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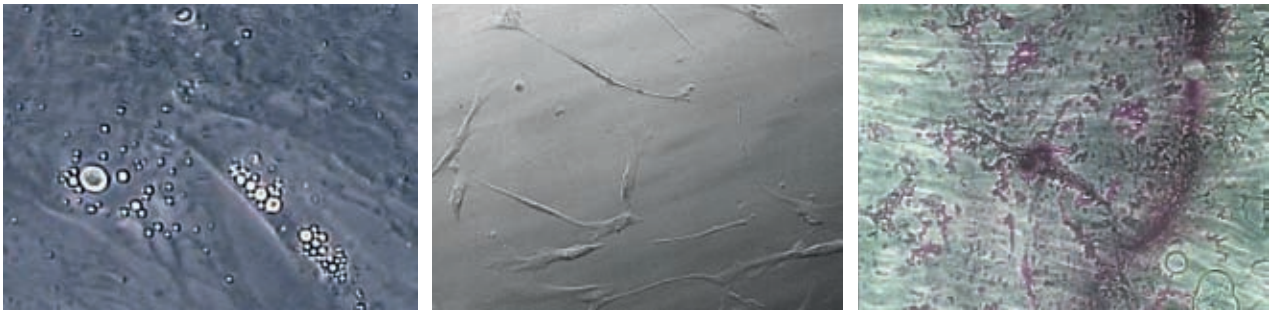

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We need practical proposals to improve the quality of dental care in Brazil

"We sell a dream and deliver a nightmare." With this sentence the minister of the Brazilian Supreme Court, Marco Aurélio Mello, summed up his vote for the constitutionality of the bar examination of the Order of Attorneys of Brazil. He defined, in a sense, the process of formation of a law graduate in Brazil. The question of the constitutionality of this examination was presented as a legal recourse by a graduate in Law. Earlier in the day of the manifestation of the minister, the general-prosecutor of the Brazilian Republic, Roberto Gurgel, said that: "The bar examination is, therefore, clearly adequate to ensure qualification of the professional and protect the rights of third parties."[1]

This important fact, necessarily, makes us to reflect on the possibility of a examination for dentistry (and other healthcare areas, such as medicine): The examination of the Brazilian Federal Council of Dentistry (CFO). Many countries, like the UK and the USA, see the obligatoriness of these examinations for our profession as the only way to ensure the qualification of the professional and protect the health of the population. In Japan, graduates in dentistry are submitted to a qualification exam after a six years undergraduate course. It is very important to warn that healthcare professionals must have some minimum knowledge to act in this area, otherwise they will become "disease professionals".

Obviously, this is not the only action needed to improve the quality of healthcare to our people. Mandatory continuing education is also one of them. In Italy, this apprehension is so intense that dentists needs to be out of service for nearly two weeks every year, to achieve the number of credits of continuing education that will enable them to keep their work permit valid. Perhaps this is an exaggerated number of hours. Some states, like Illinois, require 48 hours of continuing education every three years to renew the work permit.[2] The continuing education credits can be obtained with both in-person classes and answering to questionnaires compiled from articles, as those present in DPJO. In Brazil, there is no legal requirement of any kind and it is common that many professionals will graduate and never seek for update.

However, this discussion could not eclipse the main star of this issue, which is higher education in the dental field. There is a debate about the quality of this education. Surely it is not perfect, however, if we judge this quality from the objective point of view of knowledge production, it is among the best in the world. On the other hand, of course, good schools share space with the weak ones, not to mention the fact — known by almost all the teachers in Brazil — that several institutions of higher education pressure teachers to promote students who have

not reached the required notes for approval. And the controversy do not end here. If there is currently so much evasion in our profession, it means that many schools are simply unnecessary. The student buys a worthless diploma, because he will not exercise the profession.

So we have a problem underpinned, mainly, on a tripod. We have several weak schools — which the Brazilian population does not need — training professionals without verified qualification and, to make it worse, many of them do not maintain a continuing education. This scenario contrasts with the fact that we have dental professionals that are among the bests in the world and it means that a parcel of the population is attended with excellence and another, possibly, is attended by "disease professionals".

What is the ideal model? Effective actions to close the unnecessary weak schools? The introduction of mandatory continuing education programs? The selection of those proven to be suitable for healthcare professionals, through a test conducted by the CFO and applied to graduates? Or adopt both of these actions? Any new proposal, since concrete and feasible, is welcomed.

I'm open to criticism, suggestions and discussions.*

Good reading.

Jorge Faber
Editor-in-chief
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* Obviously, to make the treatment affordable is one of the actions needed, and this has been done by the Brazilian Federal Government through the *Brasil Sorridente* (Smiling Brazil) program. Possibly, this is the only action with real impact that we saw emerging in recent decades.

And now: Professor Dr. David Normando

Over the past five years, I have served as editor-in-chief of the *Revista Dental Press de Ortodontia e Ortopedia Facial* which, from 2010 on, is being published in English and is, now, called *Dental Press Journal of Orthodontics*. I read, then, thousands of articles and wrote 30 editorials. This is the 31st and the last of them.

The closure of all cycles moves us, naturally, to reflect and to list important people and facts. Unfortunately, I could not, in this editorial space and with justice, mention all the people who were so important for this journal and me as its editor. To represent all this group of fabulous minds, I will comment briefly on five people. Each one represents a section of the journal.

The first of them is Mr. Ronis Furquim, from Dental Press Publishing House team. He is a person of knowledge way over average, he has an enviable Portuguese and critical reading skills so sharp that redefined my standards for this attribute. Ronis, you personify this company employees in pursuing excellence and your work permeates every article submitted here.

Doctors Teresa and Laurindo Furquim, your passion for our profession materialized in a company which is a symbol of quality in dentistry. The Brazilian dentistry owes a lot to you. I am grateful for the trust you placed in my hands when invited me to be editor of this journal.

Dr. Telma Martins de Araujo, a sublime person and professional. Your unexceedable perfection is present in everything that this journal publishes, in the Specialization Course of the Center of Orthodontics and Facial Orthopedics Professor Édimo José Soares Martins, as well as on other activities as an important leader in our specialty. I am proud to be your friend and deeply admire you.

Finally, Dr. David Normando, I want to share my joy in seeing you as the new editor of this journal. You are, undoubtedly, an example for the Brazilian dentistry. Only one word can define how a boy who was educated at various public schools within the Northern region of Brazil became the editor-in-chief of one of the major world publications of orthodontics: Meritocracy. Given the demonstrated competence as adjunct editor, nothing more fair than inviting you to assume the position which I leave with these words. I finish my last editorial not wishing you luck, because your competence sets you free of it, but rather, I wish you a lot of work. Only this can further elevate the human being.

And, now, I give you: Professor Dr. David Normando, editor-in-chief of the Dental Press Journal of Orthodontics.

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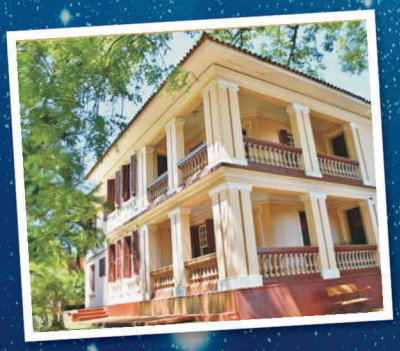

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Dr. Gustavo Barreto
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Hilton Goldreich, DDS,
MS, PA Diplomate of the American Board of Orthodontics, a member of the American Association of Orthodontists (AAO), Texas Dental Association,Southwest Society of Orthodontists and Clinical Professor of Orthodontics Department at Baylor College of Dentistry, Texas A&M University System.

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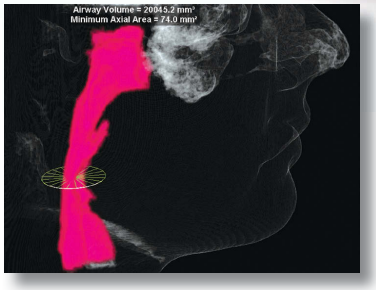

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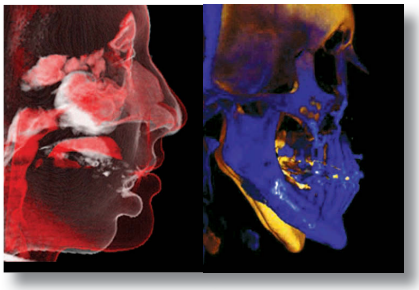
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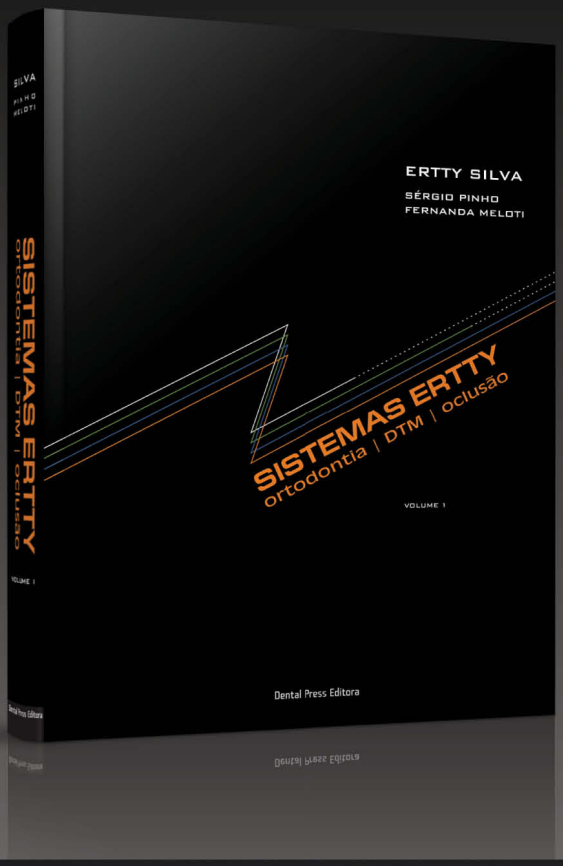

"When we think we have got all answers, life comes and changes all questions".

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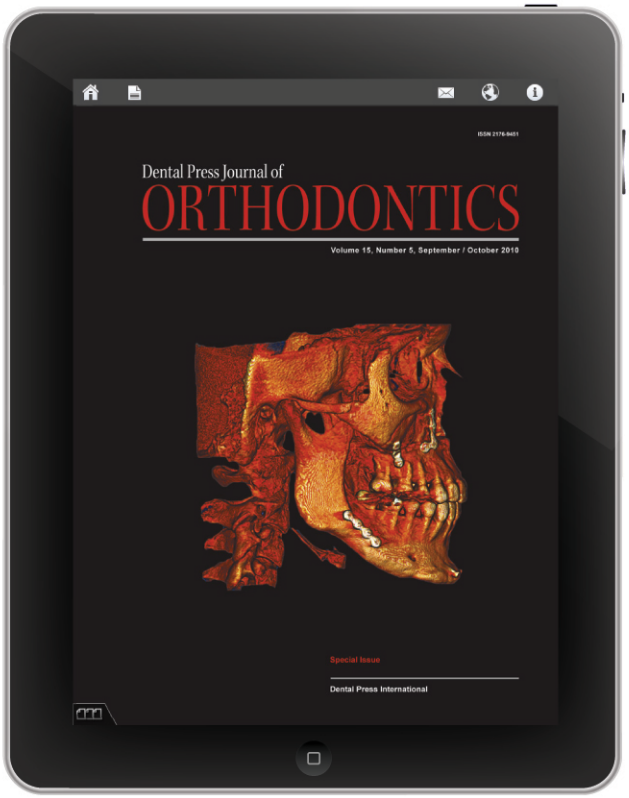

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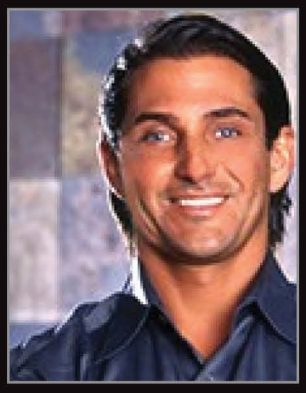

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Tele-orthodontics: Tool aid to clinical practice and continuing education

André Luciano Pasinato da Costa*, Alcion Alves Silva**, Cléber Bidegain Pereira***

Abstract

Introduction: Information technology is revolutionizing interpersonal relations. This new context has made possible the pursuit of professions in the health area, a concept known as telehealth. The essence of this area is the provision of health information at distance. In this context, orthodontics as a specialty can not remain oblivious to advances. **Objective:** This article, through a non-systematic literature review, set out to investigate which of the available technologies are likely to be used in the development of tele-orthodontics services as tools to aid clinical practice and continuing education. The use of technologies already available in the market can enable tele-orthodontics services. Even though this article has analyzed the technical conditions and technologies related to the study object, it tends to the ethical, moral, legal and economical aspects of this process.

Keywords: Telemedicine. Orthodontics. Computers. Information technology. Information systems.

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INTRODUCTION

The Information Technology (IT) has changed interpersonal relations. In a global society, electronically interconnected and with no boundaries, the exercise of professions at distance is among the new experiences.

The development of communication programs, associated with state of the art machines, has allowed quick and efficient information transmission. This new context has made possible the exercise of health professions at distance,[1,2,3] a concept known as telehealth.

According to World Health Organization (WHO), telehealth (telemedicine, teledentistry, etc.) is the provision of services related to healthcare where the distance is a critical factor. Such services can be provided through the use of communication technologies, with the goal of continuing education, necessary information exchanging to diagnose, treat, predict and prevent diseases.[4,5]

The essence of this concept is to provide services and information to the patient without leaving home. Thus, in a broader context, telehealth emerges as a new tool to overpass cultural, socioeconomic and geographic barriers.[2,6,7] Benefits include the access to specialists, improved primary health-care and increased availability of resources for education and professional information.[1-7]

Despite the current state of science for the telehealth services development, it is necessary the rational use of available technologies.[8] Currently, numerous projects for the development of at distance service networks are in progress, though most of them use computer programs themselves, a fact which makes them expensive and restricted — for this reason they are subsidized by government agencies, hindering its diffusion.[8]

In this context, orthodontics seeks to advance the use of telehealth tools, aiming to expand and modify the market when it comes to primary care to the patient, access to second opinion and professional at distance education.[2,3,5,6,9]

Brazil, a country of continental dimensions, characterized by the concentration of specialists in urban centers still provides the geographic isolation of many communities and professionals. Tele-orthodontics services can represent an efficient way to reduce these difficulties.

OBJECTIVE

This study aimed to explore, through a non-systematic literature review, which of the communication technologies available on the market are likely to be used in the development of tele-orthodontics, as a tool to aid clinical practice and continuing education.

MATERIALS AND METHODS

The investigation was designed as a non-systematic literature review. To conduct the survey of literature sources, we used the MedLine database, accessed through the PubMed search tool available on the National Center for Biotechnology Information site.

Keywords

The search strategy included the following keywords:

» Medical Subjects Headings (MeSH): *Computer. Informatics. Information systems. Orthodontics. Software. Telemedicine. Teledentistry. Technology.*

Update

Justified by the rapid scientific and technical progress in IT, the survey was limited to articles published in the last 5 years.

LITERATURE REVIEW

The paradigm change in patient care is one of the obstacles to the development of the concept of telehealth. To facilitate the interaction between professionals located in difficult access areas and big cities specialists, enabling assistance through tele-consultation represents a

new way of interaction between professionals and patients.[1-9]

Broadband

The term refers to the networking of two or more computers through fixed telephone lines, mobile or satellite radio (Fig 1). Although some countries still do not have rules on the minimum speed for which a connection is considered broadband, the International Telecommunication Union (ITU) defines as the ability to transmit more than 1.5 or 2 megabits per second.

With this technology, distant transmission of clinical data is possible, allowing a second professional opinion. However, as for the privacy and security of data transmitted, there is still a risk of interception, since the connections are not secure.[10,11]

Mobile phones

Mobile phone networks are based on cells (transmitting antennas), from which are generated and relayed signals via microwave at several frequencies, allowing the transmission and reception of information.

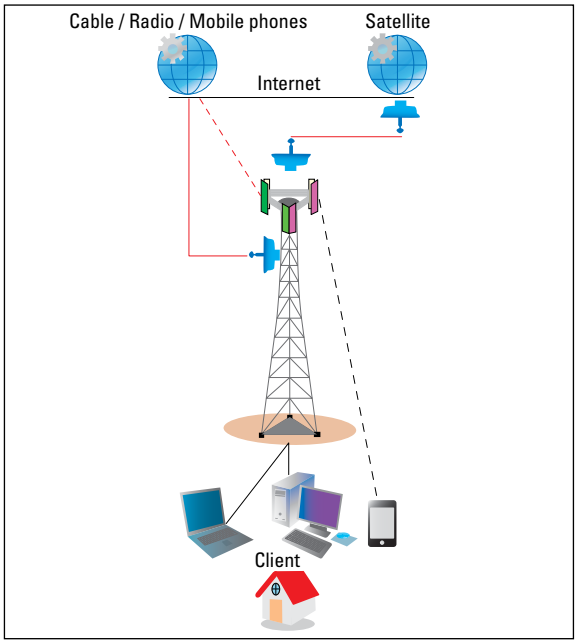

FIGURE 1 - Broadband network.

The 3G phones allow you to access the World Wide Web through devices known as smartphones, making it possible to access websites, to send e-mail and video conferencing.[1-11]

Digital photography

The high quality digital photography is an aid for the development of telehealth services, mainly in specialties that often use imaging techniques (photographic and radiographic), such as orthodontics. In this context, digital images, along with the patient's medical history, help in the diagnosis and allow one to request a second professional opinion at distance.[1,2,3,12-15] It's important to consider as limiting factors of this system: The quality of images, which can vary depending on the lighting, photographic equipment, operator skill and technical expertise.

Websites

Websites are sets of pages (hypertext) or applications (Application Service Provider - ASP) accessible through the World Wide Web, addressed through the Hypertext Transfer Protocol (HTTP). Compared with other technologies, websites have the following advantages:

» Can be accessed using all computer operating systems.
» Are available online, consuming very little computer memory.
» Allows running on older equipment and mobile phones.
» Allows the exchange of information between users in real time.
» 24/7 availability, which facilitates communication among different time zones.
» These are technologies of rapid evolution and adaptation.
» They are not linked to large corporations.

Among the limits of technology

» Vulnerability regarding confidentiality of data transferred.

» The need for constant maintenance.
» Dependence on a database.
» Dependence on a broadband access point to be accessed.
» Slow at times of high demand for access.

The use of websites in health-care allows to inform and educate the patient, and to establish two-way communication[4,5,8,12,13,14]

DISCUSSION

Although there is no definition for tele-orthodontics in literature, it can be — based on the context studied through a set of quotes — suggested that it is the area of telehealth which studies the application of telecommunication and information technologies for the practice of orthodontics, without demanding the specialist presence, with the potential to develop actions such as: Diagnosis, planning, specialist consultation, education, research and assistance to people and professionals which can not easily travel.

Given the contemporary nature of this subject and its scarcity in the orthodontic literature, it is necessary an exploratory research to understand it. For this reason, in the present study a non-systematic literature review was adopted.[16]

On the strategy and the results of the non-systematic review

After preliminary analysis of the recovered sources (Table 1), repeated sources were excluded, obtaining 28 sources as final result, which were submitted to the inclusion/exclusion criteria, resulting in 19 articles of interest to the study.

As for the accessible technologies

The analysis indicated, among the actually available technologies, four with low cost and possibility of immediate use: Broadband, digital photography, mobile telephones and websites. However, for the tele-orthodontics exercise, there is still the need for development of the processes, specialists training and development of interconnection methods between professionals and patients (Fig 2).[1-23]

The convergence of communication technologies indicates the trend of development in this area. This is signaled by the changes that mobile and fixed telephone companies provided when they started providing access to the World Wide Web via broadband connections. This process made possible the development of products that will facilitate and enhance the exercise of tele-orthodontics (smartphones, netbooks, etc).

TABLE 1 - Results of the literature search strategy in the Medline database on May 3, 2010.

DATA SEARCH STRATEGY			
Descriptors relationship	**Time criterium *(last 5 years)**	**Found sources**	**Selected sources**
Teledentistry *and* orthodontics	*	5	5
Teledentistry	*	16	16
Telemedicine *and* orthodontics	*	6	6
Telemedicine *and* orthodontics *and* software computer	*	0	0
Telemedicine *and* orthodontics *and* software computer *and* information systems *and* informatics *and* technology	*	0	0
Telemedicine *and* orthodontics *and* software computer *and* information systems *and* informatics	*	0	0
Telemedicine *and* software computer *and* information systems *and* informatics *and* technology	*	12	12

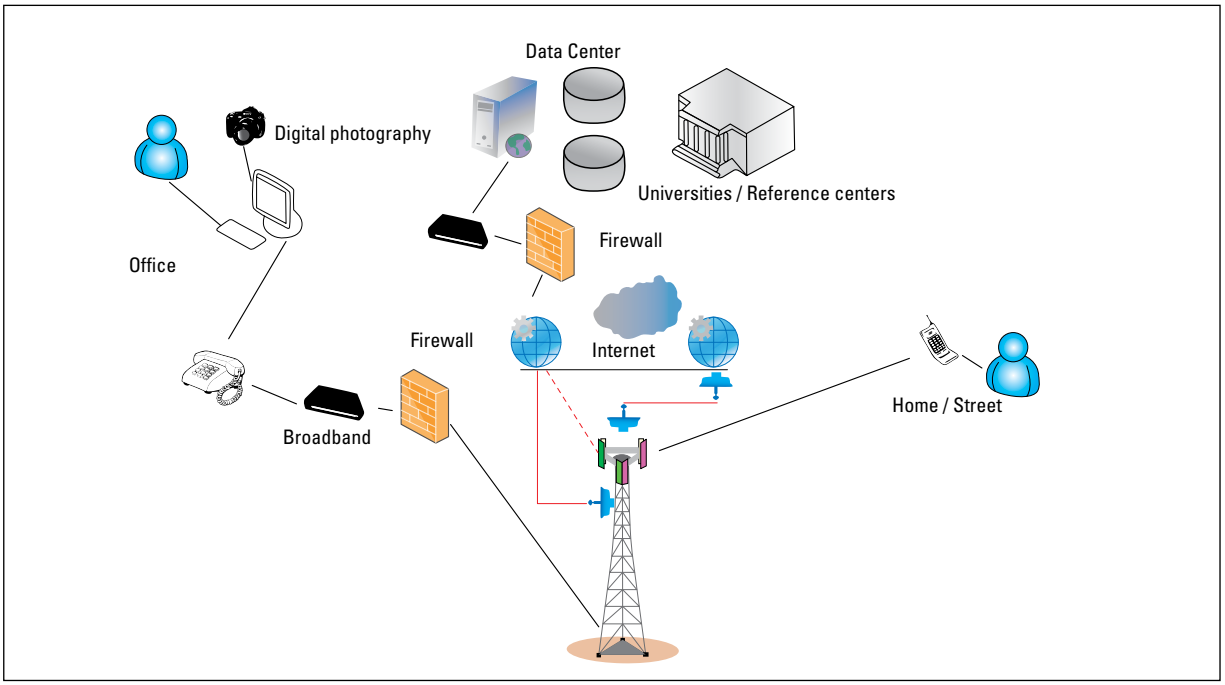

FIGURE 2 - Interaction of technologies to form a network.

Due to the availability of low cost technology and the connection to the World Wide Web, building a services portal aimed at tele-orthodontics becomes feasible. Online software can be developed using the PHP programming language, which is free and have multiple safe development environments. It also allows the use of open source softwares.[1-23]

A portal focussed on tele-orthodontics brings hope that, in a near future, general practitioners will be allowed to consult experts to better diagnose patients with dentoskeletal deviations, or it will even allows at distance consultations and teleconferences. It would be a way to overpass geographic barriers for the treatment of patients living in difficult access areas or that have locomotion difficulties.[1-23]

Technical definitions for the practice of tele-orthodontics

Observe deployment costs, local availability, users technical knowledge and the need of professionals and patients, these are important factors for effective implementation and dissemination of tele-orthodontics services. Due to the trend of development of online tools (websites) and technical advances allowing greater security in data transmission, it appears consistent the use of these resources, since it does not require significant investments in equipment.

P2P communication programs (MSN, Skype, etc.) can be used as auxiliaries, however, they alone are not viable options, since they are linked to large corporations, which may, at any time, change its technology or charge for services.

This argument reinforces the indication of use of websites because, besides having great versatility, they don't need to be installed on each computer or phone.

As for the safety factor, the problem can be minimized through the use of tools such as antivirus programs and firewalls, coupled with the use of digital certification. There are also issues of vulnerability when it comes to online applications, addressed to the present, with the development of digital signatures and data encryption.[17,22]

Validation of tele-orthodontics

Experiments conducted by many institutions demonstrate the opportunities for the field of tele-orthodontics.[2,3,5,6,7,11-14,23] The results of the comparative studies developed between the Yakima Valley Farm Workers Clinic and Odessa Brown Children's Clinic (Washington) showed no significant differences between the groups submitted to clinical treatment and using tele-orthodontics.[2] According to this study, the outcomes of cases remotely handled suggest the clinical validity of the technique.

The level of the present technologies enables the development of tele-orthodontics, because they are accessible and affordable. From the scientific point of view, identifying the limitations of these services, legal implications and impact over the professional/patient represents the first steps to take advantage of opportunities generated by this new concept.[6,7,9,23]

The actions to be performed to implement these services are: The development of tools that enable scheduling, diagnosing, planning, data transferring and conference calls to facilitate the process of continuing education. However, the digitalization of clinical data and its transmission through the worldwide network of computers still generate discussions regarding safety. For this reason, emphasis has been given to seeking resources for certification and digital signature.

Finally, we see that not only the development of computer technology (hardware and software) will consolidate the tele-orthodontics. This new reality also changes the context of social relations, opening a vast field of ethical, moral, legal and economic questions.

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Orthodontic movement does not induce external cervical resorption (ECR)

or

Orthodontic movement does not change gingival color and volume, and does not induce gingival inflammation

Alberto Consolaro*, Renata B. Consolaro**

Abstract

This study sought to explain, both anatomically and functionally, how the cervical region of human teeth is structured and organized in order to address the following questions: 1) Why does External Cervical Resorption (ECR) occur in human dentition? 2) Why is there no ECR in gingivitis and periodontitis? 3) Why ECR can occur after dental trauma and internal bleaching? 4) Why does orthodontic movement not change the gingival color and volume during treatment? 5) Why does orthodontic movement not induce ECR although it is common knowledge that the cervical region can undergo much stress? The existence of sequestered antigens in the dentin, the presence of dentin gaps in the cervical region of all teeth, the reaction of the junctional epithelium and the gingival distribution of blood vessels may explain why ECR does not occur, nor do gingival color and volume change when teeth are orthodontically moved.

Keywords: Tooth resorption. External cervical resorption. Orthodontic treatment. Gingiva.

HOW THE CERVICAL REGION OF THE TOOTH IS STRUCTURED AND ORGANIZED

On the surface of cervical region of human teeth, in the area where the enamel borders the cementum, there is a line known as the cementoenamel junction (CEJ) (Fig 1). On the circumference of the neck of all human teeth the CEJ line alternates three types of relationship between enamel and cementum.[3,7] In some areas of CEJ the cementum covers the enamel (Fig 4), in others the enamel and cementum meet edge to edge, but in other regions the enamel and cementum remain distant from each other, thereby exposing microscopic dentin gaps or "windows" facing the gingival connective tissue.

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Having completed its key function of producing enamel, this organ — formed by the outer epithelium, stellate reticulum, stratum intermedium and ameloblasts — undergoes a sandwich-like re-stratification and gives rise to the reduced epithelium of the enamel organ. This epithelium is firmly attached to the enamel and receives nutrients from the peripheral connective tissue. Together, they form the dental follicle, which generates the image of the pericoronal space in unerupted teeth.

As a tooth gradually begins to appear in the mouth, the reduced epithelium of the enamel organ fuses with the oral mucosa and together form the junctional epithelium. Initially this epithelium has three to four layers, reaching as many 10 to 20 cells of thickness with age. Close to 30 years of age, the junctional epithelium lines the enamel in its cervical-most portion, but eventually progresses gradually towards the cementum. The length of the junctional epithelium[4] ranges from 0.25 to 1.35 mm.

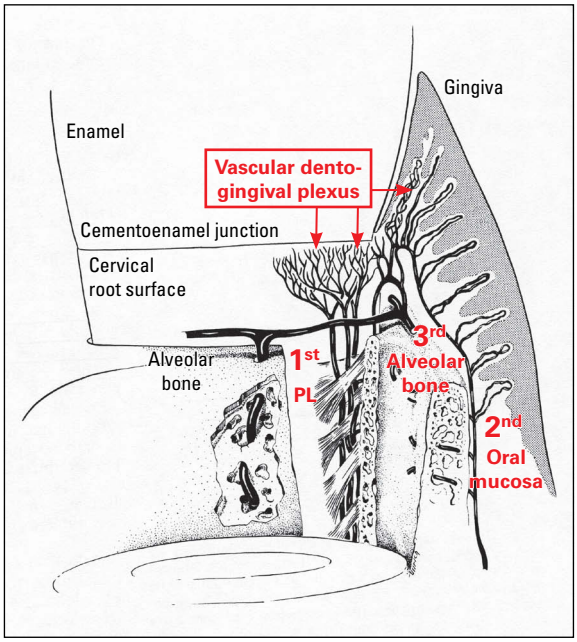


FIGURE 1 - The dentogingival plexus features anastomosis with vessels extending from the periodontal ligament (1st), oral mucosa (2nd) and alveolar bone (3rd) in the region of the connective attachment next to the cervical root surface (scheme modified from Glickman[4]).

In the cervical root region, next to the enamel, it is the connective tissue of the dental follicle, which gives rise to the connective attachment in the erupted tooth (Fig 4). Conceptually, the connective attachment in the erupted tooth comprises the space between the final portion of the enamel and the initial portion of the alveolar bone crest.

The cementum extends from the final edge of the cervical enamel and its junctional epithelium. On the cementum surface are the cementoblasts (Fig 4) nourished by the connective tissue of the dental follicle tissue and connective attachment. Progressing toward the apex, the connective tissue and cementoblasts on the root become part of the periodontal ligament. The average thickness of the cementum in the cervical third ranges from 16 to 60 µm, which is equivalent to the thickness of a human hair. In the apical third, bifurcations and trifurcations range from 150 to 200 µm. The average thickness of the cementum in a youth aged 20 is 95 µm and at age 60, 215 µm.[9]

Whatever the relationship between enamel and cementum in the cervical region, the CEJ and its components are in direct contact with the fibrous gingival connective tissue or, more specifically, with its collagen fibers and extracellular matrix gel interspersed with fibroblasts (Fig 4). In the CEJ segments, where the dentin gaps are located, it is "concealed" or protected from exposure to macrophages by the extracellular matrix gel, which plays this role with great competence.

1) WHY DOES EXTERNAL CERVICAL RESORPTION (ECR) OCCUR IN HUMAN DENTITION?

Some proteins in the dentin are recognized as antigenic by the immune system because they are deposited during odontogenesis without direct contact with the protein memory cells which develop during intrauterine life.[1] Thus, the dentin should be protected from this contact throughout its life, including in the dentin gaps of the CEJ present in all teeth.

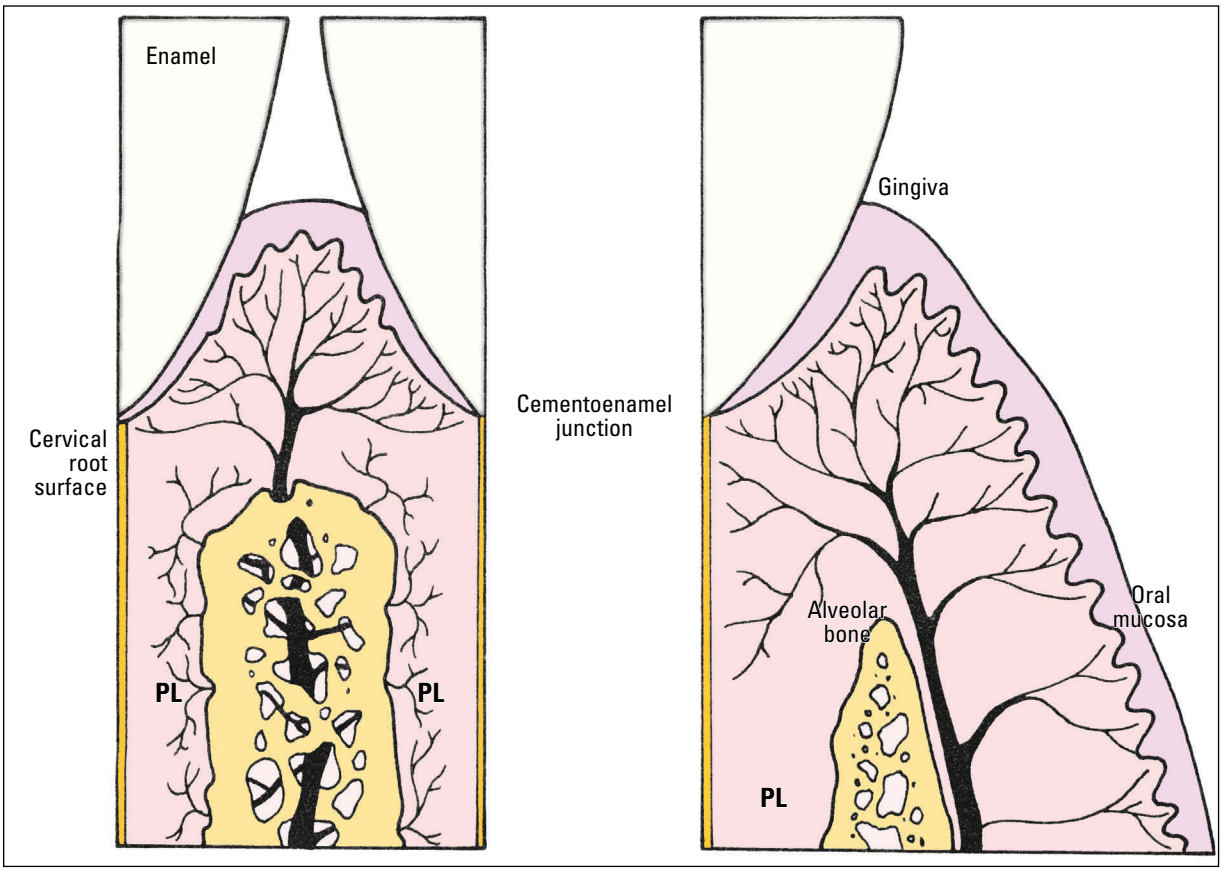


FIGURE 2 - During orthodontic movement blood supply to the periodontal ligament may be reduced or eliminated without compromising gingival blood supply, especially in the connective attachment region. Glickman's modified schemes[4] emphasize the osseous and gingival origin of blood vessels in the cervical region.

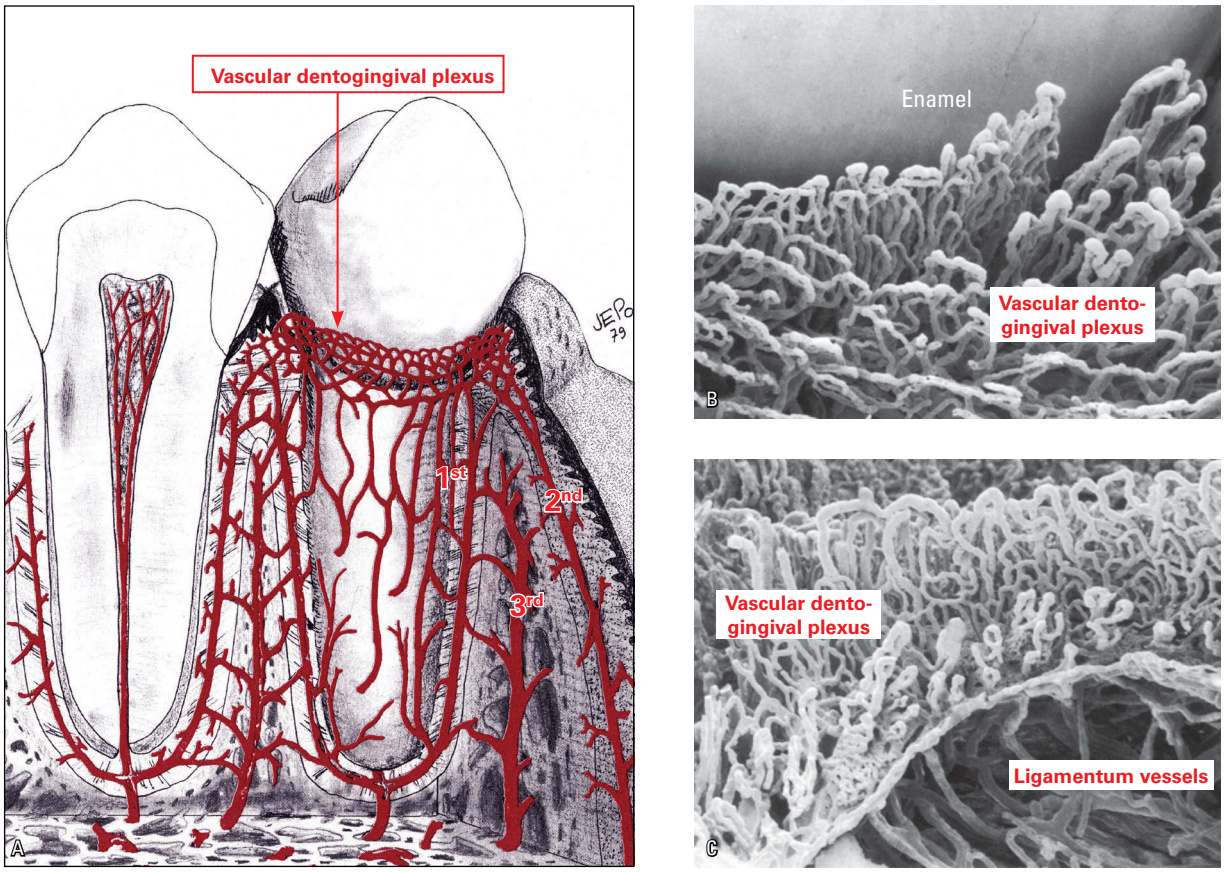
Before the dentin gaps are exposed to macrophages at the CEJ, with consequent immunological recognition, a direct exposure is required to occur as a result of the dissolution of the extracellular matrix of connective tissue where these cells circulate.

The destruction and/or dissolution of the extracellular matrix occur mainly in inflammation: A defense mechanism typical of connective tissues and dependent on vessels. The mediators and enzymes that make up the inflammatory exudate arising from vessels and leukocytes dissolve the extracellular matrix gel and, at the gingival connective attachment can provide the dentin with access to the macrophages.

Once the macrophages identify the dentin as a foreign body, they initiate a process through which foreign proteins are eliminated and, when these macrophages are present in hard tissues, bone resorption is the mechanism of choice.[1]

2) WHY IS THERE NO ECR IN GINGIVITIS AND PERIODONTITIS?

When gingival inflammation is induced by dental bacterial plaque, it promotes epithelial hyperplasia while the junctional epithelium migrates toward the apical region, placing the CEJ and its gaps in the gingival sulcus and oral environment, thereby "protecting" the ECR region. In the oral environment, macrophages are not capable of recognizing foreign proteins in the dentin and therefore fail to trigger an immune response.



FIGUR E 3 - **A**) The lace-shaped or net-shaped dentogingival plexus consists of vessels originating from the periodontium (1st), mucosa (2nd) and bone (3rd) (scheme introduced by Lascala and Moussalli[5]). **B** and **C** highlight the numerous loop-shaped capillaries of dentogingival plexus in rodents, revealed by scanning electron microscopy performed by Selliseth and Selvig (Source: Newman et al,[8] 2006).

3) WHY ECR CAN OCCUR AFTER DENTAL TRAUMA AND INTERNAL BLEACHING?

In dental trauma, inflammation of gingival connective tissue may occur, but without junctional epithelial hyperplasia. Such is the case in internal dental bleaching, where hydrogen peroxide leaks into the dentinal tubules that open out at the junction, causing a local gingival inflammation in the connective tissue, without epithelial hyperplasia. In these two situations, gingival inflammation dissolves the extracellular matrix, exposing the dentin in the CEJ gaps. However, hyperplasia of the junctional epithelium does not occur, allowing the occurrence of ECR.[2]

4) WHY DOES ORTHODONTIC MOVEMENT NOT CHANGE GINGIVAL COLOR AND VOLUME DURING TREATMENT?

One way to induce inflammation is by obstructing blood vessels, which results in local cell death. Proteins released by necrotic cells induce inflammation, as in the gingival connective tissue. Compression of the teeth against the periodontal ligament and alveolar bone often causes cells death and hyalinization of a ligament segment. Not only the arterioles and capillaries, but the veinlets would also be obstructed, along with areas of necrosis, followed by inflammation.

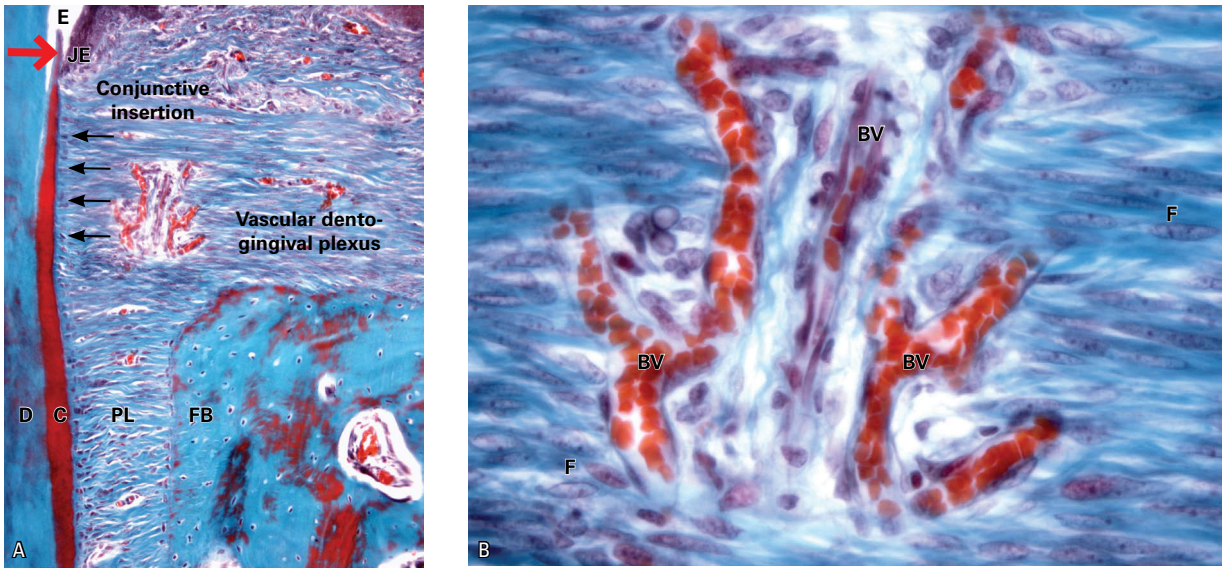


FIGURE 4 - Net-shaped dentogingival plexus in the cervical dental region of monkeys, more specifically at the site of the cementoenamel junction (larger arrow). On the root one can see the cementoblasts (small arrows) (E= enamel, JE= junctional epithelium, D= dentin, C= cementum, PL= periodontal ligament, FB= fasciculate bone, BV= blood vessel, F= fibroblast).

In orthodontic movement, compression of the vessels occurs in the periodontal ligament and could potentially influence gingival blood flow, but this does not occur. It would be natural to expect ischemia would make the gingiva turn whitish, or passive hyperemia would make it violet-red due to veinlet compression.

In the gingival tissue, more specifically at the site of the gingival connective attachment, blood vessels form a lace-like dentogingival vascular network or plexus with connections arising from periodontal vascular components. These connections also originate in the marrow spaces of the alveolar bone crest and its periosteum, as well as from the vessels of the alveolar mucous membrane via attached gingiva.[5,6,8] There are 50 capillaries within every square millimeter of gingiva[5] (Figs 1-4).

The effects of vascular compression of the cervical periodontal tissues and gingival tissues are offset by anastomosis or by connections from other sources (Fig 2). Blood supply to gingival tissues and their venous and lymphatic drainage remain at normal levels. Gingival color and volume are not changed during orthodontic movement by this mechanism or anatomical feature. Neither an edema develops — due to venous obstruction — nor does any inflammatory process emerge.

5) WHY DOES ORTHODONTIC MOVEMENT NOT INDUCE EXTERNAL CERVICAL RESORPTION?

In a similar compensatory manner, compression of the periodontal and gingival vessels does not promote focus areas of necrosis and/or gingival inflammation in the region of the connective attachment (Fig 2). In the absence of necrosis, characterized by cell rupture and protein spill, orthodontic movement does not induce inflammation and dissolution of extracellular matrix in the gingival connective tissue. The dentin gaps will not be exposed to macrophages, which in turn will not perform antigen recognition, nor present with foreign proteins that might trigger

external cervical immune and resorptive responses. This mechanism and anatomical feature does not induce ECR during orthodontic movement.

On the other hand, damage to the gingiva caused by dental trauma and internal dental bleaching cannot be offset by extensive anastomosis: Cellular injury occurs mechanically, directly and independently of blood supply. During trauma, cells and vessels are ruptured by sudden shifts while in tooth bleaching the toxic effect of hydrogen peroxide occurs independently of local blood supply.

FINAL CONSIDERATIONS

1) Dentin comprises proteins, which are considered sequestered antigens and when it is exposed to connective tissues it tends to be resorbed as a form of elimination by the body.

2) At the cementoenamel junction (CEJ), the dentin gaps found in all permanent teeth may expose the dentin whenever inflammation is induced at the connective attachment.

3) Before dentin is exposed at the CEJ, gingivitis and periodontitis reveal a hyperplasia of the junctional epithelium that covers the gaps, placing the dentin in the oral environment.

4) In dental trauma and internal bleaching, inflammation of connective gingival tissue does not promote junctional epithelial hyperplasia and direct exposure of the dentin allows antigen recognition by macrophages.

5) The gingiva receives vessels from the periodontium, bone, periosteum and mucous membrane so that its nutrition and drainage are not affected, even when the vessels of the periodontal ligament are compressed during orthodontic movement.

As a result, there is no inflammation at the connective attachment, nor there is cell death in the gingiva during orthodontic movement, with gingival color and volume remaining unchanged, even if the dentin is exposed at the CEJ gaps, which is necessary to initiate ECR.

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- Former director of the Edward H. Angle Society of Orthodontists.
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In your opinion, were there any major changes in orthodontic education in the past 50 years? If you believe so, what were they? How about in the practice of orthodontics? Are you disappointed at these changes?

Our sustaining mythology has changed. When I was a student, I was taught that orthodontics is a biologically-based medical specialty. Almost all of our orthodontic departments were staffed by people of great substance. They were powerful role models who believed that orthodontics belonged in the university. They had toiled in the vineyards of orthodontic research and had made substantial contributions to the literature. Although it wasn't clear how it would transpire, we assumed that if we piled up enough data, concepts would emerge that would advance the practice of orthodontics and enhance its reputation as the "thinking man's specialty." Under these circumstances, there were always a few who were attracted to the challenge of creating and husbanding knowledge—the true role of the academic.

Speaking personally, I was inspired by Robert Moyers at Michigan and James Scott at the Queen's University of Belfast, Northern Ireland. The probable economic penalty of an academic career meant nothing to me. My lack of concern argues that committed academics actually may be quite selfish. Alongside the excitement of a career in research, money was a secondary concern; however, my research wasn't equally exciting to my family, who no doubt would have been better served by more money and more of my time and attention.

In the article *When everything works, nothing matters* you said that "our major controversies are immortal". What are some of these controversies? Why do you say that "we really don't want them to be resolved"? Do you foresee any other "immortal controversies" on the rise?

The existence of God is an immortal controversy. Do you think the world's religious leaders would be eager to be told, say, by a superior intelligence from outer space, whether or not there is a God and, if there is, which religion—if any—is the True Faith? Somehow I doubt it. I think a similar dynamic is at work in orthodontics. Now and for the foreseeable future, the major controversies, at least in theory, are extraction, "jaw-growing," and the relationship between orthodontics and TMD. (I say "in theory" because I think the literature may now contain sufficient evidence to decide all three.) We really don't want them resolved because a final answer would expose some treatments—some popular treatments—as being inferior. Given that many successful practices are based on treatment "philosophies" that would be endangered by serious research or even a cursory examination of the literature, it is easier to pretend that the "jury is still out," no matter what. In short, a supposed lack of evidence one way or another ("we just don't know") grants perpetual license to treat any way you want.

This apparent fear of reaching a consensus has ignited a potentially more significant controversy: should contemporary treatment be evidence-based? Amazingly, the argument involves the need for evidence, rather than the evidence, itself. This basic controversy threatens the status of orthodontics as a learned calling. Here then is the problem as I see it:

1) Evidence-based treatment won't add to the "bottom line." Indeed, it may even cost money.
2) Evidence-based treatment probably would lead to better outcomes, no matter how "better" is defined.

3) The patient, however, will rarely know one way or another.

How then is the specialty to respond? When nobody dies from anchorage loss, when everything works well enough to pay the bills, orthodontic practice becomes an interesting test of personal ethics and resolve.

In one of your lectures at SLU, you stated that if we (the 14 residents present) were to design a treatment plan for a given patient, we would have 14 different treatment plans, but only one of them would be the best one for that patient. If everything works, how do we know which one is the best treatment?

That is an interesting question. Clearly, "best" can be defined in many ways: most stable, best looking (as defined, say, by the opinion of contemporary observers), least painful, cheapest, etc. Note that these definitions are based on the patient. Today, it is common instead to define "best" from the standpoint of the orthodontist: quickest, most popular (with referring dentists, patients), easiest, etc. Given a multitude of definitions of what is best (many of which may be mutually exclusive), the trick would be to determine which ones are appropriate to a given patient. Given that treatment is a gamble, both from the standpoint of the patient and the orthodontist, the precepts of game theory would come into play: from the standpoint of any given definition of "best," what treatment has the greatest "expected" gain? The much-maligned call for "evidence-based treatment" presumably would lead to research, whose results would support informed, individualized treatment-planning decisions.

What would you say were the best advances in our field in the past 50 years?

A single word: materials. Tied for second place would be pre-adjusted appliances and direct bonding (a mixed blessing, given that banding was a powerful impediment to comprehensive treatment by non-specialists). The significance of TADs has yet to be decided, although if they really can let us put the teeth anywhere we want, then "wherever the appliance *du jour* happens to put them" will no longer be good enough. We will instead be faced with the challenge of figuring out where we want to put the teeth in each individual patient. If this be true, treatment planning may once again become an important part of day-to-day clinical practice. It would perhaps herald a new "Golden Age" that would have nothing to do with money.

What do you see in the future of our specialty? Are the technological advances going to make orthodontist obsolete?

I am not an orthodontic Luddite (*q.v.*); I don't fear or dislike technology. I don't think that technological advances will make clinicians obsolete; however, technology seems to have had the effect of distancing the clinician from the patient. CAD-CAM appliances, cephalograms digitized by an assistant, internet marketing, and an increasingly popular reliance on a single treatment (say, non-extraction "bone growing") will modify the status of the orthodontist. If we come to rely on technology heavily and mindlessly, we won't become obsolete. Instead, our treatments will be indistinguishable from those of non-specialists employing the same technologies. Orthodontics by orthodontists will cease to be something special.

Are you disappointed at the course of contemporary orthodontics? How about the course of orthodontic education?

Actually, I think it would be presumptuous of me to pass judgment on the specialty's evolution. It is what it is. I wish, however, that there were more of a thirst for evidence, the real work product of orthodontic academics. If clinicians were to want an evidentiary basis for day-to-day practice, there would be no problem in staffing our departments. In my experience, it isn't laziness or "bad hands" that attracts people to "teaching," but rather the challenge of creating new knowledge. Although there obviously is more to orthodontic academics than research, it is the activity that attracts the kind of people who can survive in a tenure-track university environment and, at the same time, be successful teachers, role models, and leaders in the specialty.

What advice would you give to a recent orthodontic graduate that reading your article understands you wanting to go into practice (had you been a recent graduate too) but still wants to go into academics? How does one become an academician, not merely a teacher?

When I started out in academe nearly 50 years ago, research seemed like a game that would be fun to play. Further, I assumed that there would be a "market" for my findings. After all, I thought, why wouldn't clinicians be eager to know what works, what doesn't, and why? To prepare myself, I went on for a PhD (six years, full time; in the process, most didn't know I was a dentist, let alone an orthodontist). When I finished and started my academic career, I soon discovered that my colleagues in practice weren't as eager to be guided by evidence as I had hoped. In other words, in the game of research, the members of the specialty really weren't keeping score to decide whose ideas, hypotheses, data, etc. were the winners. Given this realization, research became a private game in which I was the score-keeper. For example, I think I have figured out how mandibular growth is controlled and how functional appliances work.

Accordingly, in my personal scoring scheme, I have won these two games, even though it is doubtful that many in the specialty have given much thought to my "explanations." On the plus side, I have been well treated by my colleagues, even those who may not think my work particularly important. I have had a very large coterie of talented and successful residents. I have been honored to teach at three great universities. I am pleased with my career; I would change nothing. Orthodontics, however, was very different when I made my career decisions. What about today's graduates?

If you are interested in research, are willing to get advanced education to prepare yourself to be a real scientist (this is an important step), and do not need ongoing, effusive affirmation from the rank and file, a career in academics is worth considering. You spend long hours; however, what you do is interesting and challenging. You work with colleagues throughout the world; you interact with generations of talented residents; you have the opportunity to make a real contribution to the specialty. Finally, contrary to what you might have been led to expect, you won't starve. For those who have "the calling," it's a great life.

How can we objectively improve orthodontic education?

I think the answer is simple, but definitely not easy: if the specialty truly values research — an important part of the job description of a serious, tenure-track academic — then there will always be a few who will self-identify and who will take the necessary steps to prepare themselves for an academic career. To paraphrase "Field of Dreams," if you want evidence, they will come. If the specialty doesn't care, I can't see any effective solution. After all, there always will be a good market for straight teeth.

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Analysis of the use of sample size calculation and error of method in researches published in Brazilian and international orthodontic journals

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Abstract

Introduction: Reliable sample size and an appropriate analysis of error are important steps to validate the data obtained in a scientific study, in addition to the ethical and economic issues. **Objective:** To evaluate, quantitatively, how often the researchers of orthodontic science have used the calculation of sample size and evaluated the method error in studies published in Brazil and in the United States of America. **Methods:** Two major journals, according to CAPES (Brazilian Federal Agency for Support and Evaluation of Graduate Education), were analyzed through a hand search: *Revista Dental Press de Ortodontia e Ortopedia Facial* and the *American Journal of Orthodontics and Dentofacial Orthopedics* (AJO-DO). Only papers published between 2005 and 2008 were examined. **Results:** Most of surveys published in both journals employed some method of error analysis, when this methodology can be applied. On the other hand, only a very small number of articles published in these journals have any description of how sample size was calculated. This proportion was 21.1% for the journal published in the United States (AJO-DO), and was significantly lower (p= 0.008) for the journal of orthodontics published in Brazil (3.9%). **Conclusion:** Researchers and the editorial board of both journals should drive greater concern for the examination of errors inherent in the absence of such analyses in scientific research, particularly the errors related to the use of an inadequate sample size.

Keywords: Biostatistics. Sample size. Error of methods.

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Editor's summary

Science advancement depends fundamentally on methodologically well-designed studies. Recently, two methodological issues have gained prominence: Method error and sample size calculation. Method error is usually obtained by duplicating some of the measurements performed within a given time interval in order to verify that the analyzed data are reproducible, which ensures that the methodology employed in the research is indeed reliable. On the other hand, sample size must be appropriate before important clinical differences, if any, can be proven statistically significant. Given the scientific importance of these calculations, the present study sought to examine the frequency with which sample sizing and method error appear in the Brazilian and international orthodontic literature.

The two foremost scientific journals of orthodontics in Brazil and abroad — according to the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) — were found to be the *Revista Dental Press de Ortodontia e Ortopedia Facial (Dental Press)* and the *American Journal of Orthodontics and Dentofacial Orthopedics* (AJO-DO). Ninety-two original articles published in the Dental Press journal (2005-2007) and ninety-four in the AJO-DO (2007-2008) were evaluated. The results showed that within this time period sample size calculation was used in only 3.9% of articles published in the Dental Press journal compared to just over 21% in the AJO-DO, with a statistically significant difference between them.

The use of method error, however, was reported in 60.9% of the Dental Press journal articles and 76.6% of the AJO-DO articles. The authors concluded that although method error is often employed, there was a fairly limited number of articles in which sample sizing was performed in both periodicals, with a greater, statistically significant difference in the Dental Press journal. In light of this finding, greater attention should be paid by reviewers, researchers and editors to appropriate sample sizing in orthodontic studies in order to ensure more reliable scientific results.

Questions to the authors

1) What issues should be addressed in defining the size of a sample in a prospective clinical study?

Proper sample size, along with an appropriate analysis of the method error, are important steps in validating the data obtained in a particular scientific study, in addition to economic and ethical issues. Studies using a small sample may not produce useful results, exposing their subjects (sample) to unnecessary risks, while an overly large sample size consumes more resources than necessary, exposing many individuals to existing risks.

To understand the importance of sample size calculation we need to understand what "power" means in statistics. Power expresses the probability of detecting a true effect. Small samples reduce the power of a study. However, excessively large samples often provide statistical significance between study groups[3] even when the difference is negligible and considered clinically unimportant. In addition to the desired level of certainty expressed by the *p* value and by power, other factors form part of the formula that defines the sample size.[1,2,4] These are:

a) The minimal clinical effect that the researcher wishes to see in the main (primary) study variable.
b) How the data obtained in the study will be measured (continuous, ordinal or nominal scale).
c) The type of statistical test to be used, and if it is a one-tailed or two-tailed test.
d) The variability of the data obtained in the study.

2) How important are studies like yours?

The results of this research disclosed that only 3.9% of the articles published in the Dental Press journal in the years 2005 through 2007 presented data regarding sample size calculation. This percentage was significantly lower (p=0.008)

TABLE 1 - Absolute and relative frequency (%), relative difference, p-value and power for papers with statistical analysis (A) and the description of sample size calculation (B), published in the *Revista Dental Press de Ortodontia e Ortopedia Facial* and in the *American Journal of Orthodontics and Dentofacial Orthopedics*.

Description	Dental Press 2005-2007	AJO-DO 2007-2008	Difference (%)	p-value	Power
Original articles with statistical analysis (A)	51 (100%)	57 (100%)	----		
Articles with sample size calculation (B)	2 (3.9%)	12 (21.1%)	-17.2	0.008**	0.78

**p<0.01.

compared to articles published in AJO-DO, in which little more than 21% of the articles comprised a description of the methods used for sample size calculation (Table 1). These data reflect a worrying neglect on the part of researchers and reviewers regarding this important factor, responsible for errors occurring in the statistical evaluation of data obtained in articles published by these two major journals.

3) How do the authors see Brazilian scientific research in the field of orthodontics in today's international context?

Orthodontics as a science has evolved continuously, as well as the use of statistical methods. In Brazil, this growth is noticeably faster. In previous decades certain studies were published which today would probably not be accepted due to methodological issues. Among these issues are the use of sample size calculation and method error. Competitiveness imposes increasingly stringent standards, and therefore whoever shows concern about this issue will certainly receive a more favorable evaluation from reviewers and editors. In a recent interview published in the AJO-DO, the then editor-in-chief,[5] remarked: "... I am amazed at the number of authors who conduct quite creative studies but submit a manuscript without considering the need of calculating the number of subjects required for the findings to be rated as statistically significant..."

In terms of published works, Brazilian orthodontic literature is the most active in the world. Given this fact, the researchers likely to achieve greater success are those who put in their best efforts in the planning and implementation of statistical methods. In other words, inspiration is still important, but perspiration has become the differentiator key.

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In vitro evaluation of force delivered by elastomeric chains

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Abstract

Objective: To evaluate and compare, *in vitro*, the decrease in the forces delivered in three groups of elastomeric chains, produced by the same manufacturer, according to the distance between links (short, medium, long). **Methods:** The segments of elastomeric chains were stretched and kept activated during the trial using a device developed especially for this purpose, which also allowed force readings. Force degradation was evaluated by measuring force along time and calculating the percentage of force decrease from initial force at each time interval and for each specimen under test. **Results and Conclusions:** Data were statistically analyzed and results showed that at the different time points after initial readings, force intensity varied within and between groups. Readings of remaining forces at each time moment compared with the initial reference force revealed statistically significant differences in all the comparisons in each group of elastics (short, medium, long). Although the comparisons between forces delivered at each time point revealed statistically significant differences, these differences do not seem to have a clinical significance. The space between links does not seem to be a clinically significant characteristic in force degradation along time.

Keywords: Orthodontic appliances. Dental materials. Elastomers.

Editor's summary

Elastomeric chains have been used in orthodontics since the 1960s, and their use has increased along time due to their many advantages. They are economic, comfortable and easily placed and removed, which reduces working time and does not require patient cooperation. Despite these advantages, elastomeric chains are not capable of producing continuous forces along time. Their mechanical properties change because of the variable amount of stretching to which they are submitted, water and saliva absorption, permanent deformation, sensitivity to saliva pH and temperature variations in the oral environment. The size of elastomeric chains, as well as their configuration — often described as short, medium or long — also seem to affect their behavior. This *in vitro* study evaluated and compared the decrease of the initial force delivered by elastomeric chains divided into three groups according to the distance between their links.

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Grey elastomeric chains produced by Dental Morelli were selected and classified according to the distance between links: short, medium and long (n=20). A device with two platforms, one fixed and one movable, and hooks in their ends was manufactured especially to keep the elastomeric chains activated during the experiment and to allow readings of the forces delivered. The elastomeric chain segments were placed in the device and stretched to deliver an initial force of about 200 gf. Measurements were made at the following time intervals: baseline, 1 hour, 24 hours, and 1, 2, 3 and 4 weeks after the chain activation.

The readings at baseline, 1 hour and 24 hours showed that the short elastics had statistically greater values than those in the medium and long groups ($p<0.05$). Medium and long elastics, in turn, had not differences from each other ($p>0.05$). There were no statistically significant differences in remaining forces between the elastomeric chain groups at 1 and 2 weeks after activation. In the 3rd week, short elastomeric chains had statistically lower values than the others. In the 4th week, all groups differed from each other, and the long group had the greatest mean values, followed by the short and medium groups. The authors concluded that the distance between links does not seem to be a clinically significant characteristic of force degradation along time.

Questions to the authors

1) According to the authors, about 20% of the initial force was lost. Based on that, would it be clinically acceptable to add 20% more force at the elastomeric chains placement time?

The application of forces greater than optimal for a certain orthodontic movement does not seem to significantly affect final clinical results of expected tooth movement. Moreover, a greater force might lead to complications, such as patient discomfort and indirect root resorption. It should also be noted that greater forces lead to equally greater losses in the first 24 hours. Therefore, there is no justification for the addition of force beyond what is classified as optimal in orthodontics.

2) Do you expect to see technological development of orthodontic elastics in the field of dental materials?

Although already being used for relatively long time, orthodontic elastomeric chains remain as object of studies whose findings are often contradictory. Clinical and laboratory studies using well designed methods and approaches that include biocompatibility, chromatic and morphological characteristics and the mechanical properties of materials should continue to be conducted, as their finding may be fundamental for the technological development of orthodontic elastomeric chains.

3) Is the efficiency of national and imported elastomeric chains similar?

The efficiency of the materials under study does not depend on its origin. Several factors affect the mechanical properties of elastics, such as material composition, manufacturer and sterilization methods. In addition, environmental variables, such as saliva, diet, temperature and pH may affect the clinical efficiency of elastomeric chains.

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ARTICLE SELECTED BY THE EDITOR

ONLINE ARTICLE*

Prospective cephalometric study of the effects of maxillary protraction therapy associated with intermaxillary mechanics

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Abstract

Objective: The early diagnosis and treatment of skeletal Class III (Pattern III) is still a much debated topic in orthodontic literature. Maxillary protraction associated with rapid maxillary expansion is the most popular and widely researched approach, producing the best results in the shortest period of time. This study aimed to evaluate the gradual changes that occur in the dentofacial complex in children with Pattern III growth treated with maxillary protraction associated with intermaxillary mechanics. **Methods:** The sample consisted of 10 patients with Pattern III, whose mean age was 8 years and 2 months at the beginning of treatment, consecutively treated with a modified Haas expander, modified lingual arch, intermaxillary elastics and Petit facemask for maxillary protraction during a 9-month period. Four lateral cephalograms were taken of each patient, one at the beginning of treatment and the other three at regular 3-month intervals (T1, T2, T3 and T4). Cephalometric measurements at each of the four times were compared using ANOVA variance for repeated measures and supplemented by Tukey's multiple comparisons test. **Results:** It was observed that the most significant skeletal changes occurred in the first 3 months of treatment. After that period the changes remained constant until the end of treatment. There were few dental compensations and the vertical changes which occurred showed reduced clinical significance. **Conclusions:** The therapy used in this study accomplished not only the correction of overjet but also improvements in the sagittal relationship of the basal bones and in soft tissue esthetics.

Keywords: Prognathism. Palatal expansion technique. Extraoral traction appliances. Malocclusion.

Editor's summary

Despite the low prevalence of Class III malocclusion compared to other malocclusions, it's salient facial characteristics lead to the need for early therapeutic approaches. The treatment of this malocclusion represents a major challenge to the orthodontist in their clinical practice due to its complex control and difficulty in predicting the morphogenetic growth pattern of the patient into adulthood. Among the modalities for

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early treatment of Class III malocclusion, maxillary protraction is the most widespread and studied protocol in the orthodontic literature. The authors' proposal with the present work was to evaluate the effect of maxillary protraction associated with the use of intermaxillary mechanics by using Class III sagittal elastics. To this end a cephalometric study was carried out with a sample of 10 patients, 6 females and 4 males, consecutively treated with the modified Haas expander followed by the use of a Petit facemask for maxillary protraction for a period of 9 months. The facemask was used associated with Class III oriented elastics anchored on the expander and on a modified Nance lingual arch. The dental, skeletal and soft tissue changes were evaluated through lateral cephalograms obtained at four different times: T1) beginning of treatment, before the installation of appliances; T2) after 3 months of treatment; T3) after 6 months of treatment; and T4) after 9 months of treatment, immediately before the removal of the appliances. After data collection, statistical tests were applied. The results showed that the most significant skeletal changes occurred in the first 3 months of treatment, and then these remained constant until the end of treatment. Few dental compensation and vertical changes occurred, showing low clinical significance. Thus, the authors conclude that the therapy not only achieved overjet correction, but also an improvement in sagittal relationship between the bone bases and in the facial esthetics.

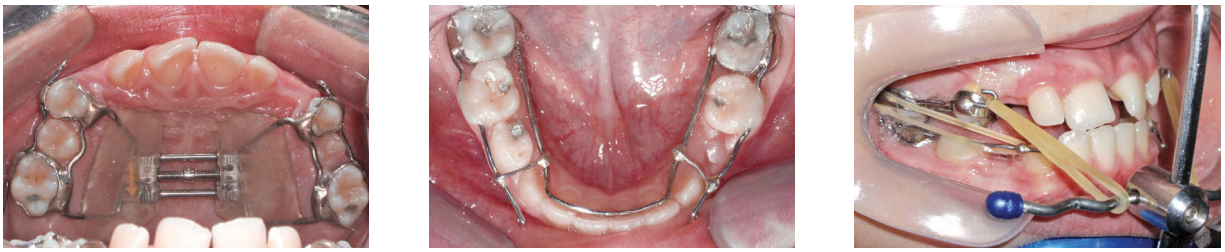

FIGURE 1 - Orthodontic appliances used in the present study.

Questions to the authors

1) What were the real gains obtained by adding the elastic-oriented therapy with Class III facemask?

Our idea was to evaluate the effects of intermaxillary forces incorporated into the maxillary protraction therapy by means of RME and Petit facemask, as some authors reported in the literature the use of intermaxillary forces in order to maximize the skeletal effects of maxillary protraction[1-4]. These authors suggest that by increasing the force applied to maxillary protraction, the displacement of the maxilla is increased. Thus, we seek to enhance this effect in growing patients without the need of skeletal anchorage resources or ankylosis of deciduous canines. With this purpose, a lingual arch reinforced by vestibular hooks was used, and hooks on the distal of the Haas expander for using Class III elastic that applied 200 to 350 grams, 24 hours a day. However, by comparing our findings with the results described in the literature, it is observed that the therapy used here could not significantly increase the desired effect in orthopedic interceptive

Pattern III treatment. However, in some very cooperative patients, a greater skeletal effect was obtained[5]. This proves that the patient's cooperation is essential to obtain good results with maxillary protraction[6] and the use of higher strength levels for these patients can be quite beneficial.

2) The use of intermaxillary elastics could not increase the effect of orthodontic therapy?

This was one of our initial questions when we started this research, in addition, of course, to evaluating the dental and skeletal effects induced by maxillary protraction therapy during this treatment (with cephalometric evaluations every 3 months). Thus, the results made it clear that the concomitant use of facemask and intermaxillary therapy, as proposed in the current article, does not maximize the dentoalveolar participation in the treatment; but it was also not possible to significantly enhance the skeletal effects of the therapy. However, our major finding was that, among the incremental effects occurring during treatment, virtually all significant skeletal changes occurred in the first 3 months of treatment, and thereafter they remained fairly constant until treatment end.

3) Do you intend to continue this research line? What are your future studies?

Yes, our intention is to continue studying ways to treat the Pattern III in growing patients. Unfortunately, as we have no Pattern III patients longitudinal control group, we intend to increase the sample presented and compare it with other different maxillary protraction methods, as the isolated use of facemask, chincup with hooks (Skyhook), among others.

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Cephalometric study of tooth position in young Afro-Caucasian Brazilian individuals with normal occlusion

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Abstract

Objective: The purpose of this study was to achieve a specific cephalometric pattern for young Afro-Caucasian Brazilian individuals and verify the presence of dimorphism between sexes. **Methods:** The sample was composed of 40 lateral cephalograms of young Afro-Caucasian Brazilian individuals (mulattos), 20 males (mean age 13.25 years) and 20 females (mean age 13.10 years), with normal occlusion and no previous orthodontic treatment. The cephalometric variables were determined according to the analyses of Downs, Steiner, Riedel, Tweed, McNamara, Ricketts and Interlandi. Independent t test was applied to compare the variables between sexes. **Results:** The maxillary and mandibular incisors were protruded and buccally tipped. There was no statistically significant difference between sexes in all variables. **Conclusions:** It was observed that young Afro-Caucasian Brazilian individuals without skeletal alterations and with normal occlusion showed specific tooth position and facial features in relation to the other Brazilian ethnic groups.

Keywords: Ethnic groups. Cephalometrics. Incisors.

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INTRODUCTION

Population context determines an intense variation in ethnic groups, especially in large urban centers, evidencing the need to acknowledge that a single pattern of facial esthetics may not be appropriate for diagnostic decisions and treatment planning for individuals of different ethnic backgrounds, who migrated to distinct geographic regions.[12,16]

In Brazil, the admixture between Portuguese settlers, Brazilian Amerindians and Africans led to the formation of a diversified population, and a significant part of the Brazilian population was originated from relationships between White-Black (Mulatto), White-Amerindian (Caboclo) and Black-Amerindian (Zambo). Each one of the three basic groups (Amerindian, White and Black) does not represent a pure ethnicity. It is important to identify the characteristics of the Brazilian population and to analyze the respective somatic aspects.[36]

The importance of investigating the skeletal and dentofacial components and relate them to normal and individual characteristics in the ethnic groups, with different cultural and social influences, is justified by orthodontic treatment limitations and its clinical implications, especially when the mechanics impairs the facial esthetics.[7,8,13-16,20,22,27,28,42] The normative values of cephalometric measurements, which are specific for different ethnic groups, should complement the diagnosis and treatment planning according to the individual needs and expectations of the patient.[1,39] The literature highlights the lack of cephalometric studies related to differences in facial morphology between ethnic groups.[1,7,14,15,26,29] The applicability of characteristics of facial, skeletal and soft tissue patterns should also be determined to establish the diagnosis and treatment planning of malocclusions, aiming to achieve occlusal, functional and skeletal ideal relationships. Therefore, the cephalometric and occlusal studies aim to promote stable orthodontic corrections, with ideal tooth position.

Therefore, considering the lack of specific studies in Afro-Caucasian individuals, the present study aimed to determine the existing cephalometric variables for the ideal maxillary and mandibular incisors position in Mulatto individuals with balanced faces.

ETHNICITY

Since the terms "racial" and "ethnic" may induce doubtful interpretations, it was used the classification of Cuvier (cited by Ávila[5]), which highlights the three main racial groups according to differentiation criteria related to the color of human skin, i.e.:

» White race;
» Yellow race;
» Black race.

The meaning of each ethnic group is closely related to culture conditions and sociopolitical integration of members of each population, regarding the language, habits and way of life. Therefore, an ethnic group is a population among others that constitutes a racial group when collectively grouped, but maintain their physical and cultural differences by limiting mechanisms as geographic or social barriers.[6,37]

The skin color classification for Mulatto individuals is due to the miscegenation between Whites and Blacks.

In 1999, IBGE (Brazilian Institute for Geography and Statistics) published data revealing that Brazilian Black population was only 5.4%. However, with the increase of 39.9% of Mulattos, Brazil was mainly defined as a Black country, as it is currently considered by many Americans and Europeans.

Considering these aspects, it is extremely important to differentiate the variations of craniofacial skeletal structures (that are closed related to the maxillary and mandibular teeth position) in the Afro-Caucasian individuals,

since the normal relationship between skeletal and tooth position is different according to ethnic variations. Thus, studies should be conducted to support the diagnosis, especially in Afro-Caucasian individuals (Mulattos), because they constitute a large community within the Brazilian population.

PROPOSITION

This study aimed to present an individual cephalometric pattern for tooth position in young Afro-Caucasian Brazilian individuals with age ranging from 12 to 14 years, by means of:

- » Achieving mean values of normality for dental cephalometric measurements.
- » Identifying the presence or absence of dimorphism between sexes.

MATERIAL AND METHODS

The study was conducted on forty lateral cephalograms of Afro-Caucasian Brazilian individuals with Angle normal occlusion (aged 12 to 14 years). The sample was selected by examining young individuals in public state schools of Bauru, Brazil.

FIGURE 1 - Extraoral photographs. Young Afro-Caucasian male individual.

FIGURE 2 - Intraoral photographs. Determination of occlusal characteristics in a young Afro-Caucasian individual, with normal occlusion.

The ethnic and racial characteristics were accurately evaluated by a questionnaire, which provided information to classify the skin color of the parents. Therefore, only young individuals of African descent were included in the sample. Adolescent clinical examinations were performed using a disposable spatula as an effective instrument for intraoral examination.

Additional inclusion criteria were: Presence of permanent teeth in occlusion, but third molars; normal molar and premolar relationship; no previous orthodontic treatment; little or no crowding; no posterior crossbites; normal overjet and overbite; pleasant soft tissue profile with balanced facial pattern (Figs 1-4).

To determine the balance between facial thirds and absence of asymmetry, a subjective facial analysis was conducted to select only young individuals with balanced facial profile (Pattern I).[12]

FIGURE 3 - Extraoral photographs. Young Afro-Caucasian female individual.

FIGURE 4 - Intraoral photographs. Determination of occlusal characteristics in young female individual with normal occlusion.

The sample of Afro-Caucasian Brazilian subjects with normal occlusion was composed of 40 young individuals, being 20 males and 20 females, with mean age of 13.15 years (range, 12.0 – 14.30 years).

Radiographs

All lateral cephalograms were obtained in maximum intercuspation with lips at rest, using a Broadbent[11] cephalostat to standardize the head positioning.

The magnification factor of the radiographic image was calculated and corrected to achieve greater accuracy. The X-ray machine showed a magnification factor of 9.8%.

Tracing of cephalograms

Cephalograms were hand-traced and the landmarks were analyzed in a digitizing tablet (Numonics Corporation, Montgomeryville, PA, USA), connected to a microcomputer with processor AMD K6-2 500MHz, for achievement of cephalometric measurements.

The tracings and digitization of points were performed by the examiner using a customized analysis in the software Dentofacial Planner 7.02 (Dentofacial Planner Software Inc., Toronto, Ontario, Canada) for the measurements. Correction of the magnification factor (9.8%) was performed by the software (Fig 5).

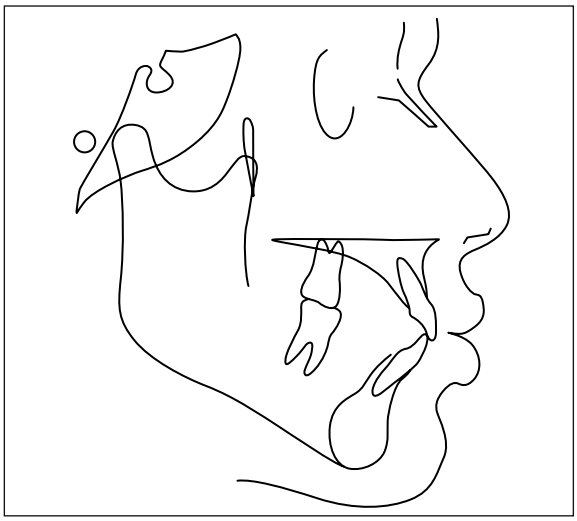

FIGURE 5 - Tracing of anatomical structures.

Dental cephalometric variables

Maxillary dentoalveolar component (Fig 6A)

1. Mx1.NA: Angle between the long axis of the maxillary central incisor and line NA, representing the degree of inclination of the maxillary central incisor in relation to the maxilla and nasion point.

2. Mx1.PP: Angle between the long axis of the maxillary central incisor and the palatal plane, representing the degree of inclination of the maxillary central incisor in relation to the maxilla.

3. Mx1-NA: Distance between the most anterior point on the crown of the maxillary central incisor and line NA, representing the anteroposterior position of the maxillary incisor in relation to the maxilla and nasion.

4. Mx1-PP: Perpendicular distance between the incisal edge of the maxillary central incisor and the palatal plane, representing the vertical position of the permanent maxillary central incisor in the maxilla.

5. Mx1-Aperp: Distance between the EMxI point (incisal edge of maxillary central incisor) and line Aperp.

6. Mx1-PTV: Distance between the EMxI point to the pterygomaxillary vertical plane.

Mandibular dentoalveolar component (Fig 6B)

7. Md1.NB: Angle between the long axis of the mandibular central incisor and line NB, representing the degree of inclination of the mandibular central incisor in relation to the mandible and nasion point.

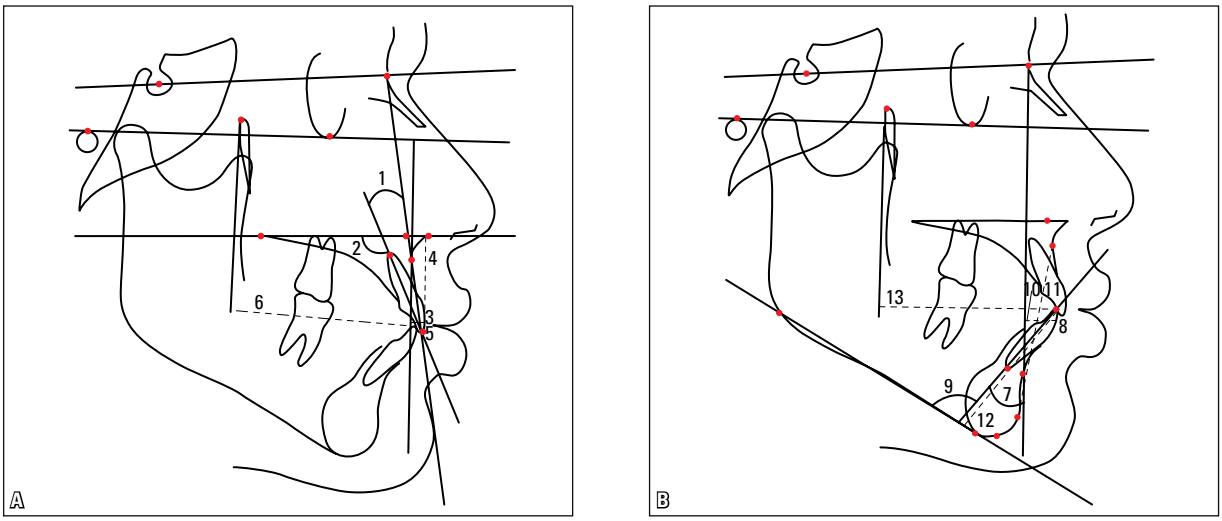

FIGURE 6 - Tracing of anatomical structures **A**) Maxillary anterior dentoalveolar component. **B**) Mandibular anterior dentoalveolar component.

8. Md1-NB: Perpendicular distance between the most anterior point on the crown of the mandibular central incisor and line NB, representing the anteroposterior position of the mandibular incisor in relation to the mandible and nasion.

9. IMPA: Angle between the long axis of the mandibular central incisor and the mandibular plane (GoMe), representing the tooth inclination in relation to the mandible.

10. "I" line: Union of points P' and "E", traced in an extent of only 1 cm, at the crossing point with the occlusal plane, determining the degree of retrusion or protrusion of the mandibular central incisor.

11. Md1-APog: Distance between the EMdI point (incisal edge of mandibular incisor) and the line A-Pog.

12. Md1-PM: Perpendicular distance between the incisal edge of the mandibular central incisor and the mandibular plane, representing the vertical position of the permanent mandibular central incisor in the mandibular symphysis.

13.Md1-PTV: distance between the EMdI point to the pterygomaxillary vertical plane (PTV).

Statistical analysis

Method error

Cephalograms were retraced by the same examiner. To determine the reliability of results, fifteen randomly selected radiographs were traced and digitized by the same investigator, after a 20-day interval.

For each cephalometric measurement analyzed, the systematic and casual errors were independently evaluated. The systematic error was calculated by the paired t test, as suggested by Houston.[25] Application of the Dahlberg[17] formula ($Se^2=\sum d^2/2n$) allowed to estimate the result of casual errors, considering as significant errors greater than 1 millimeter for linear measurements and 1.5 degree for angular measurements.[17]

Descriptive and comparative analysis

The values were matched in relation to the chronological age of subjects and are presented

in Table 1. The descriptive evaluation of values achieved in relation to the dental cephalometric variables in the Brazilian Afro-Caucasian adolescents is shown in Table 2. Table 3 presents the results of the independent t test for comparison of cephalometric variables between males and females.

For statistical analysis of data, the independent t test was applied at a significance level of $p<0.05$, for comparison of values of cephalometric variables between sexes. These tests were conducted on the software Statistica for Windows 5.0 (Statistica for Windows. StatSoft, Inc., 1995, Tulsa, OK, USA).

RESULTS

The mean age of subjects (n=40) was 13.15 years, according to the t test. A descriptive evaluation of the dental cephalometric variables in Afro-Caucasian Brazilian adolescents is presented in Table 2.

Table 3 shows the absence of dimorphism between sexes. According to the results, no significant difference was observed for all analyzed variables.

DISCUSSION

There is a lack of studies in the literature to determine the characteristics of facial, skeletal and dental normality, specifically addressing young Mulatto Brazilian individuals. Therefore, some cephalometric parameters for Black individuals

TABLE 1 - Statistical analysis of ages means for both sexes.

	Total (n=40)		Female (n=20)		Male (n=20)		
	X	SD	X	SD	X	SD	p
Age	13.15	0.61	13.10	0.78	13.25	1.04	0.560
Minimum age	12.00		12.00		12.20		
Maximum age	14.30		14.21		14.30		

Significant at $p<0.05$.

TABLE 2 - Descriptive analysis of the sample, with mean values and standard deviations of young Afro-Caucasian Brazilian individuals.

Variables	n	Mean	Minimum	Maximum	SD
Maxillary anterior dentoalveolar component					
Mx1.NA	40	24.23	14.8	33.4	4.40
Mx1.PP	40	113.61	101.4	124.1	4.68
Mx1-NA	40	6.40	3	12.6	2.16
Mx1-PP	40	26.58	21.2	30.3	2.26
Mx1-PTV	40	52.95	42.3	66.3	4.78
Mx1-Aperp	40	5.95	2	11.5	2.18
Mandibular anterior dentoalveolar component					
Md1.NB	40	28.10	13.1	36.8	5.23
IMPA	40	94.63	80.5	105.3	5.58
Md1-NB	40	5.23	1.2	9.2	2.00
Md1-GoMe	40	38.82	34.9	43.8	2.26
Md1-PTV	40	49.37	38.9	61.5	4.46
Md1-APog	40	4.10	0.4	7.9	1.56
"I" line	40	-4.82	-9.7	-0.5	1.91

TABLE 3 - Statistical analysis of independent t test for the dimorphism between sexes, in young Afro-Caucasian Brazilian individuals

Variables	Male		Female		p
	Mean	SD	Mean	SD	
Maxillary anterior dentoalveolar component					
Mx1.NA	24.44	4.46	24.01	4.43	0.762
Mx1.PP	113.81	5.09	113.42	4.37	0.796
Mx1-NA	6.53	2.28	6.26	2.08	0.698
Mx1-PP	26.70	2.51	26.46	2.04	0.743
Mx1-PTV	53.44	4.95	52.47	4.69	0.529
Mx1-Aperp	5.82	2.29	6.09	2.13	0.697
Mandibular anterior dentoalveolar component					
Md1.NB	27.65	5.70	28.55	4.81	0.591
IMPA	94.63	5.30	94.64	5.98	0.993
Md1-PM	39.51	2.29	38.14	2.07	0.056
Md1-PTV	49.90	4.62	48.84	4.34	0.462
Md1-NB	4.96	2.15	5.49	1.85	0.410
Md1-APog	4.00	1.73	4.20	1.42	0.700
"I" line	-4.69	2.19	-4.95	1.62	0.667

Significant at $p<0.05$.

were used to accomplish the present study, yet including young Afro-Caucasian individuals.[8,36,38,51]

Considering the face of young Afro-Caucasian Brazilian individuals as harmonic and pleasant, different classifications were found in the literature regarding the facial types.[12,21] The literature shows that the craniofacial features of the evaluated subjects may suffer alterations during the growth period due to heritage.[9,12,52]

The characteristic of Pattern I for Afro-Caucasian individuals slightly varied in relation to the classification proposed by Capelozza Filho.[12] The facial phenotype of male and female Mulattos presented facial convexity and a closed nasolabial, due to a slightly maxillary protrusion or incisors flaring. However, the thickness of the upper lip significantly influenced the nasolabial angle in most sample subjects, considering that the facial characteristics of these individuals exhibited peculiarities that were intermediate between Blacks and Whites.

The oblique line of nose insertion was significant in most sample subjects.

It was also observe that the mandible presented greater clockwise rotation, with compensation of mandibular incisors (buccal inclination),[9,21] significant increase of facial convexity and slight increase in the LAFH.

To certify the incisor positioning, 13 dental cephalometric variables were implemented due to the structure diversity of the craniofacial complex. Many cephalometric measurements are obtained considering the cranial base or maxillary and mandibular bone bases. However, there is large variation of the structural morphology involving the cranial base.[7,21] A short SN line may induce the orthodontist to a less accurate diagnosis, leading to a erroneously evidence of the protrusion or retrusion of bone and dental bases.[41,53]

Deflection of the cranial base may also lead to erroneous interpretations during the complementary diagnosis. However, many variations may be analyzed as typical characteristics of a certain ethnic group.[21,41]

Some variables suggested by Downs[19] and Steiner[44] are obtained from the cranial base. Conversely, Ricketts,[43] McNamara[35] and Tweed[47,48] did not use the cranial base as reference to evaluate the dental variables.

Therefore, analysis of the skeletal morphology of young Afro-Caucasian individuals on the cephalogram evidenced the great potential of tooth compensation because of the skeletal characteristics of the jaws. The maxilla exhibited slight protrusion in relation to the forehead, which therefore should be considered normal for this ethnic group. However, the mandible exhibited slight clockwise rotation with marked mandibular incisors flaring. This skeletal and dental characteristic may induce a false diagnosis of bimaxillary protrusion of the bone bases for Afro-Caucasian and Black individuals.[21]

In addition to the facial and morpho-differential diagnosis of the cephalogram, the main reference points for orthodontic treatment include the curve of Spee, anterior and posterior tooth crowding, inclination of maxillary and especially of mandibular incisors.[19,27,32,44,47,48] Therefore, when establishing these analyses, the specificity and applicability in different racial groups demonstrate evident craniofacial and dental differences. Thus, there should be a customized therapy to avoid interference on the phenotypic characteristics of the craniofacial complex.

Maxillary and mandibular incisor position for the different ethnic groups

When comparing some linear and angular variables of the present study with the report of Medeiros[36] on Black individuals, it may be inferred that the variables 1.NB, 1-NB and "I" line demonstrated significant differences. There was a greater protrusion and inclination, especially in mandibular incisors of young Afro-Brazilian individuals, which corroborates with some other studies.[2,4,9,14,16,20,22,30]

Analysis of studies that determine the protrusion of mandibular incisors by morpho-differential analysis ("I" line) evidences greater

protrusion of mandibular incisors in Afro-Caucasians and Black individuals,[8,36] compared to studies that analyzed this variable in Caucasians[27,28] and individuals of Asian descent.[42]

Another study with young Caucasian individuals assessed the craniofacial growth and development in young individuals aged 6 to 18 years.[34] The comparative analysis of values evidences that most dental variables exhibited great proximity or similarity with the present results. However, it was observed that the dental variables in young Afro-Caucasian Brazilian individuals revealed slight protrusion and inclination of incisors in relation to the Caucasians, except for the variable Mx1-PTV. For the variables Md1-GoMe and Mx1-PP, which quantified the dental extrusion and stages of eruption of mandibular and maxillary molars, the value was slightly greater for young Caucasian individuals.

Quantitative evaluation, in relation to mandibular incisor position, according to the Tweed variable (IMPA)

The Afro-Caucasian individuals showed a mean value of 94.6º for the variable IMPA. In comparison, it was observed a mean of 92.3º for the IMPA in Brazilians with Japanese descent,[46] which was greater than the value of 90º observed by Margolis[32] and Tweed[48] in North American individuals, and also greater than the 91º observed by Martins et al,[34] in Caucasian individuals aged 12 to 14 years. Conversely, Harris, Kowalski and Walker[24] found a value of 95.6º for Black individuals.

Comparison between male and female sexes

Several studies[14,18,23,30,40,42,46,51] established patterns for different ethnic groups with standardized samples, correlating the presence or absence of dimorphism between sexes. However, other studies[8,10,22,36] individually evaluated the ideal values for young and adult Black individuals.

The comparative evaluation between sexes is important to identify differences in the growth and development process between young male and female individuals.[41] Martins et al[34] observed tendencies of earlier craniofacial development for young females compared to the males, at different ages.

The observation of numeric and statistical similarity in the analysis between male and female sexes indicates the absence of sexual dimorphism between young Afro-Caucasian Brazilian individuals (Tab. 3), assuming that the dentoalveolar variables may be applied for both sexes.

Clinical application

It should be highlighted to the clinician that, since this is a cephalometric study, measurements of other studies should also be evaluated and correlated to the current study. However, the variables are obtained by mean values that present large variation (standard deviation). The orthodontist should understand these variations to properly apply this knowledge, considering that facial analysis should be the main instrument to determine the final diagnosis with the secondary aid of cephalometric measurements and lateral cephalograms. The orthodontist should also consider the variations and limitation of the facial, skeletal and dental context in the different ethnic groups when selecting the best treatment plan.

CONCLUSIONS

The results showed the mean values of dental cephalometric variables in young Afro-Caucasian Brazilian individuals (Pattern I) with normal occlusion, which leads to the following conclusions:

» The distinct characteristic observed in cephalometric patterns of Afro-Caucasian individuals differs from values of other ethnic groups showed in the literature, indicating the need for a specific or differentiated analysis for diagnosis and orthodontic treatment planning.

» There was no dimorphism between sexes.

» Further studies should be conducted in Afro-Caucasian individuals with skeletal discrepancy (Pattern II, Pattern III, Short Face and Long Face).

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Cephalometric evaluation of the effects of a mandibular protraction appliance (MPA) combined with fixed orthodontic appliance on dentoalveolar and soft tissue structures of Class II, division 1 patients

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Abstract

Objective: To perform a cephalometric evaluation of dentoalveolar and soft tissue changes in Brazilian youths with Class II, division 1 malocclusion, treated with a mandibular protraction appliance (MPA) combined with fixed corrective orthodontics. **Methods:** The sample consisted of 28 patients (16 females and 12 males) with a mean age of 13.06 years, treated for a mean period of 14.43 months. The changes were measured on 56 specific cephalometric analysis obtained from lateral cephalograms taken before and after treatment by two calibrated examiners in order to identify soft tissue and dentoalveolar changes using linear and angular cephalometric measures. The independent variables sex, age, facial pattern, MPA model, archwire, technique and treatment time were registered and analyzed using linear and angular cephalometric measures. Treatment responses were analyzed and compared by the Wilcoxon Signed Ranks and Mann-Whitney tests at a significance level of 5%. **Results:** The results showed dentoalveolar changes of great magnitude, which caused positive changes in soft tissue. It was also noted that the variables age, MPA model and technique influenced the treatment. **Conclusions:** MPA proved to be an effective alternative in the treatment of Class II, division 1 malocclusion, inducing dentoalveolar and soft tissue changes with satisfactory clinical results.

Keywords: Cephalometry. Mandibular protraction appliance. Class II, Division 1 malocclusion. Dentoalveolar and soft tissue changes.

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INTRODUCTION

Angle Class II, Division 1 malocclusion is highly prevalent among Brazilian children, affecting 55% of patients with malocclusion.[1] It is characterized by lack of sagittal harmony between the basal bones due to maxillary prognathism and mandibular retrognathia, either in isolation or in combination, being the mandibular retrognathism one of the major causes of this malocclusion.[23,26]

In recent decades, many researchers began to develop fixed intraoral orthopedic appliances to correct Class II malocclusion caused by mandibular retrognathism. These devices promote changes in mandibular posture by positioning it forward and generating forces that are delivered to the teeth and basal bone, thereby correcting the problem. One such example is the Herbst appliance.[15-21]

Due to difficulties on importing, a lack of specialized laboratories, high costs and challenging installation procedure regarding most of these appliances, Coelho Filho[3,4] was driven to devise the Mandibular Protraction Appliance 1(MPA 1) as an alternative to the Herbst appliance.[18,19] In his articles on this subject,[3,4] the author mentions as advantages of the MPA over the Herbst appliance its easy confection and installation, as well as its low cost and less bulky design, ensuring greater patient comfort.

MPA 1 was made with 0.032-in (0.9 mm) wire, which received two small loops between the headgear tube and the distal bend of the mandibular canine.

Although effective, it did not allow brackets to be bonded to premolars, mouth opening was limited and it broke frequently, leading the author to develop a second version.[3,4,9] This new version consisted of two 0.032-in archwire segments with loops in the ends and an open coil intending to maintain a proper relationship between the archwire segments, allowing greater mouth opening range and the bonding of brackets to premolars.

Coelho Filho[3] described 4 clinical cases of Class II patients with mandibular retrognathism treated during the growth period with fixed appliance and MPA. Noteworthy among the changes were those of a dentoalveolar nature, such as lingual inclination of maxillary incisors. However, some skeletal changes were also observed such as increases in the length of the mandible and its ascending ramus, resulting in reduced facial convexity, improved soft tissue profile and decreased overjet.

The author went on to develop the MPA 3,[5,6] with quite different characteristics, with the purpose of overcoming some limitations of previous versions.

MPA 3 used 0.9 mm wire rods that ran through telescopic stainless steel tubes. This imparted greater stability to the appliance during mouth opening and closing and was easier to install. However, it required a more careful fabrication procedure and, thereby, more complex.

Between the years 2001 and 2002, Coelho Filho[9,10,11,13] made changes on MPA 3 with a new design for the upper arch intermaxillary telescopic tube fitting, enhancing stability during mouth opening and closing. This new version, named MPA 4,[9,10,11,13] surpassed all previous appliances in terms of breaking strength, ease of installation and fabrication. The author[11,13] pointed out that the current version has shown clinical efficacy and final results similar to those of previous models since the mechanical principles are the same.

Therefore, this study analyzes and determines dentoalveolar and soft tissue changes — using lateral cephalograms of Class II, division 1 patients treated with MPA combined with fixed orthodontic appliance during active growth period — also relating them to the independent variables sex, age, facial pattern, MPA model, archwire, technique and MPA usage time.

METHODS

This is an uncontrolled, non-randomized clinical trial conducted on a sample comprising 56 lateral cephalograms (28 initial and 28 final cephalograms) of 28 Brazilian patients with Angle Class II, Division 1 malocclusion, 12 males and 16 females, mean age of 13.06 years at the beginning of treatment, who were treated for a mean period of 14.43 months with mandibular protraction appliances (MPA) associated with fixed orthodontic appliance. All patients were treated at the private practice of Professor Carlos Martins Coelho Filho in São Luís, Maranhão State, Brazil. The following inclusion criteria were adopted: Angle Class II, Division 1 malocclusion with mandibular retrognathism, as assessed by photographs, study models, in addition to cephalograms that allowed clear visualization of the structures of interest. Sample exclusion criteria were: Patients who had agenesis, extraction or missing permanent teeth, cases of Angle Class II, Division 1 treated only with MPA, patients with pronounced overjet.

A clinical form was used for data collection including seven variables: Patient age, sex, facial pattern (dolichofacial, mesofacial and brachyfacial, although the latter was excluded during sample selection as only one case displayed this facial type, which might lead to statistical results with a higher margin of error), MPA model (types 1, 2, 3 and 4), total time of appliance usage, archwires used during treatment with MPA (0.019 x 0.025-in, 0.021 x 0.025-in and 0.018 x 0.025-in stainless steel wires) as well as the orthodontic technique (standard Edgewise and Straight-Wire).

Research instruments consisted of 56 lateral cephalometric radiographs obtained at two stages: before (T1) and after treatment (T2). All radiographs used in this study were obtained with a Funk Orbital X15 X-ray device, with a magnification factor of 9%, by the same operator.

A sheet of acetate paper was fixed over each radiograph with adhesive tape and the anatomical structures of interest for the construction of the cephalometric analysis were traced. This tracing was performed in a darkened room by two previously calibrated examiners on a viewbox to facilitate the visualization of structures.

Examiners calibration lasted approximately three months, during which 30 randomly selected radiographs were traced and compared until minimum error was attained.

The materials used by examiners to build the cephalometric tracing consisted of a viewbox, sheet of transparent acetate paper (Cephalometric Tracing Paper® - GAC), 0.07 mm thick, size 17.5 x 17.5 cm, Pentel mechanical pencil with 0.3 mm fine point, template (Tracing Template®, Unitek Corp.), millimeter ruler, adhesive tape, soft eraser and black cardboard mask. When double images of the anatomical bony structures were visualized both images were traced and a mean position between them was found for determining the cephalometric points.

In a following stage, the images were imported via a scanner into a microcomputer containing the Radiocef Studio®cephalometry program (No. 020576, version 4.0, release 3 - Belo Horizonte, Brazil), which was used to obtain the values for T1 and T2 as well as their respective repetitions. The results were stored and subsequently subjected to statistical analysis.

Changes in the dental and soft tissue structures were measured by means of the following angular and linear cephalometric measures. Angular: 1.NA (1), 1.NB (2), IMPA (3), ANL (4); Linear: 1-NB (5), 1-FHp (6), 1a-FHp (7), 1-MP (8), 6-MP (9), 6-FHp (10), 6a-FHp (11), LL-Pog'Sn (12), LL-FHp (13), 1-NA (14), 1-FHp (15), 1a-FHp (16), 1-PP (17), 6-PP (18), 6-FHp (19), 6a-FHp (20), UL-Pog'Sn (21), UL-FHp (22).

The measures used to evaluate the dentoalveolar component were: 1.NA (1), 1-NA (14), 1-PP (17), 1-FHp (15), 1a-FHp (16), 6-PP (18), 6-FHp (19), 6a-FHp (20), IMPA (3), 1.NB (2), 1-NB (5), 1-PM (8), 1-FHp (6), 1a-FHp (7),

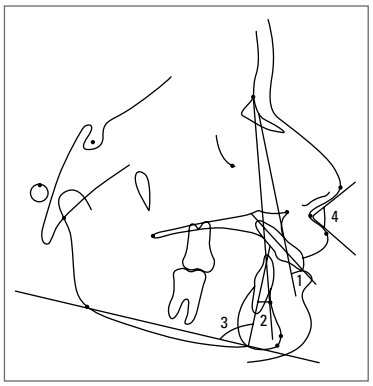

FIGURE 1 - Angular cephalometric measurements.

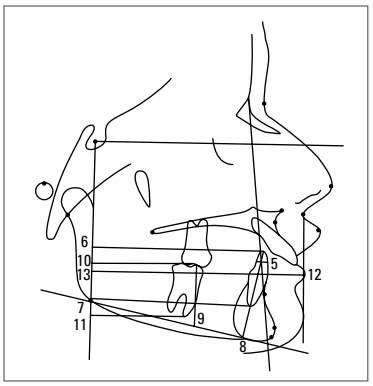

FIGURE 2 - Linear cephalometric measurements. Lower dentoalveolar and soft tissue components.

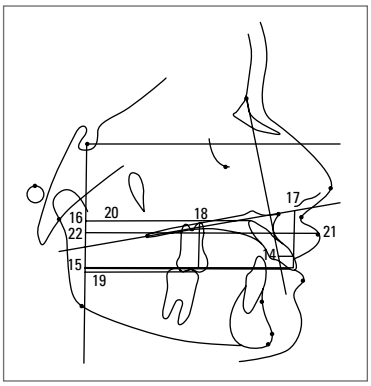

FIGURE 3 - Linear cephalometric measurements. Upper dentoalveolar and soft tissue components.

6-PM (9), 6-FHp (10) and 6a-FHp (11). For the soft tissue profile: ANL (4), UL-Pog'Sn (21), LL-Pog'Sn (12), UL-FHp (22) and LL-FHp (13).

RESULTS

The dentoalveolar and soft tissue changes induced by the combined use of MPA and a fixed orthodontic appliance were evaluated in 28 patients with Class II, Division 1 malocclusion with mean age of 13.06 years, treated for a mean period of 14.43 months (53.6%). These changes were measured in 56 lateral radiographs in two stages: Before (T1) and after treatment (T2).

Regarding the MPA model, the sample initially consisted of four groups of patients that corresponded to the four types of MPA. However, the frequency of the group that used MPA models 1 and 3 was low and statistically discrepant in relation to models 2 and 4. Therefore, the four were gathered into two groups — labeled 0 and 1 respectively — the first resulting from the sum of the number of patients with MPA 1 and 2 (46.4%) and the second, the sum of those using MPA models 3 and 4 (53.6%).

For the variable archwire, the following types were noted: 0.019 x 0.025-in stainless steel (57.1% or 16 patients), 0.021 x 0.025-in stainless steel (10.7% or 3 patients) and 0.018 x 0.025-in stainless steel (32.1% or 9 patients). The two latter were also grouped into a total of 12 cases.

The sample consisted of 57.1% (16 patients) of female subjects and 42.9% (12 patients) male. Only two of the three facial patterns (mesofacial and dolichofacial) were analyzed. The first type accounted for 64.3% (18 patients) of patients and the second, 35.7% (10 patients).

The Straight-Wire technique was used in 42.9% (12 patients) of individuals and standard Edgewise in 57.1% (16 patients). Measures 1-NB, ILi-FHp and 6-PP showed statistically significant differences compared to the group using the Edgewise technique.

Tables 1 and 2 show the initial (T1) and final (T2) dentoalveolar and soft tissue cephalometric measurements of patients of both sexes, their medians, 1st and 3rd quartiles, and statistical significance (p-value), obtained with the Wilcoxon Signed Ranks Test. Results were con-

TABLE 1 - Median, 1st and 3rd quartiles for differences between initial and final dentoalveolar cephalometric measurements and significance value.

Dentoalveolar cephalometric measurements	Median	1st quart.	3rd quart.	p
1.NA initial	29.785	24.615	35.455	0.001*
1.NA final	23.160	12.575	27.275	
1.NB initial	26.895	20.557	31.768	0.024*
1.NB final	29.515	25.102	32.865	
IMPA initial	97.420	91.420	104.312	0.179
IMPA final	99.620	95.095	103.182	
1-NA initial	4.395	3.180	7.695	0.002*
1-NA final	2.880	1.752	5.570	
1-NB initial	3.970	2.685	6.867	0.011*
1-NB final	4.855	3.235	7.545	
1-PP initial	24.290	13.977	30.535	0.007*
1-PP final	26.685	15.052	29.610	
1-PM initial	38.455	22.147	44.777	0.891
1-PM final	36.465	21.502	44.788	
6-PP initial	19.485	11.190	23.192	0.000*
6-PP final	21.065	11.940	24.258	
6-PM initial	26.075	15.780	33.470	0.000*
6-PM final	29.620	17.533	35.330	
IUi-FHp initial	77.060	43.365	86.707	0.151
IUi-FHp final	74.945	41.405	83.895	
ILi-FHp initial	69.510	39.750	78.497	0.017*
ILi-FHp final	72.475	39.877	79.782	
AUi-FHp initial	64.295	37.120	74.945	0.349
AUi-FHp final	65.750	38.297	75.852	
ALi-FHp initial	56.295	32.205	64.512	0.032*
ALi-FHp final	57.925	33.135	66.145	
CMS-FHp initial	39.560	23.907	49.892	0.092
CMS-FHp final	40.520	24.452	48.807	
CMI-FHp initial	38.745	24.167	49.672	0.001*
CMI-FHp final	43.155	26.035	51.212	
AMS-FHp initial	41.190	25.377	52.690	0.509
AMS-FHp final	41.920	26.372	50.265	
AMI-FHp initial	31.560	21.602	41.027	0.000*
AMI-FHp final	37.985	22.485	46.590	

*Significant difference (p<0.05) based on the Wilcoxon test.

TABLE 2 - Median, 1st and 3rd quartiles for differences between initial and final soft tissue cephalometric measurements and significance value.

Soft tissue cephalometric measurements	Median	1st quart.	3rd quart.	p
ANL initial	111.170	103.657	116.367	0.145
ANL final	112.790	106.480	118.387	
UL-Pog'Sn initial	5.030	2.815	7.295	0.001*
UL-Pog'Sn final	3.195	1.945	6.265	
LL-Pog'Sn initial	2.155	1.037	3.445	0.838
LL-Pog'Sn final	1.795	1.032	3.435	
Pog'-FHp initial	76.170	44.387	87.030	0.010*
Pog'-FHp final	79.970	45.685	89.912	
UL-FHp initial	88.905	50.940	101.325	0.48
UL-FHp final	91.690	50.435	101.605	
LL-FHp initial	69.510	39.750	78.490	0.016*
LL-FHp final	87.190	48.200	95.390	

*Significant difference (p<0.05) based on the Wilcoxon test.

sidered significant at 5% significance (p<0.05), indicating at least 95% confidence in the conclusions. In Tables 1 and 2 are shown the following statistically significant dentoalveolar and soft tissue cephalometric measures: 1.NA, 1.NB, 1-NA, 1-NB, 1-PP, 6-PP, 6-PM, ILi-FHp, ALi-FHp, CMI-FHp, AMI-FHp (Table 1), UL-Pog´Sn, Pog´-FHp and LL-FHp (Table 2).

Table 3 shows that sex was the only variable with a statistically significant influence on cephalometric measures 6-PM and AMI-FHp before treatment.

Tables 4 and 5 depict the values of significant difference between the cephalometric measurements at T1 and T2. These results show statistically significant labial inclination of lower incisors related to the independent variable age. The independent variable MPA model showed a statistically significant relationship with a

TABLE 3 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variable sex at T1.

Independent variable		Initial 6-PM				Initial AMI-FHp			
Sex	n	median	1st quart.	3rd quart.	p	median	1st quart.	3rd quart.	p
Female	16	16.325	11.252	30.937	0.016*	22.295	12.995	38.367	0.014*
Male	12	29.760	26.590	34.347		38.230	32.315	44.500	

*Significant difference (p<0.05) based on the Mann-Whitney test.

TABLE 4 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variables.

Difference between the cephalometric measurements (T1 - T2)		1-NB dif.				1.NB dif.				1-PP dif.				6-PP dif.			
		M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p
Sex	**n**																
Female	16	-4.355	-7.910	2.722	0.227	-0.365	-0.710	0.202	0.889	-0.910	-1.507	-0.295	0.676	-1.025	-1.680	-0.327	0.164
Male	12	-3.265	-8.837	1.442		-1.065	-1.812	0.272		-0.740	-2.290	1.045		-2.240	-3.882	-0.490	
Age	**n**																
≤13.06 years	13	-6.310	-11.03	-1.515	0.205	-0.620	-1.340	-0105	0.032*	-1.010	-2.895	-0.250	0.300	-1.010	-2.895	-0.250	0.205
>13.06 years	15	-1.360	-5.110	3.200		-0.350	-1.030	0.360		-0.650	-1.530	-0.100		-0.650	-1.530	-0.100	
Facial pattern	**n**																
Dolichofacial	10	-2.915	-8.412	-0.982	0.270	-0.810	-1.742	0.020	1.000	-1.080	-3.057	-0.292	0.195	-1.530	-3.992	-0.722	0.375
Mesofacial	18	-4.470	-8.095	2.360		-0.435	-1.137	0.372		-0.665	-1.542	0.195		-1.140	-2.420	-0.125	
MPA model	**n**																
1+2	13	-4.450	-8.755	1.260	0.147	-0.740	-1.305	0.125	0.596	-1.290	-3.330	-0.510	0.025*	-1.880	-4.100	-1.105	0.020*
3+4	15	-3.210	-7.670	3.200		-0.350	-1.250	0.360		-0.610	-0.970	0.940		-0.860	-2.600	-0.200	
Archwire	**n**																
0.019 x 0.025-in	16	-4.780	-7.910	1.442	0.642	-0.540	-1.232	-0.027	0.516	-0.630	-3.277	-0.680	0.353	-0.945	-4.040	-0.055	0.577
0.018 x 0.025-in + 0.021 x 0.025-in	12	-2.340	-8.310	2.722		-0.305	-1.330	0.387		-1.090	-1.587	-0.380		-1.090	-1.587	-0.380	
Technique	**n**																
Straight-Wire	12	-1.490	-6.320	6.075	0.013*	0.300	-0.680	0.730	0.137	-0.465	-1.020	0.160	0.137	-0.860	-1.782	0.027	0.047*
Edgewise	16	-4.565	-9.560	1.487		-0.830	-1557	-0.192		-1.090	-1.950	-0.292		-1.765	-4.075	-0.860	
Usage time	**n**																
≤ mean 14.43 (months)	13	-2.510	-6.990	5.495	0.222	-0.380	-1.065	0.300	0.222	-0.850	-4.070	0.420	0.872	-1.180	-3.285	-0.045	0.908
> mean 14.43 (months)	15	-4.680	-9.520	1.290		-4.680	-9.520	1.290		-0.870	-1.290	-0.340		-1.190	-3.710	-0.380	

*Significant difference (p<0.05).

TABLE 5 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variables.

Difference between the cephalometric measurements (T1 - T2)		6-PM dif.				AMI-FHp dif.				ILi-FHp dif.			
		M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p
Sex	**n**												
Female	16	-1.320	-2.307	-0.465	0.016*	-2.345	-4.067	0.737	0.009*	-0.785	-3.475	1.067	0.095
Male	12	-2.895	-3.640	-1.672		-8.080	-11.150	-4.467		-6.970	-8.237	0.792	
Age	**n**												
≤13.06 years	13	-1.430	-2.450	-0.685	0.222	-3.490	-8.080	-1.180	0.836	-3.220	-8.125	-0.235	0.322
>13.06 years	15	-2.590	-3.490	-1.050		-4.420	-9.660	0.400		-0.880	-6.530	1.350	
Facial pattern	**n**												
Dolichofacial	10	-2.710	-3.540	-1.410	0.080	-4.640	-10.075	-1.902	0.231	-4.730	-7.697	-0.797	0.150
Mesofacial	18	-1.515	-2.537	-0.515		-3.110	-7.357	1.117		-0.570	-6.750	1.390	
MPA model	**n**												
1+2	13	-1.440	-2.880	-0.685	0.645	-4.260	-10.490	-1.515	0.322	-3.560	-7.690	-0.715	0.093
3+4	15	-2.430	-3.230	-1.050		-2.730	-6.890	0.400		0.170	-6.530	1.450	
Archwire	**n**												
0.019 x 0.025-in	16	-2.450	-3.137	-0.457	0.501	-3.935	-8.420	0.087	0.853	-2.820	-7.777	1.142	0.577
0.018 x 0.025-in + 0.021 x 0.025-in	12	-1.435	-2.682	-0.885		-3.875	-8.397	-1.760		-1.090	-1.587	-0.380	
Technique	**n**												
Straight-Wire	12	-2.185	-3.345	-0.625	0.848	-3.000	-4.890	1.152	0.213	0.345	-2.190	1.750	0.013*
Edgewise	16	-1.610	-2.877	-0.922		-4.435	-10.075	-1.345		-4.470	-8.012	-0.797	
Usage time	**n**												
≤ mean 14.43 (months)	13	-2.590	-3.460	-0.725	0.240	-4.610	-9.700	-0.335	0.596	-1.560	-6.705	2.050	0.504
> mean 14.43 (months)	15	-1.430	-2.470	-0.830		-2.730	-7.400	-0.850		-1.220	-7.480	0.170	

*Significant difference (p<0.05).

greater extrusion of incisors and molars found in the group using the MPA 1+2. The group using the Edgewise technique showed statistically significant measurements in relation to the labial inclination of lower incisors and increased extrusion of maxillary molars.

DISCUSSION

The use of MPA in Angle Class II treatment is aimed at correcting the sagittal relationship between the maxilla and the mandible, mainly through dentoalveolar changes.[3-13] In order to evaluate the influence of the independent

variables sex, age, facial pattern, MPA model, archwire, technique and MPA treatment time in the sample described before, the means of cephalometric differences between T1 and T2 were compared and yielded statistically significant results.

The results displayed in these tables show that, for the variable sex, measures 6-PM and AMI-FHp were significant, and higher for females than males. Based on the results of the significance test (p-value), that show which independent variables affected treatment (Table 5), cephalometric measures 6-PM and AMI-FHp were statistically significant at the beginning of treatment, with measurements equal to the medians, which shows that the variable sex did not influence treatment outcome, since measurements were already significant prior to treatment.

The only measure that showed a statistically significant median value with respect to the variable age was 1.NB. The mean found for patients aged below 13.06 years was associated with greater mandibular incisor inclination. This result is probably related to a failure in banding the lower second molars, which reduced anchorage. Moreover, another factor that probably contributed to a smaller inclination of the lower incisors in the group older than 13.06 years was that in this group there was a more pronounced mandibular growth component, thereby moving point B to a more anterior position by correcting the skeletal discrepancy and consequently causing less dental compensation (mandibular incisor inclination).

Regarding variable MPA model, Group 1 (MPA 3+4) showed statistically significant means between T1 and T2 for measures 1-PP and 6-PP. These results were probably due to the aligning and leveling extrusive mechanics applied prior to MPA use and growth. Group 1 (MPA 3+4) showed lower extrusion of incisors and molars relative to the palatal plane, probably due to increased uprighting of the incisors and limited extrusion of upper molars related to a lower breakage rate in this group.

Measures 1-NB, ILi-FHp and 6-PP showed statistically significant differences in relation to Group 1 (Edgewise technique) for the independent variable technique. This result probably occurred because the group did not use pre-adjusted brackets, resulting in greater inclination of mandibular incisors and consequent lower lip protrusion. In Group 2 (Straight-Wire technique), there was significantly less extrusion of upper molars, probably due to palatal torque of molar crowns, which positioned the roots of these teeth on the buccal cortex, thereby strengthening anchorage.[22,25] The other independent variables (facial pattern, archwire and MPA use time) showed no statistically significant differences.

In order to facilitate the interpretation of results a separate discussion was conducted on the changes that took place in the maxillary dentoalveolar component, mandibular dentoalveolar component and soft tissue component.

Maxillary dentoalveolar component

The MPA forces used in this investigation were delivered by means of dental structures and, thus, significant dentoalveolar effects were expected. The maxillary alveolar component (Table 1) was assessed by means of measures 1.NA, 1-NA, IUi-FHp, AUi-FHp, 6-PP, CMS-FHp, 1-PP, AMS-FHp. Assessment of the position and inclination of upper incisors (1.NA, 1-NA, IUi-FHp) showed a marked lingual inclination that was statistically significant for measures 1.NA and 1-NA, and with no statistical significance for measures IUi-FHp and AUi-FHp, corroborating Coelho Filho,[3-13] Siqueira[24] and White.[27] The results showed a slight distal movement of upper molars, demonstrated by measures CMS-FHp and AMS-FHp, although not statistically significant. Assessment of measures 6-PP and 1-PP denoted statistically significant extrusion of the upper molars and incisors.

These results were probably due to alveolar bone growth[2,14] and the extrusive aligning and leveling mechanics utilized prior to MPA use. MPA use is probably not related to the extrusion of molars and incisors, since according to Coelho Filho,[13] MPA generates intrusive and distal forces and is therefore indicated for use in Class II patients with a high mandibular plane angle.

Mandibular dentoalveolar component

It was assessed trough measures 1.NB, 1-NB, IMPA, ILi-FHp, 1-PM, ALi-FHp, 6-PM, CMI-FHp and AMI-FHp (Table 1). However, most measures that evaluated lower incisor position (1.NB, 1-NB, ILi-FHp, ALi-FHp) demonstrated significant proclination and protrusion of these teeth, with the exception of IMPA which, although increased, was not statistically significant. This result was probably due to the occurrence of bone apposition in the mandibular plane during treatment.[2,14] The measures related to the assessment of lower molar positioning (CMI-FHp, AMI-FHp, 6-PM) exhibited significant mesial movement and extrusion of these teeth. In agreement with these results, Siqueira[24] hinted that these effects probably occur due to the direction of forces delivered by the device owing to a limited vertical development of upper molars. It is also believed that the mechanical alignment and leveling occurring prior to MPA use contributes to the extrusion of lower molars. Assessment of the degree of lower incisor intrusion, as revealed by measure 1-PM, showed little intrusion of these teeth, although not statistically significant. This decreased value may be due to lower incisor protrusion, which reduces the distance from their incisal edge to the mandibular plane.

Soft tissue component

This component was analyzed by means of cephalometric measures ANL, UL-Pog´Sn, LL-Pog´Sn, Pog´-FHp, UL-FHp, LL-FHp (Table 2). In assessing the upper lip, however, two measures (UL-Pog´Sn and UL-FHp) disclosed that the upper lip was retracted, following the retrusion and lingual inclination of the upper incisors, while only UL-Pog'Sn exhibited a statistically significant difference. This fact is probably related to bone apposition in the pogonion[2,14] and the more anterior position of the mandible at the end of treatment. According to Coelho Filho[3-13] and White[27], the dentoskeletal changes induced by MPA use caused favorable changes in soft tissue, such as upper lip retraction, which improves the soft tissue profile. The lower lip was examined by cephalometric measures LL-Pog´Sn, LL-FHp and Pog´-FHp by comparing T1 with T2. Measures LL-Pog´Sn and LL-FHp showed protrusion of the lower lip due to a marked proclination and protrusion of the mandibular incisors at the end of orthodontic treatment, although only measures LL-FHp and Pog'-FHp were statistically significant. It is worth noting that measure Pog'-FHP is related to bone apposition of the pogonion[2,14] and a more anterior position of the mandible at the end of treatment.

These findings, however, cannot be considered fully conclusive due to some limitations in this study, among which are a small sample size, absence of a control group and the fact that patients were not randomly assigned. Thus, further studies with larger samples are warranted in order to assess the influence of independent variables and compare results with the control group.

CONCLUSIONS

Based on the methods employed and results achieved in this study, the authors concluded that treatment with MPA combined with a fixed orthodontic appliance for correction of Class II, Division 1 malocclusion produces considerable dentoalveolar changes, which can be summarized as follows:

1. Maxillary dentoalveolar component: There was retrusion and substantial lingual inclination of the upper incisors.

2. Mandibular dentoalveolar component: There was protrusion and proclination of the lower incisors, in addition to mesial drift and extrusion of the lower molars.
3. Soft tissue component: The dentoalveolar changes exerted a positive, significant influence on the soft tissue profile of the patients.
4. Age: A greater lower incisor inclination was noted in the group of patients younger than 13.06 years.
5. MPA model: Less extrusion was observed in the upper incisors and molars in the group that used MPA 3 and 4 due to the greater effectiveness of these appliances.
6. Technique: A higher labial inclination of lower incisors and greater extrusion of upper molars were noted in the group using standard Edgewise brackets.

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Shear bond strength of Concise and Transbond XT composites with and without bonding agent

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Abstract

Objectives: The aim of this study was to evaluate the shear bond strength of brackets and the adhesive remnant index (ARI) of Concise and Transbond XT composites with and without the use of a bonding agent. **Methods:** The sample consisted of 60 bovine incisors divided into four groups (n=15). All teeth were subjected to prophylaxis with pumice and enamel etching with phosphoric acid at 37%. In Groups 1 and 2 brackets were bonded with Concise composite with and without application of enamel bond resin, respectively. In Groups 3 and 4, Transbond XT was used with and without XT Primer application, respectively. In these latter groups bonding was light cured for 40 seconds. Specimen shear strength testing was performed on an Instron machine at 0.5 mm/min, and ARI was subsequently evaluated. **Results:** Shear bond strength in Group 4 was statistically higher than in Groups 1 and 2 ($p<0.05$) but not when compared to Group 3 ($p>0.05$). There were no statistically significant differences between Groups 1, 2 and 3 ($p>0.05$). ARI in Group 3 was statistically higher than in Group 2 ($p<0.05$), but not statistically different from Groups 1 and 4 ($p>0.05$). There were no statistically significant differences between Groups 1, 2 and 4 ($p>0.05$). **Conclusion:** The composites Concise and Transbond XT showed adequate bond strength with or without the use of their respective bonding agents.

Keywords: Shear strength. Dental bonding. Orthodontics.

INTRODUCTION

Initially, to perform orthodontic treatment accessories were welded to bands, which were in turn cemented to all teeth. The process required prior teeth separation. This kind of fixed orthodontic appliance jeopardized the esthetic of the patient, caused infiltrations and gum diseases. It was extremely traumatic and time consuming.[1,2] Thanks to the acid etching development,[6] orthodontics has evolved from bands to the direct bonding of brackets to tooth enamel.

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When originally proposed, direct bonding technique used epoxy resin, which had many clinical, physical and chemical limitations.[18] Over time, a wide range of composites were developed and each new launch brought with it increasingly effective features.[19]

Self-curing resins were for a long time the only option for restorative dental procedures and for bonding orthodontic accessories to enamel.[15,18] This kind of material boasts great clinical efficiency but its short handling time hinders the procedure, requiring the orthodontist to have a certain amount of skill.[14,20,23]

In the late 70s, a new kind of composite was marketed whose composition comprised a substance called camphorquinone, which when exposed to light interacts with an activating agent (tertiary amine) to form free radicals which, in turn, convert the resin monomers into polymers, thereby hardening the material. These materials were called light-curing composites.[25,27]

Several experiments involving bonding of orthodontic accessories were performed to compare self-curing and light-curing materials, especially Concise and Transbond XT (3M) composites, respectively. Most experiments found similarity between the bonding strength of these composites, making it evident that both exhibit adequate adhesion to dental enamel.[5,7,8,17,23,28]

Concise and Transbond XT, when used accordingly to the manufacturer's recommendations, require the use of their own bonding agents, i.e., enamel bond resins A and B, and XT Primer, respectively. Bonding agents moisten and penetrate the enamel, promoting composite adhesion.[21] Furthermore, they protect the tooth surface that was etched but not covered against decalcification by plaque and food debris around the bracket.[16] Some authors,[12,16] however, found no difference in bonding orthodontic attachments to enamel with or without the use of a bonding agent prior to bonding. Despite some advantages, if this step in composite bonding procedure could be avoided, patient chair time would certainly diminish, facilitating the maintenance of a dry working field and preventing bond failures by contamination or moisture.

The purpose of this study was to investigate whether the use of Concise and Transbond XT bonding agents interferes with the shear bond strength of brackets bonded with these materials, while also evaluating Adhesive Remnant Index (ARI) after debonding.

MATERIAL AND METHODS

A total of 60 bovine permanent mandibular incisors were properly cleaned, placed in a solution of 10% formaldehyde and stored in a refrigerator at 6 °C. Their roots were centrally inserted in PVC tubes containing self-curing acrylic resin (Dental-Vipi, Pirassununga, Brazil) with the buccal surface of each tooth positioned perpendicularly to the base of the die. Resin excess was removed with a Lecron spatula (SS White, Rio de Janeiro, Brazil). To verify the correct positioning of each tooth, a glass positioner at an angle of 90 degrees — fabricated exclusively for this purpose — was made to rest on the buccal surface of the tooth and on top of the die.

After the teeth had been positioned, the specimens were stored in distilled water in the refrigerator until the bonding date. Prior to bonding, all buccal surfaces were subjected to prophylaxis, non-fluoridated pumice and water for 10 seconds, then washed and dried for the same time. Phosphoric acid at 37% was applied for 15 seconds to etch the enamel of all teeth, which were then washed with an air/water spray and dried for the same time.

The specimens were randomly divided into four groups (n=15), as described in Table 1.

Morelli brackets (Sorocaba, Brazil) with a base area of 14.44 mm^2 were positioned at the center of the buccal surface, pressed against it, and all composite excess was removed. These brackets were selected because the anatomy of bovine incisors resembles that of human maxillary central incisors. In Groups 3 and 4, bonding was light-cured for 40 seconds, i.e., 10 seconds on each side (mesial, distal, incisal and gingival), using curing light XL

1500 (3M ESPE, Monrovia, USA) as close as possible to the bracket base. After bonding, the specimens were once again stored in distilled water and kept in the oven at a temperature of 37 °C for 24 hours to simulate oral temperature.

After this period, shear bond strength tests were performed on the brackets using an Instron machine (Model 44.11, Canton, USA) at a speed of 0.5 mm/min with a chisel-shaped tip. Results were obtained in Kgf, converted into N and divided by the bracket base area for conversion into MegaPascal (MPa).

After debonding, each enamel surface was evaluated in a stereomicroscope (Carl Zeiss, Göttingen, Germany) with 8x magnification and rated according to the ARI scores proposed by Artun & Bergland[3], as follows:

0 = No composite remaining on the enamel.
1 = Less than half the composite remaining on the enamel.
2 = More than half the composite remaining on the enamel.
3 = All composite remaining on the enamel.

Statistical analysis

To compare shear bond strength, Analysis of Variance (ANOVA) and Tukey's test were applied with a significance level of 5%. To compare the Adhesive Remnant Index (ARI) results the Kruskal-Wallis test was employed.

RESULTS

The mean shear bond strength values and ARI results are statistically compared in Table 2.

Shear strength in Group 4 was statistically higher than in Groups 1 and 2 ($p<0.05$) but not when compared to Group 3 ($p>0.05$). There were no significant differences between Groups 1, 2 and 3 ($p>0.05$). No statistically significant differences were found between Groups 1, 2 and 3 ($p>0.05$).

Regarding the ARI results, for Group 3 it revealed to be statistically higher than for Group 2 ($p<0.05$) but showed no statistically significant differences compared to Groups 1 and 4 ($p>0.05$). No statistically significant differences were found between Groups 1, 2 and 4 ($p> 0.05$).

TABLE 1 - Groups assessed in the experiment.

Groups	Composites	Procedures*
1	Conventional Concise	Applying enamel bond resin, placing composite on bracket base and bonding
2	Concise without enamel bond resin	Applying composite to bracket base and bonding
3	Conventional Transbond XT	Applying XT primer, placing composite on bracket base and bonding
4	Transbond XT without XT primer	Applying composite to bracket base and bonding

* Procedures were performed after prophylaxis and acid etching of enamel.

TABLE 2 - Mean shear strength values (MPa), ARI median and statistical analysis between groups.

	Shear strength (MPa)		ARI	
Groups	Mean (standard deviation)	Tukey (5%)*	Median	Kruskal-Wallis
1	14.00 (1.99)	b	28.56	ab
2	14.46 (1.17)	b	24.10	b
3	19.12 (1.27)	ab	42.23	a
4	20.46 (1.4)	a	27.10	ab

Identical letters stand for no statistically significant differences (p>0,05). * Test power: $\alpha = 0.728$.

DISCUSSION

To be employed for bracket bonding a material needs to provide adhesion to the tooth surface sufficient to withstand masticatory and orthodontic forces consistently applied. According to Reynolds[22], to be suitable, such material should deliver shear strength between 5.9 and 7.8 MPa in laboratory experiments. This study found results ranging from 14 to 20.46 MPa. These values are higher than those recommended by the referred author, indicating that the tested materials and their variations can be clinically applied.

Groups 1 (conventional Concise) and 3 (conventional Transbond XT) displayed similar bond strength values with no statistically significant differences. These results partly agree with the literature[4,10] but disagree with other authors who found Transbond XT[5,8,17,28] to have higher bond strength. Conversely, other studies have found greater bond strength with Concise.[1,7,13]

Given these results and those of other experiments, it can be concluded that both materials are suitable for orthodontic bonding, considering methodological variations between experiments. One mentioned advantage of bonding with Transbond XT is greater control of working time by orthodontists, which facilitates the proper placement of brackets on the teeth.[11] On the other hand, bonding with Concise is advantageous because its polymerization process is not affected by external factors that might get in the way of the proper reaction between Concise orthodontic paste A and paste B.[15,26]

The use of a bonding agent prior to bonding with composite has the advantage of immediate obliteration of enamel pores — caused by acid etching — that are not covered by the bracket base, thereby, preventing decalcification.[16,21] Non-use of a bonding agent, however, could simplify clinical procedures and reduce chair time.[24] In Groups 2 and 4 of this study Concise and Transbond XT were utilized without their respective bonding agents. Group 4 was statistically superior to Group 2, showing greater bond strength when Transbond XT was used without XT primer than Concise without enamel bond resin. This result can only be explained by the difference in composition between the materials, although the same was not observed when the composites were used conventionally.

When each materials was compared individually, i.e., conventional Concise vs. Concise without resin, and Transbond XT vs. Transbond XT without XT Primer, no significant differences were found, which leads to the conclusion that the absence of a bonding agent did not compromise bond strength. These findings are consistent with the work of Jassem et al,[12] Farquhar[9] and Rose et al,[24] but disagree with Menezes[14], who showed that using a bonding agent creates large tags in the enamel, which despite providing higher shear strength may involve greater risk of cohesive fractures in the enamel during the debonding procedure.

In laboratory experiments involving the bonding of accessories to enamel differences or similarities in shear bond strength values are not usually accompanied by ARI results.[20,23] This study corroborated this fact. Statistical differences found in shear bond strength tests did not match the ones found in ARI analysis (Table 2). It is important to assess ARI after the debracketing procedure to check the amount of composite that remained adhered to the enamel. Ideally, all material used in the bonding procedure should remain adhered to the tooth surface (score 3)[3]. In the Groups that took part in this experiment most of the fractures occurred at the bracket/composite interface, leaving some composite on enamel, with the prevalence of score 3. These findings are commonly seen in studies that used composites to bond orthodontic accessories.[2,14,20]

CONCLUSIONS

1. Concise and Transbond XT composites exhibited adequate bond strength with or without the use of their respective bonding agents.
2. Absence of bonding agent had no impact on bond strength of Concise or Transbond XT to enamel.
3. ARI assessment revealed that most of the fractures occurred at the bracket/composite interface with some material remaining adhered to the enamel after debonding.

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Bolton analysis: An alternative proposal for simplification of its use

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Abstract

Introduction: Mesiodistal size discrepancies of upper and lower teeth and their effect on occlusion have been related. Bolton's method for tooth size discrepancies is, undeniably, one of the most commonly-used methods in orthodontics because of its simplicity. However, the application of this method requires mathematical calculations and use of tables, which often prevents its clinical use. **Purpose:** Evaluate an alternative method for Bolton's analysis proposed by Wolford that does not require table information. **Material and Methods:** The sample was composed of 90 initial dental casts of adult patients, with different malocclusions. The ratio between the sum of widths of maxillary and mandibular teeth was calculated for each patient, resulting in the attainment of two indices: The overall ratio and the anterior ratio. Indices were calculated by Bolton's method and by an alternative method, using two different formulas (one simplified and a variation of the same formula) that were separately analyzed. **Results:** In comparison with Bolton's method, the Simplified Formulas demonstrated a slight trend towards an overestimation of the inferior dental discrepancies (overall and anterior). **Conclusion:** Both formulas employed for the alternative method may be used to substitute the traditional method, since each demonstrated, on average, differences of less than 0.58 mm when compared with Bolton's method and no clinical significance.

Keywords: Bolton's analysis. Tooth size discrepancy. Diagnosis. Orthodontic treatment planning.

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INTRODUCTION

Normal occlusion exists when the 28 teeth are well arranged on the upper and lower arches and are in harmony with all the static and dynamic forces that act upon them, i.e. normal occlusion is stable, healthy and esthetically attractive.[19] However, many factors influence the correct interarch relationship, including tooth size proportionality.

The method created by Bolton[4] for the diagnosis of tooth size discrepancy is one of the most commonly used in orthodontics. Similar to previous studies,[2,13] Bolton proposed a tooth size analysis that indicates ideal proportions between the upper and lower teeth to achieve adequate occlusion. According to Bolton,[5] this proportionality is provided by the sum of the mesiodistal diameter of the lower teeth in relation to the upper ones. However, extrinsic factors such as sexual dimorphism,[1,14] racial and ethnic variations,[3,10,18] type of malocclusion,[6,7,12,14,15] inclination of anterior teeth,[8,9] incisor edge thickness,[8,9] and the smile arc[8,9] can affect this proportionality, usually requiring adjustments in the anterior ratio, as described by Bolton. In other words, a high or low Bolton ratio does not necessarily reflect the real discrepancy, and this ideal index does not guarantee an ideal occlusion.

Orthodontists should pay special attention to the presence of tooth size discrepancy because about 60% of orthodontic patients present an anterior Bolton discrepancy.[6,11] Failure to identify this disparity during diagnosis and treatment planning can invariably create difficulties for finishing such cases, especially in regard to the ideal relationship of molars and canines, while respecting the ideal overjet and overbite[15].

It is, therefore, important that the evaluation of tooth size discrepancy be applied to all orthodontic cases. Although Bolton's analysis is well-known and relatively simple to apply, many professionals do not use this methodology during clinical evaluation, since the method requires calculations and the use of tables that are not always available at the time of patient care. According to Sheridan,[17] only 47% of interviewed orthodontists often use this index.

Taken all together, the application of an alternative method is proposed for analysis of tooth size discrepancy without using tables.

MATERIALS AND METHODS

This study included data from a retrospective study[15] that used the Bolton's method to determine the overall and the anterior tooth size discrepancy. Ninety initial dental casts of Brazilian adult patients (both sexes) with different malocclusions were obtained from the Center for Research and Treatment of Orofacial Deformities (CEDEFACE, Araraquara – Brazil) and private clinics.

In this study, the reference values for the mesiodistal width of twelve maxillary and mandibular teeth (first molar to first molar) were used to calculate the tooth size discrepancy using two different methods: The method originally proposed by Bolton[4] and an alternative method proposed by Wolford,[20] consisting of two formulas that were analyzed separately.

The ratio between the sum of upper and lower teeth was calculated for each patient, resulting in the identification of two indices: The overall ratio, which compares the sum of the mesiodistal width of the twelve lower teeth with the twelve upper teeth (from the right first permanent molar to the left first permanent molar); and the anterior ratio, which compares the sum of the mesiodistal width of the mandibular anterior teeth with the upper anterior teeth.

According to Bolton[4], the overall ratio is calculated by the following formula:

$$\frac{\text{Sum of 12 lower teeth}}{\text{Sum of 12 upper teeth}} \times 100 = \text{Overall Ratio}$$

Meanwhile, the anterior ratio is calculated by:

$$\frac{\text{Sum of 6 lower teeth}}{\text{Sum of 6 upper teeth}} \times 100 = \text{Anterior Ratio}$$

To calculate the excess amount of dental material, Bolton proposed the use of a table that displays, for each sum of maxillary teeth (overall or anterior), a corresponding value for the mandibular arch. Based on these values, the excess amount existing in the upper or lower jaw could be calculated according to the overall ratio and the anterior ratio values.

After obtaining the discrepancy indices based on Bolton's original formula, we applied the alternative method for each sample case in order to evaluate which simplified formula (1 or 2) would achieve values that are closer to those obtained by the traditional method. The first formula, denominated "Simplified Formula 1", is a variation of the Bolton's original formula and maintains only one decimal place after the comma. This variation was obtained by applying the rule of three to the equation of the Bolton's total overall ratio, as indicated below:

$$\frac{\text{Sum of 12 inferior } (Mand_{12})}{\text{Sum of 12 superior } (Max_{12})} \times 100 = 91.3$$

$$Max_{12} = \frac{Mand_{12} \times 100}{91.3} \Rightarrow Max_{12} = Mand_{12} \times 1.0953$$

That is to say:

$$\text{Overall Discrepancy} = Max_{12} - (Mand_{12} \times 1.1)$$

If there is a positive value, it is indicative of a maxillary dental excess, while negative values indicate mandibular dental excess.

Likewise, the equation for calculating the anterior dental discrepancy can be simplified by applying the rule of three to the Bolton's anterior ratio:

$$\frac{\text{Sum of 6 inferior } (Mand_6)}{\text{Sum of 6 superior } (Max_6)} \times 100 = 77.2$$

$$Max_6 = \frac{Mand_6 \times 100}{77.2} \Rightarrow Max_6 = Mand_6 \times 1.2953$$

Therefore:

$$\text{Anterior Discrepancy} = Max_6 - (Mand_6 \times 1.3)$$

The other formula of the alternative method, called the "Simplified Formula 2", is similar to the Simplified Formula 1, but it uses two decimal places after the comma.

Therefore, the Simplified Formula 2 for the total ratio can be described as:

$$\text{Overall Discrepancy} = Max_{12} - (Mand_{12} \times 1.09)$$

As for the anterior ratio:

$$\text{Anterior Discrepancy} = Max_6 - (Mand_6 \times 1.29)$$

As indicated by Simplified Formula 1, positive values indicate maxillary dental excess, while negative values demonstrate mandibular dental excess.

Descriptive statistics were performed to calculate the mean, standard deviation, standard error, the minimum and maximum values and coefficient of variation of the anterior and overall ratio of all the patients, according to the Bolton and alternative methods (Formula 1 and Formula 2). Subsequently, a statistical test for linear regression was used to compare the values of the overall ratio and the two discussed methods.

RESULTS

Statistical analyses showed a high significance ($p<0.001$) when comparing the two different

TABLE 1 - Estimation, standard errors for β_0 and β_1 coefficients; t_0, f_o, r^2 and p values for the comparative linear regression model between total reason (12) of Bolton's Formula and Simplified Formulas 1 and 2.

Comparison	Rate	Standard error	t_0	p <	F_o	p <	r^2
Simplified F1 (12)	β_0 = 0.456	0.009	52.093 s	0.0001	114899.37 s	0.0001	0.999
	β_1 = 0.935	0.003	-21.666 s	0.0001			
Simplified F2 (12)	β_0 = -0.363	0.008	-45.371 s	0.0001	102985.54 s	0.0001	0.999
	β_1 = 0.941	0.003	-19.666 s	0.0001			

s = significant value; n = non-significant value.

TABLE 2 - Estimation, standard errors for β_0 and β_1 coefficients; t_0, f_o, r^2 and p values for the comparative linear regression model between anterior reason (6) of Bolton's Formula and Simplified Formulas 1 and 2.

Comparison	Rate	standard error	t_0	p <	F_o	p <	r^2
Simplified F1 (6)	β_0 = 0.250	0.012	20.695 s	0.0001	15319.87 s	0.0001	0.994
	β_1 = 0.833	0.007	-23.857 s	0.0001			
Simplified F2 (6)	β_0 = -0.059	0.011	-5.5376 s	0.0001	15683.58 s	0.0001	0.994
	β_1 = 0.834	0.007	-23.714 s	0.0001			

s = significant value; n = not significant value.

TABLE 3 - Descriptive statistics of overall and anterior dental discrepancies of Simplified Formulas 1 and 2, Bolton's formula, and the differences between them.

	Descriptive Statistical Analysis			
	Mean	s.d.	Minimum	Maximum
Formula 1 (12)	-1.89	2.56	-9.28	4.77
Formula 2 (12)	-1.01	2.55	-8.36	5.60
Bolton´s F (12)	-1.31	2.40	-8.07	5.16
Overall ratio (12)	0.927	0.025	0.864	1.001
Formula 1- Bolton´s F (12)	-0.58	0.18	-1.20	-0.37
Formula 2 - Bolton´s F (12)	0.30	0.17	-0.29	0.50
Formula 1 (6)	-1.08	1.44	-4.56	2.79
Formula 2 (6)	-0.71	1.44	-4.16	3.19
Bolton´s F (6)	-0.65	1.20	-3.38	2.97
Anterior ratio (6)	0.787	0.024	0.730	0.844
Formula 1- Bolton´s F (6)	-0.43	0.26	-1.18	-0.15
Formula 2- Bolton´s F (6)	-0.06	0.25	-0.76	0.22

methods, as well as for the correlation coefficient for the overall ratio (r^2 = 0.999) and anterior ratio (r^2 = 0.994), as shown in Tables 1 and 2.

According to the descriptive statistical analysis (Table 3), the reason for the overall ratio difference between the mean of the total Simplified Formula 1 and Bolton's Formula was -0.58 ± 0.18 mm (ranging from -1.20 mm to -0.37 mm). These values were even lower when the Simplified Formula 2 and the Bolton's Formula were compared. The average difference between the results of these two methods was 0.30 ± 0.17 mm (ranging from -0.29 mm to 0.50 mm), indicating a greater equivalence between the two formulas.

Regarding to the anterior ratio, the results showed smaller differences (<0.5 mm) than those obtained for the overall ratio when comparing the two methods. The following values were obtained for the difference between Formula 1 and Bolton's Formula: Average of -0.46±0.26 mm (ranging from -1.18 mm to -0.15 mm). When comparing to the Simplified Formula 2, smaller differences for all comparisons were found (mean -0.06±0.25 mm, ranging from -0.79 mm to 0,22 mm), demonstrating similarity between the values obtained by the two formulas (Formula 2 and Bolton's Formula).

Figures 1 and 2 show the sample distribution for the overall ratio, based on the differences

between the values of both methods. Figure 1 demonstrates the difference between Formula 1 and Bolton's Formula that always resulted in negative values, and in 95% of cases this difference was lower than 1.0 mm.

In Figure 2 (Formula 2 – Bolton's Formula), there is a more homogeneous distribution between positive and negative values for the difference, although there is a tendency towards values greater than zero.

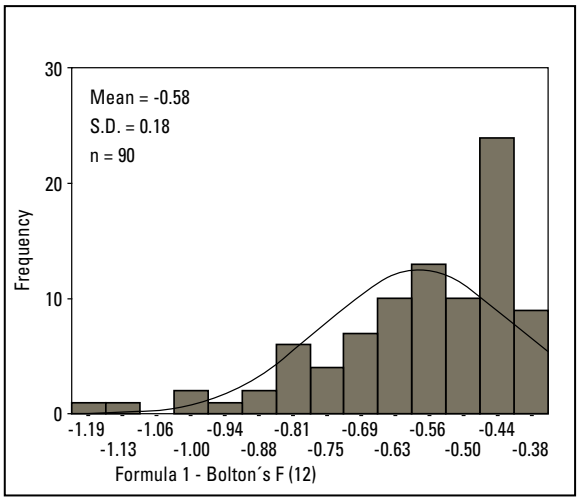

FIGURE 1 - Sample distribution, according to the mean overall ratio obtained from the difference between the Simplified Formula 1 and Bolton's Formula.

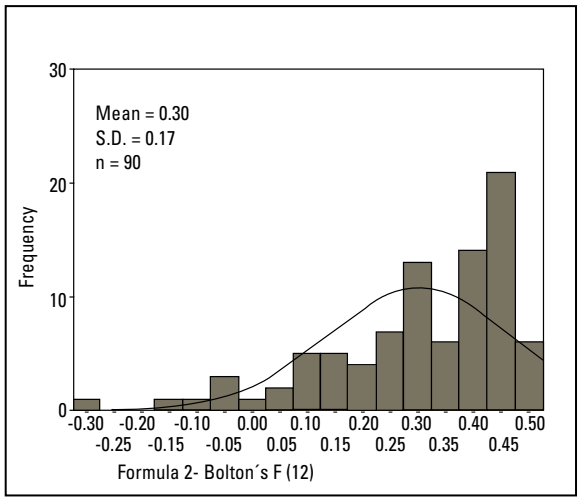

FIGURE 2 - Sample distribution, according to the mean overall ratio obtained from the difference between the Simplified Formula 2 and Bolton's Formula.

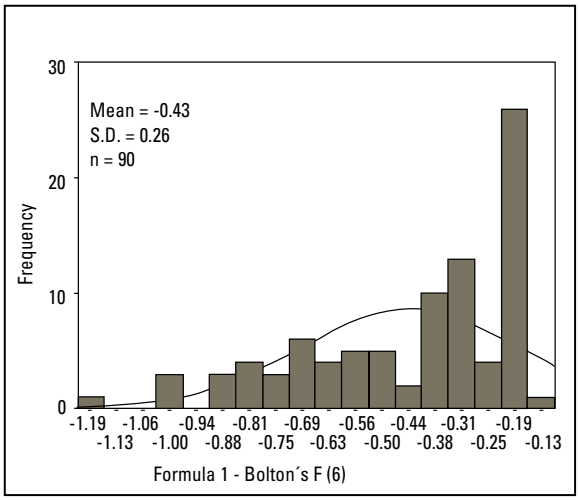

FIGURE 3 - Sample distribution, according to the mean anterior ratio obtained from the difference between the Simplified Formula 1 and Bolton's Formula.

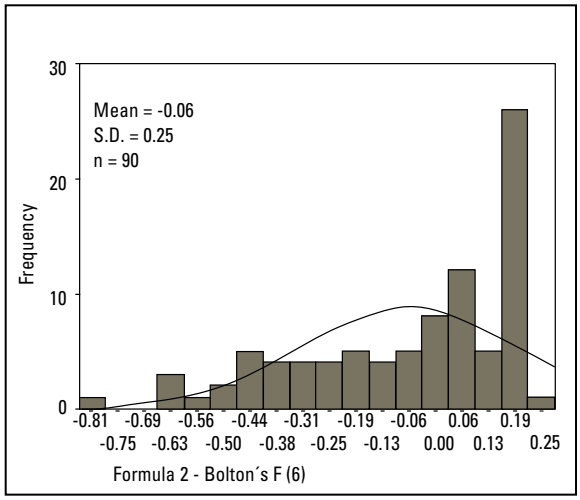

FIGURE 4 - Sample distribution, according to the mean anterior ratio obtained from the difference between the Simplified Formula 2 and Bolton's Formula.

Meanwhile, the anterior ratio shown in Figures 3 and 4 showed a better sampling distribution compared to the overall ratio, although in both graphs, there was a tendency towards negative values when comparing both methods.

For the overall ratio, Figures 5 and 6 showed a linear relationship between the Bolton's method and the corresponding values for the alternative methods (Formula 1 and Formula 2, respectively).

Figures 7 and 8 showed the same linear relationship between values obtained for the Bolton's method and the alternative method for the anterior ratio.

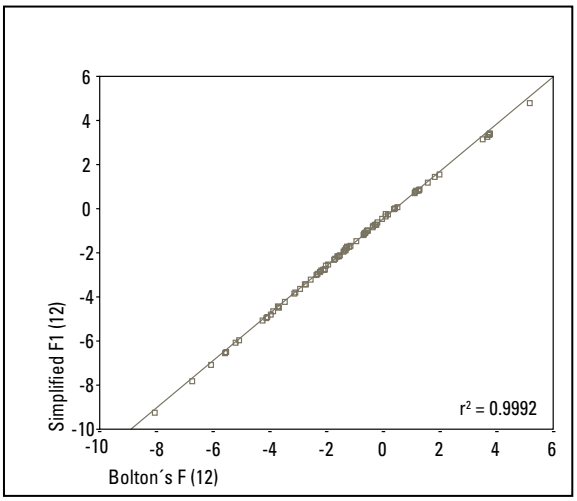

FIGURE 5 - Correlation between overall ratio obtained with Bolton's method and the Simplified Formula 1.

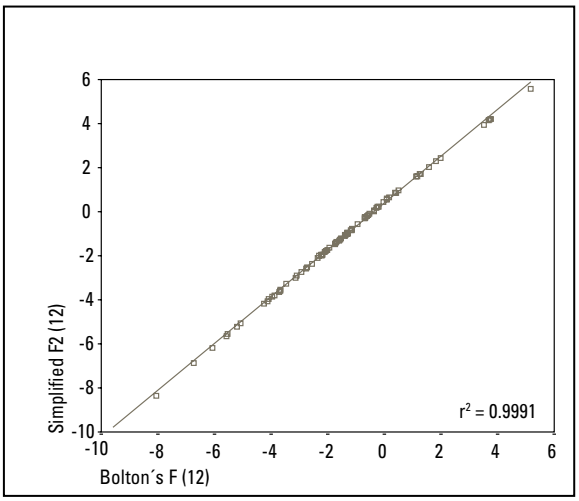

FIGURE 6 - Correlation between overall ratio obtained for Bolton's method and the Simplified Formula 2.

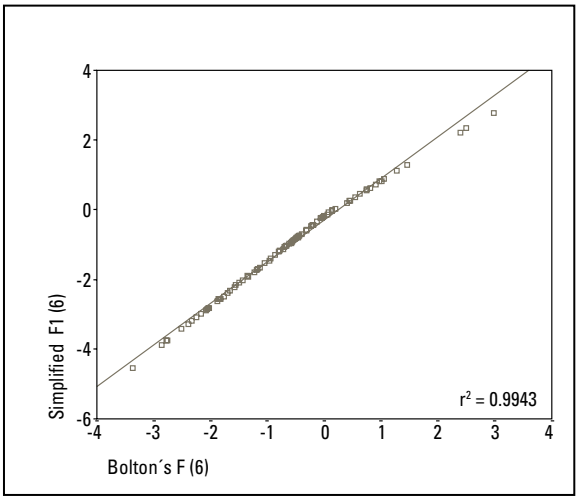

FIGURE 7 - Correlation between anterior ratio obtained for the Bolton's method and the Simplified Formula 1.

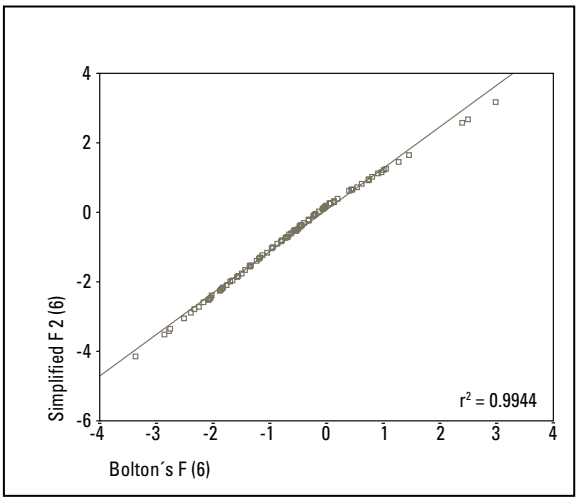

FIGURE 8 - Correlation between the anterior ratio obtained with Bolton's method and the Simplified Formula 2.

DISCUSSION

An ideal functional occlusion, with adequate overbite and overjet, requires, among other factors, an adequate ratio between the upper and lower teeth. According to some authors,[2,6,7,16,17] about 5 to 60% of people have some degree of dental discrepancy. This incidence varies according to factors such as sex,[1,14] racial and ethnic characteristics,[3,10,18] kind of malocclusion,[6,7,12,14,15] amongst others.[6,11] Even with its limitations, including the need for calculations and use of tables, the Bolton's method[5] constitutes a valuable tool to achieve the correct occlusal relationship during treatment.

Prior to Bolton's analysis[5], Neff[13] established a proportion coefficient for the anterior teeth of 1.2 (ranging from 1.17 to 1.41). This author stated that the sum of the mesiodistal width of the upper anterior teeth should be 20% higher than the lower ones to create appropriate vertical and horizontal relationships. Based on the studies of these two authors, our data support the efficacy to predict the dental interarch discrepancy by the two Simplified Formulas that were derived from the Bolton's analysis.

When comparing alternative methods to Bolton's method, there was a statistical significance ($p<0.001$) and a high correlation between them, with values of $r^2=0.999$ for the overall ratio and $r^2=0.994$ for the anterior ratio. When the overall ratio was evaluated, the Simplified Formula 1 (Figs 1 and 5) tended to underestimate the positive values of dental discrepancy. In other words, in cases of maxillary excess, Formula 1 showed smaller values than those obtained by the Bolton's method, although the maximum difference for this comparison was 0.39 mm. In contrast, when there were negative discrepancies, Formula 1 tended to overestimate negative values, compared to Bolton's analysis. Taken all together, in the present study, the first alternative method tested tended to potentiate the mandibular excess by 1.21 mm. The tendency towards negative values in Formula 1 – Bolton's Formula relationship was reinforced by the value of -0.58 mm for the mean difference.

For the Simplified Formula 2 (Figures 2 and 6), for each negative Bolton value there was an even lower value for Formula 2. In this second comparison (Formula 2 – Bolton's Formula), there was a tendency to overestimate negative values, although this tendency was smaller than the one observed on the previous comparison (Formula 1 – Bolton's Formula). The difference between the two methods was even greater for the positive values of discrepancy, which also tended to overestimate the maxillary excess. Therefore, the Simplified Formula 2 overestimated both the mandibular (up to 0.29 mm) and the maxillary excess (maximum 0.50 mm), being the latter in a greater proportion.

When the two Simplified Formulas (1 and 2) were compared together, there was an average difference of 0.88 mm between the values of dental discrepancy. There was a tendency to potentiate negative discrepancies (mean -0.58 mm) in the first one (Formula 1), and a tendency to provide positive values in the second formula that were greater than the discrepancy found by the Bolton's method (mean 0.30 mm). According to the mean results, the Simplified Formula 2 was the one closest to the Bolton's method for the overall dental discrepancy, with differences always ≤ 0.50 mm.

Meanwhile, the Simplified Formula 1 also tended to overestimate the negative values of discrepancy for the anterior ratio (minimum -1.18 mm). For the values of discrepancy close to zero (positive or negative), the difference between Formula 1 and Bolton's Formula was smaller. In cases of maxillary excess, the results showed a tendency to underestimate the positive dental discrepancies (up to -0.15 mm), with a mean difference for this comparison of -0.43 mm, i.e. tended to negative values of dental discrepancies.

When comparing Formula 2 with Bolton's Formula for the anterior region, it was observed that the greater the discrepancy (positive or negative), the greater the difference between the values of both methods. However, there was a greater tendency to overestimate negative values (mandibular excess) than positive values (maxillary excess). This becomes evident for Bolton indices of less than 1 mm, where there was a maximum difference of 0.2 mm between the methods. Meanwhile, for larger negative discrepancies (up to -2,9 mm), this difference was 0.79 mm. When comparing both formulas, Formula 2 (in relation to the Bolton's method) tended to show smaller differences (-0.6 mm) than Formula 1 (-0.43 mm) for the anterior ratio. This may be partly explained by the multiplication factor (1.29) used in Formula 2, with two decimal places, that reduced the error of method, and achieved a value that was closer to the coefficient for anterior dental proportion established by Neff[13] (1.2).

Even with the greater accuracy of Formula 2, the applicability of each formula must be considered. It is clear that the implementation of the Simplified Formula 1 is considerably simple and avoided the use of a calculator. Moreover, although the Simplified Formula 2 provided values closer to those obtained by the Bolton's method, it is much more difficult to be applied due to the use of two decimal places.

Although the difference between methods were small, in general, we should pay attention to the clinical application of these findings. According to data obtained from Bolton's method[5], the standard deviation from the average of the overall ratio and anterior ratio was established as 1.91 mm and 1.65 mm, respectively. Therefore, it may be assumed that differences between the tested methods are within acceptable parameters. Likewise, Proffit[16] found that discrepancies of less than 1.5 mm are rarely significant.

Considering that the biggest difference was 1.18 mm when both methods were compared (always less than that described by Bolton[5] and Proffit[16]), it may be stated that differences between the methods were not clinically significant.

CONCLUSION

According to the results, we conclude that:

- Both alternative methods (Simplified Formula 1 and Simplified Formula 2) to calculate the tooth size discrepancy are reliable, require less time for their application and waive the use of traditional Bolton's tables.
- The Simplified Formula 1 tends to overestimate the mandibular excess, both for the overall and the anterior ratios, while the Simplified Formula 2 tends to overestimate both the maxillary and mandibular excess, although in a smaller proportion.
- The Simplified Formulas 1 and 2 provide a greater reliability for calculating the anterior discrepancy, compared to the overall dental discrepancy.
- Both alternative methods may be used to replace the traditional method, since they demonstrated smaller mean differences (≤ 0.58 mm) and no clinical significance when compared to the Bolton's method.

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Changes in pogonion and nose according to breathing patterns

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Luégya Amorin Henriques Knop***, Luciana Borges Retamoso***

Abstract

Introduction: The soft tissue profile results from complex changes in the hard and soft tissues of the face. The pogonion and the nose are dominant facial structures that determine the degree of profile convexity and should, therefore, be analyzed and included in orthodontic treatment planning. **Objective:** To conduct a longitudinal evaluation of the anteroposterior dimensional changes of the pogonion and the nose of individuals with Angle Class II, division 1 malocclusion at two time points during craniofacial development. **Methods:** Lateral cephalograms were obtained for 40 individuals — 23 nasal breathers (NB) and 17 mouth breathers (MB). **Results:** Linear and angular measures were obtained: UL'-Pog', UL'-B', B'-Pog', Pog'-PogTeg', NB Line, Pog-NB, N'-Prn, Prn-NPog, N-Prn-Sn and Prn-Sn-UL. Two-way ANOVA was used to detect differences between mean values according to time points and/or breathing patterns. The UL'-B', Pog'-PogTeg', NB line and Pog-NB, N'-Prn, Prn-NPog, N-Prn-Sn and Prn-Sn-UL variables had significant differences ($p \leq 0.05$) between the two time points, but there were no significant differences between breathing patterns. No interaction was found between breathing patterns and time points for any variable. **Conclusion:** The pogonion and the nose undergo significant changes in the anteroposterior plane during growth, but breathing patterns do not significantly affect changes.

Keywords: Nose. Pogonion. Nose breathing. Mouth breathing.

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INTRODUCTION

An individual's soft tissue profile results from changes that affect facial bones and soft tissues. The interrelationship between facial soft tissue components (the nose, lips and pogonion) changes during growth and along orthodontic treatment. Therefore, normal growth trends of these structures should be understood.[18] At birth, the pogonion is retruded in relation to the maxilla, and this difference tends to decrease as the mandible grows. Men tend to have larger structures than women,[28] and the menton modification is not specific of any type of malocclusion.

The nose, the most dominant of all the profile elements,[17] has received little attention in orthodontic analysis, although the ones made by Steiner,[29] Ricketts,[21] Holdaway[12] and Chaconas[4] use the nose either as a reference point or just as one more facial element.

Several studies in the literature have evaluated the effect of breathing patterns on the morphology of the dentoskeletal complex, but there remains substantial disagreement between authors. Some reported that nasal obstruction affects growth and facial development; for others, the changed growth of the dentofacial complex results from environmental and genetic factors.[30]

Dentists should understand the pogonion and nose growth, and their association with the face. The prediction of the amount and direction of growth is valuable information, particularly in mouth breathing and nose breathing patients.

OBJECTIVES

To longitudinally evaluate the anteroposterior dimensional changes in the pogonion and nose of individuals with Angle Class II, division 1 malocclusion at two time points during craniofacial development.

MATERIAL AND METHODS

The study sample was composed of lateral cephalograms of 40 individuals with Angle Class II, division 1 malocclusion: 23 nasal breathers (NB) and 17 mouth breathers (MB). The patient ages ranged from 10 years and 9 months to 14 years at time point 1, and 13 years and 4 months to 16 years and 6 months at time point 2.

Breathing pattern was classified using the multidisciplinary method described by Wieler et al,[24] which consisted of a clinical evaluation of lip competence by a dentist; a questionnaire to the parents about their children breathing habits; an ear, nose and throat evaluation by an otolaryngologist; and a speech test performed by a speech pathologist. Based on these tests, scores and weighted values were assigned to each evaluation, and an index was defined to classify the predominant breathing pattern for each individual.

Cephalograms were obtained using manual and computerized methods.[25] The anatomical structures were outlined manually. After digitalization, the landmarks were marked, and values were calculated using the Radiocef 2000® cephalometric software. Study models were used to aid in tracing tooth positions.

The following parameters were used:

Linear measures referring to pogonion

- UL'-Pog' – measure from UL' to Pog', corresponding to the greatest anteroposterior dimension of the lateral image of the mandibular symphysis (total symphysis thickness).
- UL'-B' – measure from UL' to B', corresponding to the greatest anteroposterior dimension of the lateral image of the mandibular symphysis.
- B'-Pog' – measure from B' to Pog', corresponding to the greatest anteroposterior dimension of the lateral image of the mandibular symphysis.
- Pog'-PogTeg' – measure from Pog' to PogTeg', corresponding to the greatest anteroposterior dimension of the lateral image of the mandibular symphysis.

» NB line – line from nasion to Point B.
» Pog-NB – distance from Pog to NB line; refers to the most anterior point of the hard chin, measured from the NB line. Values are positive and negative when after and before the NB line, respectively.

Linear measures referring to nose

» N'-Prn – measure of the position of the tip of the nose in relation to the nasion; defines nose prominence.
» Prn-NPog – measure of the nasal depth in relation to the facial plane.

Angular measures referring to nose

» SN-Prn-Sn – measure of the nose prominence in relation to the sella-nasion
» Prn-Sn-UL – nasolabial angle; measure of the inclination of the columella in relation to the upper lip.

RESULTS

Pogonion

All variables had a normal distribution at all time points according to the Kolmogorov-Smirnov test, except B'-Pog' and Pog-NB. Therefore, mean values according to time points were compared using two-way repeated measures ANOVA.

ANOVA results revealed that F was statistically significant ($p<0.05$) for UL'-B', Pog'-Pog Teg', NB line and Pog-NB, and that there was a significant difference between mean values according to time point, breathing pattern, or both. The B'-Pog' and UL'-PogTeg' values were not statistically different ($p>0.05$) between breathing patterns or time points. To identify which conditions (breathing pattern x time points) were different from each other, the Tukey HSD test for multiple comparisons was used (Table 1).

TABLE 1 - Multiple comparison of Tukey HSD breathing patterns (Pogonion).

Breathing pattern	Time points	Nose T_1	Nose T_2	Mouth T_1	Mouth T_2
UL'-B'	Mean	10.08	8.96	9.75	8.95
Nose	Initial	—	0.000225*	0.973068	0.215061
Nose	Final	0.000225*	—	0.516552	1.000000
Mouth	Initial	0.973068	0.516552	—	0.020579*
Mouth	Final	0.215061	1.000000	0.020579*	—
Pog'- PogTeg'	Mean	10.54	10.80	10.40	10.98
Nose	Initial	—	0.327002	0.888784	0.557792
Nose	Final	0.327002	—	0.585907	0.864706
Mouth	Initial	0.888784	0.585907	—	0.049538
Mouth	Final	0.557792	0.864706	0.049538	—
NB Line	Mean	95.95	100.03	98.73	101.48
Nose	Initial	—	0.000166*	0.638323	0.012703*
Nose	Final	0.000166*	—	0.873554	0.924643
Mouth	Initial	0.638323	0.873554	—	0.0029667*
Mouth	Final	0.012703*	0.924643	0.0029667*	—
Pog-NB	Mean	1.85	2.43	1.27	1.87
Nose	Initial	—	0.005911*	0.841574	0.997777
Nose	Final	0.005911*	—	0.108289	0.880566
Mouth	Initial	0.841574	0.108289	—	0.009903*
Mouth	Final	0.997777	0.880566	0.009903*	—

*Statistically significant difference ($p \leq 0.05$).

TABLE 2 - Multiple comparison of Tukey HSD breathing patterns (Nose).

Breathing pattern	Time point	Nose T_1	Nose T_2	Mouth T_1	Mouth T_2
N'-Prn	Mean	48.46	51.17	48.65	51.09
Nose	Initial	—	0.000168*	0.998581	0.032712*
Nose	Final	0.000168*	—	0.043527*	0.999881
Mouth	Initial	0.998581	0.043527*	—	0.000426*
Mouth	Final	0.032712*	0.999881	0.000426*	—
Prn-NPog	Mean	31,44	33.37	31.16	33.54
Nose	Initial	—	0.057858	0.996643	0.239205
Nose	Final	0.057858	—	0.200245	0.999237
Mouth	Initial	0.996643	0.200245	—	0.038587*
Mouth	Final	0.239205	0.999237	0.038587*	—
N-Prn-Sn	Mean	99.74	96.09	100.88	98.00
Nose	Initial	—	0.000591*	0.961845	0.763410
Nose	Final	0.000591*	—	0.046302*	0.847989
Mouth	Initial	0.961845	0.046302*	—	0.024001*
Mouth	Final	0.763410	0.847989	0.024001*	—
Pr-Sn-UL	Mean	0.763410	126.48	120.59	122.76
Nose	Initial	0.763410	0.043676*	0.430122	0.719993
Nose	Final	0.763410	—	0.060697	0.372458
Mouth	Initial	0.763410	0.060697	—	0.142717
Mouth	Final	0.763410	0.372458	0.142717	—

*Statistically significant difference ($p \leq 0.05$).

Nose

The study hypothesis was tested using two-way repeated measures analysis of variance (ANOVA). The two time points and two breathing patterns had a normal distribution for the variables under analysis. The Kolmogorov-Smirnov test was used to test normality, and the level of significance was set at 0.05.

The Tukey HSD test for multiple comparisons was used to detect which conditions (breathing pattern x time points) differed from each other when ANOVA results revealed a difference between the mean values of N'-Prn, Prn-NPog, N-Prn-Sn and Prn-Sn-UL according to time point, breathing pattern, or both (Table 2).

DISCUSSION

Facial analysis has been used as a valuable diagnostic resource since the beginning of orthodontics,[20] and the lips, cheeks and nose, in particular, define the unique facial appearance of each individual.[19]

Skeletal growth and changes in soft tissues affect occlusion and facial esthetics. The amount of soft tissue over the symphysis has a fundamental role in facial harmony and in the response to skeletal changes.[5] In addition, the measures obtained using cephalometry, although two-dimensional, provide concrete data that make comparisons possible and complement diagnoses.[16] For this reason, cephalometry is widely used in several scientific studies.[10,11]

Changes in facial soft and hard tissues should be taken into consideration during orthodontic diagnosis and treatment planning.[2,22,28] Growth differences between sexes and age groups have been documented for these structures.[11]

The results of the present study revealed changes in the hard and soft tissue pogonion at the two time points under analysis, 10-14 and 13-16 years of age, which are in agreement with Koch et al[13] and Maltagliati et al[15] findings. Pogonion thickness, evaluated according to the UL'-Pog' measure, resulted from different bone remodeling patterns due to greater bone deposition in the lingual surface of the pogonion, characteristic of the growth phase, as confirmed by histological[6] and implant[1] studies.

In the present study, the soft tissue pogonion was directly associated with the increase of the skeletal pogonion, which differs from data reported by Genecov, Sinclair and Dechow,[9] who found that the growth of the soft tissue pogonion in patients undergoing orthodontic treatment was constant and relatively independent from the underlying bone.

The analysis of the B'-Pog' showed that this measure is shorter in nasal breathers and greater in mouth breathers. This study, however, did not investigate the reason for this reduction in nasal breathers. A smaller posterior movement of Point B might have occurred in consequence of downward and backward mandibular rotation, although the possibility of less bone deposition in the pogonion region was not ruled out.

The shorter UL'-B' and longer Pog-NB may be explained by the posterior displacement of Point B and the bone deposition in the pogonion surface. Moreover, there were variations in the mandibular plane angle. According to Rosenstein,[23] the UL'-B' line tends to be even shorter in individuals whose treatment includes extractions.

Prahl-Andersen et al[18] found that nose length, prominence and shape are associated with the growth in height and length of the maxilla and the mandible.

The nose projection onto the posteroanterior plane had a statistically significant difference in this study, which is in agreement with findings by Brant et al,[3] who reported significant changes in N-Prn-Sn when groups with and without premolar extractions were compared. According to Chanocas,[4] the tip of the nose grows downward in individuals with Class II malocclusion.

The nasolabial angle (Prn-Sn-UL) had significant changes ($p \leq 0.05$) between the two time points as a result of nasal growth and upper lip retraction, which takes place during the normal development of individuals, when the nasolabial fold may also become longer.[7] The results are in agreement with those reported by Salgado et al,[26] who found significant variations in nasolabial angles of individuals with Angle Class II and Class III malocclusion, and greater values in Class II cases. However, the results differ from those reported by Brant et al,[3] who found no significant differences in the nasolabial angle of individuals that underwent orthodontic treatment with or without extractions.

Nasal breathing is essential for adequate growth and development of the craniofacial complex.[27] Some studies found differences in the craniofacial development of mouth breathers and nasal breathers. In mouth breathers, there seems to be a greater inclination of the angle of the mandibular plane, and the growth pattern is vertical.[14,28] This finding contradicts the results of this study, which found no interaction between breathing patterns and any of the variables under study.

Changes in the thickness of the soft tissues of the nose, lips and pogonion should be taken into consideration during diagnosis, treatment planning, and actual treatment of individuals during growth.

CONCLUSION

There were anteroposterior changes in the skeletal and soft tissue pogonion and in the nose during growth, but breathing patterns were not associated with any significant changes.

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Mouth breathing within a multidisciplinary approach: Perception of orthodontists in the city of Recife, Brazil

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Abstract

Objectives: To assess the knowledge of a mouth breathing pattern among orthodontists in the city of Recife, Brazil, and to examine their treatment protocols. **Methods:** In this cross-sectional study, members of the Orthodontics and Facial Orthopedics Association of Pernambuco responded individual structured interviews. A form with 14 questions, validated using the face value method, was used to collect data. The level of significance was set at 5%. **Results:** Of the 90 participants, 55.6% were women; 78.9% were specialists (the highest educational level); 67.8% worked full-time in private practice, and 38.9% were also professors. The most frequent diagnostic criteria were: Body posture (97.8%), lip competence (96.7%), and dark circles under the eyes (86.7%), with similar results among young and old orthodontists. The use of the Glatzel mirror was infrequent (3.3%). The most frequently mentioned mouth breathing sequelae were craniofacial (94.4%) and body posture (37.8%) changes. According to interviewees, mouth breathing duration (84.4%) was the item most often associated with sequelae. There were no significant associations between time since graduation and any of the factors under analysis. Most respondents, whether working in private clinics or in the public healthcare system, believed that mouth breathers should be treated by a multidisciplinary team. **Conclusions:** Most orthodontists, regardless of experience, have knowledge of the mouth breathing syndrome and understand the need of a multidisciplinary treatment.

Keywords: Mouth breathing. Orthodontics. Perception.

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INTRODUCTION

Mouth breathing is a common respiratory disorder in childhood and one of the most serious public health problems.[5] Its extended duration may lead[15,16,21] to a series of structural and functional changes in the stomatognathic system and to physical, psychological and social effects. Mouth breathing problems and their complexity have been a matter of concern for health care workers in several specialties and have contributed to a more frequent adoption of multidisciplinary treatments and studies.[1,9,15,16,18]

The mechanism of normal breathing consists of air inhaled through the nose and its flow through the pharynx and larynx to be humidified, warmed and filtered until the lungs, where the gas exchanges occur. As a vital and innate function of human beings, breathing should be performed in a physiologically correct way to protect upper airways and promote a satisfactory development of the craniofacial complex. If there is abnormal breathing, the organism undergoes a series of adaptive changes throughout the body, which may have serious consequences if not treated at an early stage, since it affects children during the development phase.[3,8,13]

Mouth breathers are individuals that, for some organic, functional or neurological reason, develop an inadequate breathing pattern.[16] They may be classified as: Organic insufficient nasal breathers, due to the presence of nasal, pharyngeal or mouth mechanical obstacles; functional insufficient nasal breathers, which are those that need to undergo surgery; and functional disabled mouth breathers, as sequelae of neurological disorders.

The most common implications of mouth breathing are changes in: Craniofacial and dental anatomy, orofacial structures related to speech, corporal and behavioral patterns, and oral functions.[20] In dentistry, mouth breathing patients are diagnosed according to peculiar facial features, such as: Dark circles under the eyes, vacant eyes, short and incompetent upper lip, chapped lips, lip incompetence, hypotonic muscles, mandibular elevator muscle dysfunction, malocclusion, as well as swallowing, sucking and speaking disorders.[26,29]

As mouth breathing treatments should be planned within a multidisciplinary philosophy, this study assessed the knowledge of the mouth breathing syndrome among orthodontists and orthopedists in the city of Recife, Brazil, and examined their diagnostic and treatment protocols.

METHODS

A quantitative cross-sectional survey was conducted with orthodontists who are members of the Pernambuco Society of Orthodontics and Facial Orthopedics, and worked in private practices or public healthcare services in the city of Recife, Brazil, since 2006. Only 18 out of 108 orthodontists were not found or refused to participate in the study. A total of 90 participants filled out a questionnaire with 15 questions about mouth breathing.

Informed consent was obtained from all clinicians who agreed to participate in this study. The answers were written down at the time of the interview to ensure its accuracy and reliability and to avoid recall problems. Answers reliability was tested using the face validation method with 10% of the interviewees. In this method, they were asked to explain, in their own words, what they have understood about each question. The interviews were conducted in their offices (private practice or healthcare service) and, whenever possible, there was an attempt to not interfere with the routine activities of the interviewees.

Univariate and bivariate analyses were used to obtain absolute distributions and percentages, and the following statistical measures were calculated: Mean, standard deviation, variation coefficient, minimum and maximum values of age (descriptive statistical techniques). A chi-square test was used for comparisons, or the Fisher's exact test when the conditions to use the chi-square test were not met (inferential statistical techniques).

The level of significance was set at 5%. Data were stored in an Microsoft Office Excel spreadsheet, and the Statistical Analysis System v.8 (SAS) was used for statistical calculations.

This study was approved by the Research Ethics Committee of the Pernambuco University, under #020/07.

RESULTS

Only 78.9% of the interviewees were specialists (the highest educational level), 67.8% worked full-time in their private practice, and 38.9% were also professors (Table 1).

Table 2 shows that there were no significant associations between time since graduation and any other variable under study (p>0.05). Most of the interviewees made the diagnosis of breathing pattern during anamnesis (70%). The most frequent diagnostic criteria were body posture (97.8%) and lip competence (96.7%), with similar percentages between groups regarding time since graduation; the use of the Glatzel mirror was infrequent and mentioned by only 9.4% of the interviewees graduated for the longest time.

The greatest percentage differences were found between orthodontists that chose "learning disability" (behavioral changes) as a sequel of mouth breathing (Table 3). Those with 11 to 20 years of graduation had a higher percentage than those with 21 or more years (37.9% x 12.5%).

TABLE 1 - Distribution of interviewees according to sex, years since graduation, degree, place of work and position as professor.

Variable	n	%
Sex		
Men	40	44.4
Women	50	55.6
Time since graduation		
Up to 10 years	29	32.2
11 to 20 years	29	32.2
21 years or more	31	34.4
Not informed	1	1.1
Degree		
MSc	71	78.9
Specialization	11	12.2
PhD	8	8.9
Place of work		
Private practice	61	67.8
Private practice and public healthcare service	29	32.2
Professor		
Yes	35	38.9
No	55	61.1
TOTAL	**90**	**100.0**

TABLE 2 - Evaluation of items associated with diagnosis according to years since graduation.

Variable	Time since graduation								p value
	Up to 10 years		11 to 20 years		21 years or more		Total Group		
	n	%	n	%	n	%	n	%	
When do you make the patient's diagnosis?									
In the waiting room	6	20.7	10	34.5	14	43.8	30	33.3	$p^{(1)} = 0.160$
During history taking	22	75.9	21	72.4	20	62.5	63	70.0	$p^{(1)} = 0.494$
During examination	4	13.8	10	34.5	9	28.1	23	25.6	$p^{(1)} = 0.180$
Which diagnostic methods are used to define the patient's breathing pattern?									
Dental mirror	15	51.7	16	55.2	20	62.5	51	56.7	$p^{(1)} = 0.684$
Metal plate	-	-	-	-	3	9.4	3	3.3	$p^{(2)} = 0.104$
Water (3 minutes)	5	17.2	4	13.8	4	12.5	13	14.4	$p^{(2)} = 0.931$
Water (1 to 2 minutes)	8	27.6	5	17.2	11	34.4	24	26.7	$p^{(1)} = 0.316$
Spatula	1	3.4	1	3.4	4	12.5	6	6.7	$p^{(2)} = 0.360$
Radiographs	8	27.6	15	51.7	12	37.5	35	38.9	$p^{(1)} = 0.166$
Facial pattern	24	82.8	25	86.2	23	71.9	72	80.0	$p^{(2)} = 0.385$
Body posture	25	86.2	27	93.1	27	84.4	79	97.8	$p^{(2)} = 0.615$
Lip sealing	28	96.6	29	100.0	30	93.8	87	96.7	$p^{(2)} = 0.771$
Type of occlusion	21	72.4	23	79.3	23	71.9	67	74.4	$p^{(1)} = 0.765$
Swallowing	18	62.1	18	62.1	20	62.5	56	62.2	$p^{(1)} = 0.999$
Dark circles under the eyes	26	89.7	26	89.7	26	81.3	78	86.7	$p^{(2)} = 0.582$
TOTAL	**29**	**100.0**	**29**	**100.0**	**32**	**100.0**	**90**	**100.0**	

(1): Chi-square test. (2): Fisher's exact test.

Mouth breathing duration (84.4%) was the factor most often mentioned by interviewees as a cause of sequelae. There were no significant associations between time since graduation and any of the items under analysis, considering a level of significance of 5%.

All the 29 interviewees that worked in public healthcare services referred their patients to otolaryngologists and speech pathologists. Table 4 shows that the greatest percentage difference was found for those that refer to psychologists in the group with 21 or more years after graduation (7.7%) and those in the other two groups (37.5% each). For the clinicians that work in private practices, the greatest percentage difference was found in the group of those that refer patients to pediatricians, which was higher in the 11 to 22 years group than in the up to 10 years group. However, no significant association was found between time since graduation and the answers about referral by interviewees that worked in private practices and in public healthcare services.

Multidisciplinary treatment in cases of mouth breathing was classified as unimportant by two interviewees of the 21 or more years group, but this association was not significant ($p>0.05$) (Table 5).

TABLE 3 - Mouth breathing sequelae and their causes according to years since graduation.

Variable	Time since graduation								p value
	Up to 10 years		11 to 20 years		21 years or more		Total Group		
	n	%	n	%	n	%	n	%	
Which factors determine sequelae of mouth breathing?									
Patient age	20	69.0	24	82.8	23	71.9	67	74.4	$p^{(1)} = 0.444$
Etiologic factor	20	69.0	24	82.8	26	81.3	70	77.8	$p^{(1)} = 0.379$
Mouth breathing duration	26	89.7	25	86.2	25	78.1	76	84.4	$p^{(2)} = 0.508$
Other	1	3.4	-	-	-	-	1	1.1	$p^{(2)} = 0.644$
In your opinion, which sequelae are caused by mouth breathing?									
A – Craniofacial and dental anomalies									
Malocclusion	28	96.6	29	100.0	28	87.5	85	94.4	$p^{(2)} = 0.123$
Adenoid faces	6	20.7	10	34.5	8	25.0	24	26.7	$p^{(1)} = 0.477$
B – Anomalies of speech organs									
Lip sealing	7	24.1	9	31.0	10	31.3	26	28.9	$p^{(1)} = 0.790$
Gingival enlargement	1	3.4	6	20.7	3	9.4	10	11.1	$p^{(2)} = 0.111$
Abnormal pattern of facial muscles	2	6.9	6	20.7	7	21.9	15	16.7	$p^{(2)} = 0.252$
C – Body anomalies									
Changes in posture	11	37.9	12	41.4	11	34.4	34	37.8	$p^{(1)} = 0.853$
Dark circles under the eyes	4	13.8	4	13.8	4	12.5	12	13.3	$p^{(2)} = 1.000$
Respiratory deficiency	9	31.0	5	17.2	7	21.9	21	23.3	$p^{(1)} = 0.449$
D – Abnormal oral functions									
Atypical swallowing	10	34.5	11	37.9	9	28.1	30	33.3	$p^{(1)} = 0.710$
Speech anomalies	2	6.9	1	3.4	-	-	3	3.3	$p^{(2)} = 0.305$
E – Behavioral anomalies									
Learning disabilities	8	27.6	11	37.9	4	12.5	23	25.6	$p^{(1)} = 0.072$
Poor quality of life	3	10.3	3	10.3	-	-	6	6.7	$p^{(2)} = 0.135$
Physical tiredness	2	6.9	2	6.9	2	6.3	6	6.7	$p^{(2)} = 1.000$
Low self-esteem	2	6.9	1	3.4	-	-	3	3.3	$p^{(2)} = 0.305$
TOTAL	**29**	**100.0**	**29**	**100.0**	**32**	**100.0**	**90**	**100.0**	

(1): Pearson's chi-square test. (2): Fisher's exact test.

TABLE 4 - Protocol to treat mouth breathers in public healthcare services and private practices according to years since graduation.

Variables	Time since graduation								p value
	Up to 10 years		11 to 20 years		21 years or more		Total Group		
Public healthcare service - referrals	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Otolaryngologist	8	100.0	8	100.0	13	100.0	29	100.0	**
Speech pathologist	8	100.0	8	100.0	13	100.0	29	100.0	**
Psychologist	3	37.5	3	37.5	1	7.7	7	24.1	$p^{(1)} = 0.221$
Dentist	3	37.5	1	12.5	3	23.1	7	24.1	$p^{(1)} = 0.651$
Pediatrician	3	37.5	2	25.0	3	23.1	8	27.6	$p^{(1)} = 0.869$
Orthodontist or orthopedist	7	87.5	7	87.5	12	92.3	26	89.7	$p^{(1)} = 1.000$
TOTAL	**8**	**100**	**8**	**100.0**	**13**	**100.0**	**29**	**100.0**	
Private practice - referrals									
Otolaryngologist	27	93.1	29	100.0	30	93.8	86	95.6	$p^{(1)} = 0.542$
Speech pathologist	29	100.0	28	96.6	32	100.0	89	98.9	$p^{(1)} = 0.644$
Psychologist	4	13.8	6	20.7	4	12.5	14	15.6	$p^{(1)} = 0.762$
Dentist	6	20.7	7	24.1	8	25.0	21	23.3	$p^{(2)} = 0.917$
Pediatric dentist	4	13.8	10	34.5	7	21.9	21	23.3	$p^{(2)} = 0.171$
Orthodontist or orthopedist	28	96.6	28	96.6	31	96.9	87	96.7	$p^{(1)} = 1.000$
TOTAL	**29**	**100.0**	**29**	**100.0**	**32**	**100.0**	**90**	**100.0**	

(1): Fisher's exact test. (2): Pearson's chi-square test.

TABLE 5 - Evaluation of answers to the question "What is your opinion about multidisciplinary treatment in cases of mouth breathing?" according to years since graduation.

Opinion about multidisciplinary treatment	Time since graduation								p value
	Up to 10 years		11 to 20 years		21 years or more		Total Group		
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Very important	28	96.6	29	100.0	30	93.8	87	96.7	$p^{(1)} = 0.284$
Important	1	3.4	-	-	-	-	1	1.1	
Not important	-	-	-	-	2	6.3	2	2.2	
TOTAL	**29**	**100.0**	**29**	**100.0**	**32**	**100.0**	**90**	**100.0**	

(1): Pearson's chi-square test. (2): Fisher's exact test.

DISCUSSION

Changes in breathing patterns may affect the general health of an individual[1,9,15,16,18] and, therefore, are not limited to the occurrence of orthodontic disorders. For most dentists (70%), the breathing diagnosis is made according to anamnesis, which is taken when orthodontists, particularly those that graduated more recently ($p<0.05$), make an attempt to investigate other disorders associated with mouth breathing.[27]

In general, the selection of diagnostic clinical methods and criteria is directly associated with the objectives of the different healthcare specialties. One of the major problems in breathing diagnoses is the lack of an accurate definition of what a mouth breather is, as nasal breathing may occur in variable degrees.[26,28]

The main parameters to diagnose respiratory patterns were: Lip competence, body posture and dark circles under the eyes. The Glatzel mirror (3.3%), spatula (6.7%) and water in the mouth (14.4%) for 3 minutes ($p<0.05$) were diagnostic methods not often used by the interviewees (Table 2). These methods are frequently used to determine respiratory patterns and not to define causal factors. High percentages of participants mentioned the use of a dental mirror (56.7%) and radiographs (38.9%).

Mouth breathing is complex and compromises several organs and structures.[10] Therefore, diagnoses should be made by the otolaryngologist (radiographs of the cavum and fiberoptic nasal endoscopy), orthodontist (lateral radiograph) and speech pathologist.[11,13] Etiological factors should be carefully defined to avoid prescribing inadequate treatments,[20,29] and other physical, emotional and social anomalies that affect health and life quality should be analyzed.[15,16,21]

The most frequent answers for the question about what factors contribute to the deterioration of mouth breathing were: Mouth breathing duration, etiological factor and age. The difference in time since graduation was not significant ($p>0.05$). Breast-feeding in the first months of life stimulates nasal breathing,[23] and, in addition to responding to nutritional and emotional needs, ensures that infants develop facial and oral structures adequately and avoids that pacifier sucking, bottle feeding, finger sucking and nail biting become habits.[6,14,29]

Patients should be diagnosed and referred to specialists at an early stage, when facial bone deformations and cardiorespiratory, immunological and behavioral changes[22,26] have not yet developed. In this study, 87 respondents (96.5%) considered that multidisciplinary treatment is essential, and only 2 (2.2%) of those graduated for a period longer than 21 years classified it as irrelevant, although differences were not significant ($p>0.05$) (Table 5).

The dentists unanimously agreed that mouth breathing leads to several sequelae, the most frequent of which are, according to literature: Long face,[27] narrow nostrils, lip incompetence, lack of facial muscle tone,[17,24] drooping eyes, dark circles under the eyes, slanted eyes, stooping shoulders, unbalanced spine and small nose. The factors most often mentioned were: Lip sealing (97.8%), body posture (96.7%) and dark circles under the eyes (86.7%), in agreement with findings reported in other studies.[2,17,28]

The most remarkable oral features were: Hypotonic, dry or everted lips, narrow and deep palate, lip incompetence, constrict maxillary arch, Class II malocclusions (facial asymmetry, open bite and posterior crossbite)[24,26,29] and swallowing, sucking and speech abnormalities.[4,13,22,23] The highest percentage of sequelae mentioned by the dentists was in the group of craniofacial and dental changes; malocclusion was pointed out by 94.4% of the participants, in agreement with data reported in other studies.[13,21]

Mouth breathers have frequent behavioral changes, such as: Irritation, bad mood, sleepiness, restlessness, lack of concentration, agitation, anxiety, fear, depression, suspiciousness,

impulsivity[6,19] and learning disabilities.[20,30] These data confirm the opinion of the interviewees, as well as other authors belief:[1,7] Prevention and early diagnosis of mouth breathing are important to reduce problems in psychosocial adjustment.

Most dentists mentioned that mouth breathers are special patients who present a series of problems and sequelae, and need to be treated differently by using an interdisciplinary approach within a broad view of multidisciplinarity (Tables 4 and 5). This may be justified by the emphasis assigned to this problem in recent years and by the recognition that integrated approaches are important to improve life quality.[16,21] However, the difficulty to access public services and the fact that the general population is unaware of the sequelae caused by this disorder may affect the results.

CONCLUSIONS

- A high percentage of dentists have knowledge about the mouth breathing syndrome and its sequelae.
- According to most orthodontists and orthopedists interviewed, a multidisciplinary treatment is essential for full rehabilitation.

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Assessment of force decay in orthodontic elastomeric chains: An *in vitro* study

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Abstract

Introduction: Elastomeric materials are considered important sources of orthodontic forces. **Objective:** To assess force degradation over time of four commercially available orthodontic elastomeric chains (Morelli, Ormco, TP and Unitek). **Methods:** The synthetic elastics were submerged in 37 °C synthetic saliva and stretched by a force of 150 g (15 mm – Morelli and TP; 16mm – Unitek and Ormco). With a dynamometer, the delivered force was evaluated at different intervals: 30 minutes, 7 days, 14 days and 21 days. The results were subjected to ANOVA and Tukey's test. **Results:** There was a force decay between 19% to 26.67% after 30 minutes, and 36.67% to 57% after 21 days of activation. **Conclusions:** TP elastomeric chains exhibited the smallest percentage of force decay, with greater stability at all time intervals tested. Meanwhile, the Unitek chains displayed the highest percentage of force degradation, and no statically significant difference was found in force decay between Ormco and Morelli elastomeric chains during the study period.

Keywords: Elastics. Synthetic elastics. Elastomeric chain.

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INTRODUCTION AND LITERATURE REVIEW

Orthodontic biomechanics makes use of force systems that aim to promote tooth movement. Self-ligating appliances[7] have been designed to eliminate the use of elastomeric modules during treatment. However, elastomeric materials are considered important sources of forces used to move teeth with conventional brackets.

The term "elastomer" refers to any member of a class of polymeric materials with the ability to regain shape after deformation.[5,12]

The first common elastomer was natural rubber, probably used by the Maya and Inca civilizations.[5] However, its use was limited due to its physical properties, such as water absorption and thermal instability. With the advent of vulcanization, introduced by Charles Goodyear in 1839, the physical properties of rubbers were improved, considerably enhancing its use.[5]

In 1920, petrochemical industries began to manufacture synthetic rubber bands, which were adopted by orthodontists in the 60's. The internal composition of these materials is determined by the level of technology and quality of raw materials used in their manufacture.[17] The most widely used elastomer in orthodontics are elastomeric chains and ligatures. The main clinical applications are: Tying orthodontic archwires to brackets, replacing steel ligatures, closing extraction spaces, retracting canines, orthodontic traction of impacted teeth, correcting torsiversion and midline deviation. They are practical, efficient and are available in a variety of colors. With convenient placement, they are also comfortable to the patient.[5,12,14]

However, studies[4,9,10,16,19] have shown some disadvantages of elastomeric materials. They are sensitive to prolonged exposure to water, and intraoral conditions deteriorate due to the presence of enzymes and temperature variations,[8] which may influence the clinical performance of these materials. Furthermore, the pigments used in the manufacturing process of colored elastomeric ligatures can also interfere on force degradation.[13]

If elastics are kept continuously stretched under certain environmental factors, there may be a change in their behavior. Previous studies have reported increased force degradation over time when elastics are tested in a moist environment, compared with tests performed in a dry condition.[4,9,10,11,15,16] Rising temperatures have been considered an aggravating factor to reduce the forces generated by elastomeric modules.[11,16] Therefore, studies were performed in 37 °C water to simulate oral conditions.[6,8,9,18]

When elastomeric chains are activated around the brackets, they undergo changes in their physical properties and do not release constant force levels over a long period of time.[3,4,5,7,10]

In 1991, a study[2] evaluated four different brands of elastomeric chains: Tecnident, Unitek, Ormco and Dentaurum. Three-unit modules were stretched to twice their original size to yield an initial force of 200 g. The samples were submerged in a 10% Ringer's solution at an average temperature of 37 °C. Forces were measured over a period of 30 days. The results showed a force decay of 35% at the end of the first day and approximately 75% at the end of the experiment. No significant differences were found between the materials.

In 2008, an *in vivo* study[1] was conducted to determine the amount of force delivered by intermaxillary elastics and elastomeric chains from two different brands (Morelli and GAC). According to the results, the intermaxillary elastics manufactured by Morelli released an initial force of 175 g, which was greater than GAC (110 g). Meanwhile, the Morelli elastomeric chains had an initial force of 200 g, which was lesser than the GAC (220 g). The study suggested that intermaxillary elastics should be replaced on a daily basis to improve mechanical efficiency, and elastomeric chains should be replaced once a month. Although

there is a significant force degradation after 15 days, the dissipating nature of orthodontic forces is considered ideal when using fixed orthodontic appliances.

Knowledge about the mechanical properties changes that occur in stretched elastomeric chains is important, as they often remain in the oral cavity for a relatively long time. Therefore, it would be highly desirable that these chains maintain appropriate forces throughout this time period.

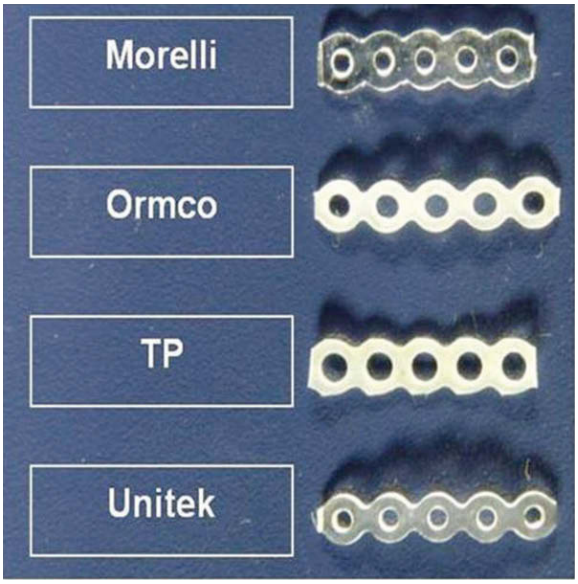

FIGURE 1 - Elastomeric chain samples.

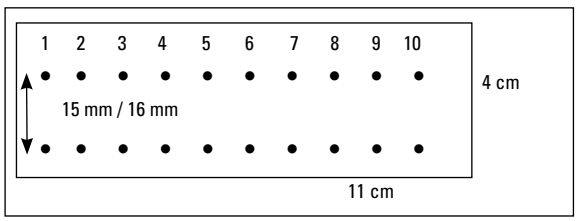

FIGURE 2 - Drawing illustrating acrylic resin plates with a 15 mm distance between the steel pins for the Morelli and TP brands, and a 16 mm for Unitek and Ormco.

The aim of this *in vitro* study was to assess the amount of force decay of commercially available orthodontic elastomeric chains that were immersed in artificial saliva at 37 °C, based on the forces delivered and stretching time.

MATERIAL AND METHODS

The study sample consisted of crystal colored short link orthodontic elastomeric chains of the brands Morelli (Sorocaba, Brazil), Ormco (Glendora, USA), TP (La Porte, Ind, USA) and 3M/Unitek (Monrovia, USA). Sealed packages of orthodontic elastomeric chains were purchased with a valid expiration date. Ten randomly selected samples, containing five-unit modules, of each brand were analyzed and stretched with a tension of 150 g.

A transparent acrylic plate (Acricenter, Porto Alegre, Brazil) of 1 cm thickness, 11 cm length and 4 cm width was fabricated with ten aligned holes (10 mm apart) that were then drilled 5 mm deep with a low speed 151 XL carbide bur (Fava, São Paulo, Brazil). Stainless steel orthodontic wires (0.9 mm - 55.01.090 Morelli, Sorocaba, Brazil) were inserted into the holes and fixed with transparent acrylic resin (Jet, Campo Limpo Paulista, Brazil). Their ends were cut off creating pins, 10 mm high.

Furthermore, ten pieces of five-unit modules of elastomeric chain were adapted to each of the 10 pins and were stretched to produce a force of 150 g, as measured by a Zeuzan 300 g dynamometer (São Paulo, Brazil PN: 800 ref. 9031.80.11). The distance in millimeters was also recorded. This procedure was repeated after 30 days for each brand. Quantifying test-retest reliability used the intraclass correlation coefficient (0.954). Each brand yielded ten specific measurements.

Each brand had its own plate as in the pilot study. The steel pins were set 15 mm apart for the Morelli and TP brands, while the Unitek and Ormco brands had a 16 mm distance between them, which corresponds to a stretching force of 150 g.

The names of the manufacturers were engraved on the sides of the plates and the samples were numbered from one to ten. The force magnitude was calibrated by a dynamometer (Zeuzan 300 g) to exert an initial force of 150 g (Fig 3).

All plates were kept immersed in artificial saliva (sodium chloride at 0.067%, natrosol 0.5%, sodium benzoate 0.05%, sorbitol 2.4%, deionized water qsp 100% neutral pH) at 37 °C, inside the incubator model 002 CB (Fanem, São Paulo, Brazil) (Fig 4).

The elastomeric chains were checked at intervals of 30 minutes, 7 days, 14 days and 21 days by the same investigator to ensure consistent handling of the dynamometer. The data were recorded and subjected to repeated measures analysis of variance (ANOVA), followed by Tukey's multiple comparisons test. A 5% confidence interval was adopted ($p \leq 0.05$). For data analysis, the Statistical Package for Social Science (SPSS) version 17.0 for Windows was employed.

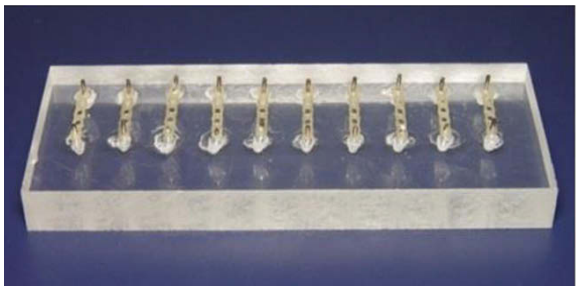

FIGURE 3 - Acrylic resin plate.

FIGURE 4 - Acrylic resin plate immersed in artificial saliva.

RESULTS

Initially, a descriptive analysis of the results was performed to evaluate force decay percentage, mean and standard deviation of each brand delivered force (Table 1).

The TP brand displayed the highest stretching force after 30 minutes (121.5 g), followed by Ormco (114 g), Morelli (112 g) and Unitek (110 g). After 21 days, the TP brand continued to deliver the greatest amount of force (95 g), followed by Morelli (74.5 g), Ormco (72 g) and finally Unitek (64.5 g).

The Unitek product exhibited a higher percentage of force degradation at almost all times, i.e.: 30 minutes= 26.67%; 7 days= 37%; 14 days= 51.67%; 21 days= 57%. The TP product displayed the lowest percentage of force decay: 30 minutes= 19%; 7 days= 29%; 14 days= 31.33%; 21 days= 36.67% (Table 2).

There was a significant difference between the stretching forces generated by the elastics at all time periods ($p<0.05$). The Tukey's HSD test showed that TP elastics delivered the highest delivering force. Ormco and Morelli elastics produced a similar force behavior. At the first two time-periods, the Unitek elastomeric chains delivered an amount of force that was similar to the Morelli and Ormco elastics. However, after 14 and 21 days, it demonstrated a greater force degradation than these two brands (Fig 5 and Table 3).

DISCUSSION

The use of elastomeric chains has been helpful in ensuring successful orthodontic treatment. This study showed that the samples of four brands (Morelli, Ormco, TP and Unitek) showed a force decay delivered during the first 30 minutes of stretching. Thereafter, forces were gradually delivered in a less intense and more stable manner.

The Unitek brand displayed the highest force degradation in almost all time-periods, while

TABLE 1 - Means and standard deviations of stretching forces according to elastomeric chain brands and stretching time.

Elastomeric chains brands	30 min	7 days	14 days	21 days
TP	121.5 ± 6.26	106.5 ± 6.34	103 ± 4.83	95 ± 5.48
Morelli	112 ± 6.32	94 ± 4.9	77.5 ± 6.77	74.5 ± 3.5
Ormco	114 ± 6.58	89.5 ± 9.6	80.5 ± 5.5	72 ± 2.45
Unitek	110 ± 4.08	94.5 ± 4.15	72.5 ± 7.55	64.5 ± 3.5

TABLE 2 - Percentage of force degradation regarding stretching time.

Elastomeric chains brands	30 min	7 days	14 days	21 days
Morelli	25.33%	37.33%	48.33%	50.33%
Ormco	24.00%	40.33%	46.33%	52.00%
TP	19.00%	29.00%	31.33%	36.67%
Unitek	26.67%	37.00%	51.67%	57.00%

TABLE 3 - Analysis of Variance and Tukey's test for intra- and inter-brand comparison of forces delivered at four different time periods.

Elastomeric chains brands	Initial		30 min		7 days		14 days		21 days	
	Diff. Intra. *	Diff. Inter. **	Diff. Intra.*	Diff. Inter. **	Diff. Intra.*	Diff. Inter. **	Diff. Intra.*	Diff. Inter. **	Diff. Intra.*	Diff. Inter. **
Morelli	a	A	b	A	c	A	d	AB	d	A
Ormco	a	A	b	A	c	A	d	B	e	A
TP	a	A	b	B	c	B	c	C	d	B
Unitek	a	A	b	A	c	A	d	A	e	C

*Comparison between different time-periods within the same row. **Comparison of different brands at the same time period within the same column. Same letters denote no significant difference between groups.

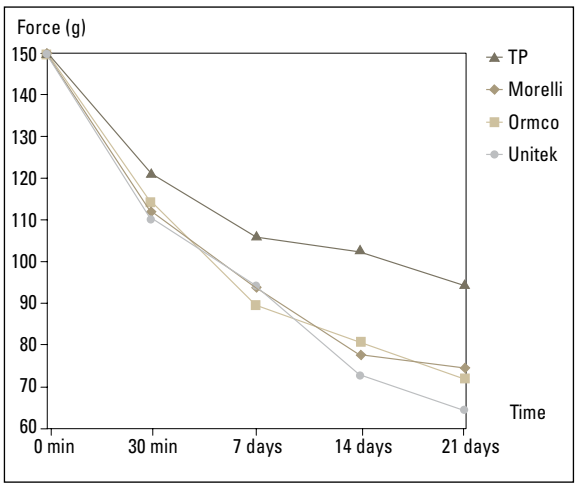

FIGURE 5 - Analysis of mean stress versus time.

the TP brand showed not only a lower percentage but also the highest stretching force when all groups were compared in all time-periods.

It is therefore essential that professionals need to learn about the features of synthetic elastics to better plan the force system to be employed and how to quantify the load. Thus, orthodontic treatment will likely be successful while preserving patients' health and comfort.

Some studies[3,5,6,8,10,13,17] have evaluated force degradation in synthetic elastics during stretching time and observed that the greatest force decay occurred in the first hour of testing, which is in agreement with the results of this

study. The results also demonstrated a greater reduction in the first 30 minutes of experiment for all tested brands.

This study, however, differed from others because a pilot study was conducted to evaluate which stretching distance would yield a force of 150 g in all studied brands. The idea was to eliminate potential differences between the brands, such as:

- Cross-sectional configuration of the elastomeric chain modules.
- Distance between the links of elastomeric chain.
- Quality of the raw materials used for manufacturing chains.
- Thickness of the links of the elastomeric chains.

Thus, all brands had an initial delivered force of 150 g, unlike other studies[6,14] that used a stretching distance of 20 mm, which led to different initial forces for all studied brands.

Other studies[15,16] have found differences in the elastic ligatures properties. Therefore, if a strict quality control is not enforced during manufacture of elastomeric chains, test results may be different.

The samples were kept immersed in artificial saliva at 37 °C to simulate oral conditions. Studies[4,6,8] have shown that the force degradation experienced by synthetic elastic materials is significantly higher when tested in moist conditions than when assessed in dry conditions. Exposure of elastomers to water or saliva weakens intermolecular forces due to water absorption and, consequently, impairs the formation of hydrogen bonds between water molecules and the macromolecules of the polymer.[2,14] Rising temperatures were also considered an aggravating factor in force degradation[8,12] because the elastomeric chains lose their ability to recover their original properties after delivering the stretching forces (strain). In addition, the force decay generated by the phenomenon of relaxation tends to occur over time.

The time intervals were determined based on the activation protocols set between visits, using conventional brackets and considering the physiology of tooth movement. In addition, studies[5,8,19] have demonstrated that elastomeric chains cannot produce constant levels of force over a long period of time. Clinically, in cases where space closure is performed with elastics, the interval between activations is often set at 15 and 21 days.

CONCLUSIONS

This study revealed that the greatest stability was observed in TP elastomeric chains, as they showed a reduced loss of elastic potential in all time-periods. The 3M Unitek elastics showed the highest force decay in most time-periods under study, whereas there was no significant difference between Ormco and Morelli brands.

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Orthodontic-surgical treatment of skeletal facial asymmetry: Case report

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Abstract

Introduction: Facial asymmetries consist of an imbalance between the homologous skeletal structures of the face. Most people present some degree of facial asymmetry, since a state of perfect symmetry is rare. This common asymmetry only becomes relevant when it is perceivable by the patient. In this situation, either orthodontic surgical correction or orthodontic treatment is normally chosen. **Objective:** This study, based on literature review, has been illustrated by a case report comprising Le Fort I orthognathic surgery for maxillary advancement and rotation, with conservative treatment for the mandible. **Conclusion:** Knowledge of the patient's chief complaint and expectations, as well as proper diagnostic exams, are important factors to decide the treatment plan and for the final treatment outcome.

Keywords: Facial asymmetry. Corrective orthodontics. Tooth extraction. Esthetics.

INTRODUCTION

Facial symmetry is a state of balance in which both sides of the face are perfectly related and therefore present the same size, shape and position. Conversely, the term asymmetry is used when there is imbalance between the homologous parts of the dentofacial complex, thereby affecting the proportion between structures.[1]

The facial asymmetry may often be subclinical. In this condition, the skeletal disharmony exists yet it is masked by the overlying soft tissues.[2,3] Thus, the soft tissues superimposed to the bone structures, such as the masseter muscle, may minimize or even compensate an existing skeletal deformity. Therefore, when there is discrepancy between the skeletal measurements and facial appearance, the influence of soft tissues on the facial asymmetries should be considered.[3]

According to some authors,[2,3] the clinical expression of asymmetry only occurs when the bone deviation is at least 4 mm. Below this value, the asymmetry is considered to be subclinical.

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That is to say, human sensitivity to notice facial imbalances occurs more easily if the deformation is closer to or greater than 4 mm. However, the expression of asymmetry or its attenuation depend on individual characteristics, such as the soft tissue thickness over the imbalance region.

Within this context, this study conducted a literature review on the skeletal facial asymmetries, illustrating with a case report of asymmetry involving both the maxilla and the mandible, in which the treatment plan of choice was the association of surgical treatment on the maxilla and conservative treatment for the mandible.

SKELETAL FACIAL ASYMMETRIES

Dentofacial deformities affect approximately 20% of the population, and patients with these discrepancies may present several degrees of functional and esthetic involvement,[4] being classified as isolated mandibular asymmetries or maxillomandibular asymmetries. However, there are no isolated maxillary asymmetries, because a deformed maxilla simultaneously causes mandibular disorders.[5]

The mandibular asymmetries may be caused by excessive or deficient growth of the mandibular body and ramus, or the mandible may be deviated due to asymmetric growth of other structures. These conditions cause mandibular laterognathism, i.e., mandibular deviation to one side of the facial midline.[5] Some studies explain that the higher prevalence of mandibular asymmetries may be related to the longer period of mandibular growth when compared to the maxilla, thus increasing the chances of deviations. Also, the mandible is a mobile bone, while the maxilla is rigidly connected to other bone structures through sutures and synchondroses.[3,6] The condyle is the main growth center of the mandible; for this reason, injuries to this area during the growth period may cause disturbances in mandibular growth.[7,8]

Even though the studies conducted by H. Peck and S. Peck[9] did not reveal significant difference in the side of mandibular deviation, in cases of mandibular skeletal asymmetry, according to Haraguchi et al,[6] the lateral deviation is more common on the lower facial third, and 85% of dentofacial deformities present lateral deviations to the left side, a tendency that is corroborated by other studies.[2,6,10] In addition, Bell, Proffit and White[11] related skeletal asymmetries to Class III malocclusion observing that 40% of these malocclusions cases presented some degree of facial asymmetry.

During the anamnesis, it is important to establish the chief complaint of the patient, identify if the facial imbalance is perceived and if this condition causes discomfort and dissatisfaction. The history of traumas, ankylosis or lesions such as osteochondromas affecting the temporomandibular joint, intra-articular disorders, birth by forceps, condylar fractures, ear infections, inadequate use of orthopedic appliances,[11,13] besides lesions to facial nerves, are possible causes of asymmetries.[12]

During the clinical examination, the extraoral analysis is fundamental in the diagnosis of asymmetries, since analysis of the facial proportions or of the degree of imbalance between the facial thirds and homologous facial structures usually indicates the site of imbalance.[11] Analysis of facial proportions allows evaluation of the harmony between facial thirds, which should have a 1:1 ratio. In the lateral evaluation, if one lip is behind or beyond the Steiner's S line, there may be a disproportion between the maxilla and mandible, consequently causing an imbalance between the facial structures.[11]

In the intraoral examination, dental evaluation in centric relation should include the analysis of dental midlines, their relation to the facial midline, existence of crossbite or inclination of the occlusal plane.[14] If the dental midlines are coincident, a deviation of up to 4 mm to one side of the facial midline may not be detected by laypersons; however, if the crowns of incisors are tipped, deviations above 2 mm may be perceptible.[15,16,17]

The radiographic examination plays an important role in this type of deformity and may aid the orthodontist in defining the site, nature and

magnitude of asymmetry.[13] The posteroanterior radiograph (PA) is a valuable tool to compare structures between the right and left sides of the face.[6] If the dental midlines are coincident and deviated up to nearly 2 mm from the facial midline, this will still be considered a harmonious situation, since the aforementioned degree of deviation is not perceptible to the layperson and may be attenuated by the soft tissues of the face.[3,6,18] The lateral cephalometric radiograph provides information on the anteroposterior component of the deformity.[5]

When the treatment options are mentioned, it is important to evaluate the efficacy of these. In case of skeletal imbalance, in which the professional must decide between surgical or non-surgical treatment, it should be clear the amount of esthetic, dental and facial improvements provided by the selected treatment plan.[13] Even though the surgical correction may be preferable for severe cases and after completion of bone growth, camouflage is a conservative treatment option indicated for correction of mild asymmetries.[16,19,20] The treatment for skeletal asymmetries may comprise an association between conservative treatment and orthognathic surgery.[21,22] Thus, the imbalance may be surgically corrected in one jaw and by dental compensation in the other one. Following the alignment and leveling stage, the final objective is to achieve adequate occlusion with coincidence of maxillary and mandibular midlines.[20]

CASE REPORT

A Caucasian female patient, 17 years and 4 months old, searched for orthodontic treatment with the chief complaint of "crossbite". The patient reported a history without dental and/or skeletal traumas to the facial structures and did not present any systemic alteration or history of previous pathologies.

Diagnosis

The extraoral examination revealed facial asymmetry of the lower facial third, with mandibular skeletal laterognathism to the left side and mild maxillary skeletal laterognathism to the right side. The deficiency in anteroposterior direction in the mid facial third was easily identified by the deep paranasal and infraorbital regions, deep nasogenian grooves, lack of support to the upper lip and thin nasal base. The lower lip was protruded in 4 mm in relation to the S line (Figs 1A-E).

The intraoral examination revealed molar Class III relationship on both sides and canine Class III relationship on the right side and Class I relationship on the left side, as well as absence of third molars and mandibular right first premolar. The maxillary dental midline was dislocated 2 mm to the right side, and the mandibular dental midline was deviated 2.5 mm to the left side. The premature contact caused by the maxillary left central incisor led to a forward mandibular deviation, generating crossbite at the region of maxillary left central and lateral incisors and canine, and left posterior region (Figs 1F-J).

The cephalometric analysis (Figs 3B, 3C and Table 1) presented a skeletal Class III pattern with an important vertical component, as displayed by these cephalometric measures: ANB= -2°, WITTS= -6,5 mm, SN.GoGn= 35° and FMA= 29°. Analysis of the posteroanterior radiograph (Figs 3D, E) revealed mild maxillary deviation of 0.5 mm to the right side and mandibular deviation of 3 mm to the left side. The panoramic radiograph (Fig 3A) revealed the presence of impacted third molars, except for the maxillary right and left third molars, which were absent.

Treatment options

The following treatment options were presented to the patient:

1) Orthodontic treatment associated with combined orthognathic surgery in the maxilla and mandible, with extraction of three premolars, followed by maxillary advancement with rotation to the left side and mandibular rotation to the right side.

FIGURE 1 - Extraoral (**A, B, C, D, E**) and intraoral (**F, G, H, I, J**) initial photographs.

The orthodontic treatment should be finished in Class I molar and canine relationship and dental midlines coincident to each other and to the facial midline.

2) Orthodontic treatment associated to orthognathic surgery only in the maxilla, with extraction of three premolars, followed by maxillary advancement with rotation to the left side. The orthodontic treatment should be finished with Class I molar and canine relationship and the dental midlines coincident to each other, yet deviated to the left side in relation to the facial midline.

Based on the diagnostic data and according to the patient decision, the second treatment plan was performed with maxillary advancement and rotation to the left side. In the mandible the treatment comprised only correction of tooth positioning, thus maintaining the mandibular lateral deviation.

FIGURE 2 - Photograph of initial dental casts.

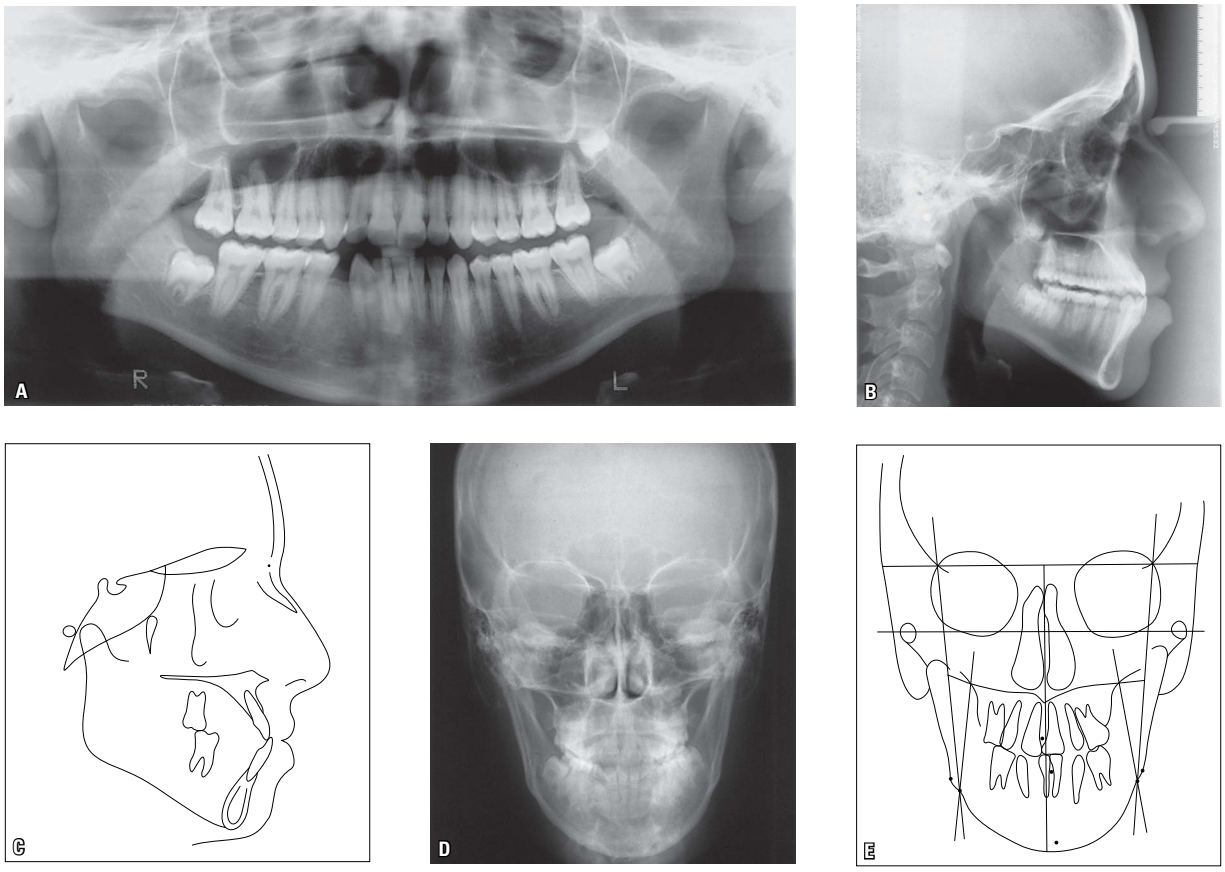

FIGURE 3 - **A)** Initial panoramic radiograph, **B**) initial lateral cephalometric radiograph, **C**) initial cephalometric tracing, **D**) initial posteroanterior radiograph, **E**) initial cephalometric tracing.

TABLE 1 - Summary of cephalometric measurements.

	MEASURES	NORMAL	INITIAL (A)	FINAL (B)
Skeletal pattern	SNA (Steiner)	82°	77°	79°
	SNB (Steiner)	80°	75°	79°
	ANB (Steiner)	2°	- 2°	0°
	Facial conv. angle (Downs)	0°	- 3°	0°
	Y axis (Downs)	59°	62°	60°
	Facial angle (Downs)	87°	85°	86°
	SN-GoGn (Steiner)	32°	35°	35°
	FMA (Tweed)	25°	29°	29°
Dental pattern	IMPA (Tweed)	90°	89°	81°
	1–NA (°) (Steiner)	22°	33°	34°
	1–NA (mm) (Steiner)	4 mm	9.5 mm	7 mm
	1–NB (°) (Steiner)	25°	24°	17°
	1–NB (mm) (Steiner)	4 mm	8 mm	4 mm
	Interincisal angle (Downs)	130°	125°	129°
	LI-to-AP (Ricketts)	1 mm	10 mm	5 mm
Profile	S line - Upper lip (Steiner)	0 mm	- 2 mm	- 2 mm
	S line - Lower lip (Steiner)	0 mm	4 mm	1 mm

Treatment stages

In the maxillary arch, a transpalatal bar with Nance button was anchored on the maxillary second molars, and the mandibular first and second molars were banded. The patient was referred to extraction of the maxillary right second premolar, maxillary left first premolar and mandibular left second premolar. After bonding of Edgewise standard brackets on the other teeth, alignment and leveling were performed using 0.014-in to 0.020-in up to 0.019 x 0.025-in stainless steel archwires. Elastomeric chains were used to retract the premolars and canines mesial to the extraction spaces, for distal movement of the maxillary left central and lateral incisors, and mesial movement of the maxillary right central and lateral incisors until the midline coincided with the center of the maxilla, as well as for distal movement of the mandibular right canine, central and lateral incisors, and for mesial movement of mandibular left central and lateral incisors. The remaining spaces were closed using 0.019 x 0.025-in rectangular archwires with loops. In the immediate preoperative period, the transpalatal bar was removed and a 0.020 x 0.025-in rectangular archwire with hooks was installed.

Subsequent impressions were taken to evaluate the intercuspation and simulate the movement for maxillary advancement and rotation to the left side (Fig 4).

In collaboration with the bucomaxillofacial surgeon, a Le Fort I osteotomy was planned for maxillary advancement and rotation to the left side (Fig 5). One month after surgery, the patient underwent orthodontic detailing and the appliances were removed.

After treatment completion, the dental midlines were coincident to each other, yet deviated to the left side in relation to the facial midline, without compromising esthetic or functional aspects, since the deviation was within the limits that are not noticeable to a layperson.

FIGURE 4 - Preoperative extraoral (**A, B, C, D**) and intraoral (**E, F, G, H, I**) photographs.

FIGURE 5 - Postoperative extraoral photographs.

Regarding function, the patient exhibited lateral and protrusive mandibular movements. Furthermore, the facial profile was more harmonious, considering the improved relationship between the lips (Figs 6, 7 and 8).

The final radiographs demonstrate orthodontic finishing with correct root position and absence of root resorptions. The cephalometric analysis revealed significant changes, presenting a final skeletal Class I pattern (ANB= 0°, WITTS= -4mm) (Fig 9 and Table 1).

DISCUSSION

In an ideal face, all structures of the craniofacial complex at one side should be perfectly equal to the structures on the opposite side.[10] However, even pleasant faces exhibited mild degrees of asymmetry between the two sides, and total symmetry is not a common condition.[13,23,24,25] Even though some studies report a tendency that the left side of the face is dominant,[24,26,27] others state that skeletal facial structures are larger on the right side compared to the left side, with statistically significant difference.[2,6,10,28,29]

FIGURE 6 - Extraoral (**A, B, C, D, E**) and intraoral (**F, G, H, I, J**) final photographs.

FIGURE 7 - Photographs of excursive movements. Canine disocclusion of all teeth during mandibular movements. PROTRUSIVE: **A)** right side view, **B)** frontal view, **C)** left side view. RIGHT LATERAL MOVEMENT: **D)** right side view, **E)** left side view. LEFT LATERAL MOVEMENT: **F)** right side view, **G)** left side view.

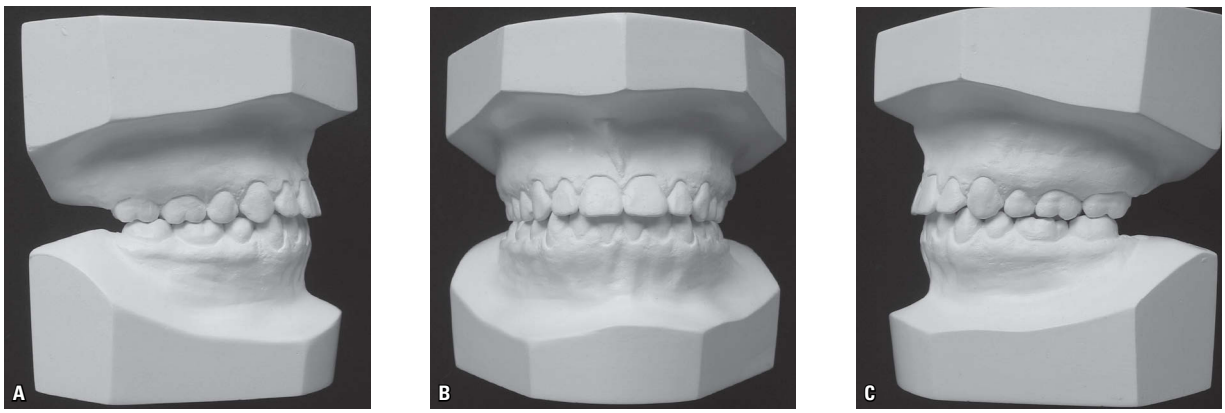

FIGURE 8 - Photographs of final dental casts.

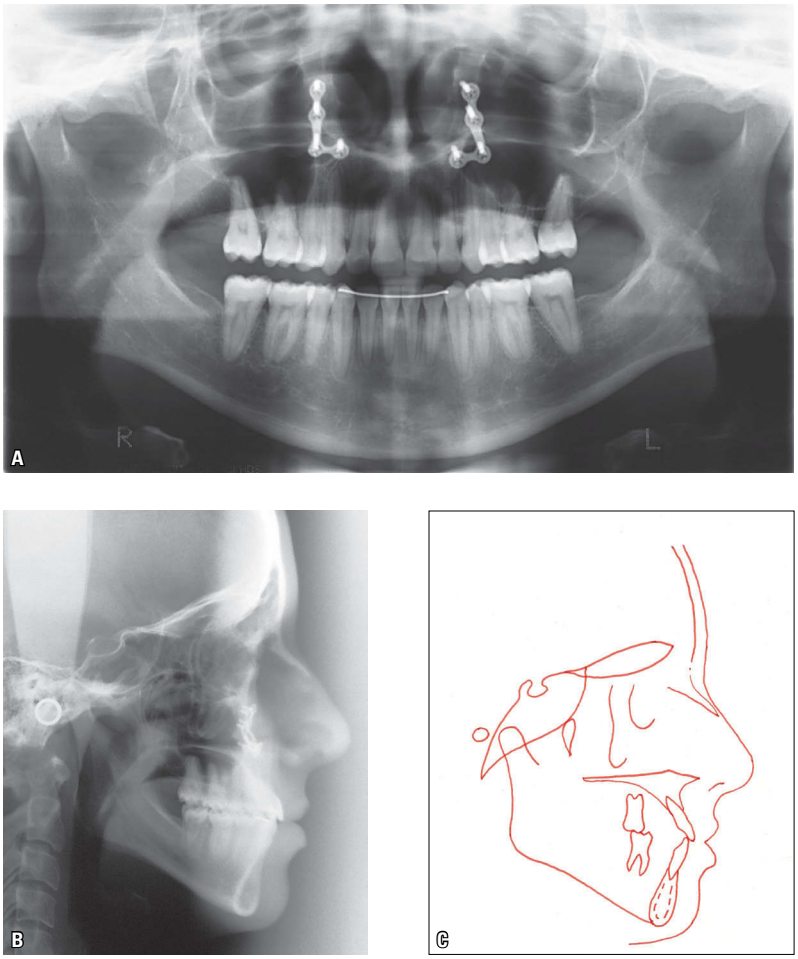

FIGURE 9 - **A)** Final panoramic radiograph, **B)** final lateral cephalometric radiograph, **C)** final cephalometric tracing.

The surgical approach for correction of severe facial skeletal asymmetries is usually the treatment of choice.[21,30] However, milder or developing cases may be treated by less invasive techniques.[16,19,20,22] In the present case, the extent of improvement of facial appearance from correction by orthognathic surgery on both jaws was carefully considered. Thus, considering that the anteroposterior maxillary deficiency had the greatest negative impact on the facial esthetics and that the mandibular lateral deviation was not the main cause of facial imbalance — which could be masked by coinciding the dental midlines —, it was decided to perform surgery on the maxilla associated with conservative treatment in the mandible. Therefore, the surgery comprised maxillary advancement and rotation to the left side and there was the need for extraction of three maxillary premolars and one mandibular premolar, considering that the patient had one mandibular right premolar missing, so that the dental midlines would be coincident to each other, though deviated to the left side. However, there was no esthetic influence on the smile, since when the tipping of incisors is correct, nearly 4 mm is the limit of deviation of the dental midline that is esthetically acceptable for the patient.[15,16,17]

CONCLUSION

By analysis of the treatment outcomes, it may be concluded that the technique employed in the present case, namely surgical treatment in the maxilla associated to conservative therapy in the mandible, allowed successful results. Even though the patient presents mandibular deviation to the left side and deviation of the dental midlines to the left side in relation to the facial midline, the final result exhibited perfect compensation, with pleasant smile and facial esthetics in both frontal and lateral views.

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Collection and culture of stem cells derived from dental pulp of deciduous teeth: Technique and clinical case report

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Abstract

Introduction: Stem cells (SCs) are capable of inducing tissue regeneration and are, therefore, potentially therapeutic. Similarly to bone marrow and umbilical cords, dental pulp is one of the available sources of SCs. The fact that these cells are easily accessible and that deciduous teeth are not vital organs, and are normally discarded after exfoliation, make them particularly attractive for use in safety and viability tests. **Objective:** To describe the collection, isolation and culture of SCs obtained from the pulp of deciduous teeth as well as their characterization by flow cytometry, and the induction of differentiation into osteogenic and adipogenic lineages. **Methods:** SCs were obtained in a relatively straightforward manner and showed good proliferative capacity, even from a small amount of pulp tissue. **Results:** Analysis by flow cytometry confirmed the characteristics of mesenchymal SCs with low expression of CD34 and CD45 antigens, which are markers for hematopoietic cells, and high levels of expression of CD105, CD166, CD90 and CD73 antigens, which are markers for mesenchymal SCs. Cell plasticity was confirmed by identifying calcium deposits in cultures that received osteogenic medium, and intracellular lipid accumulation in adipogenic cultures that received adipogenic medium. **Conclusions:** SCs collected from deciduous teeth show promising potential for application in tissue regeneration. Therefore, it is important that knowledge about the existence and characteristics of this source of stem cells be disseminated among dentists and that the technique, its limitations and possible indications are highlighted and discussed.

Keywords: Stem cells. Tissue therapy. Cell culture techniques. Deciduous teeth.

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INTRODUCTION

Science has taken a keen interest in stem cells (SCs) given their ability to stimulate tissue regeneration, which raises exciting and promising therapeutic prospects.[1-13] This fact makes SCs a viable alternative in dentistry.[14] However, there are still limitations in how they are obtained, grown and controlled in terms of proliferation and differentiation, which encourages the search for new sources, techniques and applications.

SCs can have an embryonic or adult origin.[2,6,15] Adult SCs are present in a wide range of tissues such as the pancreas, bone marrow, adipose tissue and umbilical cord. Because they are obtained from the patients themselves, these cells have the advantages of not triggering immune rejection, responding to growth factors inherent in the host, and not incurring ethical or moral objections.[6] The foundation for cell therapy is the isolation of high quality adult human SCs from different sources as these cells feature peculiar characteristics, and there may be preferred SCs sources for each specific need.[12,16,17]

Recently, it was discovered a new source of SCs deriving from the pulp of deciduous teeth. The fact that these cells are easily accessible and that deciduous teeth are not vital organs, being normally discarded after exfoliation, make them attractive for safety and viability tests. Studies conducted with these cells underscore their outstanding capacity to proliferate and induce tissue regeneration,[12,17,18,19] although limitations still exist regarding the amount of available cells as well as the techniques used for SC collection and culture.[19,20]

Although there is still the need to standardize techniques and to conduct clinical studies in order to determine their potential application, this study aims to disseminate among dentists knowledge about SCs obtained from the pulp of deciduous teeth, discussing the technique, its limitations and possible therapeutic potential through the description of a technique and a clinical case report. This will allow professionals to inform patients and/or their legal guardians that although this is still an experimental technique it shows promise and that this tissue — which is usually discarded — can be collected and cryopreserved for future use.

TECHNIQUE AND CLINICAL CASE REPORT

Tissue collection

An eight-year-old female patient with mixed dentition has been monitored since five years old by an orthodontist and was selected as pulp tissue donor after authorization by her legal guardians. Radiographic and photographic exams were requested and, in conjunction with the orthodontist, teeth 6.3, 7.3, 7.5 and 8.3 were defined as targets as they were in the phase of exfoliation and did not show any carious lesions.

The surgery was performed in two stages with a 15-day interval. The procedure requires strict control of the aseptic chain due to widespread presence of microorganisms in the oral environment. Extraoral asepsis and intraoral prophylaxis were performed and 2% chlorhexidine rinses applied. Next, infiltrating and gingival anesthesia was applied, followed by syndesmotomy and removal of the teeth with a pedodontic forceps as quickly as possible to avoid saliva contamination. Soft tissue remnants were removed and the teeth were immediately placed in individual containers filled with Dulbecco Modified Eagle medium (DMEM, Sigma Chemical Co. St. Louis, Mo, USA) culture medium with 50 mg/ml of gentamicin (Novafarma, Anápolis, Brazil), stored under controlled temperature, between 4 °C and 8 °C, and sent to a laboratory for cell isolation.

Isolation, selection and expansion of mesenchymal SCs

The entire procedure of pulp removal and cell culture was performed in a vertical laminar flow unit. Whenever necessary, access to the pulp chamber was made using diamond discs (KG Sorensen, São Paulo, Brazil) at low speed, under

constant irrigation, and the pulp tissue removed with the aid of curettes and endodontic files. Only a small amount of pulp tissue was obtained. One of the four deciduous teeth extracted no longer contained pulp tissue and the others had a small amount of pulp. Therefore, few cells were availed to begin cultivation. Once collected, the tissue was immediately placed in culture bottles containing DMEM supplemented with 10% fetal bovine serum (SBF, Cultilab, Campinas, Brazil) and stored at 37 °C and 5% CO_2 for cell proliferation and adherence to the bottle. The medium was completely replaced every three days during a period of approximately 10 days, when culture reached about 80-90% confluence. The culture was monitored by means of an inverted optical microscope. After adherence to the plastic surface, SCs initially exhibited an ovoid shape that evolved early during the first 24 hours to a fibroblastoid form, which remained until confluence (Fig 1). As the culture was replaced, the adherent mesenchymal SCs were selected while cells suspended in culture medium were gradually discarded.

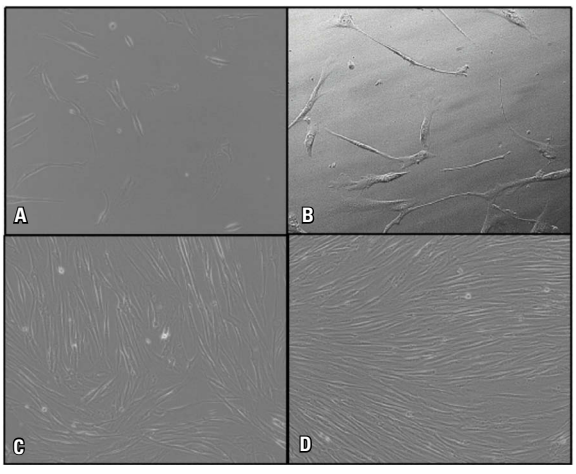

FIGURE 1 - Optical microscopy follow-up of primary culture of SCs derived from deciduous teeth. **A)** Scattered cells still showing a rounded shape. **B)** Cells with fibroblastoid features after 72 hours of culture. **C)** Stabilization of cell morphology and increased proliferation. **D)** Culture with total confluence.

After culture confluence cells were released from the plastic surface to allow the continued proliferation and cryopreservation of part of the cells. To release the cells, the medium was replaced twice with sterile saline solution and, after removing the saline solution, 0.25% trypsin (Invitrogen, São Paulo, Brazil) was added for 2-5 minutes to allow the connections between cells and extracellular matrix to be broken, thereby enabling the detachment of cells from the surface of the plastic culture flask.

After ascertaining that cells had been released through observation with an inverted optical microscope, the enzyme was inactivated by adding a complete medium. The medium of the bottle containing the cells was then collected using a pipette and centrifuged at 1500 rpm for 10 minutes. The supernatant was discarded and the cell pellet resuspended in 1 mL of DMEM supplemented with 10% fetal bovine serum (SBF). At this point, some of the cells were set aside for cryopreservation in liquid nitrogen for further studies and potential therapeutic uses, while the remaining was used for continuity of culture, allowing *in vitro* characterization.

For cryopreservation, the maximum concentration of 10^6–10^7 cells per tube was observed, with a final volume of 1 mL being added, i.e., 900 µL of complete medium containing cells and 100 µL of dimethyl sulfoxide (DMSO). Cryopreservation tubes had their cryostatic temperature lowered, ranging from 4 to –80 °C for 24 h, with subsequent storage in liquid nitrogen.

Characterization of mesenchymal SCs

Cell characterization was performed by analysis of flow cytometry and confirmation of cell plasticity through the induction of differentiation into osteogenic and adipogenic lineages.

Flow cytometry

The sample cells were labeled with specific monoclonal antibodies linked to fluorochromes. Reading was performed in a flow cytometer.

The following antibodies were used: FITC anti-human CD90, APC anti-human CD45, PE anti-human CD166, PE anti-human CD73 (BD Pharmingen), PE anti-human CD34 (Becton Dickinson) and FITC anti-human CD105 (R&D Systems).

Cells with less than 100% confluence were trypsinized as described before. Immediately after detachment, cells were resuspended in DMEM supplemented with 10% SBF and remained at rest in the oven for 2 hours. After the rest period, the cells were washed twice with saline at 4 °C, at 3000 rpm for 2 minutes at 10 °C and resuspended in 1 mL of saline solution. Two-hundred µL of the solution were placed in tubes which received 2 µL of antibodies. The tubes were incubated at 4 °C in the dark for 30 minutes and washed twice with saline at 4 °C (1 mL) by centrifugation at 2000 rpm, 10 °C for 2 minutes. After this procedure, CellQuest software was used for data acquisition and analysis with a FACSCalibur flow cytometer (Becton Dickinson, San Diego, CA, USA). At least 50,000 events were collected and analyzed.

Results confirmed the characteristics of mesenchymal SCs (Table 1) with low level expression of CD34 and CD45 antigens, which are markers for hematopoietic cells, and high levels of expression of CD105, CD166, CD90 and CD73 antigens, which are markers for mesenchymal SCs.[20]

TABLE 1 - Analysis by flow cytometry of SCs collected from deciduous teeth. Percentage of cells positive for CD90, CD73, CD34, CD45, CD166 and CD105 in the total population.

MARKERS	CYTOMETRY
CD 90	99.92%
CD 73	99.95%
CD 34	0.08%
CD 45	2.4%
CD 166	96.8%
CD 105	97%

Osteogenic differentiation

The cells were cultivated in a 24-well plate in DMEM supplemented with 10% fetal bovine serum for two days until 50% confluence was reached. From this point on, osteogenesis inducing medium was employed, which is composed of: DMEM containing 10% fetal bovine serum, 100 nM dexamethasone, 0.05 mM of L-ascorbic acid 2-phosphate and 10 mM of β-glycerophosphate (Sigma-Aldrich, USA). Culture time was 21 days. Control group cells were grown in DMEM supplemented with 10% fetal bovine serum. The experiments were conducted in triplicate, culture medium was changed every three days and the evolution of differentiation was monitored daily by optical microscopy.

Osteogenic differentiation capacity was verified by alizarin red staining, which identifies the deposition of calcium in the culture. After 21 days of cultivation, the cultures were washed with PBS, fixed with 4% paraformaldehyde (Electron Microscopy Sciences, USA) for 30 minutes, washed twice with distilled water, and 2% alizarin red staining was applied (Sigma–Aldrich, USA) for three minutes. After removing the alizarin, the cultures were washed three times with distilled water to remove residue and the stained areas were analyzed with optical microscopy to confirm color and quality evaluation.

In all cultures that received osteogenic medium, red calcium deposition was found due to staining with alizarin, whereas in the negative control group calcium deposits were not found in any of the wells, confirming the plasticity of the cultured cells (Fig 2).

Adipogenic differentiation

The cells were cultivated in a 6-well plate in DMEM supplemented with 10% fetal bovine serum until 100% confluence was reached. They were then stimulated for up to three weeks with modified DMEM containing: 10% fetal bovine serum, 60 µM of indomethacin (Sigma–Aldrich),

0.5 µM of isobutylmethylxanthine (Sigma–Aldrich) and 0.5 µM hydrocortisone (Sigma–Aldrich). Throughout the experiments a control group was maintained cultivated in DMEM supplemented with 10% fetal bovine serum. The culture medium was replaced every three days.

The evolution of differentiation was monitored daily under an inverted microscope. To allow observation of fat deposition the wells were washed with PBS, cells were fixed with 4% PFA for 1 hour at room temperature, stained with Oil Red solution (Sigma–Aldrich) (3 volumes of 3.75% Oil Red O in isopropanol and 3 volumes of distilled water) for 5 minutes and washed with distilled water to remove residue.

After 14 days intracellular lipid accumulation was found in the culture, confirming the plasticity of the cultured cells (Fig 3), whereas in the negative control group droplets were not found in any of the wells.

DISCUSSION

The scientific community has conducted research that underscores the importance and prospects of therapy with SCs in several areas, such as medullary damage,[2,3] neurological changes, such as in Parkinson's[8] and Alzheimer's diseases,[21] autoimmune diseases such as diabetes type 1,[5,15] liver diseases,[13] kidney damage,[7] and retina degeneration.[22] In some cases, such as coronary heart disease, consistent clinical results have already been found,[9,10] indicating SCs' safety and viability.

In dentistry, experiments have focused on the use of cell therapy in oral tissue regeneration[12,14,23] and on the collection, isolation, culture and characterization of SCs derived from the pulp of teeth.[16-19,24] Some studies indicate that the SCs obtained from deciduous teeth have greater regenerative and proliferative potential when compared to permanent teeth,[16,17,19] besides being more easily accessible. Furthermore, deciduous teeth are not vi-

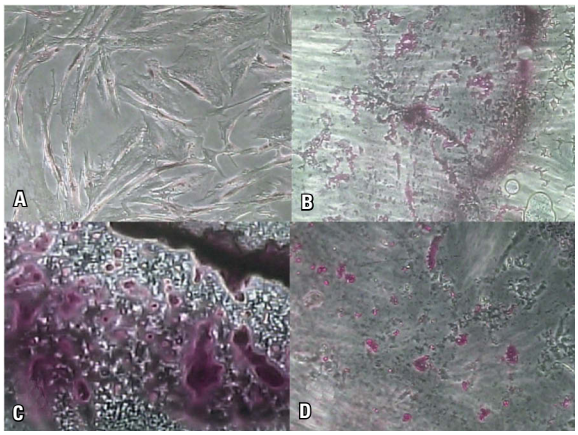

FIGURE 2 - Induction of differentiation of SCs collected from deciduous teeth cultured with osteogenic medium. Analysis by optical microscopy of calcium deposits stained with alizarin red after 21 days of culture. **A)** Negative control with DMEM, with no calcium deposits. **B-D)** Cell differentiation in osteogenic induction medium, confirmed by presence of calcium deposits stained with alizarin red.

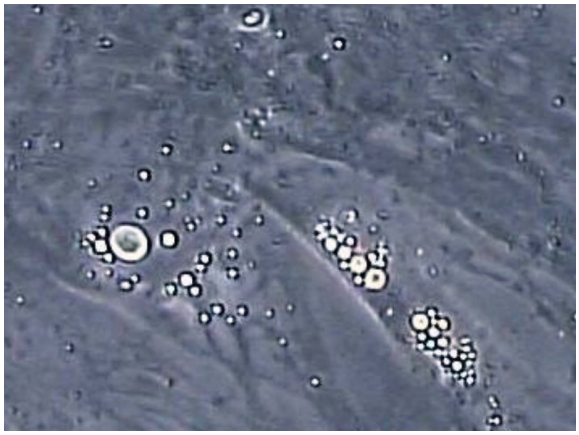

FIGURE 3 - Induction of differentiation of SCs collected from deciduous teeth cultured with adipogenic medium. Analysis by optical microscopy of intracellular lipid accumulation after 14 days of culture, confirming differentiation.

tal organs and are usually disposed after exfoliation. It is conjectured that SCs from different sources may have different characteristics and therefore specific indications for therapeutic application.

Exfoliation of deciduous teeth, however, is one of the factors hindering their use as it limits the time during which deciduous teeth remain available, i.e., from 6 to about 12 years of age.[25] This hurdle can be circumvented by informing the patient's legal guardian that tissue can be collected during the exfoliation period while the cells can be cultivated and kept by cryopreservation in liquid nitrogen. This technique is well established and described in the literature, and allows the maintenance of SC characteristics.[26,27]

There have been recent attempts at cryopreservation of dental pulp, or even of the whole tooth — instead of just SCs — with the purpose of thawing and growing them at a later date.[28,29] Once proved that these cells do not change with time, either in quality or quantity in this process of tissue (not SCs) cryopreservation, storage would be simpler and cheaper as lab cultures would only be performed when the use of cells is indicated, thereby saving time, reagents and personnel, requiring a simpler laboratory structure.

In this study, the technique for collecting and cultivating SCs obtained from deciduous teeth proved to be relatively simple and fast. However, there was only a small amount of pulp tissue to start the cell culture. This condition can pose an obstacle to the effective therapeutic use of SCs since a longer time may be required for cell culture and divisions, which can lead to changes in the characteristics of these cells.[20] Thus, an alternative solution to this shortcoming would be to request the evaluation and monitoring of patients with mixed dentition by an orthodontist, who would indicate a greater number of tooth extractions without interfering with the normal development of dentition.

Another problem to be avoided given the characteristics of the oral environment is the risk of contamination of cultures by microorganisms.[28,29] In addition to the typically careful handling

inherent in cell culture techniques, it is necessary to observe criteria such as absence of extensive carious lesions in the selected teeth, control of the aseptic chain during surgical procedure, and preventing that the pulp from the removed deciduous teeth has contact with oral fluids. Selected teeth should be in an advanced stage of root resorption, but with intact junctional epithelium to avert prior contamination of the pulp tissue.

The American Academy of Pediatric Dentistry recently published a text[30] advising dentists to monitor the progress of investigations published about SCs collected from deciduous teeth so they can educate parents about the collection, cultivation, preservation and potential uses of these cells.

CONCLUSIONS

The technique for collecting and cultivating SCs obtained from deciduous teeth proved to be relatively simple and fast. Although very promising, the use of these cells is not yet suitable for everyday clinical use. Therefore, further *in vitro* and *in vivo* experiments and clinical studies are necessary to confirm SCs safety and viability. Nevertheless, this finding should be disseminated among dentists in order to make them aware of the potential of cell therapy and allow them to inform their patients and/or legal guardians about this source of stem cells, since tissue from deciduous teeth is only available for a short period of time.

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Angle Class I malocclusion with bimaxillary dental protrusion and missing mandibular first molars*

Aldino Puppin Filho**

Abstract

This case report describes the orthodontic treatment of a 24-year-old patient presenting with Angle Class I malocclusion, bimaxillary dental protrusion and recent loss of mandibular molars. Treatment involved extraction of the maxillary first premolars and closing of mandibular first molar spaces. Treatment outcomes demonstrate the need for individualized treatment planning and highlight the key role played by biomechanical concepts in achieving proper orthodontic tooth movement. This case was presented to the Brazilian Board of Orthodontics and Facial Orthopedics (BBO) as representative of the free choice category in partial fulfillment of the requirements for obtaining the BBO Diploma.

Keywords: Angle Class I malocclusion. Corrective orthodontics. Biomechanics. Orthodontic space closure.

HISTORY AND ETIOLOGY

Female Caucasian patient aged 24 years showed good overall health, moderate history of caries, adequate restorations, periodontal health and recent loss of lower molars.

Her chief complaint concerned the possibility of closing the spaces left by the missing teeth. When asked about her facial appearance, she reported that she looked "toothy".

DIAGNOSIS

Analysis and evaluation of the data obtained in the clinical examination, with the aid of other diagnostic elements (extra- and intraoral photos; panoramic and periapical lateral cephalometric radiographs; and plaster models), revealed that the patient had a convex profile, lip incompetence, and protrusion of upper and lower lips (UL-S line=2 mm and LL-S line=3 mm).

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

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The anteroinferior face height appeared slightly increased and, based on height, the smile was classified as average.[1] In the transverse plane, the face was considered symmetrical (Fig 1 and Table 1).

From a dental point of view, as can also be seen in Figure 1, given that the lower first molars were missing, the patient was classified as presenting with an Angle Class I malocclusion, in view of the relationship between canines. The anterior region featured normal overjet and overbite with upper and lower midlines that coincided with each other and with the sagittal plane. As can be seen in Table 1, the upper and lower incisors were sharply inclined and protruded (1-NA= 30° and 7.5 mm; 1-NB= 37° and 12 mm; IMPA= 103.5°).

She had a Class II skeletal pattern (ANB=5.5°) with the mandible showing a slight tendency toward clockwise rotation (SN-GoGn=34.5°, FMA=28° and Y axis=61°).

FIGURE 1 - Initial facial and intraoral photographs.

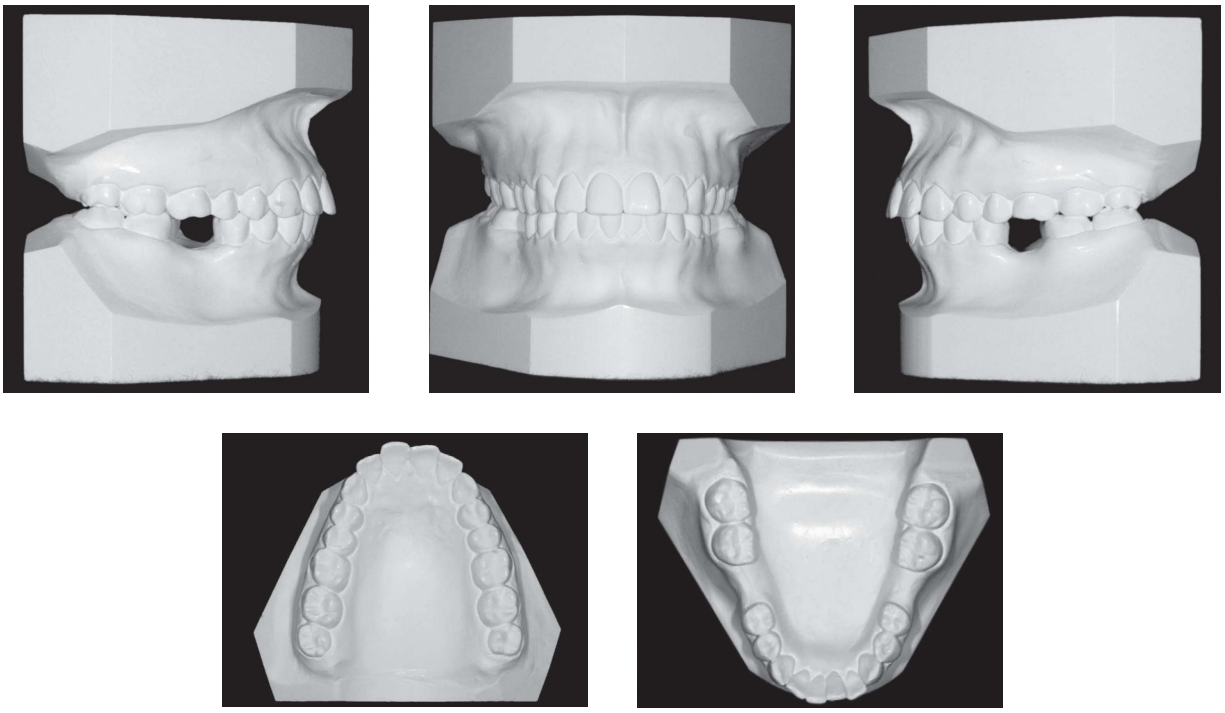

FIGURE 2 - Initial models.

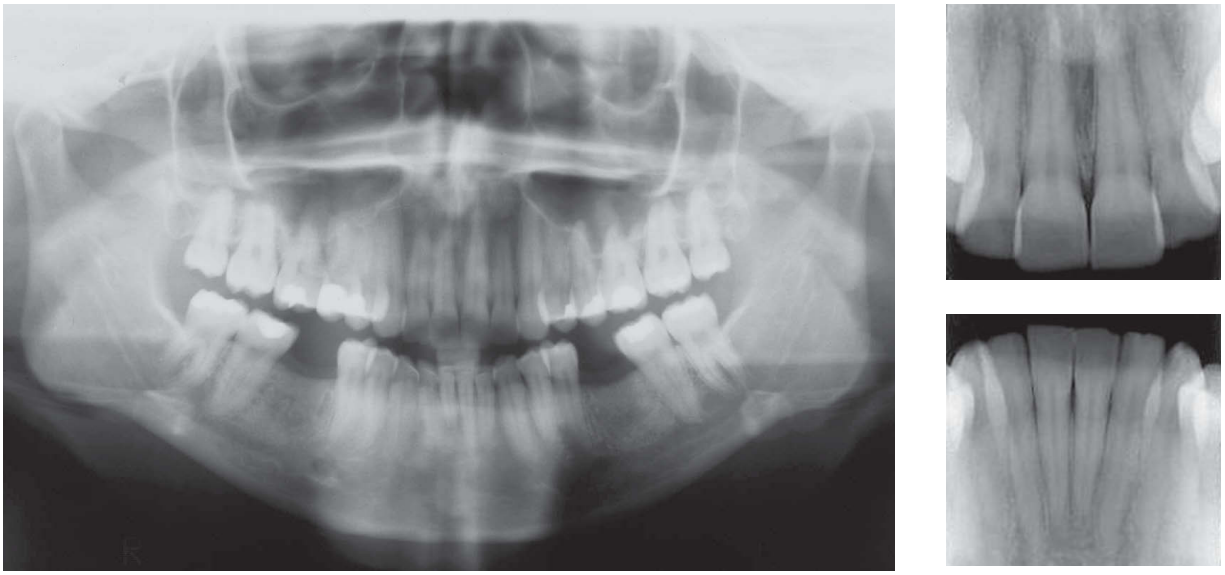

FIGURE 3 - Initial panoramic and periapical (incisors) radiographs.

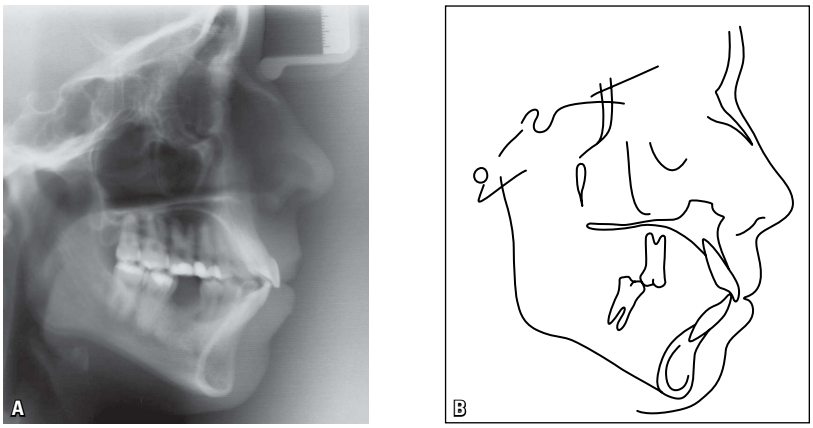

FIGURE 4 - Initial lateral cephalogram (**A**) and cephalometric tracing (**B**).

TREATMENT GOALS

Treatment goals were set based on the characteristics of the case and the desires of the patient in seeking orthodontic treatment. Since there was no significant skeletal compromise, the treatment goals were focused on reducing upper and lower incisor protrusion and closing the spaces created by the missing first molars. Thus, a normal canine occlusion would be preserved while molars would assume a Class II relationship.

As regards facial appearance, the goals would be to reduce lip protrusion, imparting balance and harmony to the relationship between nose, lips and chin.

TREATMENT PLANNING

To attain the set goals, all teeth in the upper and lower arches — including third molars — would have to be aligned and leveled using the Straight-Wire technique.

To allow the retraction of the upper teeth, extraction of the first upper premolars (teeth #14 and #24) was indicated, whereas for mandibular retraction the spaces created by the missing first molar would be utilized.

The use of mini-implants was originally planned for anchorage control in the upper arch. However, given that this hypothesis was rejected by the patient, a removable transpalatal arch was indicated in combination with headgear attached to the first molars. Additionally, planning comprised canine distalization followed by incisor retraction. In the lower arch, no anchorage control strategy was adopted.

In order to avert the tendency of lower molars to tip mesially during space closure, the force action line was designed to operate as close as possible to the center of resistance of the teeth with the aid of a power arm seated on the auxiliary tube of the second molars, along with large Gurin® auxiliaries (Morelli, Sorocaba/SP, Brazil) attached to a rectangular 0.019 x 0.025-in stainless steel archwire, where elastomeric chains would be attached to close the space.

In like manner, two large Gurin® auxiliaries attached to a rectangular 0.019 x 0.025-in stainless steel archwire on the distal side of the incisors — where the elastomeric chains would be inserted — would be used for torque control of the upper incisors during retraction.

In the retention phase, a straight wire wrap-around Hawley retainer was designed for the upper arch, and a fixed canine-to-canine stainless steel lingual retainer would be bonded in the lower arch.

TREATMENT PROGRESS

A Straight-Wire, slot 0.022 x 0.030-in appliance was used, with the exception of the first upper molars, which were banded and had auxiliary attachments welded to the buccal and palatal surfaces. All other auxiliaries were bonded directly to the buccal surfaces of the teeth.

The upper and lower arches were then aligned and leveled using straight 0.012-in, 0.014-in and 0.016-in nickel-titanium wires and 0.018-in, 0.020-in and 0.019 x 0.025-in stainless steel wires.

In the upper arch, subsequently to the use of 0.020-in archwires, the patient had teeth #14 and #24 extracted. As a result, a transpalatal arch fabricated with 0.9 mm stainless steel wire was placed and the use of headgear began with parietal traction and a force of approximately 150 to 200 g on each side.

After the extractions had been completed, distal movement of the upper canines was begun along with the *en masse* retraction of the lower teeth. In both the upper and lower arch forces were applied by means of elastomeric chains, which were replaced every four to six weeks. The initial force delivered to each canine by the elastomeric chains reached 100 g in the upper arch and approximately 200 g on each side of the lower arch.

It is noteworthy that in the upper arch, while the canines were undergoing distal movement, omega loops were placed close to the first molar tubes. After this phase, 0.019 x 0.025-in stainless steel archwires were inserted with large Gurin® auxiliaries attached to the distal region of the lateral incisors to retract the upper incisors. The elastomeric chains, which were the actual source of orthodontic forces, were attached to the first molars and the Gurin® auxiliaries. The force applied to each side was around 150 g. The elastomeric chains were also replaced every four to six weeks.

In the finishing and detailing phase, after all spaces had been closed, the transpalatal arch was removed and headgear use suspended to allow proper dental arch coordination. A panoramic radiograph was requested to evaluate the angulation of all teeth, which determined the need to rebond some of the brackets. To attain the final results, first, second and third order bends were placed and customized according to individual need. The use of intermaxillary elastics was also indicated with a view to improving intercuspation.

After removing the fixed appliance, retainers were installed. A straight wire wraparound Hawley retainer was used in the upper arch, and a fixed canine-to-canine stainless steel lingual retainer was bonded to the lower arch.

TREATMENT RESULTS

Comparison between the initial and final patient examinations demonstrates that the results were consistent with the proposed objectives.

Facial appearance improved as well as lip posture, as viewed in frontal and lateral extraoral photographs. A reduction of lip protrusion determined an excellent nose-lip-menton relationship. As a result, the patient now features effortless lip competence with a pleasant and balanced smile (Figs 1 and 5).

Retraction of the anterior teeth reduced the protrusion of upper and lower teeth (Table 1). Thus, a normal canine occlusion was preserved while molars assumed a Class II relationship. In the transverse plane, despite small midline deviations, the arches were well coordinated. Overbite and overjet remained appropriate (Figs 5 and 6).

The patient cooperated successfully by wearing the headgear along with the removable transpalatal arch, which proved effective in preserving anchorage (Fig 9). Apparently, distal movement of the upper canines was also important as it diminished the need for anchorage. On the other hand, however, there was an

increase in treatment time (which lasted a total of two years and seven months).

The spaces created by lower molar extractions performed prior to treatment were completely closed, with good root parallelism (Fig 7). As a result of having been moved mesially, the lower first molars seem to have assumed a lower position in the occlusal plane and this determined a slight mandibular counterclockwise rotation, which contributed to reducing facial convexity. The use of parietal traction headgear may also have contributed to preventing upper molar extrusion. The results achieved in this case corroborate some reports in the literature[2] (Fig 9).

FIGURE 5 - Final facial and intraoral photographs.

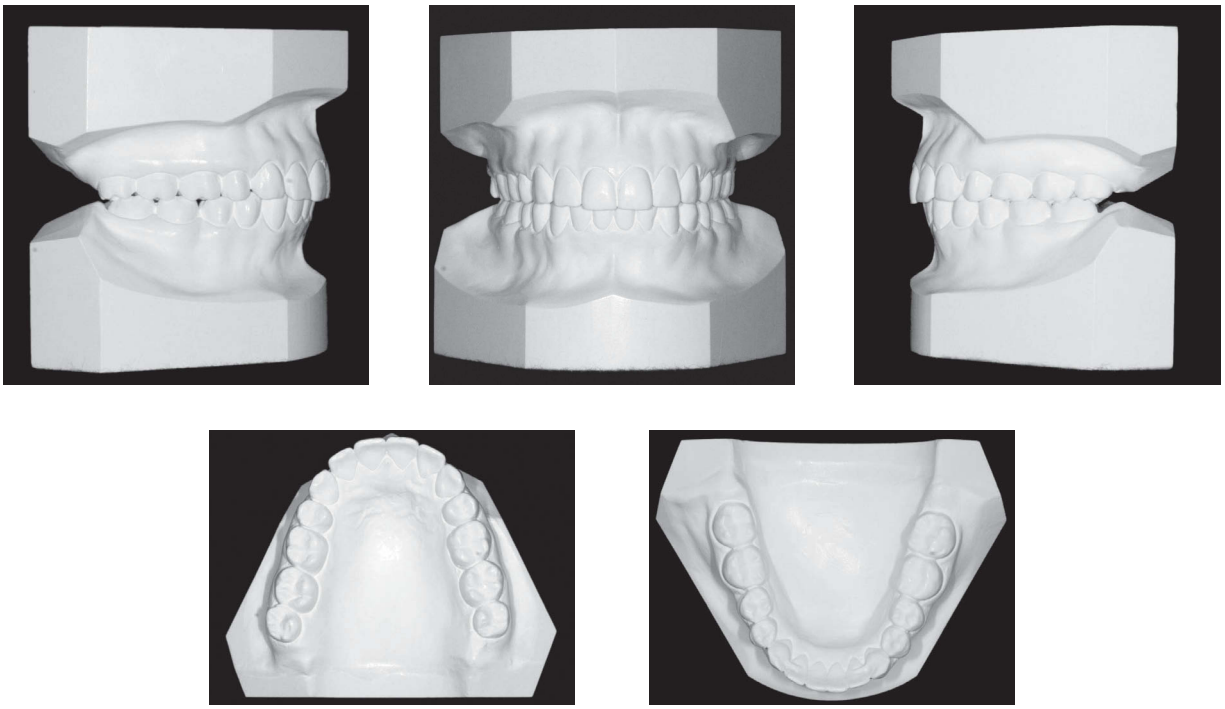

FIGURE 6 - Final models.

FIGURE 7 - Final panoramic and periapical (incisors) radiographs.

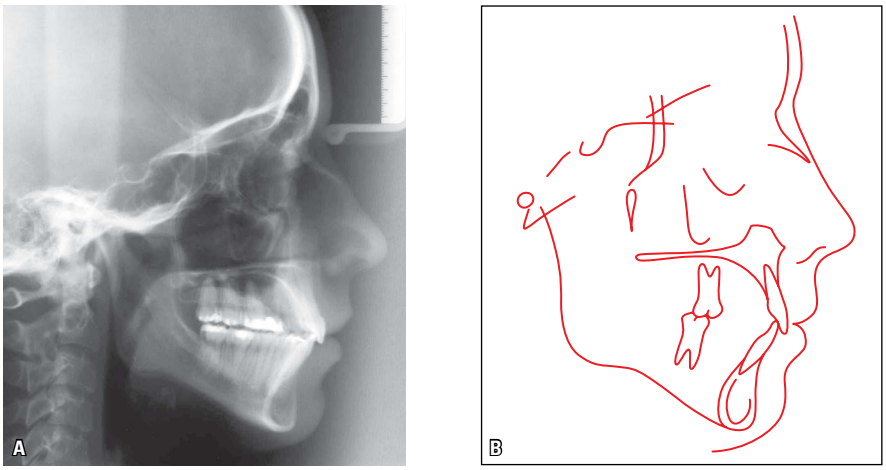

FIGURE 8 - Final lateral cephalogram (**A**) and cephalometric tracing (**B**).

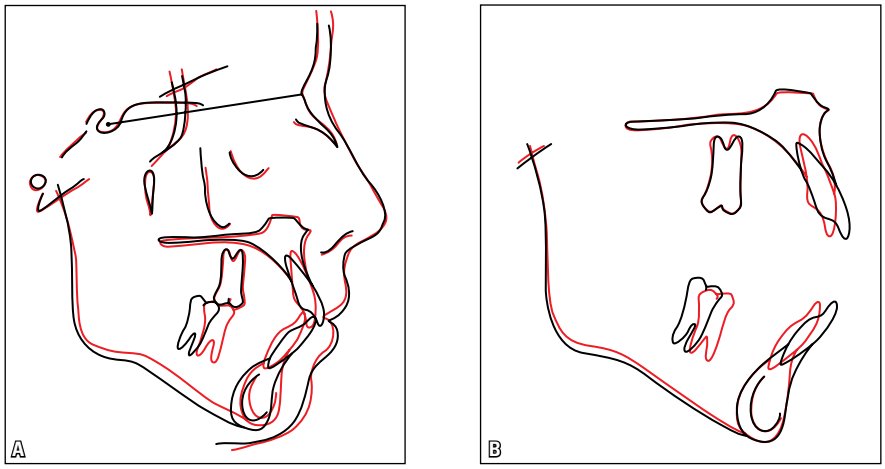

FIGURE 9 - Total and partial superimposition of initial (black) and final (red) cephalometric tracings.

TABLE 1 - Summary of cephalometric measurements.

	MEASURES	Normal	A	B	A/B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	81°	80.5°	0.5
	SNB (Steiner)	80°	75.5°	76°	0.5
	ANB (Steiner)	2°	5.5°	4.5°	1
	Convexity angle (Downs)	0°	10°	8°	2
	Y axis Angle (Downs)	59°	61°	60°	1
	Facial angle (Downs)	87°	85.5°	87°	1.5
	SN–GoGn (Steiner)	32°	34.5°	33°	1.5
	FMA (Tweed)	25°	28°	25°	3
Dental pattern	IMPA (Tweed)	90°	103.5°	99°	4.5
	$\underline{1}$ – NA (degrees) (Steiner)	22°	30°	15°	15
	$\underline{1}$ – NA (mm) (Steiner)	4 mm	7.5 mm	4.5 mm	3
	$\overline{1}$ – NB (degrees) (Steiner)	25°	37°	29°	8
	$\overline{1}$ – NB (mm) (Steiner)	4 mm	12 mm	7 mm	5
	$\frac{1}{1}$ – Interincisal angle (Downs)	130°	109°	130°	21
	$\overline{1}$ – APo (mm) (Ricketts)	1 mm	9 mm	3.5 mm	5.5
Profile	Upper lip – S line (Steiner)	0 mm	-2 mm	0 mm	2
	Lower lip – S line (Steiner)	0 mm	3 mm	1 mm	2

FINAL CONSIDERATIONS

A classic treatment strategy is adopted by most graduate orthodontics courses to tackle Angle Class I malocclusion with dental bimaxillary protrusion. This approach is taught since the initial stages of orthodontic training. It consists in indicating the extraction of the four first premolars.[3]

Choice of these teeth is usually due to their position close to the problem site. Importantly, however, common sense might suggest that the amount of space available for retraction of anterior teeth varies according to the tooth to be extracted, i.e., as a rule of thumb, the more distal the tooth, the greater the loss of anchorage and the lower the retraction.

The literature comprises estimates of anchorage loss, which is quantified as one third of the space in the case of first premolar extraction[4], and half the space when mandibular second premolars are extracted.[5] The maximum potential

retraction achieved comparing first and second premolar, and molar extraction, has been estimated at 5 mm, 3 mm and 2 mm[6], respectively.

In this clinical case, one particular factor interfered with the classic treatment plan: The patient had recently lost the first lower molars, thereby rendering impossible the extraction of two more teeth in the lower arch.

Once again, common sense might suggest that closing the spaces created by first molars would not be effective in reducing the protrusion of anterior teeth. However, the results clashed this hypothesis as they clearly demonstrate that the spaces created by extracting the first molars allowed proper retraction of anterior teeth with convenient protrusion correction. This is clearly depicted in the patient's photographs and cephalometric superimpositions. It also emerges from a comparison between the initial and final cephalometric measurements, with particular focus on the reduction of 8° and 5 mm in measure 1-NB (Figs 1, 5 and 9, and Table 1).

It is noteworthy that the upper dental arch seems to behave according to common sense, i.e., the more distally the extracted tooth is positioned, the less possibility of retraction, thereby underscoring the importance of implementing procedures for anchorage control.

The results obtained in this clinical case set the stage for new strategies in the treatment of cases that involve indication of extraction of permanent teeth. Should the first premolars always be the first option? Shouldn't the general condition of the tooth (extent of injury, malformation, endodontic treatment, etc.) be a major assessment factor? In addition, one should consider the use of mini-implants, which further expand the ability to indicate tooth extractions.

In cases where molar extractions are indicated the potential uses of third molars should be explored. However, many patients who seek treatment have missing third molars even without clinical indication. A change in this approach would be welcome. Moreover, that information should be passed on to dentists and other dental specialists.

Another important point to consider is the mechanics used in closing first molar spaces. Forces applied directly to orthodontic auxiliaries bonded to second molar crowns would unfailingly determine the mesial angulation of these teeth since the force action line would pass away from the centers of resistance of these teeth, located approximately in the furcation area. It is an often overlooked or neglected basic mechanical concept[7] because this area is inaccessible to the placement of orthodontic attachments. The indication of a power arm on the second molar auxiliary tube along with the use of large Gurin® auxiliaries helped to overcome this limitation and allowed the bodily movement of molars during space closure. Power arms are not a new concept as they were recommended by Andrews[8] when he first introduced his Straight-Wire appliance, for cases involving extractions. It should be noted, however, that it is not necessary to purchase ready-made power arms. Certain orthodontic auxiliaries are available on the market — such as large Gurins®, crossed tubes and auxiliary tubes — which when properly indicated allow movements consistent with the biomechanics.

Such considerations lead to the logical conclusion that successful treatment results presuppose a correct diagnosis and compliance with the biomechanical principles underlying tooth movement. However, above all, they presuppose the implementation of individualized treatment plans capable of affording specific approaches to different needs.

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Molar extractions in orthodontics

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Diego Júnior Silva Santos***, Michelle Machado Leser****

Abstract

Orthodontic treatment with extraction of molars in adult patients is technically more complex due to a number of factors. In general, the space to be closed is greater than premolar spaces rendering critical anchorage and longer treatment time. Often such cases exhibit some degree of periodontal involvement due to patient age. Hence, the need for greater control over orthodontic mechanics to reduce the side effects of space closure. Therefore, good finishing results can be more difficult to achieve. Thus, the purpose of this article is to determine the reasons for molar extraction indications, describe different stages of orthodontic mechanics, and explain the issues involved in this kind of planning and treatment. Additionally, it aims at describing some treatments with molar extractions.

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

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INTRODUCTION

Nowadays, a significant number of adult patients seek orthodontic treatment. These patients often present with some degree of dental involvement, including the absence of one or more molars.

In cases involving lack of space for tooth alignment, protruding teeth or intra-arch asymmetry, where extraction of permanent teeth is indicated, impaired molars may become the first extraction option when premolars are in better condition.

Orthodontic treatment with first molar extraction in adult patients is technically more complex and a positive outcome may prove harder to be achieved because there is more space to be closed, anchorage is critical and besides these patients usually have some degree of periodontal involvement. Furthermore, treatment takes longer and requires greater control of orthodontic mechanics to reduce the side effects of space closure.

Second molar extraction aiming at creating space for first molar distalization is a viable alternative that should be considered in correcting Angle Class II malocclusion. It may also be indicated in some cases of third molar impaction.

Third molar extractions are indicated for several reasons, with impaction emerging as the most common. Impaction stems from a scarcity of space in the dental arches or an inadequate axis of eruption.

This article seeks to present the manifold reasons for extracting molars in orthodontic treatment and clarify the issues involved in this type of planning and treatment.

EXTRACTION OF FIRST PERMANENT MOLARS

Indications

Extraction of first permanent molars for orthodontic purposes is indicated in the presence of excessively extruded molars endodontically treated, with caries and/or extensive restorations, with marked periodontal involvement; and in orthodontically retreated cases presenting with Angle Class II malocclusion in the absence of four premolars. Molar extractions are also indicated in severe crowding in patients with a high mandibular plane angle and convex profile as the mesialization of posterior teeth facilitates the counterclockwise rotation of the mandible and helps in cases where molars are missing from the outset.[1-4]

Contraindications

Given the complexity of orthodontic treatment involving extraction of first permanent molars, some situations must be avoided in order to prevent treatment prognosis from becoming limitated. These extractions are not indicated for patients who do not present with crowding and feature a decreased lower face height. It may be better to align the upper and lower teeth and prepare them for the use of dentures, implants or transplants in the extraction sites. Neither are these extractions indicated in noncompliant patients — due to a lengthy treatment time — or in patients who have already undergone previous orthodontic treatment and present with root resorption and/or short roots. In patients with bruxism, molar extractions should be avoided due to occlusal interferences that occur during space closure, causing an overload of forces on posterior teeth.[1-4]

Diagnosis and planning

In the diagnostic phase, first molars need to be assessed with respect to their individual clinical condition and all restorative, periodontal and periapical issues should be addressed. In some cases, clinicians may detect problems that lead to the unilateral decision to remove the corresponding tooth on the opposite side of the arch, even if it is healthy.

In cases where a first molar extraction is indicated, the presence of third molars in the dental

arch is of paramount importance, or at least there should be a high likelihood of eruption of third molars in the dental arches.

The size and anatomy of second and third molar roots must also be adequate as they undergo substantial movement and short roots may hinder this procedure.

In patients with increased lower face or severe crowding, if one or more first molars have poor prognosis, extraction of all first molars may be considered. When planning extractions, one should assess whether one or both first molars should be extracted. Treatment mechanics can also benefit from upper first molar extraction. If the upper first molars need to be extracted it is sometimes possible to avoid the extraction of lower first molars. The unilateral extraction of a first molar may cause midline shift during space closure. The loss of a premolar or molar on the opposite side helps to preserve the midlines.

In cases where the second molar has not erupted, the right time for first molar extraction can be defined in accordance with the need for space utilization. The sooner the first molar is extracted, the more challenging will be the repositioning of the second molar in order to occupy that space. If the space needs to be utilized it is advisable to wait for the eruption of the second molar. If the first molars are extracted after eruption of the second molars, as indicated by orthodontic treatment, it is necessary to ensure the anchorage of this tooth, place the orthodontic appliance and immediately start the movement to close space. This averts tip, rotation of teeth adjacent to the extraction site and bone narrowing in the extraction site.[1,2,3]

Another common situation involves the need to close edentulous spaces. Such need can emerge due to loss of first molars, mesial tip of the second and third molars, distal tip of premolars, extrusion of molars in the opposing arch, changes in the shape of the gums, with bone narrowing and formation of bone defects on the mesial side of second molars. Impact on the upper arch is usually not as severe as in the lower arch.[3,4]

The longer the time elapsed after extraction, the worse the sequelae and orthodontists are advised to have caution. Molars can be moved through edentulous areas. However, the amount of remaining bone should be noted.[3,4]

The ideal alveolar dimensions in order to succeed in closing first molar space is 6 mm or less in the mesiodistal direction and 7 mm in the buccolingual direction.[3,4]

If the patient does not fit these characteristics, one can resort to the techniques of bone regeneration, which have been widely used for orthodontic movement in areas with bone defects.[6]

Orthodontic movement in adults — compared to young adults — presents greater resistance and entails a greater likelihood of loss of alveolar bone crest height, gingival recession and root resorption, in addition to greater difficulty in maintaining the closed space, i.e., decreased stability.[8]

To reduce these effects, orthodontists must use an efficient mechanism to ensure delivery of light forces and increase the interval between activations so that the tissues involved have time to recover. This approach greatly increases treatment time.

Aware of the consequences brought about by this procedure, orthodontists should consider other alternatives such as molar uprighting, with space creation every time mesial movements can jeopardize the maintenance of molars in the dental arches.

Molar uprighting produces significant reduction in the depth of existing periodontal defects, with highly desirable changes in gingival architecture, space creation adequate for the placement of an implant or prosthetic elements, and parallelism of abutment teeth for a better distribution of masticatory forces on pontic elements.[7-10]

The space created by molar extraction can be used to attain a number of goals. In some treatments it is necessary that molars remain in position

in the anteroposterior direction, while the anterior teeth occupy the entire extraction space. In others, molars may drift mesially up to half the space, or even the entire space. There are also situations in which extraction spaces are used to establish intra-arch symmetry and correction of dental midlines, thus requiring asymmetric space closure. These different needs may render the case more complex mechanically and increase treatment time.

Anchorage loss occurs more easily in the upper arch and, therefore, when one needs to utilize the space created with extraction of the first molar to dilute crowding or even retract anterior teeth, one should establish appropriate anchorage mechanisms. In cases where there is no patient cooperation, but the patient agrees with skeletal anchorage, this is the best option to avoid anchorage loss.

Stages of orthodontic mechanics

Placement of the orthodontic appliance must be complete and include third molars if possible, starting with the initial alignment and leveling phase. Orthodontic auxiliaries should be placed on second molars so that during alignment and leveling tooth roots are tipped back mesially. This procedure seeks to accomplish parallelism between the roots of second molars and premolars during space closure. Attachments can also be positioned mesially on second molar crowns to reduce a rotation tendency when closing spaces.

In the alignment and leveling phase one can use a sequence of up to 0.018 x 0.025-in cross-section nickel-titanium wires, which can be used when molars are tipped lingually. Ideally, starting with round 0.018-in wires, steel wires should be used in coordination in the upper and lower arches. One is advised to avoid extending the initial archwires (0.012-in and 0.014-in) as far as the second and third molars to avert disrupting the region between the second premolar and second molar due to the large interbracket space present in the chewing area.

In cases with severe crowding, the use of archwires encompassing all teeth in the alignment and leveling phase will cause anterior teeth to protrude. If this is intended, small distal movements of the premolars and canines should be performed during the early stages of treatment in order to facilitate the alignment of anterior teeth. Distalization of these teeth can also be accomplished using segmented archwires with loops.

The space closure phase should only be initiated after full alignment and leveling of the dental arches.

During space closure one seeks to perform a bodily movement of the teeth, avoiding any side effects during movement, such as uncontrolled tipping and rotation of the molars, unwanted loss of anchorage, treatment lengthening, excessive incisor uprighting, increased overbite and even external root resorption.

In order for the posterior teeth to remain in their original position (steady anteroposterior position), it is necessary to use adequate anchorage, such as a Nance button, headgear or a mini-implant. The type of anchorage choice should be consistent with the patient's compliance profile. When using straight archwires in the lower arch, the maintenance of anchored posterior teeth can be achieved with tight omega loops and Class III elastics supported by the headgear on a delta loop in the lower canine region, or even by bracket hooks positioned on the lower canine teeth. This procedure is performed during the stage of premolar distalization. In the canine and incisor retraction phase the elastic can be supported directly by the retraction loop. In this type of mechanics, the premolars are distalized tooth after tooth with elastomeric chains. To reduce friction teeth may be distalized when using a 0.018-in archwire, and to reduce the possibility of rotation one can also use elastomeric chains lingually, which results in a binary system.

Since the extraction space is large and wire deformation is common in these regions, sliding mechanics cannot provide the desired efficacy. Segmented arches offer great advantages such as the elimination of friction and rotations, provided that one has control over this technique.

Special attention should be given to asymmetric cases, where it may be necessary to use mechanics comprising Class II elastics on one side and Class III elastics on the other side. Another option would be to use skeletal anchorage placed on different points of the dental arch.[11]

An ideal orthodontic appliance should deliver a relatively continuous force across a long distance. Therefore, it should feature a low load/deflection ratio and a wide activation range. To this end, it is essential that one be aware of the load/deflection ratio of the loop being used. Loops with a very high load/deflection ratio enable only limited activations so that any small change in activation will produce a very large change in the magnitude of the force released. In contrast, very flexible loops, i.e., with a very low load/deflection ratio, require a very large activation to produce the force magnitude for the desired retraction.[12]

T-loops, manufactured from 0.019 x 0.025-in stainless steel wire with a height of 7 mm and 10 mm horizontal dimension, deliver a force of about 250 g under a 1.5 mm activation. By reducing wire cross-section to 0.018 x 0.025-in or increasing the vertical height to 9 mm, or even using a TMA wire, the force released will be reduced when activated by 1.5 mm. The force will also vary in accordance with changes in the amount of activation, which can reach up to 3 mm without the risk of permanent loop deformation.[11]

During space closure, one should place in the molar region tip-back bends in the wire with an inclination of about 20° to 30° to control mesial tipping, while incorporating smooth bends of approximately 10° of lingual inclination in the third molars in order to prevent mesiolingual rotation.

It is advisable to have a panoramic radiograph taken after closing the spaces to assess root parallelism, especially in the area between second premolars and second molars. Should it become necessary to improve parallelism, second order bends (tip-backs) can be incorporated into the finishing archwires in the second molars. These teeth must remain tied together with metal ligatures to prevent the reopening of the spaces or to keep the omega loop tied back. The teeth should be kept together to allow a reorganization of the gingival fibers and bone maturation around the teeth, thereby reducing the possibility that the extraction spaces may reopened.

The use of Class II elastics increases the tendency of mandibular molars to tip mesially and incline lingually. Prolonged use of these elastics should therefore be avoided.

In first molar extraction cases, the interbracket distance between second molars and second premolars is considerable. In these areas one can observe wire deformation due to the chewing forces that are delivered to them. To avoid side effects in teeth adjacent to extraction spaces, these deformations need to be monitored frequently as they severely hinder sliding mechanics. If in this interbracket space the archwire is allowed to injure the soft tissues of the cheek, one can resort to plastic wire sheaths. The length of these sheaths should always be 1 to 2 mm smaller than the interbracket distance to prevent unwanted movements.

The use of archwires with loops allows the closure of first molar spaces with concurrent control of second and third molar mesial tip and lingual inclination. Control over inclination of posterior teeth in the buccolingual direction is obtained by incorporating torque.[13]

In its final stages, these auxiliaries must be repositioned so that the teeth can achieve their ideal position. The teeth adjacent to the

extraction area that were banded in the early stages should have their attachments replaced by bonded brackets or tubes so that all spaces are fully closed with a fixed appliance.

Retention

The purpose of using posttreatment retention in all orthodontic cases is to prevent or reduce relapse. In adult patients, the main factors affecting posttreatment stability are the soft tissues surrounding the teeth, such as the tongue, perioral muscles, connective tissue of the periodontal ligament and gingival fibers.

Muscle function is a dominant factor in retention. If muscle balance is present, a well-established intercuspation may help to preserve the final tooth movement outcome. In cases with strong adverse muscle pressure, a precise relationship between the arches will not prevent the occurrence of relapse, requiring, therefore, a permanent retainer.

The lack of a reasonable occlusal balance during chewing can create instability. If the imbalance is excessive, future treatment may be necessary and/or occlusal adjustment should be performed to eliminate interference.

When a tooth is moved orthodontically, a fold or invagination of gingival tissue is formed between the teeth that were moved closer to each other. Apparently, these teeth are not moved through the gingiva, but rather compress the adjacent gingiva, producing an invagination of connective tissue and epithelium. The clinical appearance can vary from a single gap on the buccal side of the attached gingiva to a deep cleft that extends through the interdental papilla. The longer the time before initiating tooth movement after extraction, the greater the tendency of gingival invagination being formed.[14,15]

The invagination is considered as the main cause for the reopening of extraction spaces and it is therefore necessary to retain the teeth until reorganization of the pertinent structures has occurred. This remodeling may last 12 months in children and take even longer in adults.[15]

To reduce the possibility of relapse, Reitan[16] recommends periodontal surgery before removing the fixed appliance. The surgery is aimed at cutting the elastic fibers located above the alveolar crest, which cause relapse. The orthodontic appliance should not be removed before recovery is complete.[16]

EXTRACTION OF PERMANENT SECOND MOLARS

Distal movement of maxillary first molars in cases of extraction of maxillary second molars occurs rapidly and efficiently, reducing treatment time and protrusion of anterior teeth, which is a common side effect when distalizing molars in cases without extractions.[17,18]

The space created by extracting second molars is usually larger than the space needed for correction of crowding and Class II. Nevertheless, anchorage must be considered, as there is significant mesial migration of molars during orthodontic treatment.[17] With the advent of skeletal anchorage, concern about patient compliance in wearing headgear and intraoral elastics is no longer a determining factor in treatment success.

The main reasons to consider the extraction of second molars are: To prevent excessive profile flattening, which can occur with premolar extractions; to reduce treatment time, since one only uses the required amount of space to achieve an ideal molar occlusion relationship and a convenient first molar distalization.[17,18] It also decreases the tendency of developing open bite in patients with an increased lower face.[17,19]

Second molar extraction is a viable alternative to be considered when these teeth are severely damaged or poorly positioned and when there is crowding in the posterior region, although it should not be considered as an alternative to replace premolar extraction in cases of dental crowding in the anterior region, or even in severe incisor protrusion cases.[17,20,21]

It is also indicated in cases of third molar impaction, despite the uncertainty involving its eruption in an acceptable position, and prevention of late crowding in the lower arch.[17,18,20,21]

One factor should be taken into account before recommending the extraction of second molars, i.e., verifying the presence of third molars, making sure they are well positioned and have an adequate coronary and root anatomy.[17]

The ideal time to recommend second molar extraction is when the third molars have begun root development, but it is not always possible to start orthodontic treatment in this phase, which does not preclude treatment in adults whose third molars have erupted.[21]

When treatment is started at the ideal stage it is usually completed before the eruption of third molars, causing, in some cases, extrusion of the opposing teeth (antagonists). Orthodontists must exercise caution and place an appropriate retainer. In cases where third molars erupt out of position and prevent the achievement of an adequate functional occlusion, orthodontic retreatment is indicated to position them correctly.[21]

In terms of relapses in the anteroposterior direction, cases treated with extraction of second molars seem to be quite stable.[21]

EXTRACTION OF PERMANENT THIRD MOLARS

General indications for removal of impacted third molars

The average age for eruption of third molars is around 20 years, although the eruption might continue as late as age 25.[22]

Third molars tend to tip distally during the early stages of development, and seldom tip mesially.[23]

Third molar begins to form horizontally tipped and eventually, with development and mandibular growth, the angulation changes from horizontal to mesioangular and ultimately to vertical.[24]

The ideal moment for extracting third molars is when more than 1/3 of the roots of these teeth have formed, usually between ages 17 and 20. The major issues related to retained third molars are addressed below.

Infections and inflammations

When a tooth is partially erupted and covered by the gingival operculum, the patient usually presents with repeated episodes of pericoronitis — an infection of the soft tissues around the crown of a partially erupted tooth — caused by normal oral microbiota. It is considered the most common disease related to impacted third molars. Third molars should not be extracted before the pericoronitis symptoms have been addressed.[25]

Root resorption

Root resorption of second permanent molars appears to be similar to the process of resorption that occurs with primary teeth in the presence of succeeding permanent teeth. After extraction of the impacted tooth, the adjacent tooth recovers through a cementum repair process. In a study on the prophylactic removal of asymptomatic third molars with a sample of 40 asymptomatic and impacted molars, 95% were referred for prophylactic removal with a 26% risk of root resorption of second molars.[24,25]

Odontogenic cysts and tumors

If the tooth is retained within the alveolar process, so is the dental follicle. This follicle, while maintaining its original size in most patients, can undergo cystic degeneration and become a dentigerous cyst or an odontogenic keratocyst. In general, if the follicle around the crown is larger than 3 mm, a dentigerous cyst should be suspected. Epithelial cells comprised within the dental follicle may also form an odontogenic tumor. Ameloblastoma[25] is the most commonly found tumor in this region.

Inferior alveolar nerve impairment

The surgical removal of third molars may cause injury to the inferior alveolar nerve, which leads to a proliferation of axons, plausibly a cause of paresthesia, dysesthesia, allodynia and pain, which may eventually become disabling. However, inferior alveolar nerve injury is rare and other complications related to surgical removal of third molars such as pain and trismus should be considered.[26]

The pain following extraction of third molars is directly proportional to the degree of difficulty in extracting this tooth.[27]

General contraindications for removal of impacted third molars

In principle, all impacted teeth should be removed, except when there are specific contraindications. The most common contraindication for tooth extractions is age. An 18-year-old patient may present with swelling and discomfort for 1 or 2 days after the removal of an impacted tooth but a 50-year-old adult may display an edema for 4 to 5 days as a result of the same procedure. Therefore, patients older than 35 years with impacted teeth showing no signs of disease should not have these teeth extracted. Moreover, in patients over the age of 25, the risk of complications arising from the extraction of third molars increases.[24]

A very early extraction of third molars should be postponed until an accurate diagnosis of impaction can be established.[24]

Advanced age and compromised health are usually associated. In conditions involving compromised cardiorespiratory function (congenital or acquired coagulopathy), the surgeon is advised to leave the affected teeth in the alveolus until the general health of the patient is under control.[24]

Orthodontic indications for extraction of third molars

Currently, with the use of skeletal anchorage devices, it is possible to recommend the extraction of third molars with the purpose of creating space and correcting Class II by distalizing maxillary molars.[28] A rate of 0.3 mm to 7.8 mm of distal movement of maxillary molars in a period of 7 months[29] has been reported using this type of mechanics. Unlike other distalization mechanics, which provoke extrusion, it is possible to distalize upper and lower molars with intrusive vectors and with minimal risk of opening the bite.[30]

Orthodontic contraindications for extraction of third molars

Extraction of third molars is contraindicated in cases of extraction of permanent second molars as an alternative for the treatment of Class II. With the extraction of permanent second molars space is gained for distalization of first molars while the rest of the space is closed by moving the third molars mesially.[22]

CLINICAL CASE 1

Diagnosis summary

Forty-four-year-old patient presented as chief complaint mandibular crowding and space resulting from the extraction of tooth #26. On extraoral clinical examination she exhibited a pleasant looking face (Fig 1), lip competence, normal display of incisors on smiling, convex profile, normal nasolabial angle, nasal breathing, normal speech and swallowing.

Examination of the oral cavity revealed an Angle Class II Division 1, subdivision left molar relationship, less than 5 mm crowding, 50% overbite, 2 mm overjet, 2 mm lower midline deviation to the left and 1 mm upper midline deviation to the left, absence of tooth #26, tooth #43 positioned 3 mm mesially from tooth #33, and gingival recession in the cervical region of the canines, premolars and tooth #36 (Fig 1).

Periapical radiographic examination disclosed extensive restorations in posterior teeth with excess restorative material in the mesiodistal direction, and tooth #36 with lesions and

furcation involvement (Fig 2). Cephalometric analysis revealed a skeletal Class II malocclusion, adequate inclination of the mandibular plane, incisors excessively inclined labially and a convex profile (Fig 3, Table 1).

Treatment goals

The goals were to align and level the teeth, establish intra-arch symmetry, close the extraction spaces, correct the deviated midlines, attain a normal second molar occlusion, establish adequate disocclusion guides and correct the overjet and overbite without changing the original facial esthetics.

Treatment planning

Treatment planning consisted in placing a standard Edgewise fixed orthodontic appliance, slot 0.022 x 0.028-in, on the upper and lower dental arches. The patient's teeth #16, #36 and

FIGURE 1 - Initial facial and intraoral photographs.

#46 were extracted. During the alignment and leveling phase 0.012-in, 0.014-in and 0.016-in nickel-titanium wires were used, followed by 0.018-in stainless steel wire. While using 0.018-in wire, space closure was initiated with elastomeric chains to establish symmetry between the antero-posterior quadrants. Lower reverse curve of Spee was incorporated at this stage. Once symmetry was achieved, 0.019 x 0.025-in TMA wires with a T-loop were used to proceed with space closure.

When using the rectangular wires, a sharper curve of Spee was incorporated into the upper archwire for overbite control, as well as a tip-back bend placed in upper and lower molars to control the mesial tip. During the space closure phase, 5/16-in intermaxillary elastics with around 200 g of force on each side were used in the Class II direction to control anchorage and attain a normal molar occlusion. In the final stages upper and lower 0.019 x 0.025-in TMA

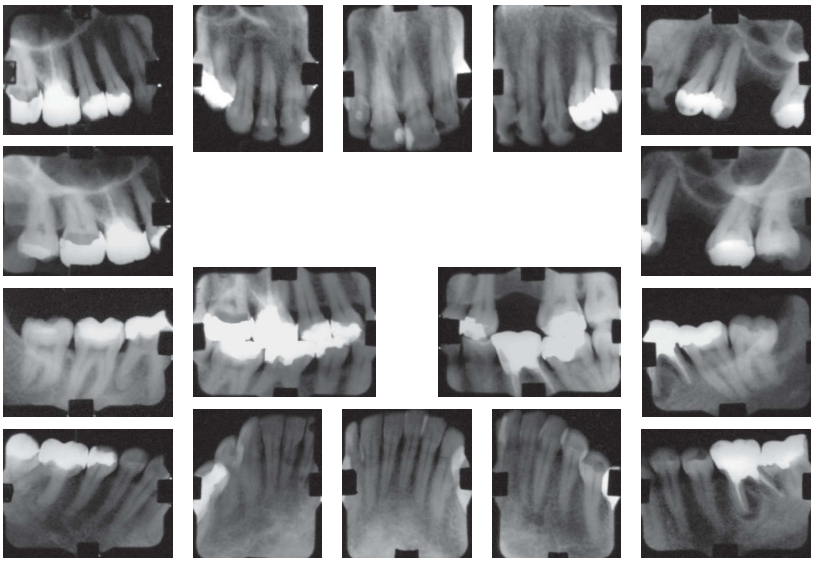

FIGURE 2 - Initial periapical radiographs.

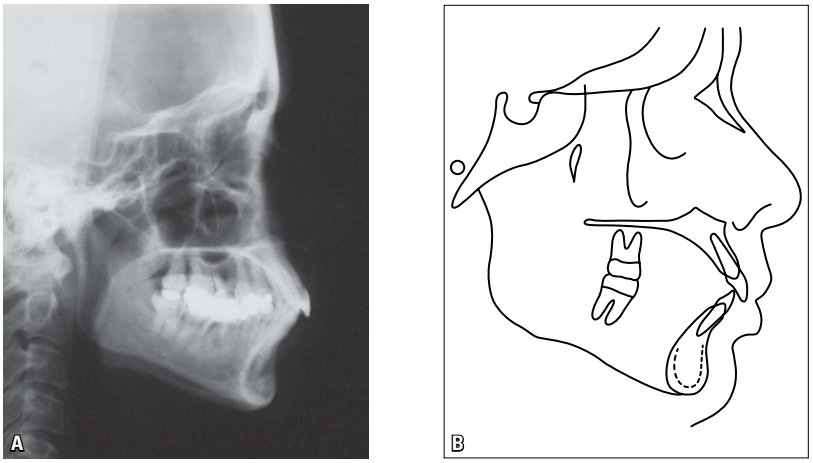

FIGURE 3 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

archwires were used in coordination. A wrap-around removable appliance was worn for retention in the upper arch 24h/day for 12 months. After this period, nighttime use was prescribed in order to prevent reopening the spaces created by the extracted molars. A 0.028-in steel wire was bonded to teeth #33 and #43 and a 0.020-in twist-flex wire was bonded to teeth #34, #35 and #37, #44, #45 and #47 to avoid reopening the spaces produced by the molar extractions.

Treatment results

The treatment goals were achieved. The pleasant facial esthetics was preserved, second molars attained a normal occlusion, overjet and overbite were corrected in the anterior region and appropriate disocclusion guides were established. The upper incisors were uprighted, the lower incisors remained protruded, the teeth were aligned and leveled, the extraction spaces were closed and asymmetries corrected,

FIGURE 4 - Final facial and intraoral photographs.

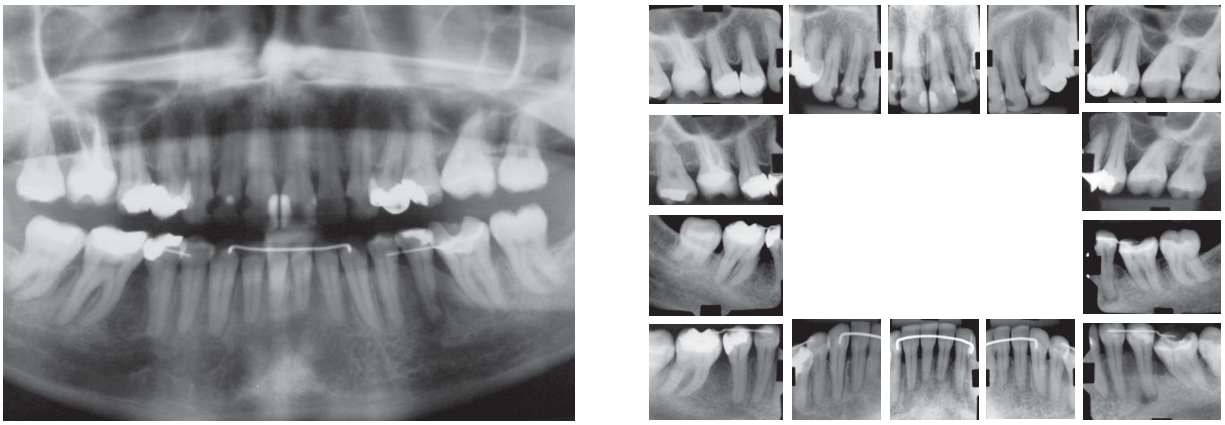

FIGURE 5 - Final panoramic and periapical radiographs.

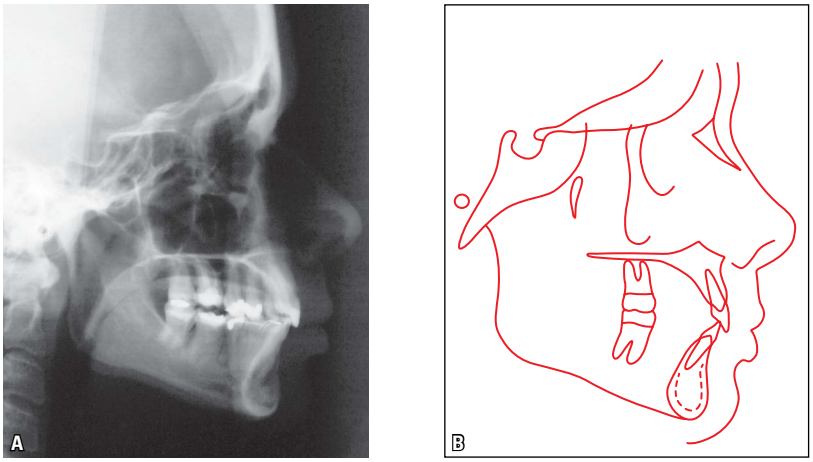

FIGURE 6 - Final lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

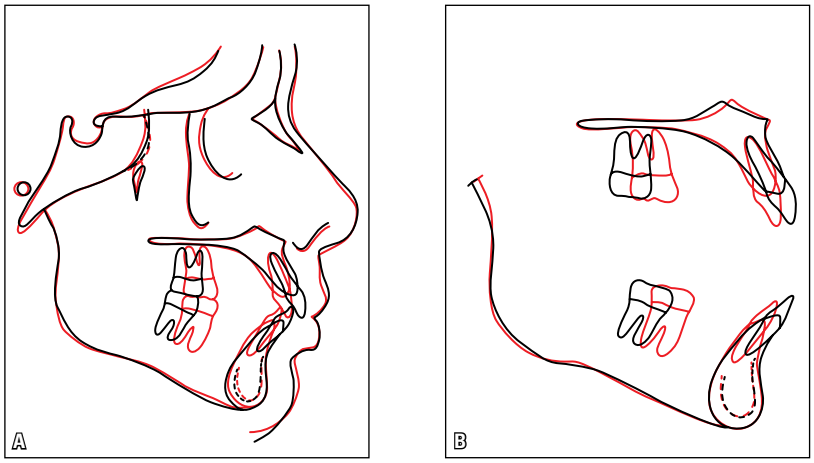

FIGURE 7 - Total (**A**) and partial (**B**) superimposition of initial and final cephalometric tracings.

TABLE 1 - Summary of cephalometric measurements.

	MEASURES	NORMAL	A	B	A/B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	82°	83°	1
	SNB (Steiner)	80°	77°	79°	2
	ANB (Steiner)	2°	5°	4°	1
	Convexity angle (Downs)	0°	9°	8°	1
	Y axis (Downs)	59°	58°	56°	2
	Facial angle (Downs)	87°	87°	88°	1
	SN-GoGn (Steiner)	32°	32°	29°	3
	FMA (Tweed)	25°	23°	20°	3
Dental pattern	IMPA (Tweed)	90°	107°	106°	1
	1-NA (degrees) (Steiner)	22°	22°	14°	8
	1-NA (mm) (Steiner)	4 mm	7 mm	2 mm	5
	Ī-NB (degrees) (Steiner)	25°	37°	35°	2
	Ī-NB (mm) (Steiner)	4 mm	10 mm	5 mm	5
	1/1 -Interincisal angle (Downs)	130°	116°	128°	12
	Ī-APo (mm) (Ricketts)	1 mm	7 mm	3 mm	4
Profile	Upper lip – S line (Steiner)	0 mm	2 mm	1 mm	1
	Lower lip – S line (Steiner)	0 mm	3 mm	2 mm	1

the dental arch form was maintained (Fig 4) and the mandible experienced a counterclockwise rotation (Fig 7, Table 1).

From the beginning of treatment bone loss was apparent in the labial surface of tooth #36, which worsened after its removal. As a result, a periodontal defect developed in the mesial surface of tooth #37 (Fig 5). As regards case stability, the protracted use of an upper retainer became necessary, as well as the maintenance of a wire bonded to the teeth adjacent to the lower extractions.

CLINICAL CASE 2

Diagnosis summary

Female patient, age 23, presented as her chief complaint lip protrusion and the presence of posterior teeth with compromised crowns.

From a dental standpoint, as can be seen in Figure 8, she presented with an Angle Class I malocclusion, 10%, overbite, 2 mm overjet, coincident upper and lower midlines, severely damaged crowns of teeth #16, #26 and #47, which was confirmed by radiographic examination (Fig 9). The patient also featured parabolic

arches with symmetry in the anteroposterior and transverse directions, negative 4 mm lower model discrepancy and absence of Bolton discrepancy. As regards her facial profile, she had a marked protrusion of both lips.

Assessment of a lateral cephalometric radiograph (Fig 10, Table 2) revealed an adequate inclination of the mandibular plane with incisors excessively inclined labially and a convex profile.

FIGURE 8 - Initial facial and intraoral photographs.

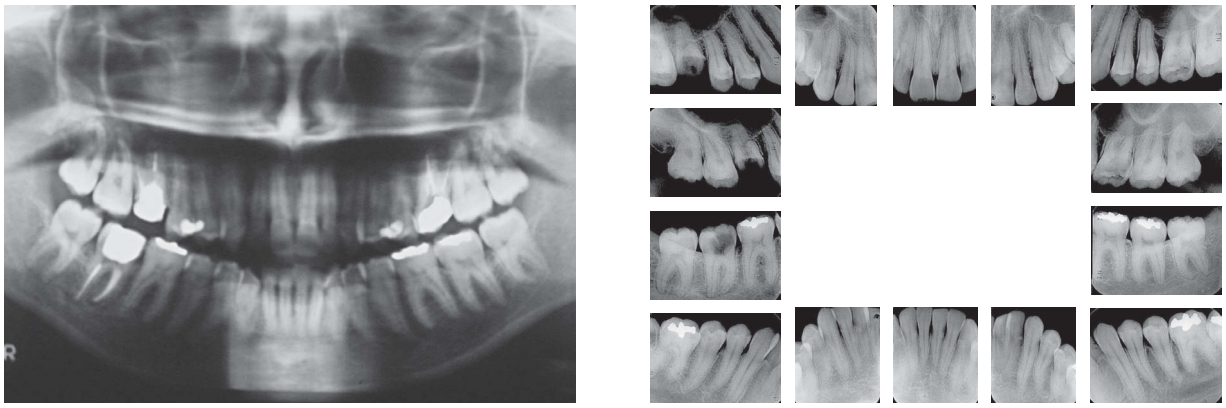

FIGURE 9 - Initial panoramic and periapical radiographs.

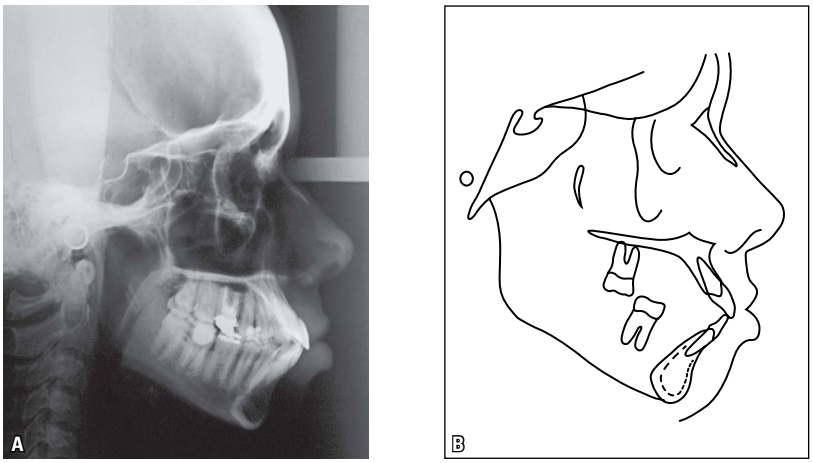

FIGURE 10 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**). **B** shows that the upper second molars were traced due to extraction of the first upper molars.

Treatment goals

To reduce the dental protrusion, establishing a correct incisor inclination and normal occlusion between the first lower molars and second upper molars.

Treatment method

Given that the patient rejected the placement of a skeletal anchorage device, it was explained that in order to reduce the dental protrusion and improve her profile convexity the treatment might require a second phase. In the first phase, teeth #16, #26, #37 and #47 would be extracted, the spaces closed, but the dental protrusion would likely only be fully corrected in a second phase, with the extraction of teeth #14, #24, #34 and #44.

A Nance button attached to the second molars was used for anchorage in conjunction with a Kloehn headgear and Class III elastics supported by the headgear to attain lower anchorage. The subject was referred for extraction of teeth #16, #26, #37 and #47 given the fact that the crowns were severely damaged. Archwire sequence and space closure were carried out as in Case 1, but with a different anchorage system.

After closing the molar spaces a new assessment was performed, where a slight retraction of the upper and lower incisors was noted as well as a minor change in her facial profile. The maxillary upper and lower first premolars were therefore extracted.

For retention, a removable (wraparound) retainer was used in the upper arch, and in the lower arch a twist-flex wire was bonded lingually from tooth #35 to tooth #45. The patient wore the retainer 24/7 during the first 12 months and, after this period, for nighttime use only.

FIGURE 11 - Final facial and intraoral photographs.

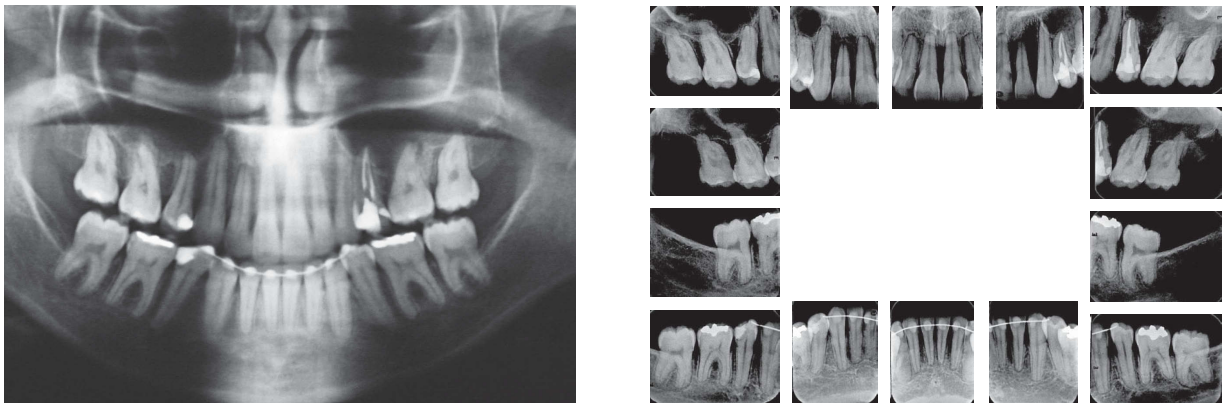

FIGURE 12 - Final panoramic and periapical radiographs.

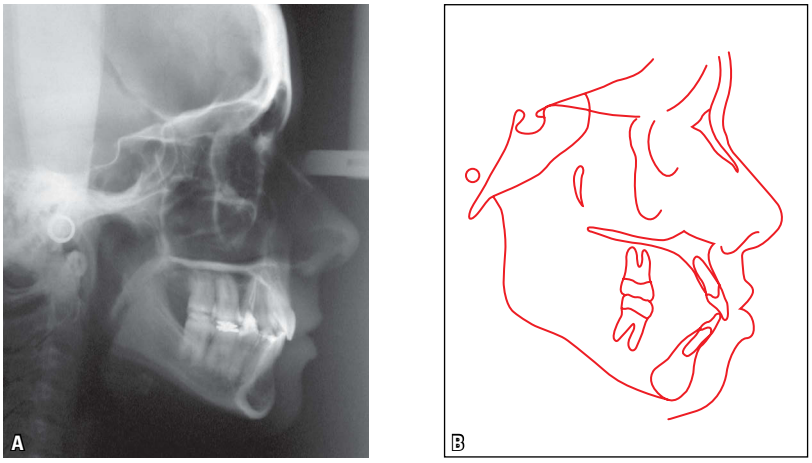

FIGURE 13 - Final lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

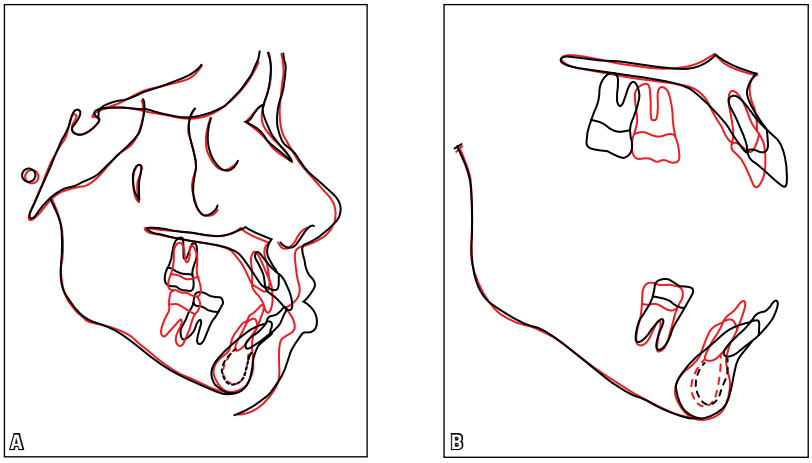

FIGURE 14 - Total (**A**) and partial (**B**) superimposition of initial and final cephalometric tracings.

TABLE 2 - Summary of cephalometric measurements.

	MEASURES	NORMAL	A	B	A/B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	85°	85°	0
	SNB (Steiner)	80°	81°	81°	0
	ANB (Steiner)	2°	4°	4°	0
	Convexity angle (Downs)	0°	9°	7°	2
	Y axis (Downs)	59°	60°	59°	1
	Facial angle (Downs)	87°	86°	87°	1
	SN-GoGn (Steiner)	32°	31°	31°	0
	FMA (Tweed)	25°	29°	27°	2
Dental pattern	IMPA (Tweed)	90°	108°	94°	14
	1-NA (degrees) (Steiner)	22°	30°	12°	18
	1-NA (mm) (Steiner)	4 mm	10 mm	3 mm	7
	Ī-NB (degrees) (Steiner)	25°	43°	28°	15
	Ī-NB (mm) (Steiner)	4 mm	13 mm	4 mm	9
	1/1 - Interincisal angle (Downs)	130°	104°	137°	33
	Ī-APo (mm) (Ricketts)	1 mm	11 mm	1 mm	10
Profile	Upper lip – S line (Steiner)	0 mm	1 mm	-2 mm	3
	Lower lip – S line (Steiner)	0 mm	7 mm	0 mm	7

Final results

In reviewing the patient's final records (Fig 11) it became clear that all intended goals were attained (Figs 5, 6 and 8). There was improvement in facial esthetics, a normal occlusion was achieved between maxillary second molars and mandibular first molars, appropriate overjet and overbite were achieved in the anterior region along with adequate disocclusion guides. The upper and lower incisors were uprighted (Fig 14, Table 2), the teeth were aligned and leveled, and the extraction spaces closed. A lateral cephalometric radiograph (Fig 13, Table 2) showed a reduction in tooth and lip protrusion.

Treatment lasted 51 months. A successful outcome was only possible thanks to patient motivation and youth, normal sized roots and the appropriate use of forces, which took into account the intervals between activations.

The root resorptions that the patient presented at the end of treatment (Fig 12) were acceptable given the movements performed, and entailed no periodontal involvement.

CLINICAL CASE 3

Diagnosis summary

Female patient, 33 years old, was referred by her dental implant surgeon to assess the possibility of closing the space of tooth #26, which was indicated for extraction. The patient had undergone previous orthodontic treatment with extraction of teeth #14 and #24. On extraoral clinical examination she exhibited a pleasant looking face, lip competence, normal display of incisors on smiling, convex profile and normal nasolabial angle (Fig 15).

Examination of the oral cavity revealed an Angle Class II malocclusion, absence of teeth #14, #24, #36, #46 and #47, 2 mm lower crowding, 15% overbite, 1 mm overjet, coincident lower midline and 1 mm upper midline deviation to the left (Fig 15). Periapical radiographic examination (Fig 16) disclosed that tooth #21 had undergone root canal therapy and tooth #26 had a perforation in the furcation area. Panoramic radiography displayed a divergence between the roots of teeth #13 and #15, and #23 and #25, and confirmed that teeth

FIGURE 15 - Initial facial and intraoral photographs.

FIGURE 16 - Initial panoramic and periapical radiographs.

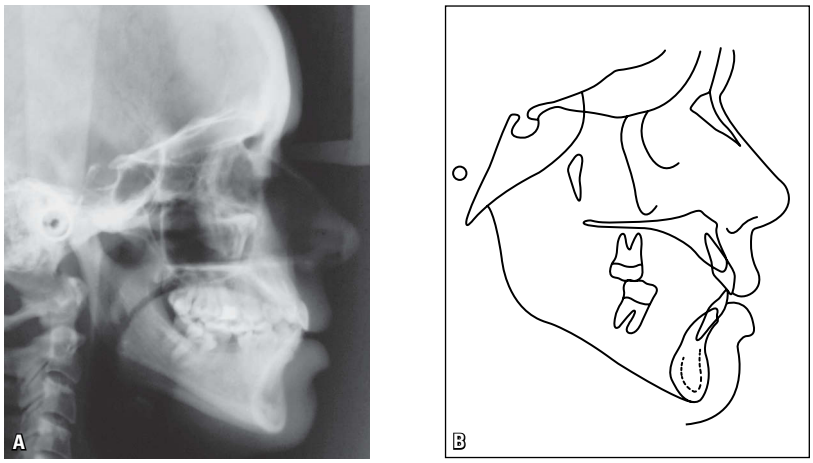

FIGURE 17 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

#14, #24, #36, #46 and #47 were missing (Fig 16). Cephalometric analysis (Fig 17, Table 3) revealed a skeletal Class I malocclusion, increased mandibular plane angle, incisors well positioned in their basal bone and a straight profile.

Treatment goals

The goals were to align and level the teeth, close the tooth extraction space created by tooth #26, upright tooth #48, correct the upper midline, establish appropriate disocclusion guides, correct overjet and overbite and preserve the original facial esthetics.

Treatment method

After placing the orthodontic appliance, the patient had tooth #26 extracted. A 0.018-in stainless steel wire was used to close the space by moving teeth #27 and #28 mesially. To this end, nickel-titanium springs were used with a force of approximately 200 g and on some occasions with elastomeric chains. For anchorage, a mini-implant was positioned between teeth #23 and #25. Figure 18 depicts the different stages of closing tooth #26 space. After space closure, panoramic and periapical radiographs were taken to evaluate root parallelism and integrity. In the finishing phase, upper and lower 0.019 x 0.025-in steel archwires were used in coordination. A wraparound removable appliance was prescribed for retention in the upper arch 24h/day for 12 months. After this period, nighttime use was indicated in order to prevent reopening of the spaces created by the extracted molar. In the lower arch, 0.028-in stainless steel wire was bonded from tooth #33 to tooth #43.

Treatment results

The treatment goals were achieved. The teeth were aligned and leveled, the space created due to the extraction of tooth #26 was closed, overjet and overbite were corrected in the anterior region, appropriate disocclusion guides were established, and facial esthetics was preserved (Fig 19). Panoramic radiography disclosed that tooth #48 was uprighted, the implant was positioned in the region of tooth #46 and the roots of teeth #25 and #27 were parallel to each other (Fig 20). Lateral cephalometric radiography showed that the facial profile was maintained (Fig 21). Cephalometric measurement evaluation showed no significant changes (Fig 22, Table 3). The only significant change consisted in the mesialization of the left upper second molar. Concerning case stability, the patient had to prolong the use of the upper retainer.

The use of a mini-implant in this case enabled unilateral space closure (tooth #26) and correc-

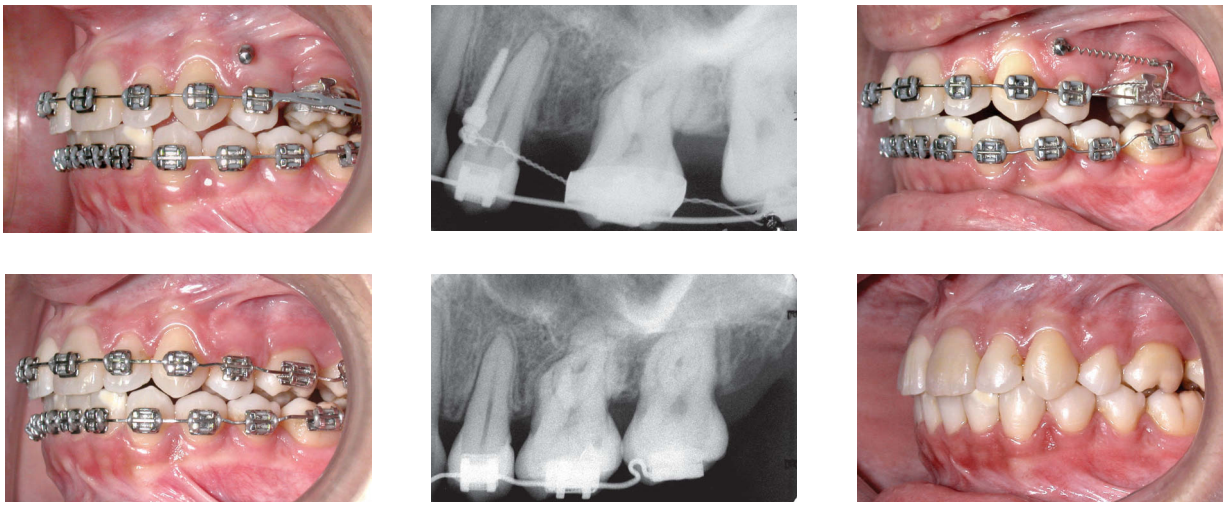

FIGURE 18 - Different stages of space closure.

FIGURE 19 - Final facial and intraoral photographs.

FIGURE 20 - Final panoramic radiograph.

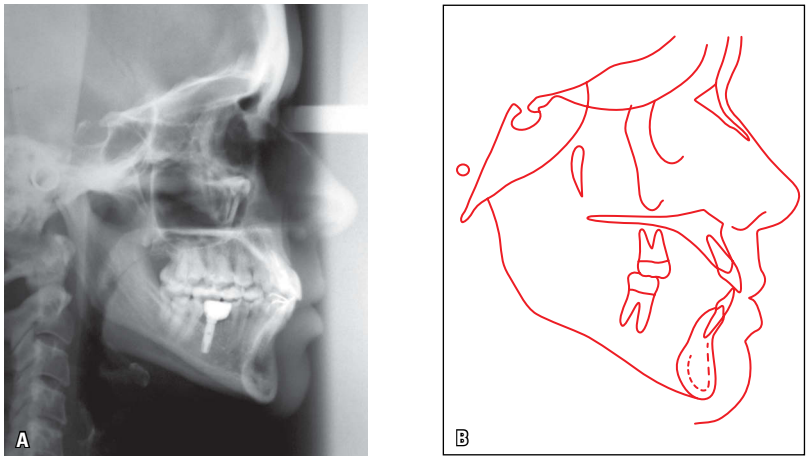

FIGURE 21 - Final lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

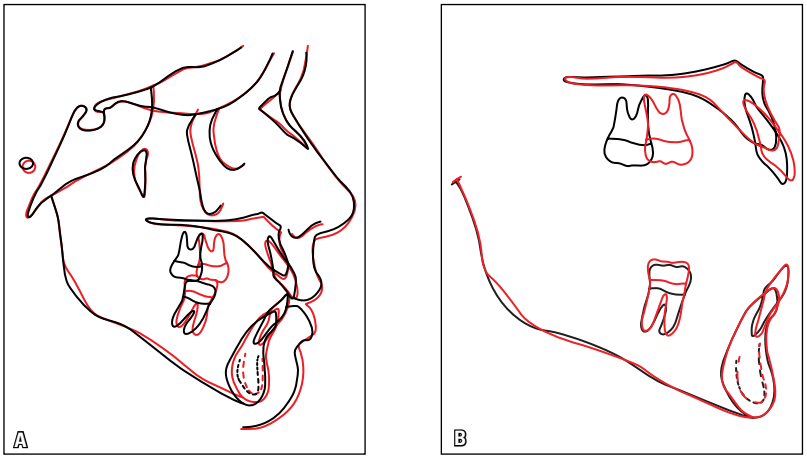

FIGURE 22 - Total (**A**) and partial (**B**) superimposition of initial and final cephalometric tracings.

TABLE 3 - Summary of cephalometric measurements.

	MEASURES	NORMAL	A	B	A/B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	81°	81°	0
	SNB (Steiner)	80°	78°	78°	0
	ANB (Steiner)	2°	3°	3°	0
	Convexity angle (Downs)	0°	5°	4°	1
	Y axis (Downs)	59°	58°	58°	0
	Facial angle (Downs)	87°	79°	78°	1
	SN-GoGn (Steiner)	32°	38°	38°	0
	FMA (Tweed)	25°	28°	28°	0
Dental pattern	IMPA (Tweed)	90°	93°	93°	0
	1-NA (degrees) (Steiner)	22°	21°	27°	6
	1-NA (mm) (Steiner)	4 mm	7 mm	7 mm	0
	Ī-NB (degrees) (Steiner)	25°	30°	29°	1
	Ī-NB (mm) (Steiner)	4 mm	9 mm	8 mm	1
	1/1 - Interincisal angle (Downs)	130°	125°	121°	4
Profile	Upper lip – S line (Steiner)	0 mm	0 mm	-1 mm	1
	Lower lip – S line (Steiner)	0 mm	2 mm	0 mm	2

tion of the midline, which was already deviated to the side of the extraction. Sliding mechanics was not working efficiently with the use of 0.018 x 0.025-in wire and so the molars were mesialized with a 0.018-in wire. As a side effect, molar torque control was lost. The use of a mini-implant as indirect anchorage would allow the use of rectangular archwires with a space closure loop, enabling a more efficient torque control.

CLINICAL CASE 4

Male patient aged 50 years with a chief complaint of incisal wear and crowding.

On clinical extraoral examination, the patient featured a pleasant appearance, with lip competence and a concave profile (Fig 23).

Clinical intraoral examination revealed an Angle Class II, Division 2 malocclusion, with upper and lower crowding of 2 mm and 6 mm, respectively. The patient had a deep Curve of Spee, 20% overbite, 3 mm overjet, lower midline deviated 1 mm to the left side and a coincident upper midline. The upper and lower left side molars were in crossbite with the lower molars occluding buccally with the upper molars. The patient had a Bolton discrepancy of over 2 mm excess in the six anteroinferior teeth.

He did not have an adequate disocclusion guide on the left side due to premature contacts caused by the crossbite.

Panoramic and periapical radiographs revealed discreet horizontal bone loss, molar restorations and endodontic treatment in tooth #47 (Fig 24).

Cephalometric analysis showed a skeletal Class II, adequate inclination of the mandibular plane, protruded lower incisors and upright upper incisors (Fig 25, Table 4).

Treatment goals

The treatment was aimed at correcting the posterior crossbite, aligning and leveling the dental arches, correcting the Class II without changing facial esthetics and improving the disocclusion guides.

FIGURE 23 - Initial facial and intraoral photographs.

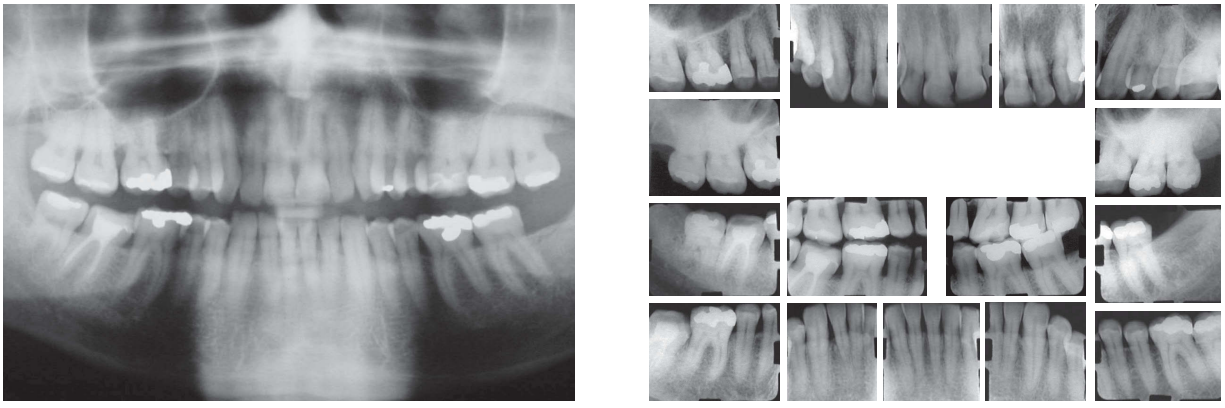

FIGURE 24 - Initial panoramic and periapical radiographs.

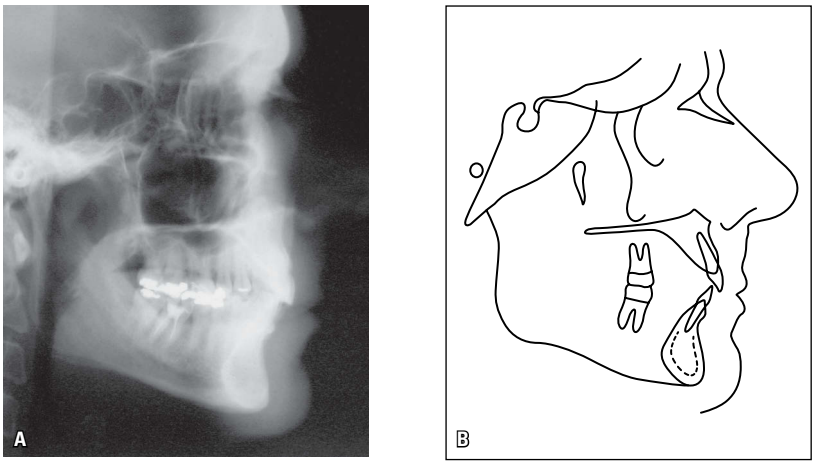

FIGURE 25 - Initial lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

Treatment method

Extraction of the upper second molars was indicated with a view to correcting the Class II because the upper third molars had erupted with a normal anatomy. Furthermore, the lower third molar on the left side was missing and tooth #27 was involved in the crossbite. The upper first molars would be distalized with greater efficiency and only to the extent that it was necessary to ensure a correct intercuspation.

Alignment and leveling were performed by controlling lower incisor protrusion. To this end, a distributed 4 mm canine-to-canine stripping was performed in the lower arch in order to create space for the leveling of the curve of Spee, alignment of the 2 mm crowding that existed originally and elimination of the Bolton discrepancy.

After the complete alignment and leveling of the maxillary teeth, distalization of the first molars was initiated by means of a straight 0.018 x 0.025-in rectangular stainless steel wire and elastomeric chains both labially and palatally. The premolars and canines were also distalized with the binary system, until they reached a suitable position in relation to their antagonists. A Nance button supported by the third molars was used for anchorage.

After canine distalization, the Nance button was removed and space closure was completed with a slight movement of the maxillary incisors. At that time, the use of Class II intermaxillary elastics became necessary.

To correct the crossbite, starting with the use of a 0.018-in steel archwire, on the left side, the lower dental arch was subjected to contraction and the upper dental arch to expansion, both supported by the Nance button.

A wraparound-style upper retainer was indicated and a 0.028-in lingual canine-to-canine steel wire retainer was bonded to the lower arch.

At the end of the orthodontic treatment, the third molar on the right side was left with no antagonist and its extraction was indicated.

Treatment results

Esthetic appearance remained unchanged, the crossbite was corrected, the canine and molar relationship became a Class I malocclusion and the disocclusion guides were improved (Fig 26).

Bone level height in the molar region was maintained after space closure and treatment completion (Fig 27). There were no skeletal changes and there was control of lower incisor protrusion since these teeth were already protruding at the beginning of treatment (Fig 28, Table 4).

FIGURE 26 - Final facial and intraoral photographs.

FIGURE 27 - Final panoramic and periapical radiographs.

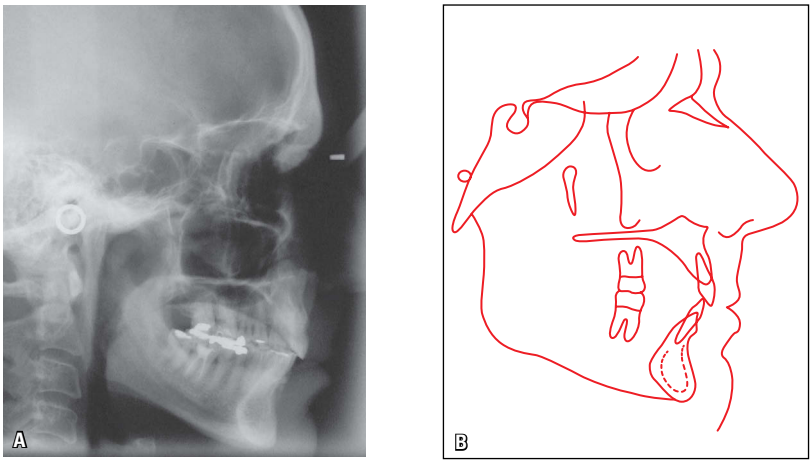

FIGURE 28 - Final lateral cephalometric radiograph (**A**) and cephalometric tracing (**B**).

TABLE 4 - Summary of cephalometric measurements.

	MEASURES	NORMAL	A	B	A-B DIFFERENCE
Skeletal pattern	SNA (Steiner)	82°	85°	85°	0
	SNB (Steiner)	80°	80°	80°	0
	ANB (Steiner)	2°	5°	5°	0
	Convexity angle (Downs)	0°	7°	7°	0
	Y axis (Downs)	59°	57°	57°	0
	Facial angle (Downs)	87°	91°	91°	0
	SN-GoGn (Steiner)	32°	26°	26°	0
	FMA (Tweed)	25°	14°	14°	0
Dental pattern	IMPA (Tweed)	90°	106°	107°	1
	1-NA (degrees) (Steiner)	22°	16°	9°	7
	1-NA (mm) (Steiner)	4 mm	4 mm	3 mm	1
	$\bar{1}$-NB (degrees) (Steiner)	25°	34°	32°	2
	$\bar{1}$-NB (mm) (Steiner)	4 mm	7 mm	7 mm	0
	1/1 - Interincisal angle (Downs)	130°	129°	142°	13
Profile	Upper lip – S line (Steiner)	0 mm	-6 mm	-8 mm	2
	Lower lip – S line (Steiner)	0 mm	-4 mm	-4 mm	0

FINAL CONSIDERATIONS

The authors of this study contend that orthodontic treatment success in cases involving molar extractions is directly related to patient complaint and psychological profile, absence of disease and skeletal discrepancies, application of biomechanical principles and professional experience. Another factor worthy of consideration is whether the patient has undergone previous orthodontic treatment with extractions. These patients usually present with some degree of root resorption, a condition that can worsen, preventing such cases from being properly finished. Currently, skeletal anchorage allows the attainment of good results while reducing treatment time.

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

Registration of these trials has been proposed in order to (a) identify all clinical trials underway and their results since not all are published in scientific journals; (b) preserve the health of individuals who join the study as patients and (c) boost communication and cooperation between research institutions and with other stakeholders from society at large interested in a particular subject. Additionally, registration helps to expose the gaps in existing knowledge in different areas as well as disclose the trends and experts in a given field of study.

In acknowledging the importance of these initiatives and so that Latin American and Caribbean journals may comply with international recommendations and standards, BIREME recommends that the editors of scientific health journals indexed in the Scientific Electronic Library Online (SciELO) and LILACS (Latin American and Caribbean Center on Health Sciences) make public these requirements and their context. Similarly to MEDLINE, specific fields have been included in LILACS and SciELO for clinical trial registration numbers of articles published in health journals.

At the same time, the International Committee of Medical Journal Editors (ICMJE) has suggested that editors of scientific journals require authors to produce a registration number at the time of paper submission. Registration of clinical trials can be performed in one of the Clinical Trial Registers validated by WHO and ICMJE, whose addresses are available at the ICMJE website. To be validated, the Clinical Trial Registers must follow a set of criteria established by WHO.

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The quality of the information available on this portal is guaranteed by the producers of the Clinical Trial Registers that form part of the network recently established by WHO, i.e., WHO Network of Collaborating Clinical Trial Registers. This network will enable interaction between the producers of the Clinical Trial Registers to define best practices and quality control. Primary registration of clinical trials can be performed at the following websites: www.actr.org.au (Australian Clinical Trials Registry), www.clinicaltrials.gov and http://isrctn.org (International Standard Randomized Controlled Trial Number Register (ISRCTN). The creation of national registers is underway and, as far as possible, the registered clinical trials will be forwarded to those recommended by WHO.

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Yours sincerely,

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Analysis of the use of sample size calculation and error of method in researches published in Brazilian and international orthodontic journals

David Normando*, Marco Antonio de Oliveira Almeida**, Cátia Cardoso Abdo Quintão***

Abstract

Introduction: Reliable sample size and an appropriate analysis of error are important steps to validate the data obtained in a scientific study, in addition to the ethical and economic issues. **Objective:** To evaluate, quantitatively, how often the researchers of orthodontic science have used the calculation of sample size and evaluated the method error in studies published in Brazil and in the United States of America. **Methods:** Two major journals, according to CAPES (Brazilian Federal Agency for Support and Evaluation of Graduate Education), were analyzed through a hand search: *Revista Dental Press de Ortodontia e Ortopedia Facial* and the *American Journal of Orthodontics and Dentofacial Orthopedics* (AJO-DO). Only papers published between 2005 and 2008 were examined. **Results:** Most of surveys published in both journals employed some method of error analysis, when this methodology can be applied. On the other hand, only a very small number of articles published in these journals have any description of how sample size was calculated. This proportion was 21.1% for the journal published in the United States (AJO-DO), and was significantly lower (p= 0.008) for the journal of orthodontics published in Brazil (3.9%). **Conclusion:** Researchers and the editorial board of both journals should drive greater concern for the examination of errors inherent in the absence of such analyses in scientific research, particularly the errors related to the use of an inadequate sample size.

Keywords: Biostatistics. Sample size. Error of methods.

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INTRODUCTION

Scientific studies are more reliable when they are carefully planned. The problem to be investigated must be well defined and operationalized from samples randomly obtained from appropriate populations. The methods should be followed carefully using measurements obtained with a reliable and previously calibrated instrument.[6] Finally, the study should have a sample size appropriate to its goals and large enough so that a clinically important effect would also be statistically significant.

The sample sizing is a mathematical process of decision of how many individuals or specimens should be included in the investigation and it must be carried out before collecting the data.[5] The sample sizing is important for ethical and economic purposes.[7] A study using a small sample cannot produce useful results, exposing the participants (sample) to unnecessary risks, while a sample with an excessive size uses more resources than necessary, besides putting in risk an unnecessary number of individuals.

Unfortunately, the natural distancing of health researchers and clinicians from the understanding of mathematics and, consequently, from the interest about statistical methods, coupled with the inaccessible language used by statisticians when communicating with health professionals, make this subject uninteresting to most researchers and clinicians[12]. The ignorance and disinterest increase the likelihood of errors in the design and analysis of the results of a scientific study, reducing the reliability of the data. Understanding these errors would help researchers to observe the reasons that led to their emergence and the necessary steps needed to minimize them.

BASIC CONCEPTS

Assuming a natural distance of a majority of researchers and clinicians from statistical methods, we will outline in a brief review the concepts necessary for understanding the calculations required to obtain an adequate sample size, and the errors inherent in the method used to measure the data.[4,10]

Sample size calculation

When conducting the statistical analysis of results, a researcher, after choosing a statistical test, is subjected to two types of errors inherent to this phase: The type I error (alpha) and type II error (beta).[7] To facilitate the understanding of both types of errors we should consider, as an example, a statistical test used to determine whether two samples have significant differences, and compare it to a trial that determines whether a defendant is guilty or innocent.

Type I error (α) or false positive

At the end of all judicial proceedings the jury should give its sentence, finding the defendant innocent or guilty, considering that, in principle, everyone is innocent until proven otherwise. Statistically, this principle is defined as the "null hypothesis" (H_0), i.e., the data obtained in the study did not produce sufficient evidence to consider the samples as significantly different.

By declaring a defendant guilty, the jury may be incurring an error if the defendant is innocent indeed. This jury's mistake illustrates, in the statistical analysis, the type I error or false positive. In the case exemplified, the samples are considered to be statistically different, but in fact are similar, or were obtained from the same population.

In statistical analysis the probability of type I error (alpha error, or false-positive) is defined by the p-value, obtained through any statistical test. The lower the p-value, the lower the possibility (probability) of error by stating, in the study, that the difference obtained when comparing the two samples is statistically significant or has occurred by random.[10] Great is the difficulty of beginner researchers to understand p-value, since they do not understand the value obtained as a

probability of error. Thus, the lower its value, the greater is the statistical significance.

The level of type I error (α) must be defined before the beginning of the study, and in dentistry it is usually defined as less than or equal to 5%. Therefore, the maximum probability of error accepted to reject the null hypothesis is 5% ($p<0.05$).

Type II error (β) or false negative

Back to the judicial proceeding...

Another possibility of error would occur if the jury found the defendant not guilty (accepting the null hypothesis), and the defendant was truly guilty. Statistically the null hypothesis (equality) would be accepted when, in fact, the samples were different, or were drawn from different populations. This type of error, known as beta (β) or false negative, may occur by chance, but is more common when the sample size is very small to achieve a statistically significant difference.[10,13] Statistical analysis did not have enough power to read a real difference.[6]

Commonly, we find scientific articles in orthodontic literature in which researchers observe a clinically significant difference between two groups. However, when evaluating the data statistically, a significant difference ($p> 0.05$) is not achieved. Also, a very common explanation is that "probably with a larger sample size we could have obtained a statistically significant difference between the groups." When researchers observe a clinically significant difference between groups, but without statistical significance, the study is defined as "underpower."

Power in statistics is the probability of a study to avoid a false negative result,[10] i.e., in the example cited before, to define the samples as similar when they really are similar. Thus, statistical power expresses the probability of detecting a true effect. Conventionally, power has been established as 80% or 90% (0.8 or 0.9) and is equal to 1–β. So for the power to be at least equal to 0.8, the probability of the type II error (β) must not be greater than 20% (0.2). Power = 1–0.2 = 0.8. Small sample size reduces the power of a study, however if you provide excessively large samples a statistically significant studied is obtained, even when the difference is too small to be considered clinically important.[7]

This review about common errors in statistics reinforces the need to design studies with adequate sample size in order to avoid misinterpretations of the results and, therefore, inappropriate clinical treatment. However, beyond the level of α and β, other factors are part of the recipe that defines the sample size:[1,6,10]

a) The minimum clinical effect that the researcher expects on the primary outcome. The lower the effect to be examined, a larger sample size (n) will be required.

b) How the data will be measured (continuous scale, ordinal, or nominal). Nominal (e.g., Presence x Absence; Class I x Class II x Class III) or ordinal data (e.g., severe pain, moderate, mild) require larger samples when compared to continuous numeric data (e.g., cephalometric measurements).

c) The type of statistical test being used, and whether it is uni- or bilateral. The type of test is chosen from the type of variable measured and the type of data distribution, normal or free. Parametric tests, which use continuous data with normal distribution (e.g., t test / ANOVA / Pearson correlation) require samples with a smaller number of participants, compared with non-parametric tests (e.g., Chi-square / Fisher's exact test / Mann-Whitney / Wilcoxon / Spearman correlation).[8] A tutorial on selecting the appropriate statistical test[8] for a given study can be obtained in www.dentalpress.com.br/bioestatistica.

d) The variability of the data. The higher the data variability (standard deviation, variance, inter-quartile deviation), the greater must be the size of the sample. In general, paired outcomes assume better control of data variability.

An important question then arises: Will the orthodontic science researchers have actually bothered to properly size the samples used in their studies? Recently the Institute of Dental and Craniofacial Research in the United States required the inclusion of all this information in clinical research submissions to obtain funding from this institution.[9]

Although absent in the dental literature, few studies have been published in medical literature about the adequacy of sample size or power of statistical tests used in clinical research. In general, the analysis of studies that fail to observe statistically significant differences between a treated group and control reveals the use of underpowered sample size to read differences clinically important, indicating the usual presence of the type II error or false negative.[2,11]

A study analyzing 2000 clinical trials on the treatment of schizophrenia[10] found that only 1% of a published research (n=20) presented an evaluation of the statistical power or sample size calculation. The authors noted that only 3% of the studies analyzed (n=60) had a sample size powered enough to read 20% of difference between the results of the treatments employed.

Error of the method

Another type of error that can occur in scientific studies is related to the reliability of the data obtained, i.e., the ability of these data to represent the truth about the phenomenon that is being examined, and to be reproducible at a later date.[4,13]

Although common among studies with continuous variables (e.g. cephalometric measurements),[13] the calculation of error of measurements should also be examined for non-parametric data (e.g. epidemiological studies on the prevalence of malocclusion). However, as it is not always possible to collect the appropriate sample size for a given study, for ethical or economic issues, in some other situations it is impossible to make a proper analysis of the error of the method. For example, when the loss of the specimen is inevitable during data collecting. This loss is often common during the shear bond tests of orthodontic brackets, since it is impossible to repeat the exact procedures after bracket debonding.

The error of a particular method is achieved using doubled measurements made at a given time interval. Two types of errors are typically examined: The random error, which measures the degree of precision for a specific variable and the systematic error, which evaluates the reproducibility of a given measurement.[4] A large part of the variance of an outcome is related to the inaccuracy of measurements, which also has a huge implication for the sample size.[3] The smaller the errors of method, the greater the validity and reliability of data.[3] Measures should therefore have "precision and be reproducible." Precision is defined as the ability of the method to make an accurate reading of the measurement examined, "reproducibility" is the possibility of this measure to be repeated at different times under the same conditions.

Although widely required in the most renowned and highest impact journals, we can still observe numerous scientific papers without proper examination of sample sizes, and the errors of methods used to obtain the data.

PROPOSITION

Taking into account the importance of an adequate sample size in scientific research, as well as the reliability and reproducibility of the data obtained from these samples, this study aims to analyze the frequency of reported use of the sample size calculation and error of the method in Brazilian and international orthodontic literature.

MATERIAL AND METHODS

Two orthodontic journals were selected and evaluated in this study. One edited in Portuguese and published in Brazil, the *Revista*

Dental Press de Ortodontia e Ortopedia Facial (Dental Press, Maringá, Brazil) and the other edited in English and published in the United States, the *American Journal of Orthodontics and Dentofacial Orthopedics*, AJO-DO (Elsevier, Saint Louis, USA). These two journals were selected because they represent the orthodontic journals of the highest scientific impact in Brazil and worldwide respectively, according to CAPES (Brazilian Federal Agency for Support and Evaluation of Graduate Education).

The analysis of published articles was initially made by their abstract, where it was observed whether the paper described any statistical results. If so, a single examiner began reading the Materials and Methods and Results sections. A close reading of these sections was performed to assess whether or not the article presented an analysis of the sample size calculation, or "power" of the statistical test used, and the description of the error of method, where possible to be applied. There was no judgment on the appropriateness of the statistical methods used and/or reliability of the results.

Both in the Dental Press journal and in the AJO-DO only articles published in the "original articles" section were evaluated. In these sections, we have examined only papers with some descriptive and/or analytical statistics. Case reports and literature reviews were not examined, for obvious reasons.

Sample size calculation

Initially a pilot study was done from the reading of the 20 original articles published in the Brazilian journal (Dental Press) in 2007 (v. 12, n. 4, 5 and 6) in order to obtain the proportion of published articles describing the sample size calculation in this journal. In this initial search only one article, among the 20 examined, described the sample size calculation, which corresponds to a ratio of 5%. Reproducibility was possible in 16 (80%) of the 20 studies analyzed. The analysis of these 16 articles revealed the assessment of the method error in 8 papers, i.e. a ratio of 50%.

The sample size calculation was obtained by BioEstat 5.0 software (a freeware available at www.mamiraua.org.br), considering the use of a binomial two-tailed statistics with 80% power (0.8) and alpha level of 5% able to read a 20% difference between the articles published between the two journals. Therefore, the sample size was defined as 49 items for each group for sample size calculation and an analysis of 93 articles per group for the reading of the use of method error.

The more recent volumes of the two journals were selected for evaluation because they represent the most current trend of the articles published in both journals. In order to obtain the sample size to evaluate the use of sample size calculation or statistical power, it was necessary to read all articles published in the Dental Press journal in 2007 (v. 12, n. 1, 2, 3, 4, 5 and 6), and one number published in 2006 (v. 11, n. 6), totaling 51 articles published in seven issues of the journal. For the AJO-DO journal, it was necessary to read issues of the journal published in five months (v. 132, n. 3, 4, 5, 6, year 2007) and one issue published in January 2008 (v. 133, n. 1) with a total of 57 articles.

Among the 51 articles examined in Dental Press journal and 57 articles in the AJO-DO, it was considered possible to evaluate the error of the method in 43 studies published in the Dental Press and 41 of the AJO-DO. Thus to reach the number determined on the sample size calculation for reading a difference of 20% (α= 5%, β= 20%), it was required to read six more issues of the Dental Press journal (v. 11, n. 1, 2, 3, 4 and 5; v. 10, n. 6) and 7 issues of the AJO-DO (v. 132, n. 1 and 2; and v. 131, n. 2, 3, 4, 5 and 6), totaling 49 more articles published in the Dental Press journal (total n=92) and 53 more in the AJO-DO (total n=94).

Error of method

In order to assess the reproducibility of the method, 15 articles published in each journal (n=30) were randomly reevaluated one week later by the same examiner. The Kappa test with a confidence level of 95% (α=0.05) was used to analyze the replicability of the study. The level of agreement was set for the presence of sample size calculation as to the error of method analysis.

Statistical analysis

Frequencies observed for the use of sample size calculation and error of method in both journals were compared using the Binomial test for two proportions. The confidence level was set at 95% (α=0.05).

RESULTS AND DISCUSSION

Reproducibility for the evaluation of the articles

The error analysis revealed an excellent reproducibility in re-reading the articles for the use of sample size calculation, with 100% agreement (Kappa = 0.9, p <0.001, 95CI = 1.0–0.53). Regarding the analysis of the reproducibility to describe the use of the method error, a concordance level of 97% (Kappa= 0.79, p<0.001, 95CI = 1.0–0.44) was observed.

These preliminary results show an excellent reproducibility of the method used to evaluate the papers.

The use of a sample size calculation

Planning the sample size is often important and difficult to run, requiring careful consideration in choosing the scientific objectives and appropriate information even before beginning the study.

The results of the present study revealed that only 3.9% of articles published in the Brazilian orthodontic journal, in the years 2005-2007, presented some information regarding sample size calculation or power. This percentage was significantly lower (p=0.008) when compared to articles published in AJO-DO which had just over 21% of the articles describing the methods used for sample size calculation (Table 1). These data reflect a worrying lack of attention of researchers and reviewers to this important factor, leading to a strong potential of introducing errors in the statistical evaluation of data published in these two important journals.

Study of method error

Regarding the concern about the assessment of method error, our findings revealed a different picture from that obtained for the use of sample size calculation. For the Dental Press journal, in just over 15% of published articles it was not possible for authors to reproduce the measurements made in the study and thus to carry out error analysis. For the AJO-DO, the study of error was considered impossible to run on 28.1% of published articles (Table 2).

Among the papers where it was possible to run the error analysis, most reported to use some type of analysis (Table 2). For the journal published in Brazil, 60.9% of the articles (n=56) in which it was possible to study the error of the method, had performed such analysis, while for the AJO-DO, 76.6% of the articles (n=72) presented the study of error of method (Table 2).

Comparatively, for papers published in the AJO-DO, the authors (76.6%) seem to be a little more concerned with the study of the error of the method than in those articles published in Dental Press (60.9%, p=0.02). However, we emphasize the large number of scientific papers published in the Dental Press journal that have used a tool to evaluate the error of method. We must also consider the fact that the articles analyzed in the AJO-DO have been published in the last 12 months (Feb. 2007 to Jan. 2008), while in the Dental Press journal it

was necessary to include articles published in 2005 and 2006 in order to compose a sample with an appropriate size.

However the data show that the articles published in the two journals have a relatively small level of concern for the application of methods to calculate the sample size. The result raises concerns for both journals, but is most critical for that published in Brazil where, among 51 articles that were analyzed and published between late 2005 and late 2007, only 2 (3.9%) examined the sample size.

On the other hand, the data are better regarding the use of the error of the method. Most studies published in both journals, in which such analysis was possible, reported its use although that number is slightly higher for the AJO-DO.

TABLE 1 - Absolute and relative frequency (%), relative difference, p-value and power for papers with statistical analysis (A) and the description of sample size calculation (B), published in the *Revista Dental Press de Ortodontia e Ortopedia Facial* and in the *American Journal of Orthodontics and Dentofacial Orthopedics* (AJO-DO).

Description	Dental Press 2005-2007	AJO-DO 2007-2008	Difference (%)	p-value	Power
Original articles with statistical analysis (A)	51 (100%)	57 (100%)	----		
Articles with sample size calculation (B)	2 (3.9%)	12 (21.1%)	-17.2	0.008**	0.78

** p<0.01.

TABLE 2 - Absolute and relative frequency (%), relative difference, p-value and power for papers with possible analysis of error of the method (C) and the description of this analysis (D), published in the *Revista Dental Press de Ortodontia e Ortopedia Facial* and in the *American Journal of Orthodontics and Dentofacial Orthopedics* (AJO-DO).

Description	Dental Press 2005-2007	AJO-DO 2007-2008	Difference (%)	p-value	Power
Original articles with statistical analysis (C)	92 (84.3%)	94 (71.9%)	12.4		
Articles with sample size calculation (D)	56 (60.9%)	72 (76.6%)	-14.6	0.02 *	0.64

* p<0.05.

CONCLUSION

Most researches published in the Revista *Dental Press de Ortodontia e Ortopedia Facial* and in the *American Journal of Orthodontics and Dentofacial Orthopedics* adopt some method to evaluate method error, however only a very small number of these articles showed a sample size calculation. This ratio, already small (21.1%) for the journal published in the United States (AJO-DO) is significantly lower (p=0.008) in the orthodontics journal edited in Brazil (3.9%). Researchers, reviewers and the editorial board of both journals should address this major concern regarding the evaluation of the limitations inherent in analysis of scientific research, especially the errors when an improper sample size is used.

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In vitro evaluation of force delivered by elastomeric chains

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Abstract

Objective: To evaluate and compare, *in vitro*, the decrease in the forces delivered in three groups of elastomeric chains, produced by the same manufacturer, according to the distance between links (short, medium, long). **Methods:** The segments of elastomeric chains were stretched and kept activated during the trial using a device developed especially for this purpose, which also allowed force readings. Force degradation was evaluated by measuring force along time and calculating the percentage of force decrease from initial force at each time interval and for each specimen under test. **Results and Conclusions:** Data were statistically analyzed and results showed that at the different time points after initial readings, force intensity varied within and between groups. Readings of remaining forces at each time moment compared with the initial reference force revealed statistically significant differences in all the comparisons in each group of elastics (short, medium, long). Although the comparisons between forces delivered at each time point revealed statistically significant differences, these differences do not seem to have a clinical significance. The space between links does not seem to be a clinically significant characteristic in force degradation along time.

Keywords: Orthodontic appliances. Dental materials. Elastomers.

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INTRODUCTION

Orthodontics is based on the principle that an external force intentionally applied to a tooth can promote tooth movement and produce a biological response from dentoalveolar tissues. No consensus has been reached about what is the ideal orthodontic force to achieve tooth movement, but continuous low forces have been described as optimal.[4] The knowledge of orthodontic biomechanics provides resources to use a number of force systems capable of promoting optimal force at the highest movement speed without causing discomfort to the patient or damage to supporting tissues.

Elastomeric chains were first used in orthodontics in the 1960s,[3-8] and their applications have increased along time due to the many advantages that they have over other ways to replace metal ligatures, closure archwires, and open and closed coil springs. They promote space closure, rotation corrections and movement canines distally.[19] Elastomeric chains are also economic, comfortable and easily placed and removed, which reduces working time and does not require patient cooperation.[23] They are also relatively hygienic and often compatible with the oral mucosa, factors that contribute to their high level of acceptance among orthodontists.[4,7,12,24] However, they are not capable of retaining a continuous force strong enough to move teeth.[3]

The mechanical properties of elastomeric chains change along time due to the amount of stretching to which they are submitted and because of factors such as water and saliva absorption, permanent deformation, sensitivity to saliva pH and temperature variations in the oral environment.[8] The distance between links of elastomeric chains — often described as short, medium or long — as well as their configurations also seem to affect their behavior.[8,9,10,28] According to some authors, short elastomeric chain modules, which have no distance between the links, retain the greatest percentage of force along time.[3,8]

Elastomeric chains are usually placed and replaced at three- to four-week intervals.[6] After that time, they seem to be permanently elongated and discolored.[1] Also, they should not be used continuously for more than six weeks, due to both their incapacity to retain their mechanical properties and the possible bacterial biofilm formation on the surface of the material.[12]

According to some authors, the greatest decrease in force delivered by elastomeric chains occurs in the first hour,[15,16,18] but losses of 33% to 50%[11] have been found in the first 24 hours after placement. Other authors found losses of up to 73% in the same time interval followed by three weeks during which forces delivered were considerably constant.[1,27]

To conduct orthodontic treatments satisfactorily, it is necessary to know the characteristics and properties of orthodontic elastics, as well as to monitor the amount of force delivered at different time intervals. Several studies investigated the mechanical properties of elastomeric chains, but findings reported in the literature are contradictory, particularly in terms of decrease of force delivered along time.[4,10,13-18]

This study evaluated and compared, in vitro, the initial force delivered and its decrease measured at pre-established time intervals in elastomeric chains from the same manufacturer divided into three groups according to the distance between links: Short, medium, long.

MATERIAL AND METHODS

Elastomeric chains produced by Dental Morelli (Sorocaba, Brazil) and classified according to the distance between links (short - 60.05.501; medium - 60.05.511; long - 60.05.521) were included in this study. Before tests, the elastomeric chains were kept in their original packaging, according to manufacturer's instructions.

Each group had 20 elastomeric chain segments, and groups were formed according to distance between links: Short group, medium group, and long group. The elastomeric chains were carefully re-

moved from their spools, and care was taken not to stretch them. For all the elastomeric chain segments, only the central links were activated, and one extra link was left at each end to rule out the chance of accidental damage to the chain during cutting and spool removal, which might have rendered the structure fragile and prone to fractures, although such damage might not be visually detected.

A device with two platforms, one fixed and one movable, and hooks in the ends was manufactured especially to keep the elastomeric chains activated during the experiment and to allow readings of the delivered forces. The device platforms were adjusted to a distance of 20 mm between the hooks using a digital caliper (serial number 001296; Starret Indústria e Comércio Ltda., Itu, São Paulo, Brazil) which simulated the distance between the mesial tie-wing of the canine bracket and the distal tie-wing of the second premolar.[8,17] After that, the elastomeric chain segments were placed in the device and stretched to deliver an initial force of about 200 gf.

Measurements were made at the following time intervals: Baseline, 1 hour, 24 hours, and 1, 2, 3 and 4 weeks after the chain activation.

Force degradation was evaluated by measuring forces along time and calculating the percentage of differences from initial force at each time interval and for each specimen under test.

The devices with the activated elastomeric chain segments were immersed in artificial saliva and kept in an incubator at a controlled temperature of 37±1 °C. A few moments before measurements, the devices were removed from the container and, after the tests, were returned to it.

The level of artificial saliva in the container was measured everyday to ensure that the chains remained immersed in this solution at all times. The artificial saliva was prepared at the Pharmacy of the Federal University of Rio de Janeiro (Brazil).

The distance between the hooks of the fixed and movable platforms was shortened 0.5 mm each week to simulate orthodontic distal movement of a canine.[5,11] Therefore, the distance between the platforms at the end of the first week was 19.5 mm, and successively so until it reached 18 mm at the end of the experiment.

Statistical analysis

Data were analyzed statistically by comparing the values of force delivered by the elastomeric chains to check the existence of statistically significant differences between groups for each time interval separately and within each group, considering the force differences from one time point to the other.

The Shapiro-Wilk tests were used to check the normal distribution of data. To check differences between the three groups, parametric analysis of variance (ANOVA) was used. The Levene test was used for normally distributed data, and the non-parametric Kruskal-Wallis test for groups with non-normally distributed data, followed by the Mann-Whitney test to detect differences. The level of significance was set at 5% for all the descriptive tests listed above.

The non-parametric Friedman and Wilcoxon tests were used to check differences within each group. The level of significance was set at 1%.

RESULTS

Means and standard deviations of the force delivered by the elastomeric chains in the short, medium and long groups, as well as the mean percentage of force degradation at the different time points are shown in Table 1.

Table 2 shows the levels of significance for the mean forces delivered (gf) in the comparison between groups at the different time points.

Mean forces initially delivered in the short, medium and long groups were 237.3 gf, 227.3 gf and 230.3 gf, respectively. There was a statistically significant difference ($p<0.05$) between the values of force delivered by short elastomeric chains and the other two groups (medium and long), but there were no statistically significant differences ($p>0.05$) between the forces in these two latter groups.

TABLE 1 - Means and standard deviations of the force (in gram-force) delivered by the elastomeric chains in the short, medium and long groups and the mean percentage of force degradation at the different time points.

Time point	Group	Force delivered		Force degradation	
		mean (gf)	s.d.	mean (%)	s.d.
Initial force	short	237.25	11.64	-	-
	medium	227.25	11.29	-	-
	long	230.25	7.52	-	-
1 hour	short	230.00	12.25	3.06	1.73
	medium	218.25	10.04	3.92	2.13
	long	219.25	7.99	4.78	1.66
24 hours	short	193.25	11.50	18.55	2.48
	medium	182.25	6.97	19.69	3.44
	long	185.75	6.34	19.32	1.61
1 week	short	148.75	10.24	37.29	3.23
	medium	148.25	7.66	34.68	3.65
	long	149.50	8.41	35.08	2.75
2 weeks	short	136.25	11.11	42.61	2.86
	medium	130.75	7.66	42.44	2.46
	long	134.00	6.81	41.79	2.54
3 weeks	short	112.25	10.82	52.74	3.08
	medium	116.25	7.59	48.85	2.10
	long	120.00	6.69	47.89	2.28
4 weeks	short	102.75	8.19	56.72	2.21
	medium	96.25	6.86	57.63	2.41
	long	109.75	5.95	52.35	1.71

TABLE 2 - Levels of significance for the different mean force (gf) delivered in the comparison between groups at the different time points.

Time point	Groups		
	short X medium	short X long	medium X long
Initial force	10*	7*	-3^{ns}
1 hour	11.75*	10.75*	-1^{ns}
24 hours	11*	7.5*	-3.5^{ns}
1 week	0.5^{ns}	-0.75^{ns}	-1.25^{ns}
2 weeks	5.5^{ns}	2.25^{ns}	-3.25^{ns}
3 weeks	-4*	-7.75*	-3.75*
4 weeks	-7*	6*	-13.5*

* = statistically significant (p>0.05), ns = non-significant.

For the comparisons between the initial forces and the remaining forces at each time point within each group of elastomeric chains (short, medium, long), the non-parametric Friedman and Wilcoxon tests were used, and the results revealed statistically significant differences ($p<0.01$) in all the comparisons made.

The results of the elastomeric chain groups at the first time points (initial, 1 hour, 24 hours) were compared using ANOVA because these data were normally distributed, and followed by multiple comparison methods to detect differences. In the following time points (1, 2, 3, 4 weeks), data were non-normally distributed, and the comparisons of the elastomeric chain groups were preceded by non-parametric methods, specifically the Kruskal-Wallis analysis of variance, and followed by the Mann-Whitney test to detect differences.

One hour after activation, the values for the short, medium and long groups were 230 gf, 218.25 gf and 219.25 gf, respectively. After one hour and at a statistically significant level ($p<0.05$), the force delivered by short elastomeric chains was greater than that delivered by either of the other two groups (medium and long), and there were no statistically significant difference ($p>0.05$) between the force values in these two latter groups.

The remaining force values obtained in readings after 24 hours for the short, medium and long elastomeric chains were 193.25 gf, 182.25 gf and 185.75 gf, respectively. Also, statistical analyses revealed a significant difference between forces in the Short group when compared with the Medium and Long groups.

One week after the beginning of measurements, mean forces delivered by the short, medium and long elastomeric chains were 148.75 gf, 148.25 gf and 149.50 gf, respectively. At a level of significance of 0.05, the non-parametric analysis of variance (Kruskal-Wallis test) found evidence of homogeneity ($p>0.05$) between the remaining forces in the three groups of elastomeric chains. There were no statistically significant differences in remaining forces between the elastomeric chain groups one week after activation.

After two weeks, mean values were 136.25 gf, 130.75 gf and 134 gf in the Short, Medium and Long groups. At a level of significance of 0.05, the non-parametric analysis of variance (Kruskal-Wallis test) found evidence of homogeneity ($p>0.05$) between the remaining forces in the three groups of elastomeric chains. There were no statistically significant differences in remaining forces between the elastomeric chain groups at two weeks after activation.

At three weeks, the force delivered by the short elastomeric chains, 112.25 gf, was statistically lower ($p<0.05$) than that in the Medium and Long groups (116.25 and 120 gf). However, there were no statistically significant differences ($p>0.05$) between the remaining forces delivered by these two latter groups.

The statistical analysis of the values at four weeks revealed that the remaining forces delivered by the elastomeric chains were all different from each other; in the Long group, the remaining force (109.75 gf) was statistically greater ($p<0.05$) than in the Short group (102.75 gf), which, in turn, was statistically greater ($p<0.05$) than in the Medium group (96.25 gf).

DISCUSSION

The vast literature on the properties of elastomeric chains is difficult to analyze and compare due to the variable nature of study methods, the differences between the configuration of several chains already tested, and the impossibility to find out the exact composition of these materials, often kept secret by manufacturers.

In addition to the influences of environmental changes or compositions and the effects of disinfection on elastomeric chains, the forces delivered and their degradation, as well as their pre-stretching, are variables that have been analyzed.[20] However, it seems impossible to control all the factors that may affect a clinical situation.[23]

According to some studies,[2,13,14,15] the degradation of forces delivered by synthetic elastic materials, when evaluated in a wet environment, is significantly greater than when in a dry environment. Therefore, the elastomeric chain segments in this study were immersed in artificial saliva. The temperature was kept at 37±1 °C because this is the temperature of the human body and it is known that temperature significantly affects the degradation of the force delivered by elastomeric chains.[14,25] Elastomeric chain pre-streching does not seem to induce any significant improvement in the mechanical properties of elastic materials; therefore, this procedure was not used in this study.[6,16]

The purpose of this study was not to compare elastomeric chains from different manufacturers, but, rather, to evaluate the behavior of chains with different distances between links (short, medium, long) produced by the same manufacturer. Therefore, the synthetic elastic material used in this study was chosen for its wide application and acceptance by orthodontists, and our purpose was to provide additional knowledge about their mechanical behavior.

Some authors evaluated the behavior of elastic materials during three weeks,[4,8,27] while others used four weeks or longer times.[11,16,17,23] We chose a time interval of four weeks because it is the usual interval between orthodontic visits.

The initial intensity of the force delivered by the elastics was standardized. However, its variation could not be avoided and was found even within the same group, probably due to the random spatial configurations of the polymer macromolecules, previously reported.[9] Similar variations were also reported by other authors.[1,11] The initial value adopted, about 200 gf, is within the range classified as adequate for distal orthodontic movement of canines in cases of extraction of the first premolar.[21,22,26]

In the subsequent time points, force intensity varied considerably within each group at the different time points. Both the elastomeric chains in the short group and those in the medium and long groups had, from the first hour on, statistically

significant differences from the force delivered initially. The percentages or remaining force in comparison with initial values for each group of elastomeric chains under study at each time point are shown in Figure 1.

The force used for distal canine movement along time degrades due to two factors: The relative movement of teeth used for anchorage, and the degradation of the elastomeric chains themselves.[12] Therefore, the decrease in the distance between the device hooks seems to be justified as it aimed at simulating the effect of tooth movement over the decrease of elastomeric chain force.

Elastomeric chains lose a large amount of the force initially delivered during the first day after activation and may, according to some authors, have a decrease of up to 75% of the initial force.[13,18] Andreasen and Bishara[1] recommend the use of an initial force 40% greater than optimal force for a certain orthodontic movement to compensate for the degradation that usually occurs in the first 24 hours. However, other authors suggest that there are no differences in the final outcome of expected tooth movement when greater forces are applied.[5] Moreover, increased forces might cause more patient discomfort and other complications, such as distant bone resorption.[28] In this study, about 20% of the initial force was lost in the same time interval, which suggests that there are differences between products from different manufacturers, as well as in variables used in each study method.

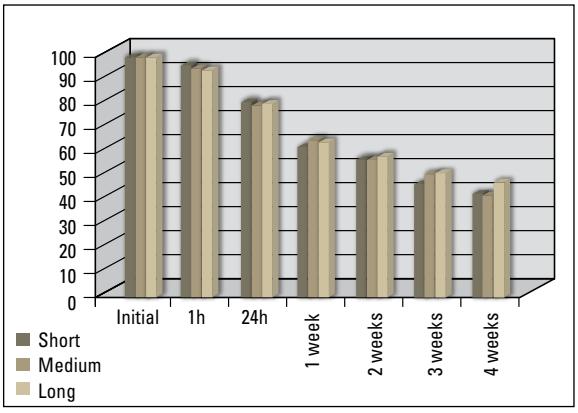

FIGURE 1 - Graphic representation of remaining force percentage, for each studied group of elastomeric chain, for each experimental time in relation to the initial values.

The analysis of force degradation along time revealed that the three groups of elastomeric chains had a substantial reduction in force delivered, and reached a mean percentage of about 55% decrease from initial force at the end of the trial (Fig 1). From the third week on, remaining forces seemed not to be within the optimal range for orthodontic tooth movement any longer.[22,26] However, according to the results reported by Boester and Johnston,[5] it is still possible to move canines distally using this force, although more slowly.

The elastomeric chains in the short group had a mean initial force greater than that in the other groups, but at the end of the trial the greatest value was found in the long group. Our results differ from those reported by other authors[4-8], who found that short elastomeric chain modules with no spaces between the links retain the greatest percentage of force along time.

Mean percentage values found in this study for force degradation at the different time intervals under study differed from those found in other studies, which might be assigned to the fact that elastomeric material was produced by different manufacturers and had different compositions. Moreover, there are method differences between studies, as well as limitations due to details of configurations already tested, such as color and distances between links of the elastomeric chains.

Although the comparisons between forces delivered at each time point revealed statistically significant differences between the Short, Medium and Long groups, these differences do not seem to have any clinical significance because the greatest difference was about 12 gf between the Short and Medium group, which is not enough, clinically, to affect the resulting tooth movement.

CONCLUSIONS

After the analysis of comparisons between groups of elastomeric chains with short, medium and long distances between links, we concluded that this difference does not seem to be a clinically significant characteristic of force degradation along time. In the three groups of elastomeric chains, there was a considerable decrease of the force delivered, and the mean percentage of decrease from initial values to the end of the trial was about 55%. The interval between visits to replace the segments of grey elastomeric chains in any of the three configurations of the brand studied here should be three to four weeks. This is supported by findings in the literature and the results of this study and tested for tooth movements in cases of space closure after extraction of the first premolar and the distal movement of the canine.

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Prospective cephalometric study of the effects of maxillary protraction therapy associated with intermaxillary mechanics

Juliana de Oliveira da Luz Fontes*, Guilherme Thiesen**

Abstract

Objective: The early diagnosis and treatment of skeletal Class III (Pattern III) is still a much debated topic in orthodontic literature. Maxillary protraction associated with rapid maxillary expansion is the most popular and widely researched approach, producing the best results in the shortest period of time. This study aimed to evaluate the gradual changes that occur in the dentofacial complex in children with Pattern III growth treated with maxillary protraction associated with intermaxillary mechanics. **Methods:** The sample consisted of 10 patients with Pattern III, whose mean age was 8 years and 2 months at the beginning of treatment, consecutively treated with a modified Haas expander, modified lingual arch, intermaxillary elastics and Petit facemask for maxillary protraction during a 9-month period. Four lateral cephalograms were taken of each patient, one at the beginning of treatment and the other three at regular 3-month intervals (T1, T2, T3 and T4). Cephalometric measurements at each of the four times were compared using ANOVA variance for repeated measures and supplemented by Tukey's multiple comparisons test. **Results:** It was observed that the most significant skeletal changes occurred in the first 3 months of treatment. After that period the changes remained constant until the end of treatment. There were few dental compensations and the vertical changes which occurred showed reduced clinical significance. **Conclusions:** The therapy used in this study accomplished not only the correction of overjet but also improvements in the sagittal relationship of the basal bones and in soft tissue esthetics.

Keywords: Prognathism. Palatal expansion technique. Extraoral traction appliances. Malocclusion.

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INTRODUCTION AND LITERATURE REVIEW

Class III malocclusion, originally defined by Angle as a mesial relationship between mandibular and maxillary molars, is actually linked to several skeletal and dental changes, which often result in a disharmonious facial appearance. Thus, Pattern III can be defined as a conspicuous anteroposterior imbalance expressed in the soft tissues of the face resulting from a sagittal skeletal discrepancy between basal bones (mandibular prognathism, maxillary deficiency, or a combination of both), accompanied or not by changes in the vertical and transverse directions. These discrepancies promote skeletal changes in the position of the teeth both inter and intra-arch.[4]

Despite its low prevalence when compared to other malocclusions,[6,21] it's prominent facial characteristics determine the need for therapy in the early development stages of individuals with this condition. However, early treatment of Pattern III can prove a major challenge to orthodontists in their clinical practice because of its complex control and difficulty in predicting the patient's morphogenetic growth pattern until adulthood.

Conversely, many professionals prefer to wait for skeletal maturity to treat this deformity through orthognathic surgery given uncertainties regarding the success and stability of early treatment. However, recent studies with long-term follow-up of patients who received early treatment with orthopedic mechanics have shown that good results can be achieved in a considerable number of patients.[26,28]

Among the early treatment modalities of Pattern III, maxillary protraction is the most popular and widely researched approach in the orthodontic literature, yielding the best results in the shortest period of time, especially in individuals who are in the late deciduous or early mixed dentition stage. Among the changes that occur during treatment, one could highlight maxillary displacement in the anterior direction, clockwise rotation of the mandibular plane, antero-superior displacement of the upper arch, lingual inclination of mandibular incisors, increased antero-inferior facial height and increased facial convexity.[1,6,10,16,18,19,23] Recently published studies report the use of different maxillary expanders, which may be associated with other intra- or intermaxillary appliances designed to enhance the skeletal effects of maxillary protraction.[3,12,14,22]

Given the undeniable importance of this topic as well as the many controversies that still surround it, this study aimed to evaluate how to maximize the effects of a proven method, i.e., maxillary protraction, through the concurrent use of this approach in combination with Petit facemask and intermaxillary mechanics with the continued use of Class III intraoral elastics. Moreover, there are no orthodontic studies in the literature assessing the gradual effects of this therapy throughout treatment, although some authors[4,7] have speculated that most skeletal effects occur during the first months of therapy.

MATERIAL AND METHODS

Sample description

To perform a prospective cephalometric study of the dental, skeletal and soft tissue changes induced during treatment, 10 patients (6 females and 4 males) were consecutively treated with a modified Haas expansion appliance, modified lingual arch and Petit facemask for maxillary protraction for a period of 9 months. Mean subject age was 8 years and 2 months at the beginning of treatment (ages ranging from 5 to 11 years). The sample was provided by the Department of Orthodontics of UNISUL – Florianópolis, Brazil.

Some selection criteria were used for inclusion of individuals in the experimental group: 1) Facial Pattern III with maxillary deficiency assessed by examining the nasolabial folds and

marked deficiency in the malar region; 2) Pattern III skeletal growth, as determined by Wits≤ 0 mm; 3) deciduous dentition or mixed dentition, 4) anterior crossbite or end-to-end relationship; 5) no previous orthodontic treatment, 6) absence of congenital and/or other facial deformities.

The skeletal age of the patients was assessed using the method of cervical vertebrae maturation proposed by Bacceti, Franchi and McNamara.[2] This method consists of six stages of increasing development, but all the patients selected for this study were in the third stage, i.e., before the peak of pubertal growth spurt.

Anchorage system

Upper arch

The anchorage system used in the maxillary arch of all patients (Fig 1) was a modified fixed Haas type expansion appliance made of 1.2 mm steel wire (Dentaurum®) with buccal and lingual connecting bars. The buccal bar was extended distally in order to allow the insertion of Class III intraoral elastics. Deciduous second molars were banded whenever possible. When banding these teeth was not possible the first permanent premolars and molars were banded instead (Universal Band Kit – Morelli®). All other posterior teeth were often bonded with composite (Z100 – 3M). An 11-mm expansion screw was used (Dentaurum) and the activation protocol involved 2/4 turns per day, and the screw was opened to its maximum amplitude in all cases. During the active expansion phase (14 days after screw activation), Petit facemask for maxillary protraction was placed using an mean force of 400-600 g on each side. Patients were instructed to wear the facemask for an mean time of 12 hours per day.

Lower arch

The anchorage system used in the lower arch (Fig 2) was a modified Nance lingual arch made of 1.0-mm steel wire (Dentaurum®) with a buccal connecting bar and hooks in the canine region for the use of Class III intraoral elastics. Either the second deciduous molars or the first permanent molars were banded (universal band kit, Morelli®). The other posterior teeth were bonded with composite (Z100, 3M).

Class III elastics were extended (Fig 3) between the hooks on the posterior region of the modified Haas expander and the hooks in the anterior region of the modified Nance lingual arch. Patients were instructed to wear them 24 hours a day (removing them only for feeding and hygiene). The average force applied by the Class III intraoral elastic was 200-350 g.

All subjects in the experimental group wore the modified Haas appliance, the modified lingual arch and the facemask for a period of 9 months after which a positive overjet was attained.

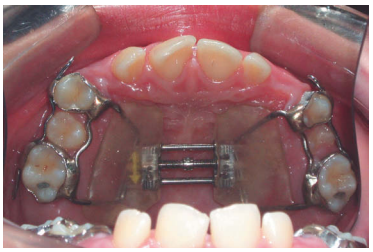

FIGURE 1 - Modified fixed Haas type expansion appliance.

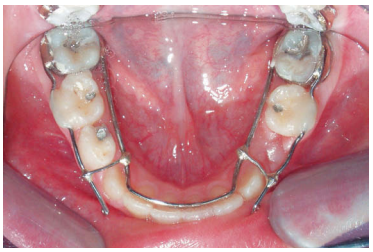

FIGURE 2 - Modified Nance lingual arch.

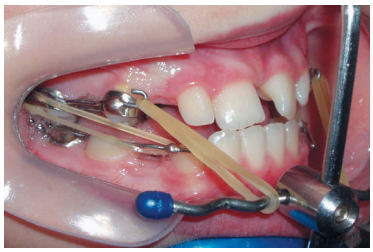

FIGURE 3 - Class III intermaxillary elastics associated with facemask extraoral elastics.

Measuring the changes

The dental, skeletal and soft tissues changes were evaluated through lateral cephalograms obtained at four different times: T1) beginning of treatment, before appliance placement; T2) after 3 months of treatment; T3) after 6 months of treatment; and T4) after 9 months of treatment, immediately before the appliance removal.

All radiographs were performed in the Radiology Department of Nivaldo Nuernberg Dental Institute (IONN, Florianópolis/SC, Brazil) using a lead protection and without charging the patients. It was always used the same X-ray machine (Siemens®, Germador-type, with a Margolis cephalostat).

The radiographs were processed by an employee of the IONN radiology department in a Al-pró Imagcorp processor (model A/T 2000M) in a dark chamber, using a total processing time of 3.5 minutes.

The cephalometric tracings were performed manually by the same previously calibrated examiner using black pencil. Comparative analysis between the two groups was conducted by measuring angular and linear profile cephalometric radiographs with scales of 0.5° and 0.5 mm, pairing up the four times in the experimental group (T1, T2, T3 and T4). No correction was made for linear magnification of the radiographic images (approximately 7% relative to the sagittal plane).

To calculate intra-examiner error, 20% of radiographs of experimental group were randomly selected and once again traced and measured with a two-week interval between the first and second evaluation. Error was calculated using Student's t-test for paired samples, comparing the values obtained in the first measurement with the values of the second measurement at a significance level of 5%. To calculate random error, Dahlberg's formula was employed.

After collecting the data, a database was structured to enable application of statistical tests using the software Statistica for Windows, version 6 (StatSoft). The cephalometric measurements were compared between the four times with ANOVA for repeated measures at a 5% significance level, since the same individual was measured at different times. To complement the analysis of variance, Tukey's multiple comparisons test was applied also at a 5% significance level, indicating when there were differences between the means (T1, T2, T3 and T4). Dental, skeletal and soft tissue changes were measured using angular (SNA, SNB, ANB, SN.Ocl, SN.PP, SN.GoMe, 1.NA, 1.NB, FMA, IMPA, 1./PP) and linear (Wits, ANS-Me, Co-A, Co-Gn, NPerp-A, NPerp-Pog, UL, LL, 1/-NA, /1-NB) cephalometric measures.

RESULTS

Calculation of intra-examiner error was performed by applying Student's t-test for paired samples at a 5% significance level. No statistically significant difference was found for any of the measures assessed. Likewise, no significant random error value was found for the angular and linear measures. The largest measurement differences were found to be 0.5° and 0.7 mm respectively.

Table 1 shows that most of the sagittal skeletal changes occurred in the maxilla in the first 3 months of therapy as revealed by the SNA, NPerpA and CoA measures. Moreover, it was confirmed that maxillary incisors underwent lingual inclination in the first three months of maxillary protraction. After that period, these teeth showed progressive proclination as treatment evolved. This initial retroclination was probably due to the substantial maxillary expansion experienced by these patients, which increased the perimeter of the maxilla.[5,27] After this initial period, labial inclination increased in the sixth and ninth months of therapy, corroborating the findings of several studies.[3,15]

Table 2 shows that measures SNB and NPerp-Pog remained virtually stable throughout treatment, exhibiting a slight reduction in the first 3 months of therapy, although not statistically significant. Effective mandibular length increased during treatment, confirming that patients' mandibles had grown during the evaluation period. However, this mandibular growth did not mean a mandibular protrusion probably due to the fact that the mandible rotated during that period.

Lower incisors showed mild retroclination during treatment as demonstrated by measures 1-NB, 1.NB and IMPA.

As shown in Table 3, treatment induced significant changes in the maxillomandibular relationship (ANB and Wits). These changes were significant in the first 3 months of treatment and remained almost stable until its end.

Table 4 allows assessment of vertical changes occurring during the treatment period. Although some mandibular rotation was noted during therapy (increases in FMA and SN.GoMe), this change was not statistically significant for any of the evaluated times. By the same reason, the palatal plane did not change significantly during treatment.

However, there were statistically significant changes in the anteroinferior facial height (ANS-Me) and in the occlusal plane (SN.Ocl). It is noteworthy that although there were changes in the occlusal plane during therapy, these changes were considered minor and clinically negligible after treatment.

Table 5 shows the measures that assess upper and lower lip protrusion relative to Steiner's S line (S-UL and S-LL). Upper lip protrusion was observed, with a significant increase in the

TABLE 1 - Means, standard deviations and variance analysis for measures used to evaluate maxillary effects.

Measure	Mean value of maxillary measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SNA	78.18 (2.85)^{A}	80.57 (3.47)^{B}	80.28 (2.60)^{B}	80.30 (3.05)^{B}	0.0001
NPerp-A	-0.51(2.79)^{A}	2.22 (2.22)^{B}	2.10 (2.39)^{B}	2.55 (2.11)^{B}	<0.0001
Co-A	83.50 (3.04)^{A}	85.56 (3.02)^{B}	86.31 (3.08)^{BC}	86.88 (3.34)^{C}	<0.0001
1.NA	4.53 (3.82)^{A}	3.47 (2.48)^{AB}	4.15 (2.93)^{AB}	5.08 (3.57)^{B}	0.0007
1/-NA	4.53 (3.82)^{A}	3.47 (2.48)^{AB}	4.15 (2.93)^{AB}	5.08 (3.57)^{B}	0.009
1.PP	115.28 (8.52)^{BC}	111.29 (9.12)^{A}	113.35 (6.80)^{AB}	116.35 (7.12)^{C}	0.0002

* Means followed by different letters differ significantly.

TABLE 2 - Means, standard deviations and variance analysis for measures used to evaluate mandibular effects.

Measure	Mean value of mandibular measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SNB	78.20 (3.09)	77.13 (2.88)	77.27 (2.85)	77.10 (3.67)	0. 082
NPerp-Pog	-1.19 (6.78)	-1.69 (6.40)	-1.64 (4.79)	-0.67 (4.97)	0.725
Co-Gn	109.79 (5.91)^{A}	110.89 (6.31)^{AB}	111.94 (7.40)^{AB}	112.95 (8.17)^{B}	0.006
1.NB	24.61 (5.87)	22.35 (4.64)	21.43 (6.04)	21.38 (6.57)	0.096
1/-NB	3.75 (2.18)	3.08 (2.14)	3.01 (2.14)	3.10 (2.40)	0.1
IMPA	89.26 (7.15)^{B}	85.50 (6.03)^{A}	85.83 (7.35)^{A}	85.10 (7.01)^{A}	0.0002

* Means followed by different letters differ significantly; where there are no letters, no significant difference was found.

TABLE 3 - Means, standard deviations and variance analysis for measures used to evaluate intermaxillary effects.

Measure	Periods				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
ANB	-0.02 (3.26)^{A}	3.34 (2.31)^{B}	3.02 (2.41)^{B}	3.20 (2.46)^{B}	<0.0001
Wits	-5.56 (3.29)^{A}	-1.78 (4.31)^{B}	0.48 (4.14)^{B}	-0.17 (3.46)^{B}	<0.0001

* Means followed by different letters differ significantly.

TABLE 4 - Means, standard deviations and variance analysis for measures used to evaluate effects in the vertical direction.

Measure	Mean value of vertical measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SN.Ocl	19.33 (6.77)^{AB}	19.74 (6.84)^{B}	15.99 (7.34)^{A}	17.49 (8.51)^{AB}	0.031
SN.PP	8.25 (3.24)	7.62 (3.16)	7.70 (3.01)	8.26 (3.22)	0.728
SN.GoMe	37.35 (4.03)	39.32 (4.02)	38.34 (4.87)	38.35 (5.88)	0.084
FMA	26.18 (5.12)	27.59 (5.96)	26.40 (4.64)	26.85 (5.25)	0.062
ANS-Me	61.07 (5.63)^{A}	64.57 (5.38)^{B}	65.13 (5.01)^{BC}	65.84 (5.22)^{C}	<0.0001

* Means followed by different letters differ significantly; where there are no letters, no significant difference was found.

TABLE 5 - Means, standard deviations and variance analysis for measures used to evaluate soft tissues effects.

Measure	Mean value of soft tissue measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
S-UL	-0.19 (3.32)^{A}	0.15 (3.08)^{AB}	1.03 (3.18)^{B}	1.36 (2.92)^{C}	0.0003
S-LL	1.56 (3.17)^{A}	0.51 (3.27)^{AB}	0.76 (3.14)^{AB}	0.82 (3.16)^{B}	0.04

* Means followed by different letters differ significantly.

S-UL measure during treatment. Conversely, lower lip protrusion gradually decreased until the end of treatment.

DISCUSSION

Maxillary protraction in nowadays orthodontics has become the most widely used technique to correct the development of Pattern III maxillomandibular growth pattern. The popularity of maxillary protraction has increased due to awareness that maxillary deficiency plays a partial or key role in the structural etiology of Pattern III. Moreover, numerous reports have demonstrated that this appliance accomplishes a higher success rate in the long term when compared to other techniques, such as chin cups, functional appliances or camouflage therapy.[8,23,25]

Regardless of posttreatment stability, the major purpose of performing early treatment of Pattern III is to induce maximal skeletal changes with minimal dental compensation. Thus, a variety of extra and intraoral devices have been developed to enhance desirable orthopedic effects during orthopedic treatment of these patients.[12,14]

Furthermore, the results achieved by Holberg, Mahani and Rudziki[9] also should be taken into account. They reported that the forces

commonly employed to promote maxillary protraction by using facemasks are apparently insufficient to significantly stimulate bone formation in circum-maxillary sutures. According to the authors, who analyzed maxillary protraction by means of the finite element method, it seems unlikely that the magnitude of the stresses induced in the sutural areas of the mid-face during therapy is sufficient to generate significant skeletal effects.

Therefore, the aim of this study was to evaluate the use of maxillary protraction associated with intermaxillary mechanics through the analysis of the gradual skeletal, dental and soft tissue effects induced by the treatment. Thus, the major goal of the therapy postulated in this study, which involves the concurrent use of intermaxillary mechanics in combination with a facemask, would be to maximize the orthopedic effect of early treatment of Pattern III.

It was noted that the mechanotherapy employed in this study proved superior—in terms of skeletal advancement of the maxilla—compared to most findings in the literature.[6,17,19,21,23,29] However, its performance was similar or inferior to others.[12,13,15,22] The same applies to the maxillomandibular relationship, which shows that the mechanotherapy applied in this study proved effective for the treatment of Pattern III, but similar to some studies that employed facemask alone.[10,11,15,22] The measures used to assess anterior mandibular protrusion exhibited a mild reduction, statistically insignificant and in line with other studies.[10,13,15,16,18,22,23]

At the end of the treatment proposed in this study, mild dentoalveolar compensations appeared in the upper arch (slight incisors buccal inclination assessed by measures 1.Na, 1-Na and 1.PP). In the lower arch, mandibular incisors experienced a slightly bigger retroclination but similar to what has been reported by other authors.[3,8,15]

Finally, these results clearly show that the simultaneous use of facemask and intermaxillary therapy, as suggested in this article, may not unreasonably potentiate the desired orthopedic effects in the interceptive treatment of Pattern III, but it neither maximize the role of the dentoalveolar component in the treatment.

Analysis of the four different assessment times revealed that most of the skeletal changes caused by therapy occurred within the first 3 months of treatment. After that period they remained almost constant until the end of treatment (as evidenced by the SNA, NPerp-A, Co-A, ANB and Wits measures presented in Tables 1 and 3).

Although most of the skeletal changes occurred in the first 3 months, it should be stressed that stopping treatment at this time could lead to relapse. Further investigation is necessary to clarify these issues.

Dental compensations were more evident in the last months of maxillary protraction (T3 and T4), and the maxillary incisors flared and mandibular incisors experienced progressive retroclination with treatment. However, the dental changes that occurred in this study can be considered minor. This leads to the conclusion that during treatment there is a tendency toward gradual dentoalveolar compensation with maintenance of the orthopedic effects achieved in the first months of maxillary protraction therapy.

The data presented in this study, which assessed maxillary protraction every 3 months, have significant clinical value as they shed light on the effects generated during treatment. Thus, the ideal time for intervention with this approach can be more accurately defined. However, some limitations of this study should be considered, including the lack of a control group, currently unfeasible for ethical reasons. Despite exhibiting normal distribution, the sample size used in this study can be considered somewhat small. In addition, longitudinal follow up is required to assess whether or not the positive effects achieved herein will be preserved until the end of the patients' growth period.

CONCLUSIONS

In observing the gradual skeletal changes that occurred during treatment one finds that virtually all significant skeletal changes took place in the first three months of treatment and remained constant until its end. From the dental point of view, there were few dental compensations. Vertical changes were also reduced and had little clinical significance. After treatment, it was found that maxillary protraction combined with intermaxillary mechanics was able to not only correct overjet but also improve sagittal relationship between basal bones and soft tissue esthetics, although these changes were not significantly enhanced when compared to others findings in the literature.

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