a higher caries resistance.

2. The enamel surface morphology became smoother after the argon laser treatment in the orthodontic bonding parameters.

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Submitted: July 2007
Revised and accepted: November 2007

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Epidemiology of long face pattern in schoolchildren attending middle schools at the city of Bauru - SP

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Abstract

Objective: This study aimed to classify and determine the prevalence of individuals with vertical alteration of facial relationships, according to the severity of discrepancy, especially individuals with long face pattern. **Methods:** The sample was composed of 5,020 individuals of Brazilian nationality, of both genders, aged 10 years to 16 years and 11 months, attending middle schools at the city of Bauru-SP, Brazil. Examination of facial morphology comprised direct observation of the face in frontal and lateral views, always with the lip at rest, aiming to identify individuals presenting vertical alteration of facial relationships. After identification, these individuals were scored, according to severity, into three subtypes, namely mild, moderate and severe. The prevalence of individuals with long face pattern considered only the individuals scored as subtypes moderate and severe. **Results:** There was prevalence of 34.94% of vertical alteration of facial relationships and 14.06% of long face pattern. **Conclusions:** The results obtained in this study revealed that the prevalence of vertical alteration of facial relationships and long face pattern was higher than that reported in the literature.

Keywords: Epidemiology. Craniofacial abnormalities. Diagnosis.

INTRODUCTION

The denomination of long face represents a stigma from the conventional perspective of malocclusion classification,³ because it suggests the presence of a large morphological deviations in comparison to the normal pattern,⁵⁻¹⁰ often with significant esthetic impact.⁸ Since a long time, in orthodontic practice, it was more acceptable that for these individuals,

when the face was unattractive, a surgical approach is indicated.^{3,5,8,9,26,27,29}

This deformity manifests early in life, maintains the features of the individual,¹⁷ and may magnify or not during adolescence.¹² It may be associated to all anteroposterior dental relationships, although, Class II malocclusion is more predominantly associated.^{1,5-14,22,26,29}

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The children and adults that express this excessive vertical facial growth present a characteristic face, labeled in the literature as long face syndrome,^{3,22} hyperdivergent face¹⁴ and, recently, long face pattern.⁵⁻¹⁰ Other denominations, such as skeletal open bite⁴ or open bite face,¹⁷ disregard the primary skeletal error^{5,9,10} and are mistaken, since the open bite condition may be less frequent than normal in these individuals.^{5,8,10,18}

The main characteristic of these individuals is excessive maxillary incisor exposure—anteroposterior, with the lips at rest, and gummy smile¹—due to the excessive increase in the lower facial height.^{1,22,29} Under a classic perspective, these morphological signs constitute the essence of the deformity, which generally provides unattractive faces. In this context, the orthodontic treatment alone is very limited, and a surgical approach would be more appropriate.^{5-10,12,26}

The facial analysis, the first tool in diagnostic hierarchy, provides a more appropriate perspective to the examination and qualification of the long face, the deformity that, despite the vertical component, presents a three-dimensional expression. Thus, besides giving a more realistic tone to the many features common to these individuals, such as increased total anterior facial height,^{1,5-10,14,18} as consequence of increased lower anterior facial height,^{1,3,5-11,13,14,22,29} which result in an oval²⁹ or tapered¹ facial appearance associated with normal middle^{13,14} and upper facial thirds,^{13,14,22} it aggregates the visualization of other characteristics.

The lip incompetence, a mandatory characteristic in long face deformity, caused by the inability of passive lip sealing, is evident with the lips at rest posture.^{1,3,11,13,22,29} During lip sealing, it occurs the contraction of perioral musculature, which accentuates the deficiency of the chin contour.^{1,3,13,22} This provides a more retrognathic mandibular appearance^{14,29} and generates a short chin-neck contour line as well as chin-neck angle.⁵

Excessive teeth and gingival structures are evidenced at smile,^{3,13,22} a reflection of anterior and posterior maxillary dentoalveolar growth excess,¹ which provokes overexposure of upper incisors, normally, the chief complain of patients.^{1,13,14,22,29}

Also, a deficiency may be observed in the zygomatic prominence^{1,29} and chin,¹¹ besides the accentuated nasolabial depression.²² The length of the upper lip is normal^{13,14,22} and the deformity is aggravated when the patient presents a short upper lip.⁹ The lower lip posture often is impaired, with excessive lip vermilion display at rest.^{13,14} The nose is long^{1,3,13,14} and the nostrils are narrow^{1,11,13,14,22,29} with prominent nasal dorsum at facial profile view.^{3,13,14,22}

Dental relationship analysis is helpful to understand why long face pattern malocclusions have been evaluated from a different perspective since a long time.⁵ The most relevant factor is the impossibility of defining this pattern by molar relationship which can be Class I or Class III, despite the tendency for Class II (prevalence of 13.2%, 15.8% and 71.0%, respectively).¹⁰ In addition, the expressive variation in the dental arch morphology in long face pattern—that fluctuates from open bite to deepbite, negative to significantly positive overjet, even the presence or not of a crossbite¹⁰—makes the dental parameters useless for its denomination.^{5,18} The literature presents varied data with regard to the prevalence of long face pattern. Wolford and Hilliard²⁹ reported that vertical maxillary excess is the most frequently found facial deformity, and often misdiagnosed as anteroposterior mandibular deficiency, although they have not specified the prevalence. Woodside and Linder-Aronson³⁰ found lower facial height excess in 18% of young Caucasian males, aged from 6 to 20 years.

In contrast, a survey conducted by the National Center for Health Statistics¹⁵ found a prevalence of approximately 1.5% in a young American population aged from 12 to 17 years.

In this study, the authors reported that a surgical procedure would be necessary for half of these individuals (0.75%), due to facial unattractiveness. This prevalence of 0.75% was very close to the estimate of 0.6% reported by Proffit and White.²⁰ The low percentages referred in these surveys were probably related to the severity that the deformity imposes on the patients.

Therefore, it seems necessary that the magnitude that the vertical impairment affects the face should be considered in the investigation of the prevalence of long face pattern. From this perspective, the spectrum of variation would be large, ranging from individuals without temporary passive lip sealing, a reflection of imposed functional deviations² considered as typical disarrangements during growth in humans,¹⁹ until those individuals traditionally identified as long face due to facial unattractiveness. This may result in a proper understanding of the occurrence of vertically involved malocclusions, and within this broader context, in the correct determination of the prevalence of long face pattern malocclusion.

The literature lacks of epidemiological survey that considers uniquely the facial pattern, correlating the prevalence with the severity in individuals with vertically impaired facial relationships by excess, with emphasis on the absence of lip sealing. This is of great importance for clinicians, especially with regard to the determination of the prognosis for treatment to be approached, whether in the correction of malocclusion or in the management of the effects of malocclusions on intra and perioral functions.^{7,18}

PROPOSITION

This survey, with middle school students in Bauru - SP (Brazil), aimed to classify and determine the prevalence of individuals with vertically impaired facial relationships by excess (according to three levels of severity), and especially, of individuals with long face pattern.

MATERIAL AND METHODS

This cross-sectional descriptive study, held in Bauru-SP (Brazil), is in accordance with National Health Board 196/96 Resolution, with the Helsinki Declaration and the Nuremberg Code for human experimentation, and was approved by the Ethics Committee of the São Paulo State University at Araçatuba (FOA 2005-01085).

The sample consisted of 5,020 Brazilian ethnicity subjects: 2,480 females (49.40%) and 2,540 males (50.60%). The sample ages ranged from 10 years to 16 years and 11 months, with an average age of 13 years (SD = 1 year and 3 months) for the total sample, 12 years and 11 months (SD = 1 year and 3 months) for females, and 13 years (SD = 1 year and 3 months) for males. This epidemiological survey period comprised from August 17 of 2005 to May 15 of 2006.

This study aimed to evaluate all individuals enrolled in public and private middle schools (5th to 8th grades), regardless of age, dentition and race. The percentage of student participation was 88.4%. The percentage of loss (11.6% - 660 students) in the sample was due to absence on the examination day or, for some reason, unavailability to participate in the survey.

The sample size was calculated assuming a 95% of confidence interval. According to the literature, the estimated prevalence of long face pattern in the population is 1.5%.¹⁵ By assuming a margin of error of 0.35% in the population estimate, a necessary sample size of 4,643 subjects was determined. Added to an estimate of potential loss of approximately 10%, a final sample size of approximately 5,000 subjects was established for achieving the desired accuracy.

In 2005, the Municipal and State Education Secretary reported in a survey that, in all middle schools in Bauru-SP, there were 1,443 students enrolled in the municipal schools, 4,347 students in the private schools and 14,127 students in state schools (Table 1). These amounts are close to those provided by Demographic Census in 2000, which

indicate a coverage of 89.0% of participation in the public sphere in offering this type of education in Brazil.⁴ Among the students assessed by the present survey, 3,759 (74.88%) belonged to the state schools, 1,157 (23.05%) to private schools and 104 (2.07%) to the municipal schools (Table 1).

With regard to the sample of this survey, the prevalence and the percentages of the sampled students from the municipal, private and state schools were very similar in relation to the distribution of all enrolled students in the middle school in Bauru (Table 1 and Fig 4). Concerning the amount and the similarity of distributions of the sample in relation to all the students enrolled in middle schools, the sample from this survey can be considered as representative for the population of middle school students in Bauru-SP. From this myriad, 14 schools were selected by convenience—eight state schools, five private and one municipal school—in search of respecting the ratio of students enrolled in middle schools in Bauru.

All students present on the day of evaluation, who agreed to participate in the study, were evaluated with basis only on the facial morphology.¹¹ The criterion for the identification of individuals with vertically impaired facial relationships by excess was the lack of lip sealing. Assuming that the study concerns the identification of long face patients, the term “by excess” should be implied as a reference to the vertical facial impairment. According to Capelloza Filho⁵ diagnostic criteria, first permanent molar anteroposterior relationships as

well as the vertical distance of upper and lower incisors were not considered.

As inclusion criteria, the individual should not present clinically observed syndromes and/or history of surgery or fractures in the facial or skull region. The history of previous or ongoing orthopedic and/or orthodontic treatment was not an exclusion factor for sampling, considering that such treatments are known to be unable to change significantly the facial proportions and relationships.^{26,30}

All subjects were evaluated under natural light by one examiner who is experienced in orthodontics and properly calibrated for facial morphology evaluation.⁷ The individuals were evaluated in standing natural head posture with the lips at rest without the help of any special equipment.²⁴

The diagnosis of patients with vertically impaired facial relationships by excess is morphological, based on the subjective facial analysis.^{5,7-10} The subjects of this study were evaluated based on direct observation of the face in the frontal and lateral norms, with their lips always at rest, trying to identify those who had incompetency in this relationship. The rest position was prioritized, since those individuals with vertical excess have a tendency to seal the lip unconsciously and camouflage the deformity.

Once identified, individuals with vertically impaired facial relationships were classified into three subtypes according to the severity: mild, moderate and severe.⁷ With proper calibration and training, the classification method by level of severity presented a high reliability.^{7,21} That is, the diagnostic conclusion established in the first examination was maintained, with high probability, when the examination was repeated after three weeks.

As classification criteria for mild subtype, there are demanded: presence of lip incompetence, excessive exposure of the upper incisors at rest and/or gummy at smile; presence of, even with postural component, mild disproportion between the middle and lower facial thirds. In summary, these individuals

TABLE 1 - Frequency distribution of the total and sampled middle school students from the municipal, private and state schools at Bauru-SP/Brazil.

Schools	Total students		Sampled students	
	n	(%)	n	(%)
Municipal	1,443	7.24	104	2.07
Private	4,347	21.83	1,157	23.05
State	14,127	70.93	3,759	74.88
TOTAL	19,917	100	5,020	100



FIGURE 1 - Extraoral photographs in frontal, lateral and smiling aspects of a white individual with vertically impaired facial relationship by excess, mild subtype.



FIGURE 2 - Extraoral photographs in frontal, lateral and smiling aspects of a white individual with vertically impaired facial relationship by excess, moderate subtype.

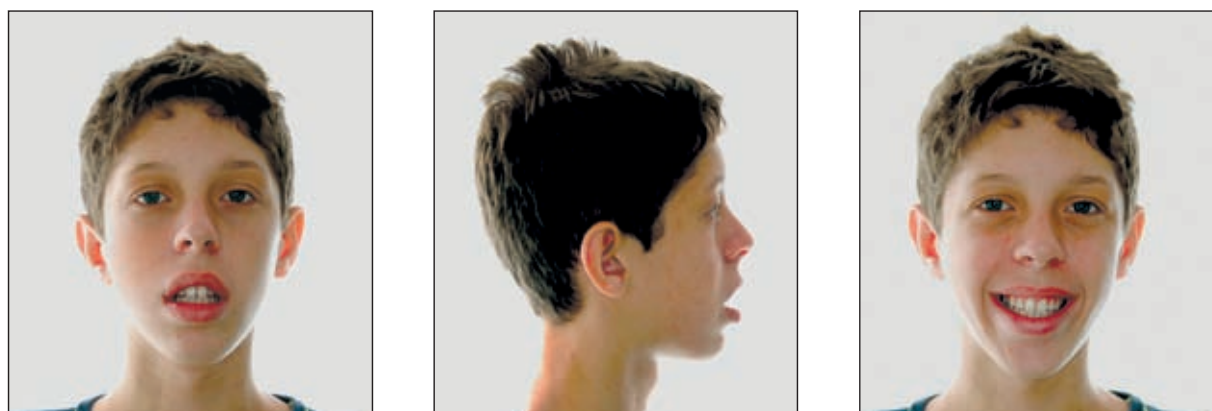


FIGURE 3 - Extraoral photographs in frontal, lateral and smiling aspects of a white individual with vertically impaired facial relationships by excess, severe subtype.

could be considered as transitory long face, postural or even borderline to long face.¹⁹ In this way, they would present good prognosis for conservative treatment (orthodontic and/or orthopedic)⁷ (Fig 1).

With regard to moderate subtype, the classification criteria were the presence of a genuine discrepancy between the middle and lower facial thirds, besides the features already described in previous subtype, which characterize, therefore, with certainty, a long face pattern individual. In these individuals, the prognosis is regular for conservative treatment (orthodontic and/or orthopedic)⁷ (Fig 2).

Individuals that belong to severe subtype should present a severe disproportion between the middle and lower facial thirds, associated to the features described in previous subtype and summed by more typical signs of long face, to an extent sufficiently to provide unattractiveness. In these individuals, the prognosis is poor for conservative treatment and orthognathic surgery is indicated for normalization of facial relationships⁷ (Fig 3).

To determine the prevalence of patients with long face pattern, only the individuals classified as moderate and severe subtypes were considered. This is justified by the brevity of vertical discrepancy in mild subtype individuals. As previously described, the mild individuals could be affected by transitory growth disarrangement,^{2,19} or only by postural changes related to functional disturbances that, if eliminated, would allow an adequate growth.¹⁶ From the treatment perspective, it seems inappropriate to include mild subtype individuals in the myriad of long face pattern, although it is important to consider and emphasize the vertical facial impairment, and especially their lip relationships.

For statistical processing, all results were analyzed by the software Statistica 5.1 (Stat Soft Inc., Tulsa, USA). Chi-square (χ^2) test was used, at 5% ($p < 0.05$) of statistical significance level, to compare the frequency ratios of individuals with vertically impaired facial relationships in the total sample, according to the three levels of severity.

It was also used to compare the frequency ratios of individuals with long face pattern in the total sample.

RESULTS

After data statistical processing, the epidemiological information, in absolute and percentage values, on the prevalence of individuals with vertically impaired facial relationships by excess (according to three levels of severity) and individuals with long face pattern (only those with moderate and severe levels of severity) was organized.

The distribution of the total evaluated sample, with distinction between individuals with vertically impaired facial relationships by excess—according to severity—and long face pattern can be visualized, respectively, in Tables 2 and 3.

DISCUSSION

Prevalence of individuals with vertically impaired facial relationships by excess and long face pattern

In this study, we found a prevalence of 34.94% of individuals with vertically impaired facial relationships by excess (Table 2). Such high prevalence seems to be surprising, and no data from surveys executed with similar methods could be used for comparison. Some studies that reported the prevalence of vertical growth pattern may be referred: Siriwat and Jarabak²⁵ found a prevalence of 10% with hyperdivergent patterns in a sample of 500 patients treated in the private practice of Dr. Jarabak; Willems et al²⁸ found a prevalence of 29% of heterogeneous age subjects with vertical growth tendency that underwent orthodontic treatment in Belgium. For comparative analysis, the limitation related to the survey of individuals who had sought for treatment should be considered.

Perhaps it is reasonable to compare with 18% of Canadian male Caucasians from Toronto area, evaluated longitudinally from 6 to 20 years, with impaired respiratory function that showed varied

TABLE 2 - Prevalence of individuals with vertically impaired facial relationships by excess, according to levels of severity in the total sample.

	Mild		Moderate		Severe		TOTAL	
	n	%	n	%	n	%	n	%
Vertically impaired facial relationships by excess	1,048	20.88	672	13.38	34	0.68	1,754	34.94
TOTAL							5,020	100.00

TABLE 3 - Prevalence of individuals with long face pattern in the total sample.

Long face pattern		Others		Total sample	
n	%	n	%	n	%
706	14,06	4,314	85.94	5,020	100.00

degrees of excess in lower anterior facial height.³⁰ These authors consider this excess in anterior facial height, regardless of severity, as responsible for the deterioration or impairment in facial relationships. Considering the population pattern assessed by Woodside and Linder-Aronson,³⁰ it is reasonable to accept the high prevalence found in Brazilian population.

Actually, for a better understanding, these data should be analyzed under the perspective that motivated this survey and defined the evaluation method. Besides the prevalence of long face pattern which has always been the primary purpose of this study, the investigation of the frequency of individuals with vertically impaired facial relationships and the definition of their magnitudes were secondary, but no less important, objectives. The reason of this motivation may be understood as follows.

The absence of passive lip sealing at rest, a demanded criterion for classification of individuals with vertically impaired face, is very frequent in human during growth. So frequent that it can be considered as normal.² The results of the present survey, with a prevalence of 34.94% for all individuals with vertically impaired facial relationships by excess, mirror a frequency that is not described similarly in the literature, although it

appears reasonable. A correct understanding of what that means has an absolute clinical importance for diagnosis and prognosis in these subjects. The first point, and perhaps the most important one, is to understand that the presence of this impairment may be normal. The individual may not have malocclusion, and therefore do not require treatment; or may present a malocclusion regardless of this facial sign, and proposed with a prognosis and treatment which retain no correlation with the vertical facial impairment.

On the other hand, there are circumstances where malocclusion is mandatorily present and retains a close correlation with the vertical impairment; so intense and correlated that, according to the magnitude, the malocclusion could not be treated only by orthodontic and/or orthopedic procedures.²⁶ This variability determines the need for accurate diagnosis which implies, in the first instance, the determination of the severity and allows the prognosis. This is one of the objectives in this study, which will be elucidated in this section.⁷

The general perspective to be adopted presumes that the inadequate vertical facial relationships, always with lip incompetence, may represent a normal condition or a sign of severely

compromised growth patterns. In this context, there is a chance that orthodontic and/or orthopedic treatment is not indicated—due to the condition of normality—or, at the other extreme, counter-indicated because of the recognized limitations in the management of long face pattern malocclusions.^{5,26} It seems clear that there is an extreme importance to predict the prognosis of the malocclusion severity and facial impact that growth will generate. In this thought, interpreting facial deformity and/or malocclusion at an early age only is not enough, but is necessary to recognize the localization and, therefore, the primary cause of the dysplasia.

Within this perspective, a proper diagnosis can be set, as well as prognosis to support or not the indication of therapeutics, targeting for realistic therapeutic goals. In summary, the ranking of the magnitude of impact on the face and localization of facial dysplasia permit more consistent therapeutic approach; or, in other words, correction of malocclusions with vertical facial impairment conducted in consonance with predicted facial attractiveness at the end of growth. This implies conservative treatments in faces that might be acceptable and surgical procedures in faces that would worsen along time and growth.⁷

With regard to the prevalence of different severities on the vertical facial impairment, individuals with mild subtype (20.88%) were predominant (Table 2 and Fig 5). Mild subtype individuals (Fig 1) may be different from each other. For whom it is likely to speculate that the primary etiologic factors are not genetic, but local or general. Identified at an early age, the mild long face could be only postural that represents, morphologically, a mandatory but temporarily inadequacy between the internal and external functional components. This would be proven by the brevity of this vertical discrepancy present in these individuals.

Proffit and Mason¹⁹ described the concept of transitory lip incompetence, among other

functional irregularities that exist between the intra and perioral musculature, such as tongue thrust, resultant from expected asynchronism during the process of normal facial growth. The relationships that were described and recognized as normal could not necessarily be present during growth, which could be manifested only at the end of adolescence and, consequently, of the growth period. This hypothetical concept has been proven by researches and, since the early 90's, has been introduced as the basic core of information recommended by the American Speech-Language-Hearing Association (ASHA)² for the conception of diagnosis for intra and perioral musculature disorders.

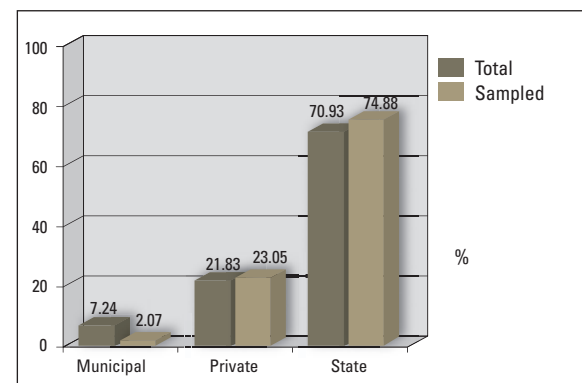


FIGURE 4 - Frequency distribution of the total and sampled middle school students from the municipal, private and state schools at Baruru-SP/Brazil.

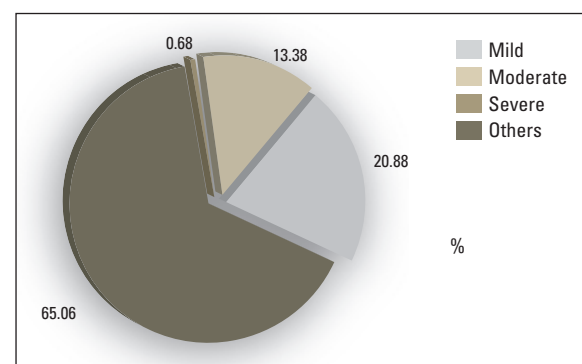


FIGURE 5 - Prevalence of individuals with vertically impaired facial relationships by excess, according to levels of severity in the total sample.

Also, these individuals may present postural changes related to true functional disturbances.

It is recognized that there are much more open-mouthed oral breather than genuine long face pattern individuals. Acquired or mandatory habits, and hypertrophic pharyngeal and palatal tonsils, allergic rhinitis, obstructive sleep apnea, and others,¹⁶ acting on a predisposed face^{5,26}, would create, at least, vertically impaired faces with mild level of severity. According to Linder-Aronson and Woodside,¹⁶ these would be the environmental copies from genetic models. As it is known, the change in the breathing and all the possible postural and functional competency that this change allows seem to be able to influence positively on the growth,¹⁶ specially in patients who present the features described as mild subtype.

Individuals with vertically impaired facial relationships by excess with moderate and severe levels were classified as long face pattern individuals. A prevalence of 14.06% of individuals with long face pattern was found in this survey (Table 3), and resulted from the sum of the prevalence of moderate subtype individuals (13.38%) and severe subtype (0.68%) (Table 2). In the composition of the group of patients with long face pattern, individuals with vertically impaired facial relationships by excess with mild subtype were not included, who were classified as having transitory long face, postural or even borderline for long face.

This prevalence for long face pattern (14.06%), in which patients with transient or postural long face were not considered, is lower but close to that found by Woodside and Linder-Aronson.³⁰ In their study, as discussed earlier, 18% of individuals with vertical impairments were not subdivided according to severity, but described as having discrepancies ranging from mild to severe. Probably the inclusion of persons with mild severity contributed to create this difference between the obtained results.

The main reason for the differences observed in the values from this study—for patients with long face pattern—in comparison to other surveys^{15,20} probably is related to the study focus; since this study considered, in addition to severe subtype patients, individuals belonging to moderate subtype. In these individuals, a real disproportion between the middle and lower facial thirds can be observed, which can be classified certainly as long face pattern individuals, who were difficult to be identified in an epidemiological survey with focus on molar relationships.⁵

For individuals with long face pattern classified as moderate subtype (Fig 2), a prevalence of 13.38% was evidenced (Table 2 and Fig 5). In opposition to mild subtype, moderate subtype individuals cannot be considered as an environment's product. The clinician should be conscious about the genetic determinants in the observed facial pattern. More than facial expression and malocclusion, it is imperative to recognize the irreversibility of the facial morphology destiny. The features of the face in individuals considered to have vertically impaired facial relationships, classified as moderate subtype, are more accentuated. In these individuals, as already discussed, a true disproportion between the middle and lower thirds can be observed and may facilitate their identification, in addition to features already described in the mild subtype.

In this context, although a conservative treatment may be indicated, it must follow the rules considered essential for the management of these individuals, always with the intention of not increasing or decreasing the intraoral dental volume and exercise the function of the intra and perioral musculature,^{5,18} or, in other words, to facilitate the balance between the internal and external functional components.²⁶ Additionally, the prognosis is uncertain, necessarily punctuated by periodical follow up to evaluate the therapeutic effectiveness and, thus, to indicate or not the treatment. This is true not only for orthodontic procedures, but to all professionals who are involved in the interdisciplinary effort for treatment.

For long face pattern individuals classified as severe subtype (Fig 3), a prevalence of 0.68% was found (Table 2 and Fig 5). This prevalence is close to the estimate of approximately 1.5% for the U.S. population. These data were collected by "U.S.A. Health Statistics",¹⁵ in a young American population aging from 12 to 17 years. In the sample, the authors reported that a surgical procedure would be necessary, justified by the facial impairment, in approximately half of individuals (0.75%). This percentage of individuals who require surgery was close to the prevalence of 0.68% of long face pattern severe subtype individuals evaluated in the present epidemiologic survey, which corroborates the estimate of 0.6% reported by Proffit and White.²⁰

For severe subtype individuals, an interceptive orthopedic procedure is innocuous, in consequence to the unattractiveness of the patient's facial relationships. This should superimpose on other exams, such as cephalometric and clinical dental examination.⁷ During the time from first examination until confirmation of a severe subtype, priority must be given to the management of tooth eruption and must be maintained, at each step, the patient and the family members aware about the evolution and possibilities for the complete correction of the face and teeth at the end of the growth period.

A slightly higher prevalence (4.1%) was reported in a retrospective study of 1,460 consecutive patients who sought for treatment in the orthognathic surgery service in North Carolina (USA).²³ These results are difficult to be compared with those found in this study, since the sample consisted of individuals that sought for surgical treatment and, furthermore, the focus of the investigation was facial asymmetry instead of the long face pattern itself.

The extensive material collected in this study in a population of different ethnicity compared to the literature,³⁰ reported high frequencies of individuals with long face pattern. The difference in

prevalence may be explained by the classification criteria adopted by the examiner during the sampling. But one conclusion is certain: the relationship between the results found by Woodside and Linder-Aronson³⁰ and those found in this study express a high prevalence of this facial pattern in the population.

FINAL CONSIDERATIONS

The prevalence of individuals with vertically impaired facial relationships by excess was significant (34.94%), and probably higher than expected. Considering that the prevalence was obtained from a sample of individuals with growth potential that properly represents Brazilian population, the reliability of the present study seems probable. The described arguments for the vertical impairments in the facial relationships in growing individuals, even postural or transitory, support the concentration of prevalence evidenced in mild subtype (20.88%).

For the prevalence of long face pattern (14.06%), the results appear to be logical and predictable specially when analyzed under proper perspective. The characteristics of the facial morphology of Brazilian population as a whole, and particularly black and pardo races, seem to predispose to the occurrence of vertical discrepancies, helping to increase the prevalence of long face pattern. From the practical standpoint or the meaning of prevalence obtained in this epidemiologic study, it seems clear that the minimum percentage values such as described in about 1.5% should be considered,¹⁵ for the occurrence of long face pattern. Based on the literature review, this low percentage refers to the most severe cases, those with significant facial impairment.

This is an erroneous generalization, adopted until now due to the lack of data, and should be avoided. The comparison of this minimum value, that was described and accepted in the

literature, shows the similarity with the prevalence obtained for long face pattern severe subtype patients (0.68%). In other words, this minimum percentage of prevalence is referred to long face individuals with the presence of facial features able to create unattractiveness and indicated for orthognathic surgery.

CONCLUSIONS

This survey, which aimed to classify and determine the prevalence of individuals with vertically impaired facial relationships by excess,

according to the severity of the discrepancy, and specially of long face pattern individuals, in 5,020 students from middle schools in Bauru/SP (Brazil), showed the following conclusions:

- » There was a total prevalence of 34.94% of individuals with vertically impaired facial relationships by excess including all three levels of severity.
- » The prevalence of long face pattern was 14.06%; 13.39% for moderate subtype and 0.68% for the severe subtype, and this value (14.06%) was higher than that presumed by literature.

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Submitted: December 2010

Revised and accepted: February 2011

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Angle Class II malocclusion treated without extractions and with growth control

Maria Tereza Scardua**

Abstract

Angle Class II malocclusion is defined according to the anteroposterior molar relationship with or without a discrepancy between basal bones. Maxillary protrusion and mandibular retrusion are included in this pattern. When orthodontic treatment starts at an early age, it is possible to affect growth of both basal bones and the dentoalveolar region, which helps to correct tooth positioning in the corrective phase. This report describes the treatment of a case of Angle Class II, division 1 malocclusion that was presented to the Committee of the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) as partial fulfillment of the requirements to obtain the BBO Diploma. The case was representative of category 1, that is, Angle Class II malocclusion treated without extractions and with growth control.

Keywords: Angle Class II malocclusion. Interceptive orthodontics. Corrective orthodontics.

HISTORY AND ETIOLOGY

A white, 11-year-old girl presented for orthodontic treatment. She was in good general health and did not report any important disease or trauma. She had no oral sucking habits, and posture, swallowing and speech were normal.

She was in the mixed dentition and had a conoid lateral incisor (Figs 1 and 2). Her main complaints were the diastemas and the shape of maxillary incisors. She had not undergone any previous orthodontic treatment.

DIAGNOSIS

The evaluation of facial features revealed a pleasing middle third, a short lower third height and a symmetrical face. She also had a very convex profile, mandibular retrusion and maxillary protrusion. The acute nasolabial angle and the oblique nasion perpendicular line reflected the maxillary involvement in malocclusion. At the same time, the everted lower lip, the deep mentolabial fold, the short mandibular line forming an open angle with the neck also indicated mandibular compromise (Fig 1).

* Clinical case report, category 1, approved by the Brazilian Board of Orthodontics and Facial Orthopedics (BBO).

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Lateral radiograph findings, morphological analysis and cephalometric measures confirmed the Class II skeletal pattern ($ANB = 7^\circ$, $SNA = 89^\circ$, and $SNB = 82^\circ$). The horizontal planes and the morphological characteristics defined the patient's profile as brachyfacial. The vertical maxillary incisors ($I-NA = 20^\circ$) and the mandibular incisors tipped buccally ($I-NB = 32^\circ$ and $IMPA = 105.5^\circ$) confirmed the skeletal deficiency (Fig 4 and Table 1).

The patient had a Class II molar relationship, exaggerated 100% overbite and 6 mm overjet. She had diastemas in the maxillary and mandibular arches, a 1 mm deviation to the right from the maxillary midline, tooth # 26 was crossed and tooth # 12 had a conoid shape (Fig 2).

No third molars were seen on the panoramic radiograph (Fig 3).

TREATMENT OBJECTIVES

The treatment should reduce the anteroposterior skeletal discrepancy and redirect mandibular growth, to restrict maxillary growth anteriorly, to retract maxillary molars and to increase vertical dentoalveolar growth to correct overbite. The extraoral appliance should also contribute to reposition tooth # 26.

These skeletal changes should decrease facial profile convexity, increase lower facial height and decrease the depth of the mentolabial fold.

The dentoalveolar objective was to obtain a molar relationship as the key to occlusion and to correct overbite, overjet and tight interproximal contacts. Maximal intercuspation (MI) with simultaneous bilateral contacts, small difference between centric relation (CR) and MI, and effective, mutually protected guidance and occlusion were also part of the treatment objectives.



FIGURE 1 - Initial facial and intraoral photographs.

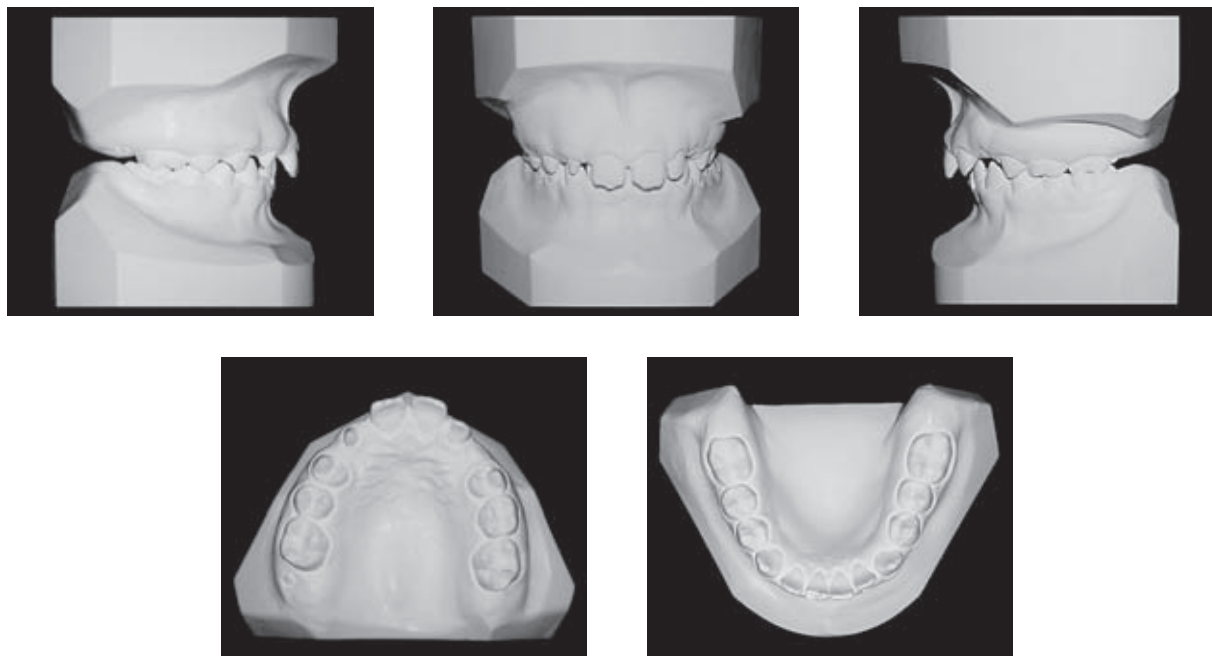


FIGURE 2 - Initial dental casts.

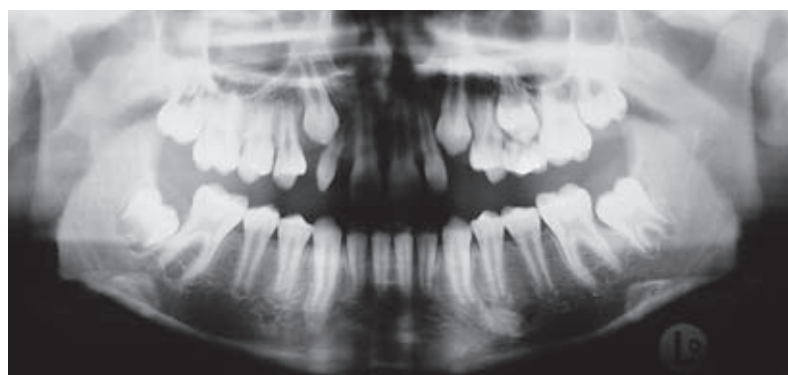


FIGURE 3 - Initial panoramic radiograph.

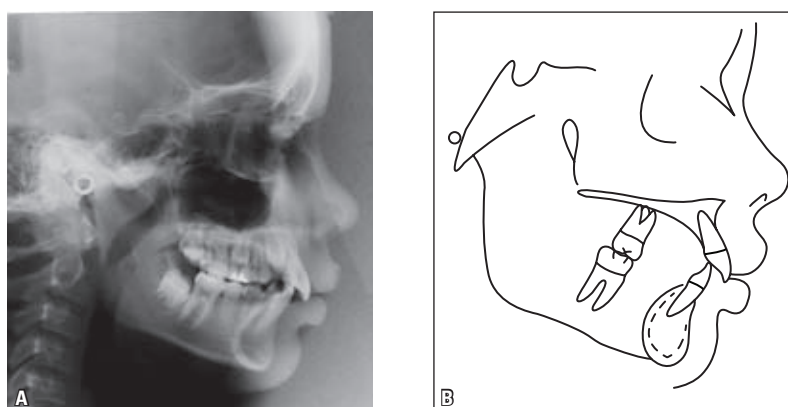


FIGURE 4 - Initial cephalometric profile radiograph (A) and cephalometric tracing (B).

TREATMENT PLAN

Treatment should initiate with the placement of a Bionator and a Kloeohn headgear. After correcting the skeletal discrepancy, the fixed maxillary and mandibular appliance should be placed together with 0.014-in to 0.020-in stainless steel archwires for alignment and leveling. After that, rectangular 0.019 X 0.025-in stainless steel archwires should be used to close residual spaces. Finally, individualized maxillary and mandibular rectangular 0.019 X 0.025-in stainless steel archwires should be used according to need.

Planned retention consisted of a maxillary wraparound clasp plate and, in the mandibular arch, a fixed retainer between teeth #33 and #43 fabricated with 0.032-in stainless steel wire.

After removal of the fixed appliance, the patient should be referred to a specialist for contouring of teeth # 12 and # 22.

Treatment progression

As planned, the Bionator was placed. The acrylic plate was drilled in the region of the mandibular premolars to improve the curve of Spee and in the region of the maxillary molar for retraction due to the effect of the extraoral appliance. After some months, the occlusal acrylic plate was removed to increase posterior dentoalveolar growth and promote overbite correction. Treatment time was 14 months in this phase. However, for 18 months the Bionator was kept in the mouth so that the premolars reached full eruption and the alveolar process increased vertically, and perfect relationships as the key to occlusion. After full eruption of the second molars, the corrective phase began.

Metal brackets with 0.22 X 0.028-in slots were bonded using torque and angulations as prescribed by Andrews. Sequentially, round NiTi and stainless steel 0.014-in to 0.020-in archwires were placed for alignment and leveling. After that, upper and lower 0.019 X 0.025-in stainless steel archwires were placed. In the

maxilla, residual spaces were reduced and managed to correct the midline.

After the achievement of planned objectives, the fixed orthodontic appliance was removed for the placement of retainers. A removable plate with wraparound clasps was used for the maxilla. In the mandible, a fixed 0.032-in stainless steel intercanine bar was bonded to teeth # 33 and 43. The use of an upper retention plate for 24 hours a day for 6 months was recommended, followed by six more months of overnight use, at a total of 12 months. The use of the maxillary intercanine bonded retainer was recommended for an undetermined length of time.

RESULTS

At the end of the treatment, the patient underwent diagnostic tests again. The results revealed that the orthopedic treatment changed the maxilla and the mandible. The objectives set for the treatment were achieved. The patient cooperated in wearing the appliances; maxillary growth was restricted with the use of extraoral anchorage, and the increase of mandibular growth was controlled, which resulted in a reduction of 5° in the ANB angle. The SNB angle increased 2.5° in consequence of the increase in mandibular length, whereas the vertical increase resulted in a decrease of the mandibular plane, with an increase in anterior and posterior face heights (Table 1, Figs 5, 6 and 8).

The superimposition of cephalometric tracings according to lateral radiographs of the face clearly showed that there was greater vertical than anteroposterior growth of the mandible (Fig 9). The use of a Bionator for a long time and the patient cooperation may have favored a more marked condylar growth, that is, forward and upward, which resulted in bone apposition on the lower border of the mandible and mesial movement of teeth in relation to the mandibular body.

The decrease of the mandibular plane resulted from the anticlockwise mandibular rotation, as well



FIGURE 5 - Final facial and intraoral photographs.

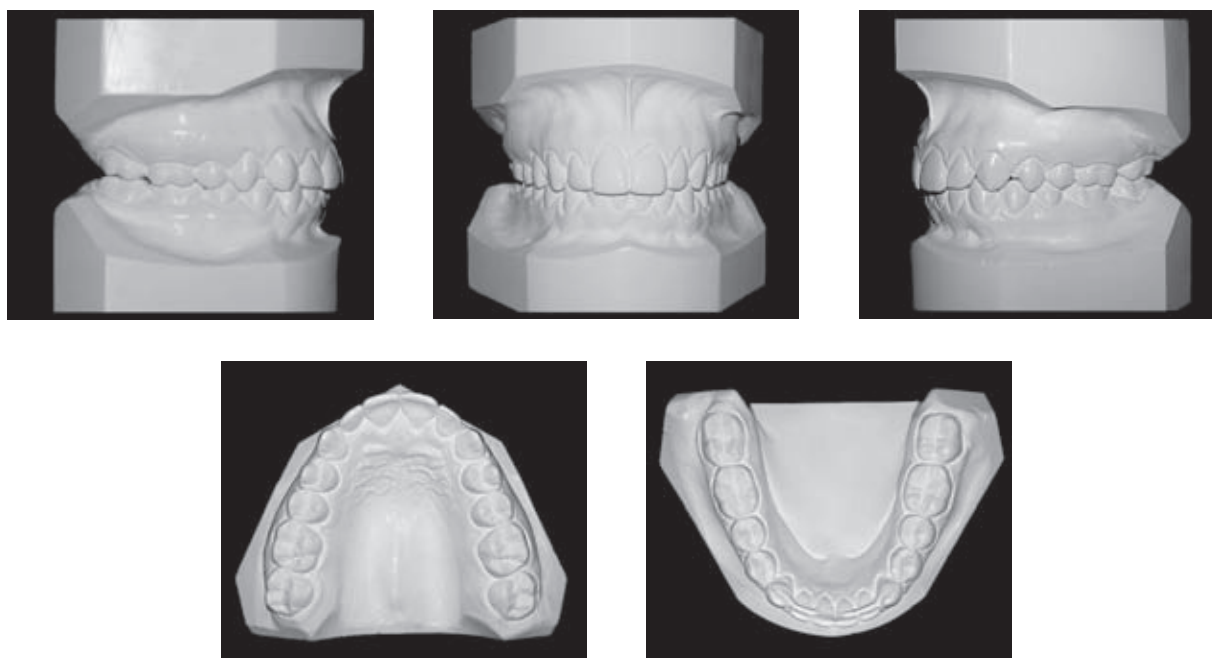


FIGURE 6 - Final dental casts.



FIGURE 7 - Final panoramic radiograph.

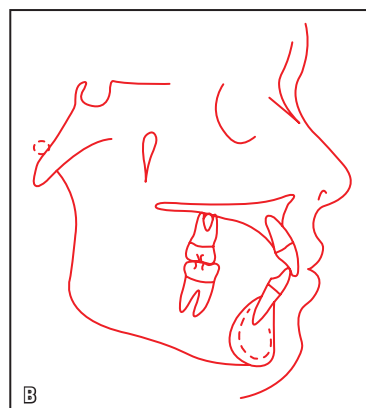


FIGURE 8 - Final cephalometric profile radiograph (A) and cephalometric tracing (B).

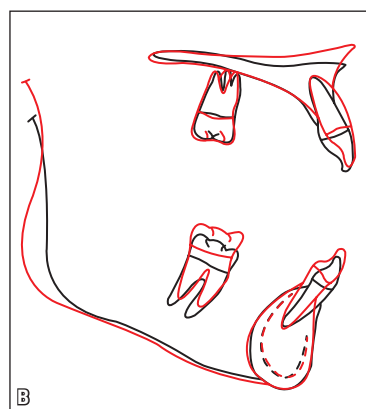
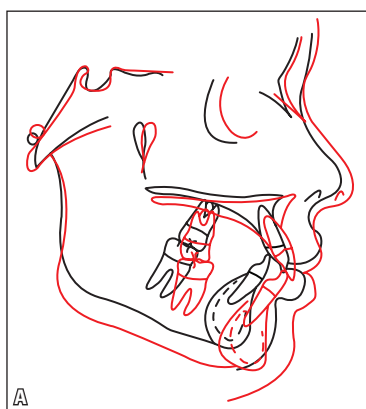


FIGURE 9 - Total (A) and partial (B) superimpositions of initial (black) and final (red) cephalometric tracings.

as from the direction of condylar growth. The superimposition of baseline and final tracings showed that there was substantial growth for the long time interval between baseline and final records.

The analysis of teeth revealed that maxillary incisors moved 7° buccally due to the tipping of canines according to Andrews' prescriptions (11°). Mandibular incisors kept their buccal tipping, which is common in patients with a mandibular deficiency. At the end of the treatment, there were well established molar, premolar and canine relationships as the keys to occlusion.

The analysis of facial features revealed a decrease in profile convexity and a greater height in the lower third of the face, which resulted in improvement of the mentolabial fold.

The clinical evaluation showed that the periodontium was healthy and had no occlusal pathologies; occlusion occurred with simultaneous bilateral contacts in MI and a very small difference between CR and MI, and satisfactory guidance was achieved.

The panoramic radiograph did not show any root resorption or periodontal lesions. The patient was referred to a specialist for the extraction of maxillary third molars (Fig 7).

The evaluation of results two years after treatment completion confirmed stability of results (Figs 10 – 14). Despite the frequent recommendations, the patient had not had the third molars extracted yet at the time when this report was prepared (Fig 12).



FIGURE 10 - Facial and intraoral photographs two years after treatment completion.

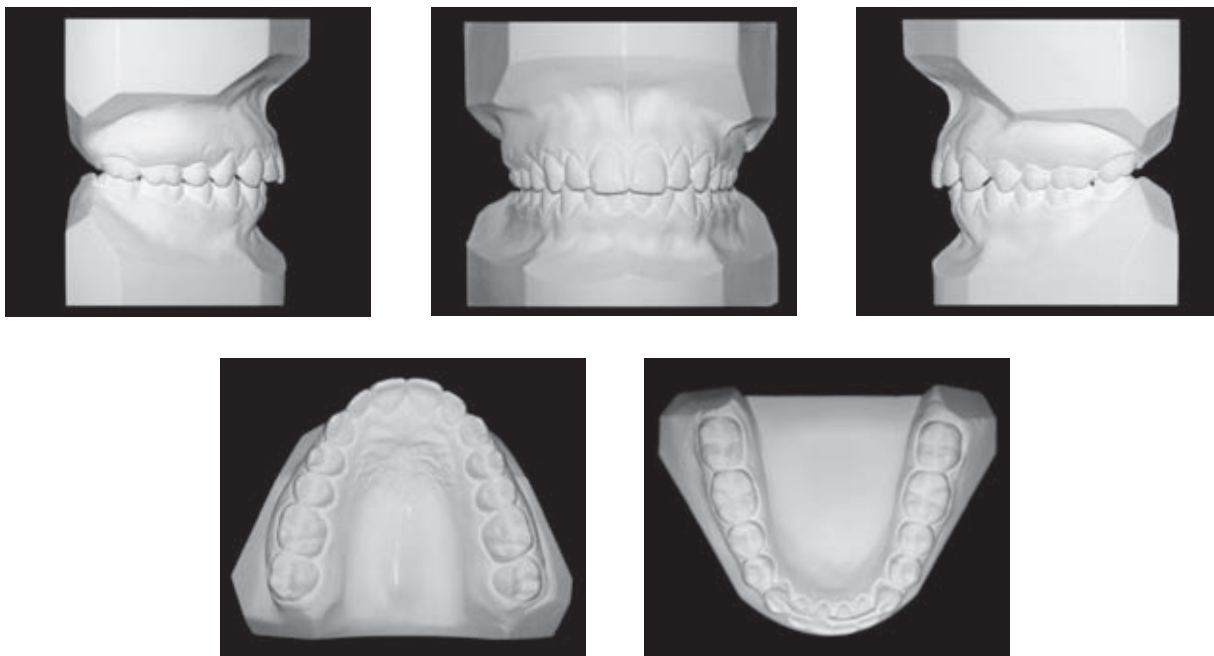


FIGURE 11 - Control dental casts two years after treatment completion.

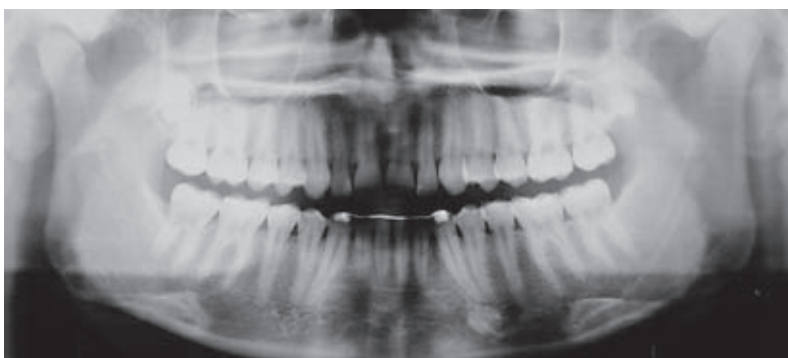


FIGURE 12 - Control panoramic radiograph two years after treatment completion.

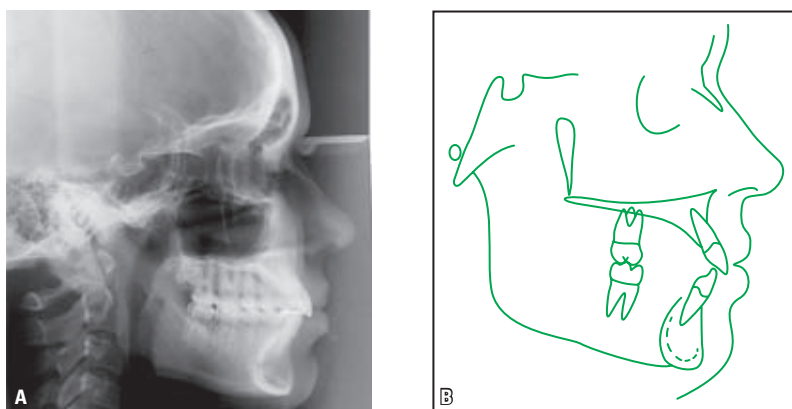


FIGURE 13 - Cephalometric profile radiograph (A) and cephalometric tracing (B) two years after treatment completion.

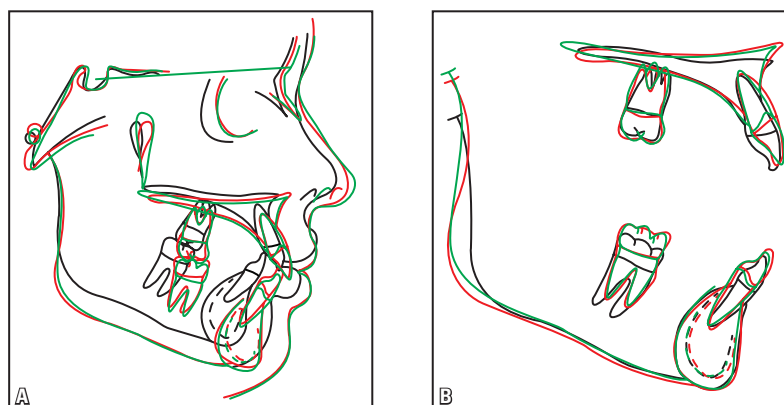


FIGURE 14 - Total (A) and partial (B) superimposition of cephalometric tracings at initial (black), at treatment completion (red) and two years after treatment (green).

TABLE 1 - Summary of cephalometric measurements.

	MEASUREMENTS	Normal	A	B	Difference A/B	C
Skeletal Pattern	SNA (Steiner)	82°	89°	86.5°	2.5	86.5°
	SNB (Steiner)	80°	82°	84.5°	2.5	84.5°
	ANB (Steiner)	2°	7°	2.5°	4.5	2.5°
	Convexity Angle (Downs)	0°	13°	5.5°	7.5	5°
	Y-Axis (Downs)	59°	62°	64°	2	63°
	Facial Angle (Downs)	87°	83.5°	86.5°	3	86°
	SN – GoGn (Steiner)	32°	23°	21°	2	19°
	FMA (Tweed)	25°	22°	19°	3	18°
Dental Pattern	IMPA (Tweed)	90°	105.5°	106°	2	105°
	$\underline{1}$ – NA (°) (Steiner)	22°	20°	27°	7	26°
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	4 mm	5 mm	1	5 mm
	$\bar{1}$ – NB (°) (Steiner)	25°	32°	32°	0	30°
	$\bar{1}$ – NB (mm) (Steiner)	4 mm	5.5 mm	6 mm	0.5	5.5 mm
	$\frac{1}{1}$ – Interincisal Angle (Downs)	130°	121°	126°	5	127°
	$\bar{1}$ – APo (mm) (Ricketts)	1 mm	0.5 mm	2 mm	1.5	2 mm
Profile	Upper Lip – S Line S (Steiner)	0 mm	5 mm	0 mm	5	0.5 mm
	Lower Lip – S Line (Steiner)	0 mm	4 mm	2 mm	2	2.5 mm

FINAL CONSIDERATIONS

Angle Class II malocclusions are defined according to the sagittal molar relationships, although basal bones are not always compromised. When they are, there may be abnormal sagittal positioning of the maxilla, mandible, or both. Sagittal abnormalities may also be found in basal bones regardless of the relationship between dental arches as a result of tooth compensation to the skeletal problem.¹

Orthopedic interventions, both in the maxilla and in the mandible, are possible. In the maxilla, extraoral anchorage had its potential confirmed in a study with implants.³ In the mandible, however, the effect of orthopedic treatment on growth is discrete, and clinical responses are dental rather than skeletal. In this sense, reports in the literature are greatly variable. Patients with a good facial pattern may positively contaminate samples and generate optimistic results. A study conducted by Tulloch et al⁴ in 1997 brought important contributions to clarify this issue. Two groups were treated with orthopedic appliances, and a third was used as control. Both the treated groups and the controls had a similar variation in extension of growth, which led to the conclusion that the individual with the worst increase in the control group, even if treatment was provided, would probably not reach its group mean and would have less growth than the mean growth for the untreated group.

Another interesting study that made us think about orthopedic responses was the theory of facial growth mortgage. This theory suggests that facial growth obtained during treatment is an advancement of the total growth available to each patient. After treatment, patients do not keep the growth rate seen during the treatment and grow less than would be expected for them.⁵

The fact that we currently know the effects of

orthopedic appliances better and know that they are less significant for growth than previously imagined, does not reduce our interest in their use, but suggests a more realistic prognosis based on high quality scientific data.⁶ Maybe it is possible to use patient growth not only to produce results, but also to correct malocclusion using the growth achieved during treatment.²

In this case, we chose to treat the Class II malocclusion using an extraoral Kloehe headgear and a Bionator. Our purpose was to obtain retraction of maxillary molars and anterior maxillary growth restriction, as well as the mandibular advancement and vertical dentoalveolar increases. Growth was an ally in the correction of malocclusion. Therefore, the maintenance of the existing dentoalveolar compensations and the treatment results were expected and contributed to malocclusion correction. The marked tipping and the already great mandibular incisors protrusion had an additional slight increase. This, however, was not a matter of concern, because the radiographs showed a good amount of bone on the buccal and lingual surfaces of the mandibular symphysis. Although different from mean values, incisors and facial structures are balanced in terms of shape and function.

The comparison of baseline and final tracings showed that there was substantial growth for the long time interval between baseline and final records. The use of a Bionator for a long time and patient cooperation may have favored a more marked condylar growth, as well as mesial movement of the teeth in relation to the mandibular body and protrusion of the incisors. These growth characteristics have been brilliantly described by Björk⁷ in longitudinal studies.

The analysis of control records two years after treatment completion revealed that occlusion remained stable and that the facial appearance was very pleasing (Figs 10 – 14).

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Submitted: December 2010
Revised and accepted: March 2011

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Checklist of esthetic features to consider in diagnosing and treating excessive gingival display (gummy smile)

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Abstract

Introduction: Excessive gingival display on smiling is one of the problems that negatively affect smile esthetics and is, in most cases, related to several etiologic factors that act in concert. A systematic evaluation of some aspects of the smile and the position of the lips at rest can facilitate the correct assessment of these patients. **Objective:** To present a checklist of dentolabial features and illustrate how the use of this record-keeping method during orthodontic diagnosis can help decision making in treating the gummy smile, which usually requires knowledge of orthodontics and other medical and dental specialties.

Keywords: Orthodontics. Esthetics. Smile.

INTRODUCTION

Whenever patients are able to clearly view their own gummy smile (GS) this condition becomes an important esthetic complaint during orthodontic anamnesis. Although it appears fairly frequently in private offices, very few studies in the literature address GS, its diagnosis and treatment as a central topic. Treating the smile is a challenging task for orthodontists. One historical reason for this fact is that in the 20th century, particularly in the 1950s and 1960s, orthodontic diagnosis and treatment were based on cephalometry and, therefore, esthetic concepts

were defined primarily based on a profile view of the patient. Nevertheless, in their orthodontic records orthodontists continued to focus on the use of plaster models, which provide but a static record of occlusion, neglecting the dynamic analysis of speech and smile, as well as the evaluation of morphological and functional characteristics of the lips. Since the act of smiling is a dynamic process, the beauty of a smile depends not only on correct dental and skeletal positioning, but also on the anatomy and function of the lip muscles, over which orthodontists must recognize that they exercise little or no control.

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GUMMY SMILE (GS)

Most dental professionals believe that during smiling the upper lip should position itself at the gingival margin of the maxillary central incisors.^{1,2,3} However, it is known that displaying a certain amount of gingiva is esthetically acceptable and in many cases imparts a youthful appearance.^{4,5,6}

Although there are several parameters in the literature that define GS (amount in millimeters of gingival display on smiling), what seems most likely to arouse orthodontists' interest are the beliefs held by the general public concerning what is, or is not esthetically acceptable. Research conducted by Kokich Jr et al⁷ found that a smile is considered unesthetic—by both clinicians and lay people—when gingival exposure reaches 4 mm. For orthodontists, who tend to be more demanding, 2 mm gingival exposure on smiling is enough to compromise smile harmony (Fig 1).

Smile height is influenced by sex and age. There is evidence that women display higher smiles than men^{8,9} and that dentogingival exposure decreases with age.⁸ This information has

clinical relevance since GS self-corrects to a certain extent over time, especially in men.¹⁰

Its etiology is related to several factors, such as: Vertical maxillary excess, upper dentoalveolar protrusion, extrusion and/or altered passive eruption of anterosuperior teeth and hyperactivity of upper lip levator muscles. In most cases, however, some or all of these factors are correlated. Orthodontists seem to be the professionals most qualified to critically assess the weight of each of these factors, among which hyperactivity of the upper lip levator muscles is the least studied and hitherto understood.

DIAGNOSIS

Despite the etiologic factors involved in the gummy smile, some issues should be necessarily considered during clinical evaluation. Systematic recording of (a) interlabial distance at rest, (b) exposure of upper incisors during rest and speech, (c) smile arc, (d) width/length ratio of maxillary incisors and (e) morphofunctional characteristics of the upper lip by means of a checklist (Fig 2). All these records can be very



FIGURE 1 - Different degrees of gingival display on smiling: **A)** 0 mm; **B)** 1 mm; **C)** 2 mm and **D)** 4 mm.

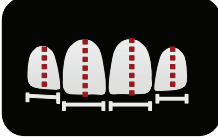
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☐	<1 mm ☐	Pleasant ☐	<65% ☐	Short ☐
>3 mm ☐	1-4.5 mm ☐	Flat ☐	75-80% ☐	Thin ☐
	>4.5 mm ☐	Reverse ☐	>85% ☐	Hypermobility ☐

FIGURE 2 - Suggested checklist with five items for assessing dentolabial characteristics (download available at www.dentalpress.com.br/journal).

useful in the diagnostic stage. By including these data in the orthodontic consultation file one ensures that information key to the treatment plan are not forgotten or overlooked.

1. Interlabial distance at rest

When entering this information, it is crucial that orthodontists include in the initial orthodontic records a photograph showing the patient's lips at rest. Phonetic assessments based on video footage can also prove useful.

There is no direct relationship between GS and amount of interlabial space at rest.¹¹ Contrary to a long-standing belief, patients with normal upper lip length and reduced interlabial space can present with excessive gingival display on smiling. When interlabial space at rest is normal (1-3 mm), GS is considered to have a predominantly muscular origin (Figs 3 A, B and C). Usually, the main cause of increased interlabial space is dentoskeletal disharmony (vertical maxillary excess and/or protrusion of upper incisors), which may or may not be associated with anatomical and/or functional changes in the upper lip (Figs 4 A, B and C).^{11,13} Diagnosing GS's muscular etiology is crucial for immediately recognizing the limitations of orthodontic treatment and seeking help

from other specialties such as, for example, esthetic medicine. Moreover, a correct diagnosis can decrease the risk that GS correction may interfere with other favorable esthetic features of the smile. This fact lends support to the paradigm of contemporary orthodontics, which consists in identifying the positive esthetic features of the smile to ensure that such features are not affected by treatment of dentofacial problems.¹⁴

2. Upper incisor exposure during rest and speech

It is known that when the lips are at rest the amount of exposure of the upper incisors is approximately 2 to 4.5 mm in women and 1 to 3 mm in men (Fig 5). This characteristic is directly related to the youthful appearance of the smile and it is expected to decline throughout life (given the lengthening of the upper lip that results from the process of tissue maturation and aging).^{10,11,12}

To keep a record of this condition, one can use a standard lateral cephalometric radiograph of the lips at rest and measure the distance in millimeters between the incisal edge of the maxillary central incisor and the lower contour of the upper lip (Fig 6). Phonetic assessments during clinical examination are also important. Patients should



FIGURE 3 - Patients with interlabial space between 1 and 3 mm, normal exposure of upper incisors at rest and gummy smile. In this situation, intrusion of upper incisors to reduce gingival display on smiling is contraindicated.



FIGURE 4 - Patients with interlabial space >3 mm, increased exposure of upper incisors at rest and gummy smile. In this situation, orthodontic intrusion and/or ortho-surgery of upper incisors is needed to reduce gingival display on smiling.

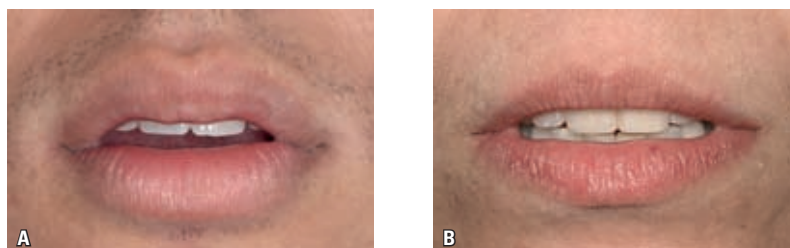


FIGURE 5 - Amount of upper incisor exposure at rest in men (A) is usually smaller than in women (B).

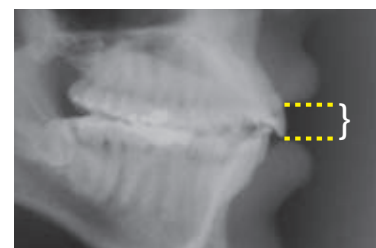


FIGURE 6 - Amount of upper incisor exposure in lateral cephalometric radiograph.



FIGURE 7 - **A)** Smile arc parallel to curvature formed by the lower lip during smile, giving it a young look. **B)** Flat smile arc due to excessive labial inclination of maxillary teeth.

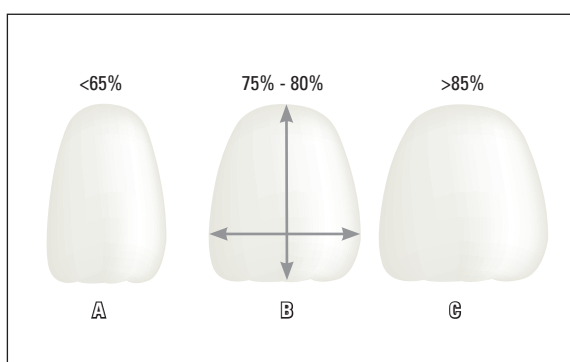


FIGURE 8 - Upper central incisors with different proportions, indicating that teeth are: **A)** Narrow and long, **B)** Proportional, **C)** Short and square.

be instructed to articulate phrases formed by phonemes that induce greater incisor exposure⁸ such as the following sentence (in Brazilian Portuguese): “Tia Ema torce pelo time do Corinthians,” followed by a broad, spontaneous smile, as exemplified at www.dentalpress.com.br/journal.

The following factors are related to increased exposure of the upper incisors at rest: Upper incisor extrusion, dolichocephalic facial pattern, vertical maxillary excess and a short upper lip. When treatment planning involves maxillary impaction and/or intrusion of anterosuperior teeth, the magnitude of dentoskeletal change should not be based on the amount of gingival display one wishes to decrease, but rather on the degree of incisor exposure (at rest) that one wishes to maintain. Patients whose esthetics can benefit from upper incisor intrusion do not usually pose a significant

challenge to the orthodontic or surgical planning of GS correction (Figs 3 A, B and C). On the other hand, patients who exhibit adequate incisor exposure during rest and speech require more careful planning (Figs 4 A, B and C).^{11,14}

3. Smile arc

The term smile arc is defined as the curvature formed by the incisal edges of anterosuperior teeth. To be considered an esthetic and youthful smile, this curvature must be parallel to the superior margin of the lower lip (Fig 7A).¹⁵ Women’s smiles feature a sharper curvature, whilst in men the curvature appears more flat. In individuals with brachycephalic facial pattern, the smile arc is flatter than in meso- and dolichocephalic individuals.¹¹

In some patients with GS maxillary incisor intrusion can be performed. However, failure to assess the smile arc can result in inappropriate flattening of its curvature, rendering it less attractive.^{16,17}

4. Width/length ratio of maxillary incisors

Cosmetic dentistry provides pertinent information regarding tooth proportions and morphology. According to some authors, it is of paramount importance that smile proportions conform to the face.^{17,18,19} The ratio known as “gold standard” determines that the width of the maxillary incisors should be approximately 80% of its length (Fig 8), with acceptable variations between 65% and 85%, whereas for upper lateral incisors that same ratio should be around 70%.^{17,18,19}

A high width/length ratio (W/L) is often found in squared teeth, while lower ratios are associated with a more elongated appearance. Prosthetic dentistry concepts determine that the proportions and morphology of upper central incisor crowns should be in harmony with the patient's facial pattern.^{12,18,19}

In subjects with GS, it is important to assess whether the crowns of anterior teeth appear very short. If this is the case, the next step is to establish the reason for such shortness, which may occur primarily for two reasons:

A) Reduction in height of the incisal edges of upper teeth by friction and/or fracture

In these cases, as incisors extrude so do their periodontal attachment and support. This process, called "compensatory tooth extrusion,"²⁰ may be responsible for excessive gingival display during smile. On periodontal probing, these teeth show normal gingival sulcus depth, and treatment can be accomplished through periodontal surgery with

prosthetic rehabilitation, or orthodontics associated with restorative dentistry.

- Clinical crown lengthening surgery with osteotomy

In view of the fact that this procedure induces exposure of the root surface and requires additional restorative treatment, it should be thoroughly discussed with the patient (Fig 9). Moreover, due to the tapering of tooth roots, prosthetic crowns will tend to acquire a more triangular shape, making it hard to achieve satisfactory interproximal esthetics. The emergence of "black spaces" after surgery is not uncommon. The advantage of this approach includes shorter treatment time and no need for fixed orthodontic appliances. On the downside, there is a decrease in crown/root ratio, loss of bone support and need for prosthetic restoration of the teeth involved.^{12,18,19,20}

- Orthodontic intrusion and subsequent restoration of tooth proportions using restorative dentistry procedures (Fig 10).¹⁷



FIGURE 9 - Case of compensatory tooth extrusion whose chief complaint was small size of maxillary central incisors. At patient's request, surgical lengthening of clinical crowns of teeth 11 and 21 was performed and new porcelain crowns fabricated.



FIGURE 10 - Compensatory dental extrusion of teeth 11 and 21, treated with orthodontic intrusion and provisional restoration of incisal thirds with composite.

B) Gingival overgrowth

The etiologic factors behind gingival overgrowth are diverse, ranging from tissue hypertrophy due to infection and/or medication, to altered passive eruption.^{20,21} The process of tooth eruption is deemed completed when teeth reach the occlusal plane and go into function. The soft tissues follow this trend and ultimately the gingival margin migrates apically almost as far as the cemento-enamel junction (CEJ). This whole process is called passive eruption. When, for reasons hitherto unknown, the gingiva fails to migrate to its expected position, this condition is named altered passive eruption. If, on periodontal probing, these teeth exhibit increased values of gingival sulcus depth, such situation constitutes a clear indication that the patient should be referred to a periodontist to treat his/her gummy smile (Fig 11).^{20,21} Normally, the lengthening of incisor crowns is accomplished by removing excess gingival tissue

overlying the cervical enamel. When the distance between alveolar bone crest and CEJ is less than 1 mm (insufficient for adaptation of connective tissue attachment), osteotomy is necessary to establish accurate biological distances.²¹

5. Morphofunctional characteristics of the upper lip

The lips play a pivotal role in facial expression, especially in the act of smiling, whose variations are related to the morphofunctional features of the lip, such as: Length, thickness and insertion, direction and contraction of various lip-related muscle fibers.²²

As regards length, the average value for men's upper lip is 24 mm and for women, 20 mm.²³ It may seem that individuals with a short upper lip display more gingiva when smiling, but lip length is probably not directly related to a gummy smile.¹¹ Severe vertical maxillary excess cases, for example,



FIGURE 11 - Case of altered passive eruption with short upper incisors and gummy smile.

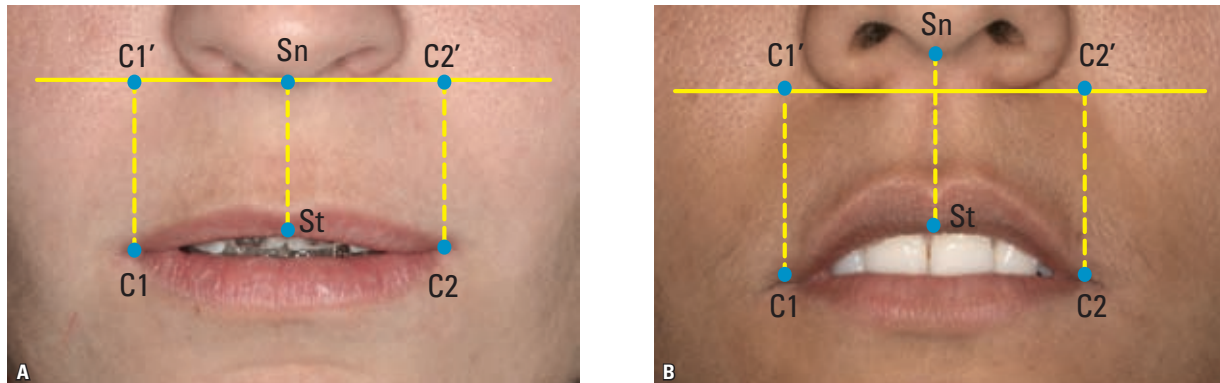


FIGURE 12 - Measurement of upper lip length: **A)** Long upper lip, **B)** short upper lip.

may have an upper lip of normal size or even quite long, which complicates GS correction, as lip length allows little or no incisor intrusion whatsoever.^{11,14}

To assess upper lip length one needs to measure the height of the philtrum and labial commissures. Philtrum height is reflected in the distance between the subnasale (Sn) and Stomion (St) points of the upper lip. In turn, commissure height is obtained by measuring perpendicularly the distance between these structures (C1 and C2) and their projections (C1' and C2') in a horizontal line that joins the two wing bases (Fig 12).

The linear values of these measures are not as important as the relationship between the length of the philtrum and commissures. In children and adolescents, philtrum height is slightly lower than commissure height and this difference can be explained by differential maturation of the lips during growth. Normally, when this happens in adults it causes increased exposure of the incisors during rest and speech (Fig 12B).¹⁴

Thin lips are also known to exhibit greater strain and responsiveness both to dentoalveolar changes and to the contractile pattern of the muscles.^{9,23}

Upper lip mobility, which results from the action of specific muscles, seems to be the main feature to consider in evaluating the soft tissues

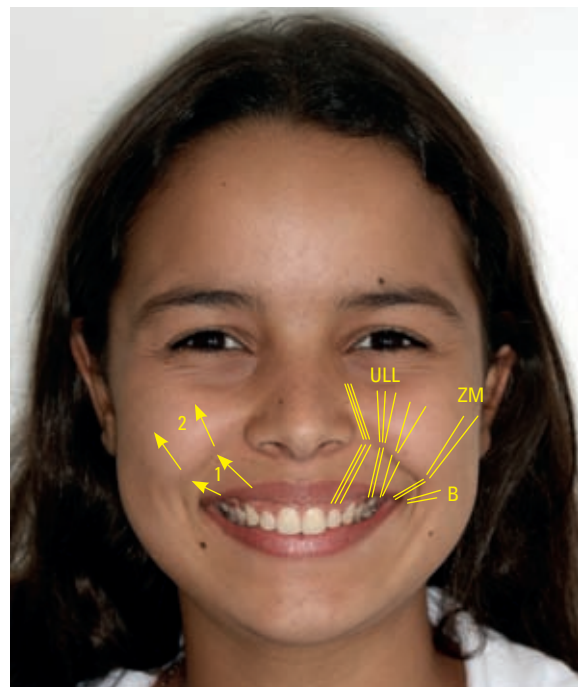


FIGURE 13 - Facial muscles involved in smile dynamics: Upper lip levators (ULL), zygomatic major (ZM) upper fibers of buccinator muscle (B). Stages of a smile: Voluntary smile (1); spontaneous smile (2).

involved in smiling.²⁴⁻²⁸ In addition to the muscle that surrounds the lips internally (orbicularis oris), several other muscle groups influence upper lip movement, i.e.: Levator muscle of upper lip, levator muscle of upper lip and nose wing,



FIGURE 14 - Patients with thin and hyperactive lips are subject to greater gingival display on smiling.

levator muscle of the corner of the mouth, zygomatic major, zygomatic minor, depressor of the nasal septum (Fig 13).¹¹

Smile takes shape in two stages: In the first (voluntary smile) the upper lip is elevated towards the nasolabial sulcus by contraction of the levator muscles, which originate from this sulcus and are inserted into the lips. The medial bundles elevate the lip in the region of the anterior teeth, and the lateral bundles in the region of the posterior teeth until they meet with resistance from the adipose tissue in the cheeks. The second stage (spontaneous smile) starts with a higher elevation of both the lips and the nasolabial sulcus through the agency of three muscle groups: The upper lip levator, which originates from the infraorbital region, the zygomatic major muscle and the superior fibers of the buccinator muscle (Fig 13).^{11,22}

According to the classification of Rubin,²² there are three types of smile: (a) The so-called “Mona Lisa” smile, whereby the labial commissures are displaced upwards through the action of the zygomatic major muscle; (b) the “canine smile,” when the upper lip is elevated in uniform fashion; and finally (c) the “complex smile,” when the upper lip behaves like the “canine smile” and the lower lip moves inferiorly exposing the lower incisors.

Studies show that the upper lip muscles of individuals with GS are considerably more efficient than those with a normal level of gingival display.^{11,24-28}

In GS patients with normal facial proportions, lip length within average limits, marginal gingiva located near the CEJ and normal width-length ratio, etiology may be associated with hyperactivity of the muscles that move the upper lip during smile. A non-hyperactive lip moves approximately 6 mm to 8 mm from a resting position to a broad smile. On the other hand, a hyperactive upper lip moves a distance 1.5 to 2 times greater (Fig 14).²³ For these cases, some cosmetic procedures are available which have been studied in patients with facial paralysis since 1973.²⁷ Among these, silicone implantation at the bottom of the vestibule at the base of the anterior nasal spine, infiltration of botulinum A toxin and resective procedures in the muscles responsible for upper lip mobility produce satisfactory esthetic results.²⁴⁻²⁷

Cost-effectiveness, considering the durability, safety and low morbidity of these procedures, must be analyzed by orthodontists before this approach is safely and more often suggested to patients.

USING THE CHECKLIST

Clinical Case 1

The patient, a 13-year-old girl, reported as chief complaint the reduced size of her maxillary incisors and presented with the following characteristics: Facial thirds with balanced proportions, slightly convex profile, mild mandibular retrusion, competent lip seal, moderate GS, Angle Class I malocclusion with slight extrusion of upper incisors and excessive overbite (Fig 15).

Checklist assessment (Fig 16) revealed interlabial space, exposure of upper incisors at rest and normal morphofunctional upper lip, as well as appropriate smile arc curvature. A low width/length ratio of maxillary incisors was the only

feature assessed as unfavorable. (Fig 17). Initial periodontal probing of these teeth showed increased values of gingival sulcus depth, suggesting a state of altered passive eruption.

Orthodontic treatment was performed without extraction and, after further probing during the finishing phase, gingivectomy was indicated across the entire anterosuperior region (Fig 18). This procedure achieved a better width/length ratio of maxillary incisors and reduced gingival display (Figs 19 and 20). The patient's smile benefited from increased aesthetics and improved dental proportions, preserving incisor exposure at rest and a pleasant smile arc curvature (Figs 20 and 21).



FIGURE 15 - Clinical case 1 – Initial facial and dental aspects.

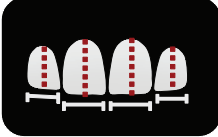
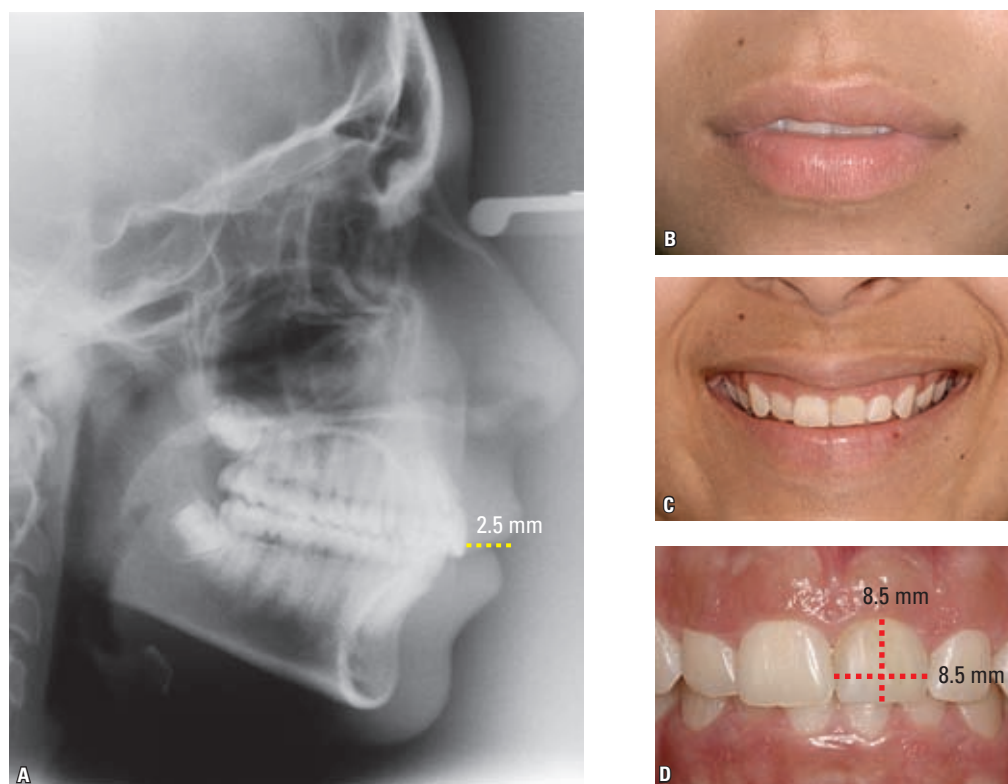
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☒	<1 mm ☐	Pleasant ☒	<65% ☐	Short ☐
>3 mm ☐	1-4.5 mm ☒	Flat ☐	75-80% ☐	Thin ☐
	>4.5 mm ☐	Reverse ☐	>85% ☒	Hypermobility ☐

FIGURE 16 - Clinical case 1 checklist.

FIGURE 17 - Checklist features evaluated: **A)** Exposure of upper incisors at rest; **B)** interlabial distance at rest and morphological characteristics of upper lip; **C)** smile arc and functional characteristics of upper lip; **D)** Width/Length ratio of upper incisors.

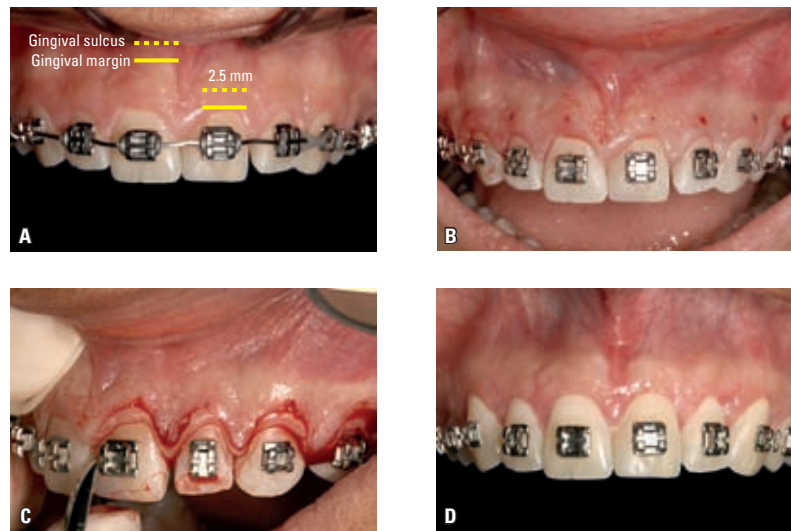


FIGURE 18 - **A** and **B**) Results of periodontal probing during finishing phase of treatment. **C**) Gingivectomy performed in upper arch. **D**) Gingival appearance one week after surgery.

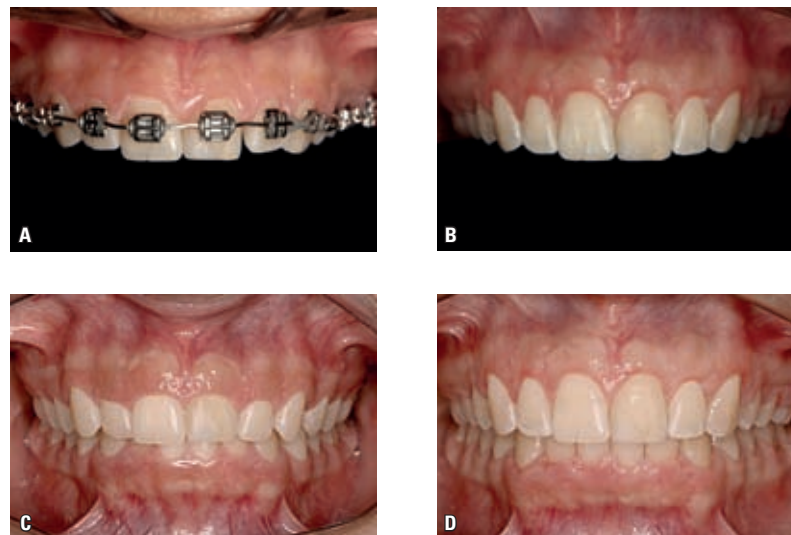


FIGURE 19 - **A** and **B**) Improved width/length ratio of anterosuperior teeth in close up view. **C** and **D**) Impact of gingivectomy on esthetic appearance of occlusion.



FIGURE 20 - Initial and final close up photos of smile, showing removal of maxillary gingival excess.



FIGURE 21 - Change in smile aesthetics between initial and final phases of treatment.

Clinical Case 2

The patient, an 18-year-old girl, reported as chief complaint the reduced size of her maxillary incisors and excessive maxillary gingival display, presenting with the following characteristics: Facial thirds with balanced proportions, straight profile, GS, Angle Class I malocclusion

with extrusion of maxillary incisors and excessive overbite (Fig 22).

Checklist assessment (Fig 23) revealed normal interlabial space and upper incisor exposure at rest as well as pleasant looking smile arc. The low width/length ratio of maxillary incisors and hypermobility of the upper lip on smiling were



FIGURE 22 - Clinical case 2 – Initial facial and dental aspects.

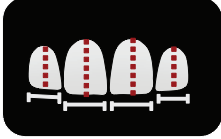
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☒	<1 mm ☐	Pleasant ☒	<65% ☐	Short ☐
>3 mm ☐	1-4.5 mm ☒	Flat ☐	75-80% ☐	Thin ☐
	>4.5 mm ☐	Reverse ☐	>85% ☒	Hypermobility ☒

FIGURE 23 - Clinical case 2 checklist.

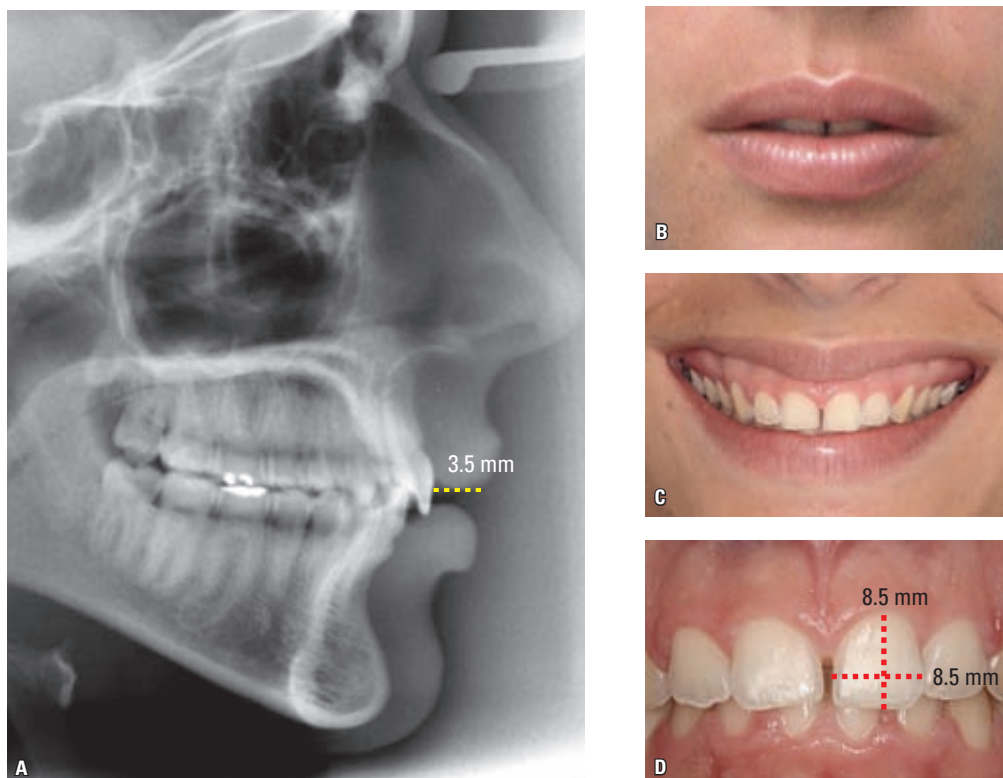


FIGURE 24 - Checklist features evaluated: **A)** Exposure of upper incisors at rest; **B)** interlabial distance at rest and morphological characteristics of upper lip; **C)** smile arc and functional characteristics of upper lip; **D)** Width/Length ratio of upper incisors.

regarded as negative features (Fig 24).

Initial periodontal probing showed increased values of gingival sulcus depth, suggesting a state of altered passive eruption associated with upper lip hypermobility. These two factors contributed substantially to increased gingival exposure in

the anterior and posterior regions of the smile.

Corrective orthodontic treatment was performed without extractions. In the final phase, after further periodontal probing, gingivectomy was performed to eliminate gingival pseudopockets present throughout the anterosu-

perior region (Fig 25). Composite restorations on the incisal edges of teeth 12, 11, 21 and 22 helped smoothen the incisal profile, which combined with an adequate width/length ratio of maxillary incisors to improve smile esthet-

ics (Fig 26). Despite a certain degree of gingival display still present due to hypermobility of the upper lip, the esthetic outcome of the treatment was rated as satisfactory by the patient (Figs 27 and 28).

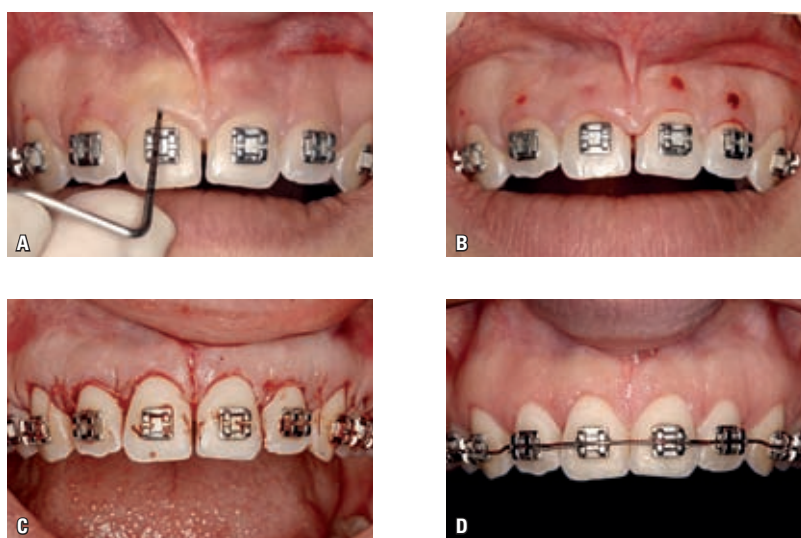


FIGURE 25 - **A** and **B**) Periodontal probing during finishing phase of treatment. **C**) Gingivectomy performed in upper arch. **D**) Gingival appearance one week after surgery.



FIGURE 26 - Impact of gingivectomy on width/length ratio of anterosuperior teeth and on esthetic appearance of occlusion. Provisional composite restorations were performed to smoothen upper incisal silhouette.



FIGURE 27 - Initial and final photos of smile, showing removal of maxillary gingival excess.



FIGURE 28 - Change in smile esthetics between initial and final phases of treatment.

Clinical Case 3

The patient, a 21-year-old woman, reported as chief complaint dental crowding and excessive upper gingival display, and exhibited the following characteristics: Facial thirds with balanced proportions, slightly concave profile, competent

lip seal, GS, Angle Class I malocclusion, excessive overbite, extrusion and lingual inclination of maxillary central incisors (Fig 29).

Checklist assessment (Fig 30) revealed normal interlabial space and pleasant smile arc. Normal exposure of the upper central incisors at rest, low



FIGURE 29 - Clinical case 3 – Initial facial and dental aspects.

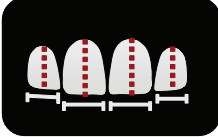
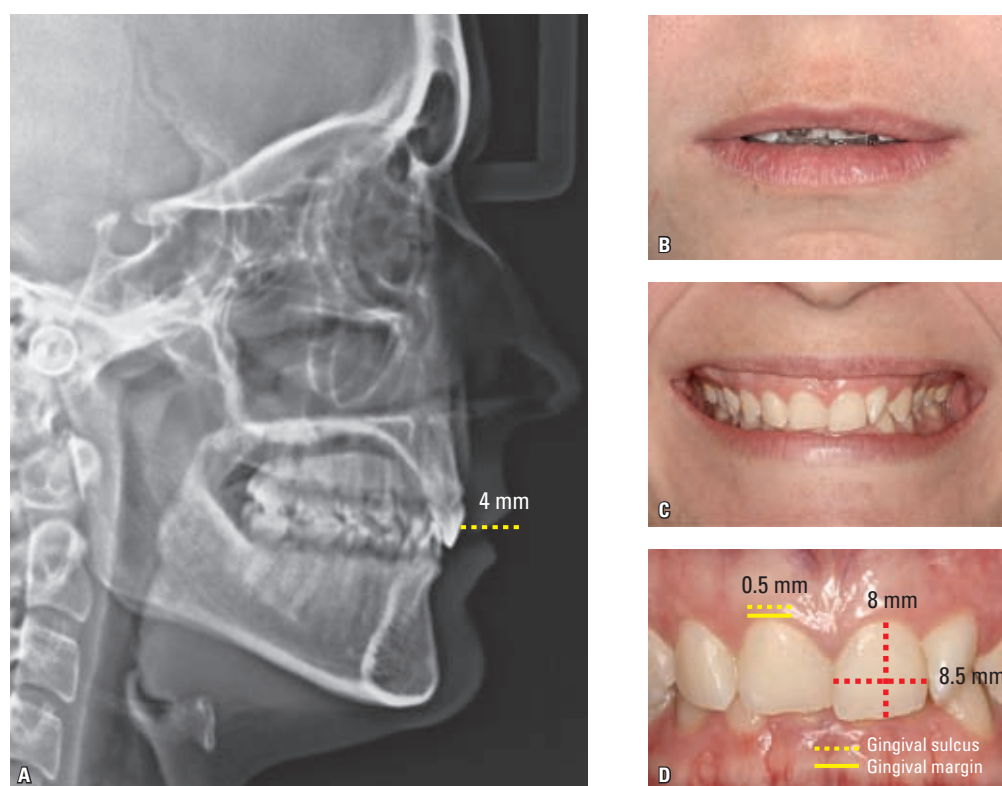
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☒	<1 mm ☐	Pleasant ☒	<65% ☐	Short ☐
>3 mm ☐	1-4.5 mm ☒	Flat ☐	75-80% ☐	Thin ☒
	>4.5 mm ☐	Reverse ☐	>85% ☒	Hypermobility ☒

FIGURE 30 - Clinical case 3 checklist.

FIGURE 31 - Checklist features evaluated: **A)** Exposure of upper incisors at rest; **B)** interlabial distance at rest and morphological characteristics of upper lip; **C)** smile arc and functional characteristics of upper lip; **D)** Width/Length ratio of upper incisors, whose probing depth appeared normal.

length/width ratio of these teeth and upper lip hypermobility were considered as unfavorable features. Initial periodontal probing disclosed normal gingival sulcus depth. Incisal edge wear of maxil-

lary central incisors was observed, which led to a diagnosis of compensatory tooth extrusion (Fig 31).

Total corrective orthodontic treatment was performed without extractions, with intrusion

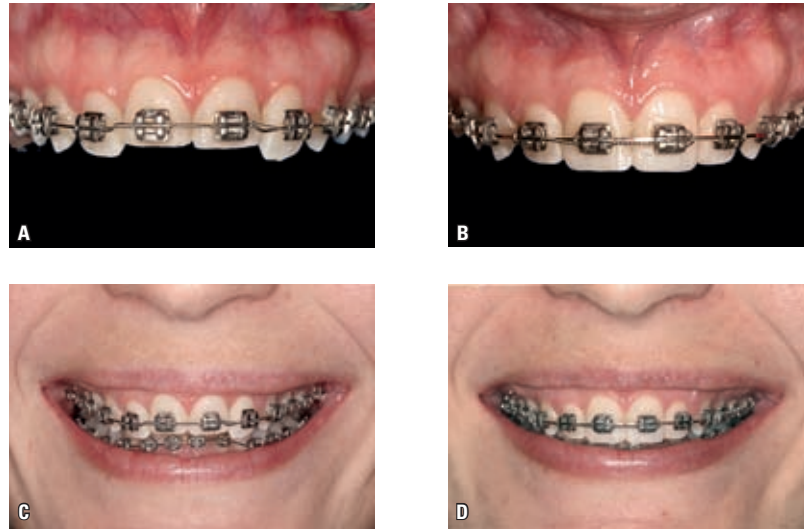


FIGURE 32 - **A and C)** Orthodontic intrusion of maxillary central incisors. **B and D)** Provisional restoration of incisal third of units 11 and 21 and ameloplasty to smoothen incisal edge height of teeth 12 and 22.



FIGURE 33 - Width/Length ratio of maxillary central incisors restored, providing dominance and prominence to these teeth and decreased maxillary gingival excess on smiling.

and correction of upper central incisor lingual inclination. After leveling the upper arch, the incisal edges of teeth 12 and 22 were smoothened through ameloplasty and units 11 and 21 were restored temporarily with composite (Fig 32).

This approach improved the width/length ratio and preserved upper incisor exposure at rest. Some small gingival exposure still remained due to lip hypermobility but not enough to compromise final smile esthetics (Figs 33 and 34).



FIGURE 34 - Change in smile esthetics between initial, intermediate and final phases of treatment.

Clinical Case 4

The patient, a 36-year-old woman, reported as chief complaint the presence of spaces in the first premolar region and showed the following characteristics: Facial thirds with balanced proportions, slightly convex profile, adequate lip seal, GS, Angle Class I

malocclusion, residual spaces resulting from first premolar extractions, extruded and lingually inclined upper incisors and excessive overbite (Fig 35).

Checklist assessment (Fig 36) revealed: Interlabial space and increased exposure of upper incisors at rest, pleasant smile arc (with pronounced



FIGURE 35 - Clinical case 4 – Initial facial and dental aspects.

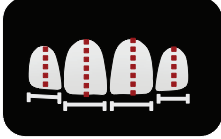
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☐	<1 mm ☐	Pleasant ☒	<65% ☐	Short ☒
>3 mm ☒	1-4.5 mm ☐	Flat ☐	75-80% ☒	Thin ☒
	>4.5 mm ☒	Reverse ☐	>85% ☐	Hypermobility ☒

FIGURE 36 - Clinical case 4 checklist.

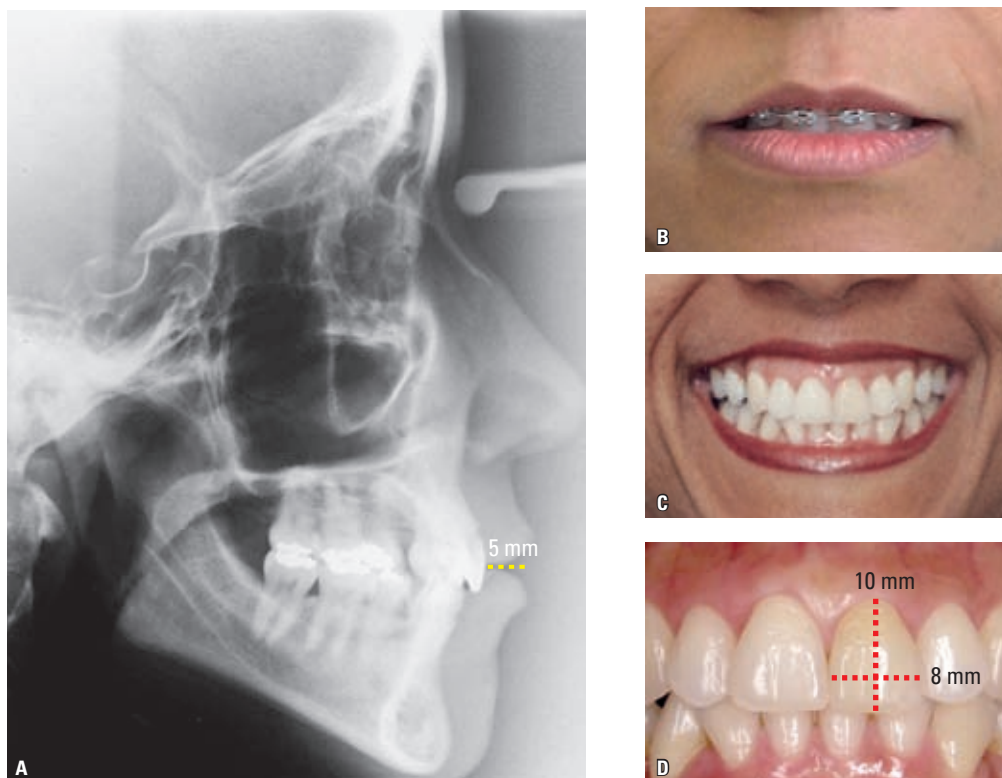


FIGURE 37 - Checklist features evaluated: **A)** Exposure of upper incisors at rest; **B)** interlabial distance at rest and morphological characteristics of upper lip; **C)** smile arc and functional characteristics of upper lip; **D)** Width/Length ratio of upper incisors.

curvature) and a short and thin upper lip with hypermobility. Upper incisor length/width ratio was satisfactory (Fig 37).

Dental alignment and leveling, correction of axial inclination of the incisors, canines and second premolars and space closure with retraction

of anterior teeth were performed during orthodontic treatment (Figs 38 and 39, and Table 1). Although part of the checklist points to the possibility of intrusion of the upper teeth, any attempt to correct excessive gingival display by this means could cause undesirable flattening of the smile arc.



FIGURE 38 - Front and side views of final occlusion, showing provisional restorations of incisal edges of maxillary central incisors.

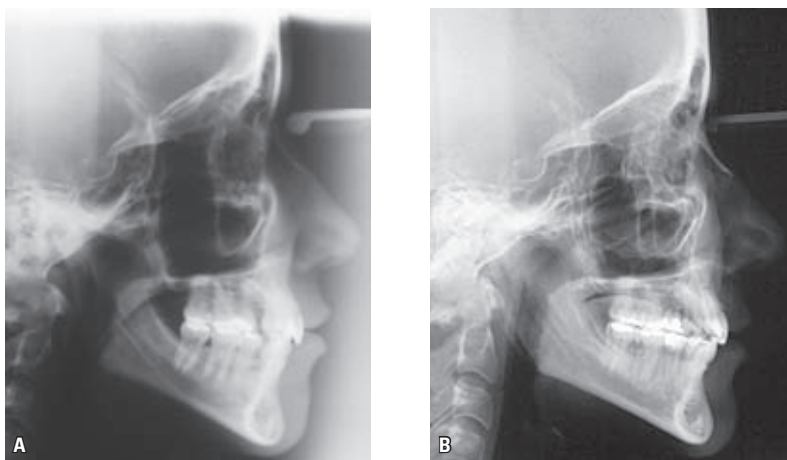


FIGURE 39 - Comparison between initial (A) and final (B) cephalometric radiographs, showing dental changes due to treatment.

TABLE 1 - Comparison of initial and final cephalometric measurements (case #4).

	Initial	Final
SNA	78°	78°
SNB	76°	76°
ANB	2°	2°
GoGn-SN	39°	39°
IMPA	80°	95°
1-NA	21°	18°
1-NB	15°	32°
1-NA	5 mm	5 mm
1-NB	5 mm	4 mm
Ls - S Line	0 mm	-2 mm
Li - S Line	1 mm	-0.5 mm



FIGURE 40 - A) Complex smile with high lip mobility. B) Voluntary smile after treatment. C) Maintenance of gingival display during spontaneous smile after treatment.

Therefore, leveling of upper teeth demanded special care. The morphofunctional characteristics of the upper lip—thin, short and with hypermobility—produced a complex smile and posed a major obstacle to the orthodontic treatment of excessive gingival display.

The upper incisal silhouette was restored through cosmetic dental remodeling. Ameloplasty

of the incisal edges of teeth 12 and 22 was performed and, additionally, composite was provisionally added to the incisal edges of teeth 11 and 21.

Despite improved smile esthetics in terms of dental position, gingival display was virtually maintained to ensure that the orthodontic approach would be consistent with the contemporary treatment paradigm (Figs 40 and 41).



FIGURE 41 - **A)** Initial smile. **B)** and **C)** Spontaneous smile and voluntary smile, respectively, after treatment.

Clinical Case 5

The patient, a 25-year-old woman, reported as chief complaint dentoalveolar bimaxillary protrusion and incompetent lip seal, and exhibited the following characteristics: Increased lower face, convex profile, incompetent lip seal,

GS, Angle Class I malocclusion and pronounced dentoalveolar bimaxillary protrusion (Fig 42).

Checklist assessment (Fig 43) revealed significant changes in some features: There were significantly increased interlabial space and upper incisor exposure at rest, a short upper lip



FIGURE 42 - Clinical case 5 – Initial facial and dental aspects.

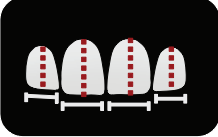
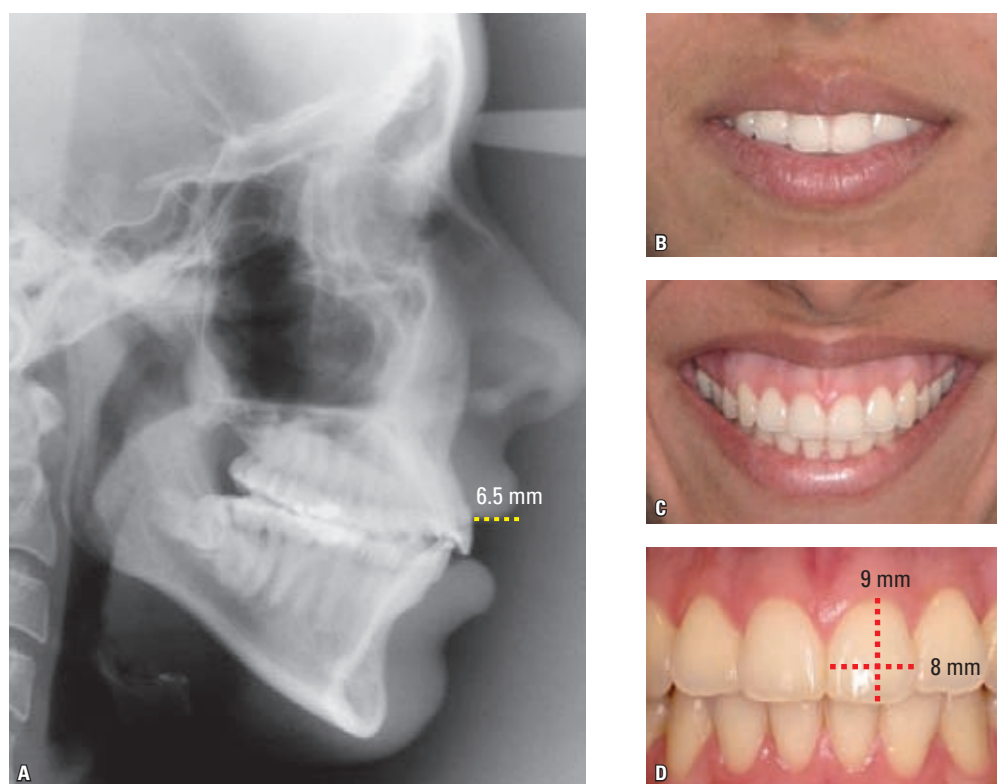
Interlabial Distance at rest	Exposure of upper incisors at rest	Smile arc	W/L ratio of maxillary incisors	Morphofunctional features of upper lip
				
1-3 mm ☐	<1 mm ☐	Pleasant ☐	<65% ☐	Short ☒
>3 mm ☒	1-4.5 mm ☐	Flat ☒	75-80% ☒	Thin ☐
	>4.5 mm ☒	Reverse ☐	>85% ☐	Hypermobility ☒

FIGURE 43 - Clinical case 5 checklist.

FIGURE 44 - Checklist features evaluated: **A)** Exposure of upper incisors at rest; **B)** interlabial distance at rest and morphological characteristics of upper lip; **C)** smile arc and functional characteristics of upper lip; **D)** Width/Length ratio of upper incisors.

with hypermobility, flat smile arc and adequate width/length ratio of maxillary central incisors, although there was disparity between the size of the central and lateral incisors (Fig 44).

The upper alveolar protrusion—present in Angle Class II, Division 1 malocclusions, and

Angle Class I bimaxillary protrusion—may be related to the gummy smile, a fact long reported in the literature.²⁹ The alveolar “plateau” formed by the maxillary incisors was overly inclined labially, which seemed to cause the muscle of the upper lip to stretch further, pulling the upper



FIGURE 45 - Facial and occlusal appearance after treatment with restoration of incisal edges of teeth 11 and 21.

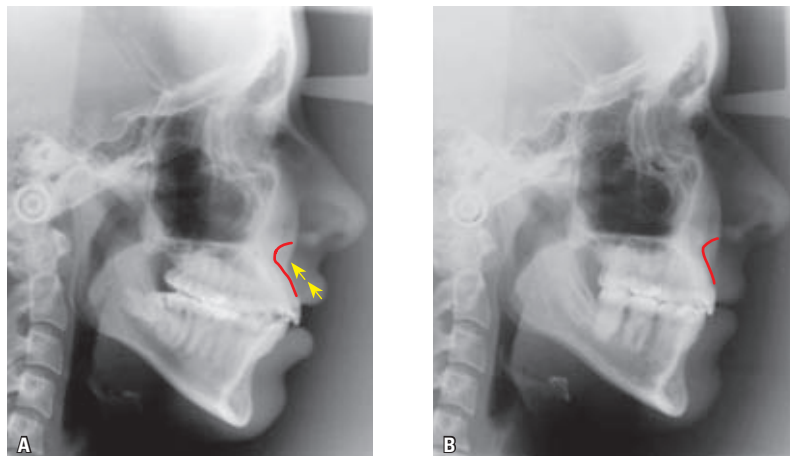


FIGURE 46 - **A**) Presence of deep anterosuperior alveolar sulcus resulting from alveolar protrusion. Arrows indicate direction of displacement of upper lip during smile. Comparison between initial **(A)** and final **(B)** cephalometric radiographs, showing change in anterior alveolar contour due to upper incisor retraction.

TABLE 2 - Comparison between initial and final cephalometric measurements (Case #5).

	Initial	Final
SNA	76°	76°
SNB	72°	74°
ANB	4°	2°
GoGn-SN	45°	42°
IMPA	98°	88°
1-NA	21°	14°
1-NB	37°	23°
1-NA	11 mm	6 mm
1-NB	12 mm	6.5 mm
Ls - S Line	-1 mm	-2.5 mm
Li - S Line	2 mm	-1 mm

lip upward and backward, as it settles in the deepest region of the alveolar process (Fig 46A).

Since the correction of maxillary protrusion often reduces excessive gingival display on smiling, this issue should always be addressed when

planning GS treatment.^{29,30}

Although this is a classic case of vertical maxillary excess with an indication for surgery the patient rejected this option. The only other option would be to reduce gingival display through

orthodontic treatment by reducing the bimaxillary protrusion and the anterosuperior dentoalveolar "plateau." Total corrective treatment was performed with extraction of teeth 14, 24, 75 and 44, incisor retraction and maximum vertical control (Figs 45 and 46, and Table 2).

Correction of bimaxillary protrusion benefited facial esthetics (Fig 45), improved lip competence (Figs 45 and 46) and decreased apical displacement of the upper lip during smile (Fig 47B). A closer view reveals some major changes: Behavior change of upper lip muscles on smiling (evidenced by the elimination of the horizontal sulcus formed between the upper lip and nose base), and improved relationship between the

smile arc and the lower lip (afforded by the fact that the latter was repositioned superiorly and posteriorly) (Fig 47).

With the purpose of improving the leveling of the anterosuperior gingival contour teeth 11 and 21 were intruded and their incisal edges enlarged with composite. To further establish a proportional relationship between upper central and lateral incisors, teeth 12 and 22 underwent interproximal stripping and cosmetic remodeling by rounding of the distolabial angle.

The amount of gingival display still present after treatment completion did not affect the degree of patient satisfaction in terms of dento-facial benefits (Fig 48).



FIGURE 47 - Initial voluntary (A) and spontaneous (B) smiles: Poor ratio between size of upper central and lateral incisors, exposure of lower incisors, pronounced upper gingival display, presence of horizontal sulcus between upper lip and nasal base. Final voluntary (C) and spontaneous (D) smiles: Dominance of upper central incisors, reduction in gingival display and horizontal labial sulcus, reduction in exposure of lower incisors, improvement in relationship between smile arc and lower lip curvature.



FIGURE 48 - Change in smile esthetics between initial and final phases of treatment. Reduction in gingival display resulting from correction of bimaxillary protrusion and decrease in lip hypermobility.

FINAL CONSIDERATIONS

Excessive gingival display on smiling is considered a cosmetic issue that often leads patients to seek orthodontic treatment. Addressing this problem can prove challenging as it involves a wide range of etiological factors which, in most cases, work in concert. To evaluate these cases, orthodontists should analyze the patient's static and dynamic smile, as well as their speech and lip position at rest. In this analysis it is mandatory that the following factors be observed: (a) Interlabial distance, (b) exposure of upper incisors during rest and speech, (c) smile arc, (d) width/length

ratio of maxillary central incisors and (e) morphofunctional characteristics of the upper lip. The checklist advanced in this article can assist in GS diagnosing and planning and may lead to the GS correction within the scope of today's orthodontic treatment paradigm.

ACKNOWLEDGEMENTS

The authors wish to thank Drs. Edmália Barreto (periodontics), Eutímio Torres (prosthodontist), Maria Cândida Teixeira and Alessandra Matos (restorative dentistry), for their contribution to the clinical cases presented in this study.

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Submitted: December 2010
Revised and accepted: March 2011

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