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HUMAN BRAIN
THE MOST ADVANCED AND IMPORTANT 3D TOOL IN DIGITAL WORKFLOW

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"It must be the ambition and determination of every orthodontist, to treat each of your patients in a way that will produce the best possible results with the least inconvenience for both."

Harold Dean Kesling

Kesling[1] is considered to be the father of clear aligners, at least of the most important concept behind the technique that is most evident in Dentistry worldwide and which has been responsible, to a large extent, for all the good and bad in the profession over the last two decades. Kesling's conviction, which we vehemently share, can be seen already in the title of his classic 1946 article, published in *American Journal of Orthodontics and Oral Surgery*[1] — "*Coordinating the predetermined pattern* and *tooth positioner* with *conventional treatment*". Taking into account the scientific evidence and therapeutic devices available in the post-war period, for the visionary Kesling only 15% of what we do is what actually contributes to the final result of our treatments. That is, an incredible 85% of the time, expenditure, and our efforts are in theory wasted on unnecessary adjustments, diagnostic errors and planning, lack of patient cooperation, among others.

What Kesling realized with great mastery and, which has changed little after eight decades, is that the greatest dilemmas of Orthodontics are the difficulties posed by the challenge of abstracting[2] how to move the teeth in order to obtain a stable, functional dental rearrangement and in harmony with the aesthetics of the smile and face, considering the significant individual morphological variations both of the skeletal bases, as well as of the soft tissues and teeth[3].

To "pour gasoline on the flames", theories that demystify the classic paradigms of Orthodontics have recently gained strength, which often "force" us to try to fit results into arbitrary norms that were randomly determined, based on intangible ideals and little found in the nature in part influenced by the sectarian theories of Eugenics, notoriously related to the ideals of the Nazi Party[2] in 1930s Germany. The new "Quality of Life Paradigm"[3] frees the orthodontist from the curse of supposedly having to treat "bad" occlusions as if they were "diseases", a concept that in fact would be better defined as: individual morphological variations, subject to genetic and environmental factors with greater or lesser impact on the lives of individuals. In other words, what must be "treated" are the negative impacts of such "bad" occlusions and this varies greatly, as it is no longer possible to exclude from this equation the socio-emotional issues and the expectations of each person regarding the treatments.

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1 *American Journal of Orthodontics and Dentofacial Orthopedics.*

2 Abstraction is a type of thinking that allows us to reflect on things that are not present in space and in the current moment. It also allows us to reflect on general concepts and principles, both in our daily lives and in a more academic or professional environment.

3 It is know from experience that mechanics applied to dentofacial biology is something of considerable complexity, as it is not about moving a "free element in space" from point A to point B linearly on a flat surface, but to move three-dimensionally several dental elements "trapped" in their alveoli, which in turn are "grasped" in their dental arches that are dependent on the positions of their skeletal bases, one fixed (maxilla) and the other mobile (mandible), which adds an even more destabilizing difficulty factor, which are the relationships between the heads of the mandible and the joint fossa, having between them the soft tissues that form the TMJs, such as the ligaments, cartilages, connectives, muscles, vessels and nerves. All this, occurring many times during the process of growth and development.

But what was Kesling's ingenious "ace in the hole"? What is the most important concept behind the transparent aligners that imposes itself on its well-known use for the manufacture of aligners?

The "pre-determined pattern" in the title of his article of 1946 is nothing more than what we know today as an orthodontic "setup"[4].

Praising the role of setup in the therapeutic decision process and planning of orthodontic treatments is without a doubt one of the greatest contributions that the specialty has received throughout the 20th century, comparable to Angle's edgewise appliance concept and to the development of the pre-adjusted appliance of Andrews.

The setup is a prerequisite for making transparent aligners, whether done in an "analog" manner or, more recently, digitally after Align Technology launched the Invisalign® device on the world market in 1999[4]. However, the value of this "tool" is inestimably greater than simply serving as a software algorithm to be used in order to generate sequencing of models for 3D printing and subsequent thermo-plastic stamping.

On the one hand, the possibility of increasing the unprecedented level of health care offered to clients, placing the professionals in their prominent and relevant place, as the original manager of the diagnosis, therapeutic decision, and planning process. And on the other, frightening, and growing threat of total profession robotization aggravated by the declining levels of academic training in Brazil. As such, it is vitally important that new generations really understand the value of that "natural algorithm" that we all have access to 24/7, which is contained in the most important "3D tool" of all.

The process of carrying out the virtual, quick, and accurate re-arrangement of teeth enhances that exercise of abstraction that we all have to do for each clinical case, allowing the possibility of choosing between several scenarios to define together with clients the best clinical alternative. These insights that occur naturally in the dynamics of the digital setup allow the definition of a logical sequence of steps, in order to increase both the effectiveness and efficiency of treatments. In other words, it is much simpler to determine tangible goals with the additional possibility of detailing the design of the devices, whether they are fixed labial, lingual or plastic plates (aligners), additionally to auxiliary devices such as the new MSE[5] and anchoring tools, as mini-implants with the possibility of clinical transfer of the positioning of these devices through transfer guides printed in 3D.

In other words, the setup value is directly related to the search for better results, in the most convenient way for both clients and professionals, as Kesling said the advent of computer graphics combined with new intraoral scanning equipment represents the biggest watershed that Dentistry has ever faced.

However, as the saying goes, "there is no free lunch". The learning curve to master these new tools, especially the multiples softwares and systems that are available today, can be long and is dependent on several factors, such as the quality of the machines that will be configured to run these programs, in addition to other variables that involve information technologies. In addition, the need to make these investments implies choosing the best program and/or system that meets the needs of each clinical context, which can range from the exclusive practice of Orthodontics to comprehensive clinics with an interdisciplinary approach that requires additional resources such as access to CT images, PACS and eventually other features such as face scanners.

Besides the factors described above, there is an even greater challenge, which is the temptation to outsource ad aeternum this primary responsibility to a manufacturer that, in general, makes us mere spectators of the process. We agree that initiating the new digital flow in the clinic by hiring a supplier that is able to offer a well-built digital platform that allows the submission of cases online, through an intuitive interface (front-end), a planning center that is run by orthodontists, and a final product with certified quality makes perfect sense and is preferable for those just starting out.

4 Setup is the way in which something, especially an organization or equipment, is organized, planned, or arranged.

5 **MSE** - *Maxillary skeletal expander*.

However, as the learning curve evolves, investing in a good software can be extremely valuable for anyone who wants to remain in the profession independently with success, financial return and maintaining the status of a higher-level health professional.

The alternative is to become one of the many "delivery boys and girls" that are serving the corporate interests of large publicly traded multinationals, whose "commitment" to Dentistry is directly related to the value of their shares on stock exchanges[5]. Delegating the essence of the profession, which is our freedom of conviction to indicate each therapeutic resource and our competence to carry out the planning of each clinical case, is something that puts the future of Orthodontics at risk[6], and is creating a growing generation of zombies, fulfilling tasks. This scenario is even more delicate, especially at a time when science is under attack and meritocracy, a currency that has unfortunately lost its value. Those who set the rules today are the CEOs of large companies that use social media KOLs[6] very well selected to redefine the meaning of success in OUR profession.

Pay homage to the true thinkers of Orthodontics, meritorious par excellence for the great contributions given to the specialty, is something that imposes itself. Among countless valuable brains, some already mentioned here, it is also worth knowing the incredible stories of two pioneers who honor us a lot: Henry Isaac Nahoum[7] and John Joseph Sheridan[8]. Nahoum, a professor at Columbia University, before being the first to use thermo-plastic stamping in 1959 to make a liner, fought in World War II as a Lieutenant in the 109th Regiment of the 28th Infantry Division and helped free Jews from Concentration Camps of Nazi Concentration in 1945. Sheridan besides developing the well-known Essix® System in 1993, was Captain of the United States Marine Corps as a fighter pilot, a chapter in his life that shaped many of the personality traits of the United States, a chapter in his life that shaped many of the personality traits for which he was justifiably known and highly respected. It is to these true heroes of our profession that I pay my respects.

6 The idea of Key Opinion Leader originated in the 1940s by communication theorist Paul Lazarsfeld. He established a concept that people could change their opinions and preferences much more because of "trusted figures" in their networks than because of the more conventional forces, like advertising or scientific evidence about something.

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SUMMARY


Coloque o seu coração, mente e alma
até mesmo em seus menores atos.
Este é o segredo do sucesso.
Swami Sivananda
EDITORAPLENA

TREATMENT OF CLASS II/2 MALOCCLUSION WITH CLEARCORRECT® ALIGNERS - CASE REPORT

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ABSTRACT

The aim of this research was to address the planning and treatment of a Class II/2 malocclusion treated without extractions, using orthodontic clear aligners. In the treatment of this malocclusion it is necessary to consider the severity degree, whether it is dental or skeletal (assess whether it affects only maxilla, mandible, or both), whether there is growth or not, patient collaboration, among other factors. Currently, many patients seeking orthodontic treatment wish to use more aesthetic appliances, especially those who have already used conventional fixed appliance. Thus, there was a great increase in the demand for removable clear aligners, providing benefits such as aesthetics, easier hygiene and shorter treatment time. In this case report, we tried to maintain good maxillo-mandibular relationship, the profile and good lip sealing. For this, ClearCorrect® aligners were used, we have chosen not to extract premolar and perform sequential distalization on the Class II malocclusion side, associating with Class II intermaxillary elastics, interproximal wear (IPR) and attachments. The results achieved were highly satisfactory, restoring good molars and canines relationship, adequate upper and lower incisors buccolingual inclinations, overjet, overbite and middle line correction.Therefore, it was concluded that the treatment of this clinical case with aligners was relatively fast, as efficient as the treatment with conventional fixed appliance and met the aesthetic expectations of the patient.

Descriptors: Orthodontics, Angle Class II malocclusion, ClearCorrect®, clear aligners.

RESUMO

O objetivo deste trabalho foi abordar o planejamento e o tratamento de uma má oclusão de Classe II/2 tratada sem extrações, utilizando alinhadores transparentes. No tratamento dessa má oclusão é necessário considerar o grau de severidade, se é dentária ou esquelética (avaliar se acomete somente a maxila, somente a mandíbula ou ambas), se há ou não crescimento, a colaboração do paciente, dentre outros fatores. Atualmente, muitos pacientes que procuram o tratamento ortodôntico desejam utilizar aparelhos mais estéticos, principalmente aqueles que já utilizaram o aparelho fixo convencional. Dessa forma houve um grande incremento na demanda pelos alinhadores transparentes removíveis, proporcionando benefícios como estética, maior facilidade de higienização e menor tempo de tratamento. No presente caso clínico, procurou-se manter o bom relacionamento maxilo-mandibular, o perfil e o bom selamento labial. Para tanto foram utilizados os alinhadores da ClearCorrect®, optou-se por não extrair pré-molar e realizar a distalização sequencial do lado da má oclusão de Classe II, associando com elásticos intermaxilares de Classe II, desgastes interproximais (IPR) e attachments. Os resultados alcançados foram altamente satisfatórios, restabelecendo o bom engrenamento dos molares e caninos, as inclinações vestíbulo-linguais adequadas dos incisivos superiores e inferiores, o overjet, o overbite e a correção das linhas médias. Portanto se concluiu que o tratamento desse caso clínico com alinhadores foi relativamente rápido, tão eficiente quanto o tratamento com aparelho fixo convencional e atendeu às expectativas estéticas da paciente.

Descritores: Ortodontia, má oclusão de Classe II de Angle, ClearCorrect, alinhadores transparentes.

INTRODUCTION

Orthodontic treatment has been increasingly sought by adult patients and conventional fixed appliances, with brackets and bands, have always been the Gold Standard in Orthodontics[1]. However, these devices are much more prone to the accumulation of bacterial plaque and make oral hygiene difficult, which can result in white spot lesions, caries and periodontitis[2,3]. Periodontal health should be considered one of the success factors of orthodontic treatment and, during fixed orthodontic treatment, pathological phenomena such as gingival bleeding, gingivitis, gingival hypertrophy and worsening of periodontal pockets may occur [4-10].

Another important factor for patients seeking orthodontic treatment is the concern with aesthetics. Many patients who have previously undergone orthodontic treatment, using conventional fixed appliances, request treatment with removable clear aligners. In addition to better aesthetics, they can cause less root resorption and discomfort[6,9,11-14]. Aligners are capable of treating many types of malocclusion with great predictability in dental movements[13].

Class II malocclusion is a frequent problem and can be unilateral, named by Edward H Angle as a subdivision. In treatment planning, the orthodontist should consider the asymmetry etiology and its correction, which generally involves Class II elastics, extractions, extraoral traction, orthodontic distalizers, temporary skeletal anchorage devices and fixed functional appliances[15]. The proportion of Class II malocclusion successful treatment may be influenced by factors such as malocclusion severity, patient age, and the collaboration with treatment[16]. For the treatment of Class II without extraction, distalization of the upper molars is often the method of choice to obtain 2mm to 3mm of space in the arch[4,17]. This distalization can be performed by means of extra or intraoral forces, but some devices produce unwanted inclination of the upper molars and/or loss of anterior anchorage during movement[18]. On the other hand, for Simon et al (2014)[19], aligners can promote translational movements such as molar distalization, incisor torque and premolar rotation, however they considered that incisor torque and premolars rotation are challenging movements for this treatment modality.

Therefore, the aim of this research was to address the planning and treatment of Class II/2 malocclusion treated without extractions, using ClearCorrect® aligners associated with intermaxillary elastics, interproximal reduction (IPR) and attachments.

Clinical case report

A 20-year-old caucasian female patient reported as her main complaint the upper and lower anterior crowding and that she would not like to be submitted to treatment with a conventional fixed appliance. For the preparation of diagnosis and treatment plan documentation was requested for aligners, consisting of extra and intraoral photographs, panoramic radiography, profile teleradiography and digital scanning of both arcades (STL file).

In the facial evaluation, we found a patient with facial symmetry, straight facial profile, adequate nasolabial angle and pleasant smile (Figure 1).

Figure 1 - Extraoral views: **A)** frontal, **B)** profile, **C)** smiling.

In the intraoral assessment, ClassII/2 right subdivision malocclusion was found. The upper midline was 0.5mm diverted to the left and the lower line was 1.0mm to the right, there was a marked overbite, adequate overjet, tooth 13 rotation, upper and lower anterior teeth crowding. The upper and lower arches presented moderate atresia, presence of the third upper and lower molars and element 37 required endodontic treatment (Figure 2).

Figure 2 - Intraoral views at the beginning of treatment: **A)** right lateral view in the study model, **B)** frontal view with mouth slightly open, **C)** left lateral view in the study model, **D)** right lateral view, **E)** frontal view, **F)** left lateral view, **G)** upper occlusal view, **H)** Lower occlusal view.

In the profile teleradiography, there is a good relationship between bone bases, balanced profile and verticalized upper incisors (Figure 3). And in the panoramic radiography, there is the presence of the third upper and lower molars, tooth 37 with endodontic problems, root resorption in teeth 16, 26 and 35 (Figure 4).

After preparation of the treatment plan, the case was submitted to the ClearCorrect® to perform the virtual setup. In the virtual planning it was verified that the treatment would be performed in 14 *steps* in both arches, as the aligner was changed every 14 days, the total treatment time was approximately 7 months (Figure 5).

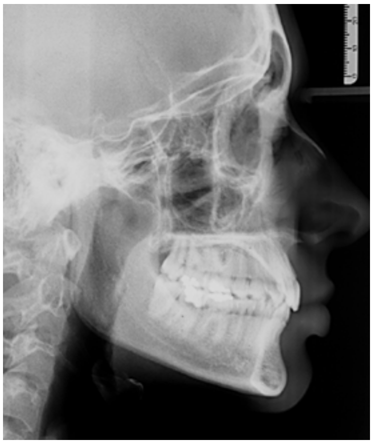

Figure 3 - Initial profile teleradiography.

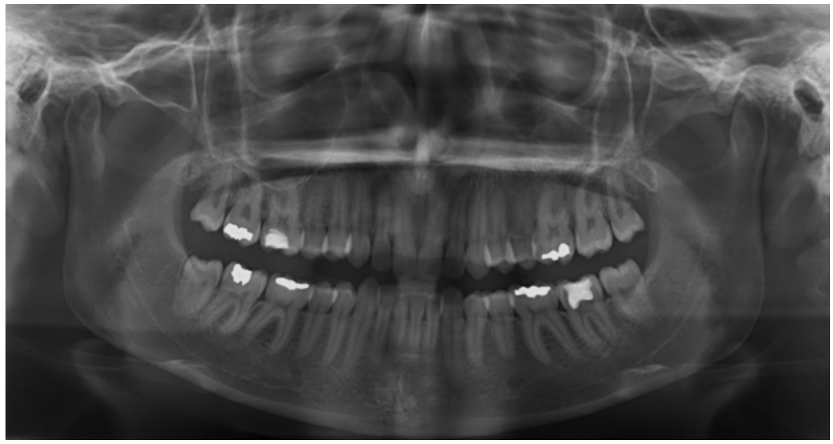

Figure 4 - Initial panoramic radiography.

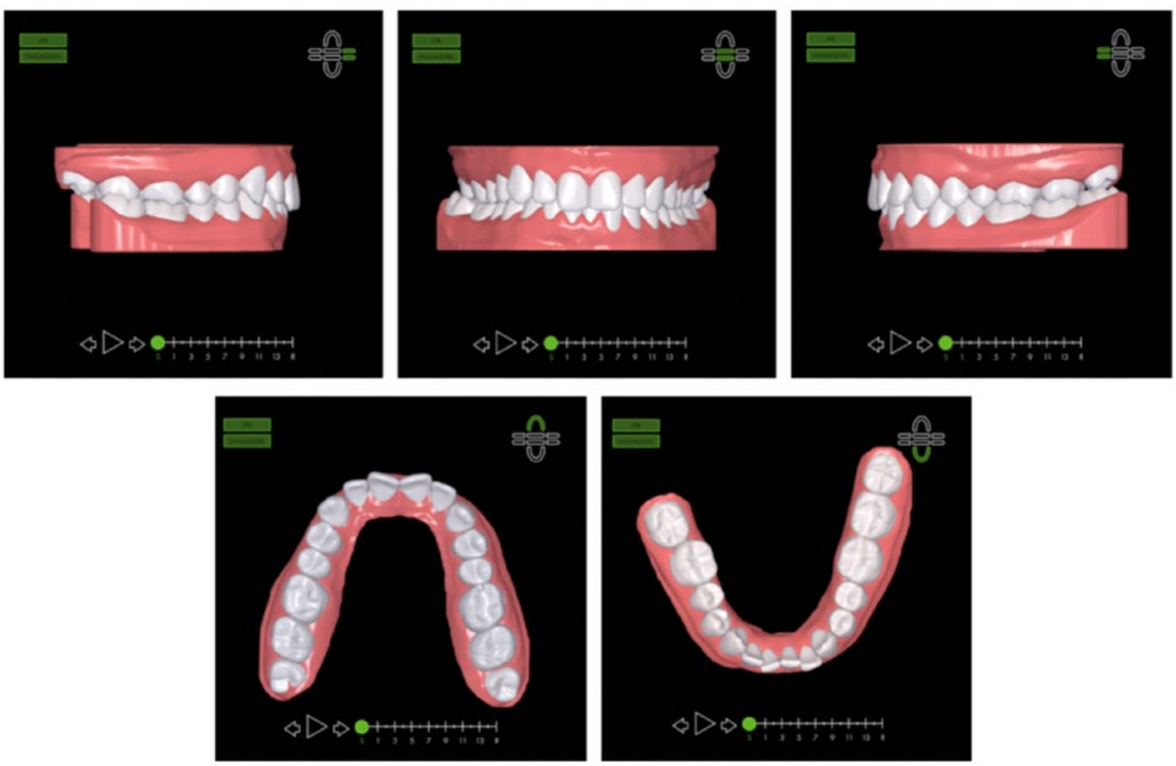

Figure 5 - Initial ClearCorrect® virtual setup.

Dental appointments were scheduled once a month to make the necessary adjustments. There was need of interproximal wear (IPR) of 1.8mm throughout the treatment and attachments bonding to enhance aligners stabilization and optimize the movements required for the correction of malocclusion. The IPR procedures and attachment bonding in the ClearCorrect® protocol are always performed in odd steps so that the patient can be programmed for every one month from step 1. In step 3, attachments (which appear in blue in the setup) were bonded and IPR was also started (Figure 6).

Figure 6 - ClearCorrect® virtual setup: step 3 with attachments bonding and IPR start.

In step 5, the use of medium Class II 5/16 elastics on the right side was initiated to establish the Class I molar and canine relationship, as seen in Figure 7. And in step 9, Class II elastics are recommended for both sides to improve the final meshing.

In the clinical case presented in this study, the patient used Class II intermaxillary elastics (5/16 medium) 22 hours a day from step 5 on the Class II side and after step 9 until the end of treatment, she used elastics on both sides.

Figure 7 - Intraoral views with the use of unilateral Class II elastic: A) right lateral view, B) frontal view, C) left lateral view.

In *step* 7, the crowding was partially corrected, as well as there was a better mesh between the dental arches, as seen in Figures 8 and 9.

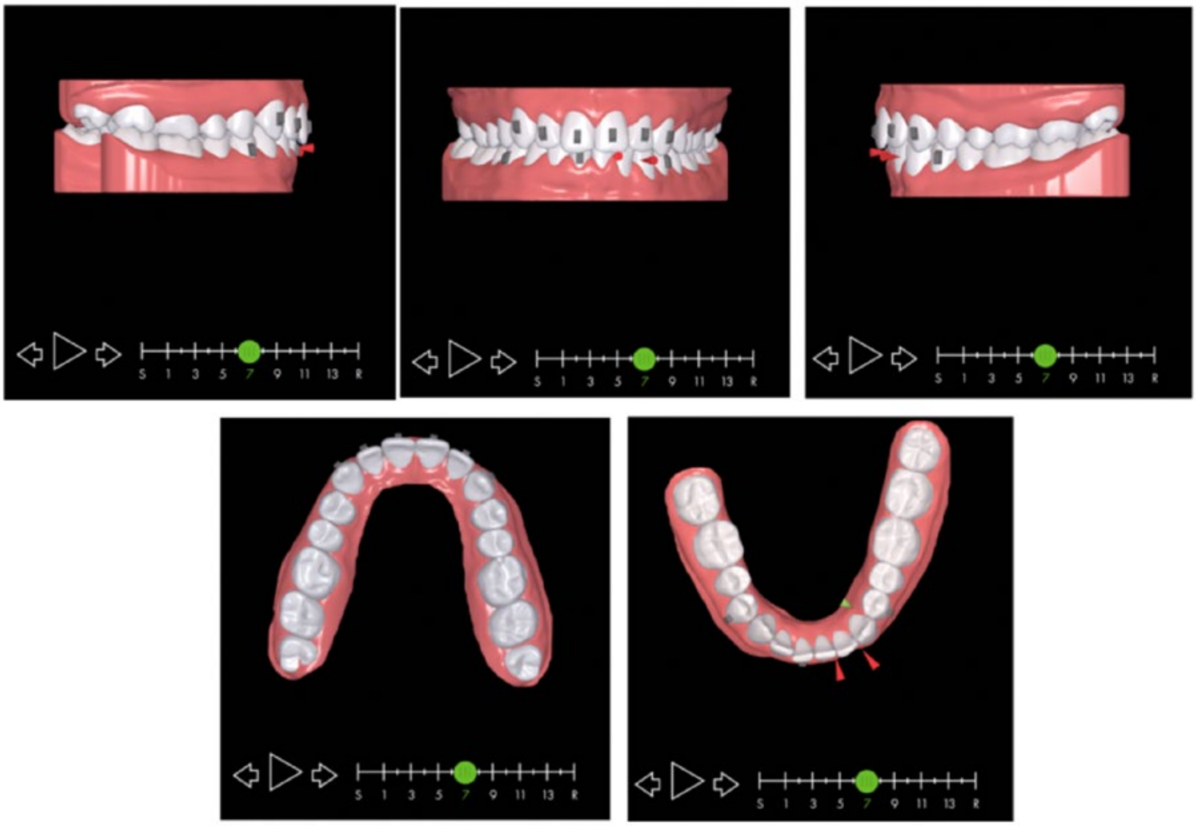

Figure 8 - ClearCorrect® virtual setup - step 7 of treatment indicating IPR need.

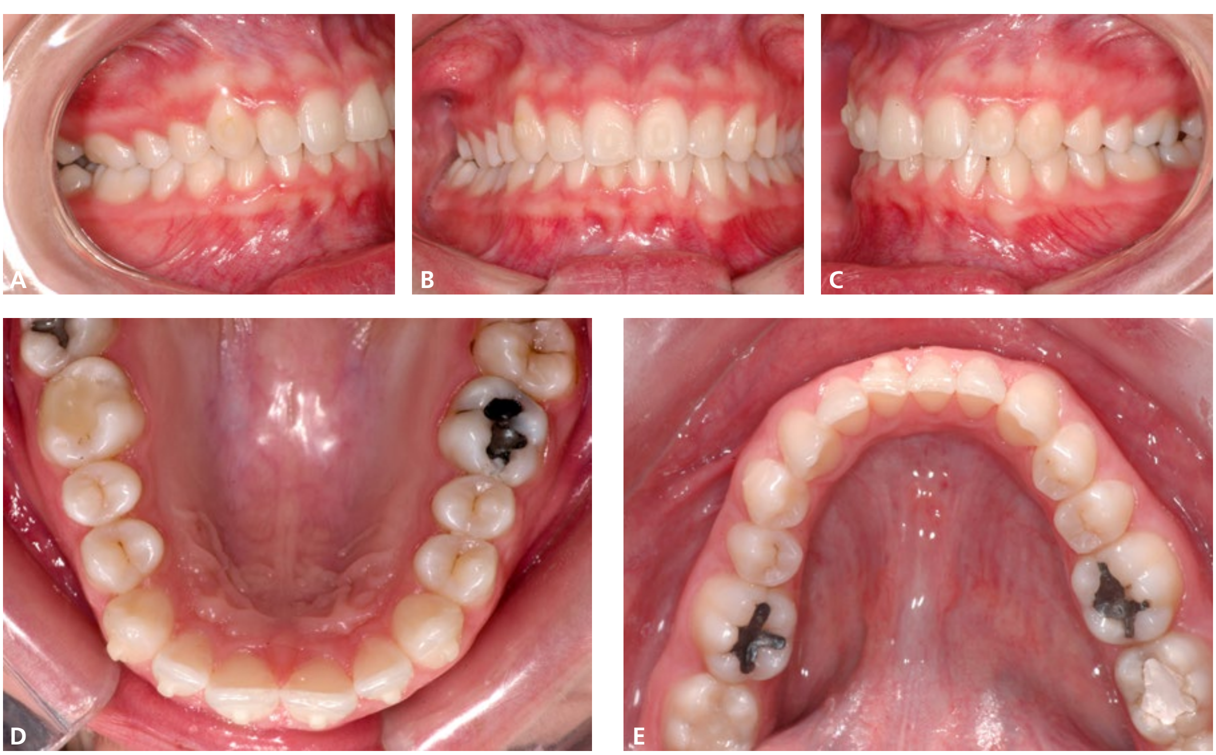

Figure 9 - Intraoral view of the treatment in step 7: **A)** right lateral view, **B)** frontal view, **C)** left lateral view, **D)** upper occlusal view, **E)** lower occlusal view.

After 14 steps, a very balanced face, a nice profile and a harmonic smile were seen (Figure 10). In intraoral photos, correction of the upper and lower middle lines, an increase in the gingival recession of tooth 13 may be verified due to rotational movement (recession present at the beginning of treatment due to the small amount of ceratinized gums), a good meshing and significant improvement in the relationships between canines and molars (Figure 11).

Figure 10 - Extraoral views: **A)** frontal, **B)** Profile, C) Smiling.

Figure 11 - End of treatment intraoral views: **A)** right lateral view, **B)** frontal view, **C)** left lateral view.

In the final assessment of profile teleradiography, an adequate restoration of the inclination of the upper incisors and the maintainance of the profile that was already very good and the harmony between the bone bases may be verified (Figure 12). And in Figure 13, the extractions of the third upper molars (the patient opted for the extractions of the lower after treatment), control of the root resorptions present and the endodontic treatment of the tooth 37 are seen.


Figure 12 - Teleradiography of final profile.


Figure 13 - Final panoramic radiography.

DISCUSSION

The correction of Class II malocclusion can be performed by several forms of treatment and is influenced by skeletal or dental malocclusion severity, degree of patient collaboration, age and aesthetics[4,13,16]. The protocol with extractions basically consists of extracting four premolars (upper and lower) or two upper premolars. In cases cases in which extractions can be avoided, distalization of the upper molars is preferred, being a more conservative treatment[16]. Therefore, according to Ravera et al 2016[4], the third upper molars, when present, should be extracted to allow distalization movement. Extraoral appliances are traditionally used for this mechanics, but as reported by Bolla et al (2002)[18] and Higa (2015)[20] depend on patient the collaboration. Other methods indicated for Class II treatment are pendulum appliances, Herbst, Forsus, Carriere distalizer, interproximal wear, use of Class II intermaxillary elastics and temporary anchorage devices[13,15,16,21,22].

According to Garino et al (2016)[17] attachments inserted in the vertical direction increase the posterior anchorage and present greater control in the inclination during the distalization movement. In the present clinical case, six attachments were used in the upper arch - anterior region - and three in the lower arch, all in the vertical direction, optimizing movements control during anterior teeth retraction. Although Djeu et al (2016)[4] have stated that aligners are deficient in the malocclusions correction in the anteroposterior direction, in the present clinical case it was possible to correct Class II malocclusion with the use of aligners associated with IPR, attachments and intermaxillary elastic of Class II during molars sequential distalization and anterior retraction. Another advantage presented by aligners is the lower incidence of root resorption when compared to conventional orthodontic treatment[11,12,23,24,25,26]. Both Yi et al (2018)[23], and Fang et al (2019)[25] reported a lower incidence and severity of root resorption when compared to conventional fixed appliances. In a recent study by Li et al (2020)[26], aiming to investigate and compare the prevalence and severity of apical root resorption (ARR) in patients treated with conventional aligners and fixed appliances, using Cone Bean Computed Tomography (CBCT), they concluded that both the prevalence and severity of ARR were lower in patients with clear aligners.

Although this clinical case presents root resorption at the beginning of treatment, it was verified that there was no increase after the intervention with the use of aligners.

It is important to emphasize that in the treatment with aligners individual movements are performed, that is, certain teeth are selected in a priority way, and are corrected sequentially. This causes there to be no back and forth movements, providing, when well indicated, a shorter treatment time[27].

Class II treatment time depends on patient's age and malocclusion severity. Cases in which early treatments are performed in children (two phases) require more time, when compared to one only phase treatment in adolescent or adult patient with a lighter degree of malocclusion. According to the results of Yin et al (2019)[21], treatment with the use of Class II elastics, despite the need for longer use is faster, when compared with the Carriere distalizer and Forsus appliance, since after removal the Carriere distalizer it is necessary to assemble the conventional fixed device. However, Shupp, Haubrinch and Neuman (2010)[28] found that treating a young Class II patient with Carriere distalizer appliance, prior to treatment with aligner, becomes faster and equally efficient, as demonstrated by the authors in a patient who used Carriere distalizer for 4 months and after another ten months of aligner with the use of intermaxillary elastics and attachments. For them, the treatment of Class II patients with aligners is almost impossible without associating with anchorage provided by the Class II elastic, which should be used all night and for at least three hours during the day. Fischer (2010)[29] reported three clinical cases of young patients with Class II malocclusion, in which he did not use auxiliaries as elastics or a technique combined with conventional fixed appliance. Treatment was successfully performed, but the longest took 26 months, and 51 upper and 6 lower aligners were required. For Lombardo et al (2018)[13], the combined use of clear aligners with auxiliaries is one of the ways to solve Class II malocclusion, within a period of time comparable to conventional fixed Orthodontics. However, they stated that without the use of auxiliaries, aligners cannot achieve 100% predictability of movements. In the clinical case presented in this study, the patient used Class II intermaxillary elastics (5/16 medium) 22 hours a day from step 5 on the Class II side and, after step 9 until the end of treatment, she used elastics on both sides.

The extrusion and torque control of the upper central incisors were not fully achieved during the previous/anterior retraction with the aligners[30]. This lack of control can affect final occlusion quality, as the crown lingual torque and the incisors extrusion can hinder or prevent perfect intercuspidation during previous/anterior retraction. Probably due to the higher resistance generated by polyurethane – material used in ClearCorrect® aligners – and its 2mm cut out above the gingival zenith, there was an excellent control of the upper incisors torque, including increasing their vestibularization.

According to Li et al (2016)[31], the amount of activation substantially influences the magnitude of force generated by the aligners and, therefore, stated that the activation should not exceed 0.5mm to produce a translational movement of the upper central incisor. They also stated that the aligners presented a rapid relaxation in the first 8 hours and then slowly decreased until they stabilized on the 4th or 5th day, concluding that these first 4 or 5 days are important for orthodontic treatment. However, for White et al[32], patients treated with conventional fixed devices reported greater discomfort and consumed more analgesics than patients treated with clear aligners. In the present clinical case, the patient reported a strong pressure on the teeth whenever she changed the aligners, but that decreased considerably after the first days.

Regarding periodontal disease, the authors Bollen et al (2008)[2], Karkhanechi et al (2013)[9] and Levrini et al (2019)[6] concluded that patients treated with clear aligners had better periodontal health status, when compared to patients treated with conventional fixed devices. Because they are removable, they facilitate oral hygiene, evidencing decrease in plaque levels, gingival inflammation, bleeding at probing and depth of periodontal pockets. Thus, these results suggest that patients at risk of periodontitis are more indicated for treatments with orthodontic aligners.

FINAL CONSIDERATION

It was observed that for the present clinical case, ClearCorrect® aligners were efficient in correcting Class II malocclusion and met the patient's aesthetic expectations.

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CAD/CAM TECHNOLOGY IN ORTHODONTICS: ORTHODONTIC SETUP AND INDIRECT BONDING USING THE EXCEED™ SYSTEM

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ABSTRACT

CAD/CAM systems, including the eXceed™ system, enable orthodontists to perform diagnosis, clinical case planning and virtual brackets positioning. The position of each accessory determined by the software is transferred to the patient three-dimensional model on which an indirect bonding transfer device (IB) of brackets is produced. IB allows improvement in orthodontic accessories bonding accuracy, reducing time and cost of treatment due to lower need of finishing folds and brackets repositioning. The clinical case report aims to present an orthodontic treatment using the IB method with brackets virtual positioning created by the eXceed™ system. Brackets positioning programmed by the eXceed™ system allowed an "ideal" tooth positioning without the implementation of finishing folds and providing an ideal occlusion. This new technology proved to be efficient and effective, and the orthodontic setup provided by the system agreed with the final result of the orthodontic treatment.

Descriptors: CAD-CAM, digital models, corrective Orthodontics, fixed orthodontic device.

RESUMO

O sistemas CAD/CAM, incluindo o sistema eXceed™, possibilitam aos ortodontistas a realização de diagnóstico, planejamento de casos clínicos e posicionamento virtual de bráquetes. A posição de cada acessório, determinada pelo software, é transferida para o modelo tridimensional do paciente sobre o qual um dispositivo de transferência para colagem indireta (CI) de bráquetes é produzido. A CI permite uma melhoria na precisão da colagem de acessórios ortodônticos, diminuindo o tempo e o custo do tratamento devido a uma menor necessidade de dobras de finalização e reposicionamento de bráquetes. O caso clínico apresentado tem o objetivo de apresentar um tratamento ortodôntico utilizando o método de CI com posicionamento virtual de bráquetes idealizado pelo sistema eXceed™. O posicionamento dos bráquetes programado pelo sistema eXceed™ permitiu um posicionamento "ideal" dos dentes, dispensando a implementação de dobras de finalização e proporcionando uma oclusão ideal. Essa nova tecnologia demonstrou ser eficiente e eficaz, e o *setup* ortodôntico fornecido pelo sistema ficou acordante com o resultado final do tratamento ortodôntico.

Descritores: CAD-CAM, modelos digitais, Ortodontia corretiva, aparelho ortodôntico fixo.

INTRODUCTION

A common technical difficulty faced by orthodontists is brackets positioning in direct bonding technique (DB). Dental morphology variation, difficulty of direct vision of the anatomical structure, control of the oral soft tissues added to subjectivity can determine variations in the teeth final position. Bonding errors make it difficult to express the “ideal” vestibular-lingual adjustments, angulations, and inclinations built into the pre-adjustable brackets[2,17]. Brackets indirect bonding technique (IB)[14] allowed an improvement in the accuracy of accessories bonding and has proved to be an advantageous method in relation to the conventional method of DB[12].

The development of new digital technologies has helped Orthodontics to achieve greater accuracy. *Computer Aided Design/Computer Aided Manufacturing* (CAD/CAM) systems introduced in Orthodontics in 2001 have enabled optimization of laboratory processes and orthodontic treatment predictability. The “ideal” position of each accessory determined by the software is transferred to the patient’s initial three-dimensional (3D) model on which a transference device for brackets IB is produced by the CAD/CAM system. The creation of an individualized base made of resin, the pads, when necessary, allows the correction of tooth positioning in the three planes of space. This prerogative could significantly decrease treatment time and costs due to lower need for finishing folds.

The eXceed™ system has been enabling to orthodontists to perform clinical case diagnosis and planning, brackets virtual positioning and treatment with invisible aligners. This clinical case report aims to present an orthodontic treatment using the IB method with brackets virtual positioning created by the eXceed™.

DIAGNOSIS AND ETIOLOGY

Patient V.B.O., 22 years old, male, sought care at the University of Odontology of Araraquara (UNESP) for orthodontic treatment with the main complaint of misaligned teeth. Acceptable oral hygiene and moderate periodontal inflammation were observed in intraoral examination. After the initial assessment, a cone beam computed tomography (CBCT), facial and intraoral photographs and models of dental arches were requested for diagnosis and orthodontic planning.

Facial analysis demonstrated a mesoprosopic pattern, facial symmetry, and convex profile. Misalignment of the lower incisor teeth and the presence of a slight buccal corridor on the right side were observed in the smile (Figure 1). CBCT and 3D digital models were used to assist in the diagnosis and planning of the orthodontic treatment. The analysis of CBCT images showed a Class I skeletal pattern and the 3D models were analyzed by eXceed Pro Software™(Table 1). Intra-arc and inter-arc measurements obtained by the software tools showed there was no need to obtain additional space for incisors alignment in the lower arch (Table 1). Despite the convex facial profile, bilateral Angle Class I molar relationship made the treatment plan favorable, making extraction with consequent implementation of dental retraction mechanics unnecessary.

Treatment objectives were to performed tooth alignment and leveling with dissolution of lower dental crowding, and correction of dental inclinations and deep bite.

Figure 1 - **Patient pre-treatment facial and intraoral photographs.**

	Inferior arch			Superior arch						
	T0	T1	T2	T0	T1	T2		T0	T1	T2
Arc length	87,00	93,71	91,22	103,00	104,41	100,27	**Overjet**	2,62	2,50	1,50
Space required	87,18	87,18	87,18	95,28	95,28	95,28	**Overbite**	4,59	1,40	1,30
Intermolar distance	43,41	43,72	41,37	43,68	43,54	41,25				

Table 1 - Analysis of dental arches 3D models using eXceed Pro software. The measurements obtained (mm) of the models in the three times, initial (T0), end of treatment (T1) and orthodontic setup (T2).

Laboratory Stage

The initial models of the patient were obtained by intraoral molding of the dental arches with alginate, followed by casting with plaster. The models obtained were scanned by a 3Shape R700 table scanner and the scanned files were exported to the Ortho Analyzer™ 2013 software (3Shape Dental System™, Copenhagen, Denmark) for conversion of files into stereolithography (STL).

The process of inclusion of a case in the eXceed™ system requires, in addition to 3D digital models, sending a panoramic radiography, and at least five photos of the patient (two photos of the face and three intraoral). The orthodontic setup was obtained with the aid of the analysis and diagnostic tools of Doctor WebGL 2.0 *software* on the platform. The eXceed™ has two different types of solutions for planning and positioning conventional orthodontic brackets, the RX and TX, and a lingual system, the LX. The system used in this clinical case was the TX, which differs from the RX for using the orthodontic setup methodology for review after the analysis of occlusion and determination of the treatment plan created. Self-ligating brackets easyClip Plus slot 0.022”x0,028” Roth prescription (Aditek do Brasil, Cravinhos, São Paulo) available in different configurations within the eXceed™ library. The “ideal” position of each tooth was established by the system according to the information of the angulation of each bracket chosen. The “ideal” position of the brackets was recorded on the 3D virtual model and the information stored for later printing of the pads on the models (Figure 3A). There is the possibility of making adjustments and refinement of occlusion after receiving the treatment plan sent by eXceed™ through specific software tools. After treatment plan approval the project was sent to the company *Aditek do Brasil* for IB devices production.

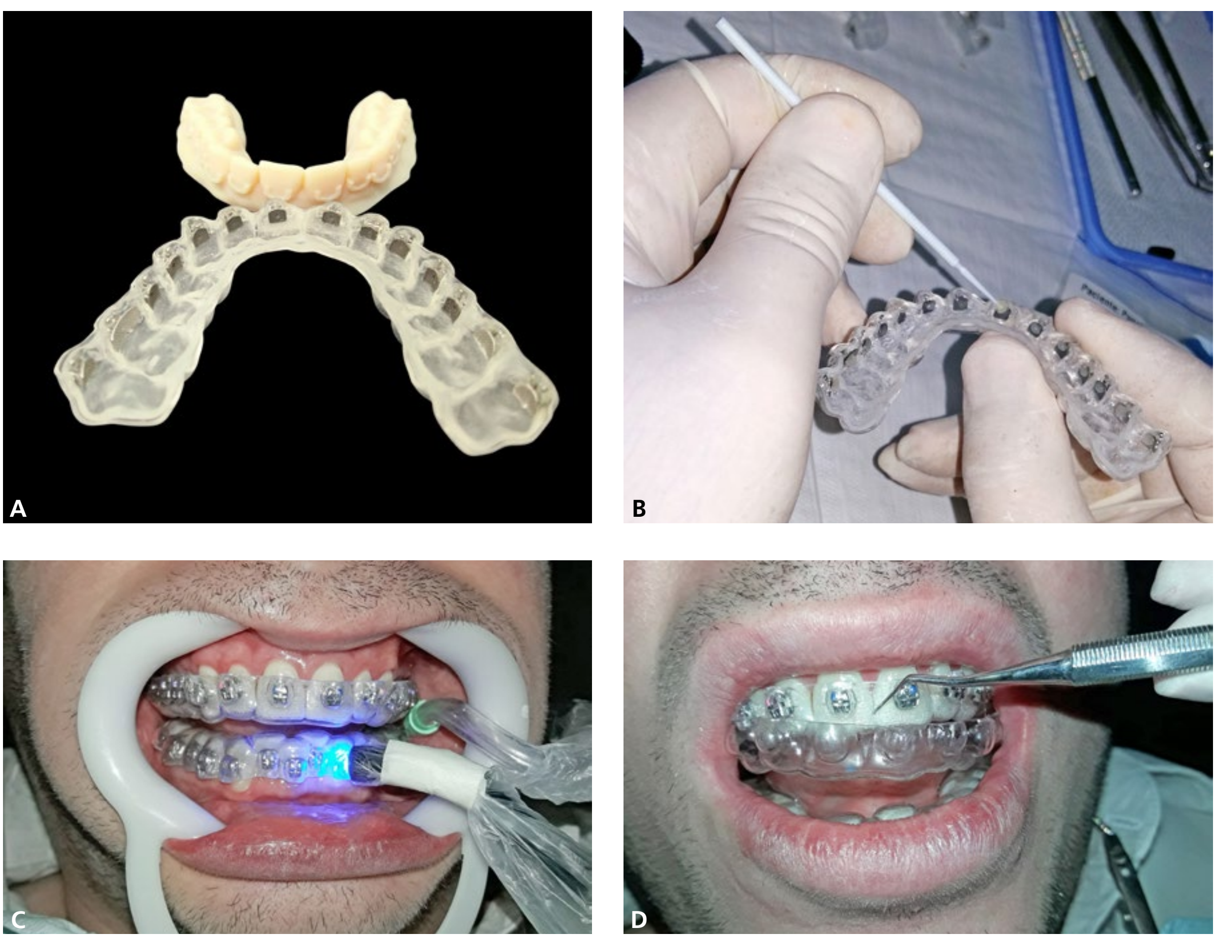

Figure 2 (A-D) - A) Polymer model with pads for brackets fitting and IB devices with brackets transferred to the “ideal” position; **B)** Application of the adhesive on the brackets base; **C)** Positioned IB devices and brackets light curing **D)** Removal of overlapping plates of polyvinyl acetate.

The next step was to perform the bracket IB, in which the first step was to check possible distortions and to verify the adaptation of the devices inserted in the patient's arches. The dental enamel acid etching technique was performed with 37% gel for 30 seconds, except for the third molars, which were excluded from the treatment plan, followed by washing and complete drying. The adhesive primer was applied to all conditioned teeth and a thin layer of resinous adhesive Transbond XT Light Cure Adhesive (3M Unitek, Monrovia-California, USA) - (Figure 2B) was applied to brackets base surface. When necessary, an additional layer of resin was applied to the base to allow the creation of the pads, whose purpose was to fill the space between the base and the tooth resulting from the "ideal" positioning determined by the eXceed™. Then, the device was inserted under slight pressure for complete laying on the teeth and all the brackets were polymerized for 20 seconds (Figure 2C). After full polymerization of the adhesive in the arches, the IB device was removed, starting with the rigid plate followed by the flexible plate (Figure 2D). Removal of adhesive excess was carried out with high-speed polishing drills followed by polishing with a rubber cup. Brackets positioning on the teeth after IB was compared with the orthodontic setup and demonstrated the precision of the transfer of the planning created by the eXceed™ (Figure 3).

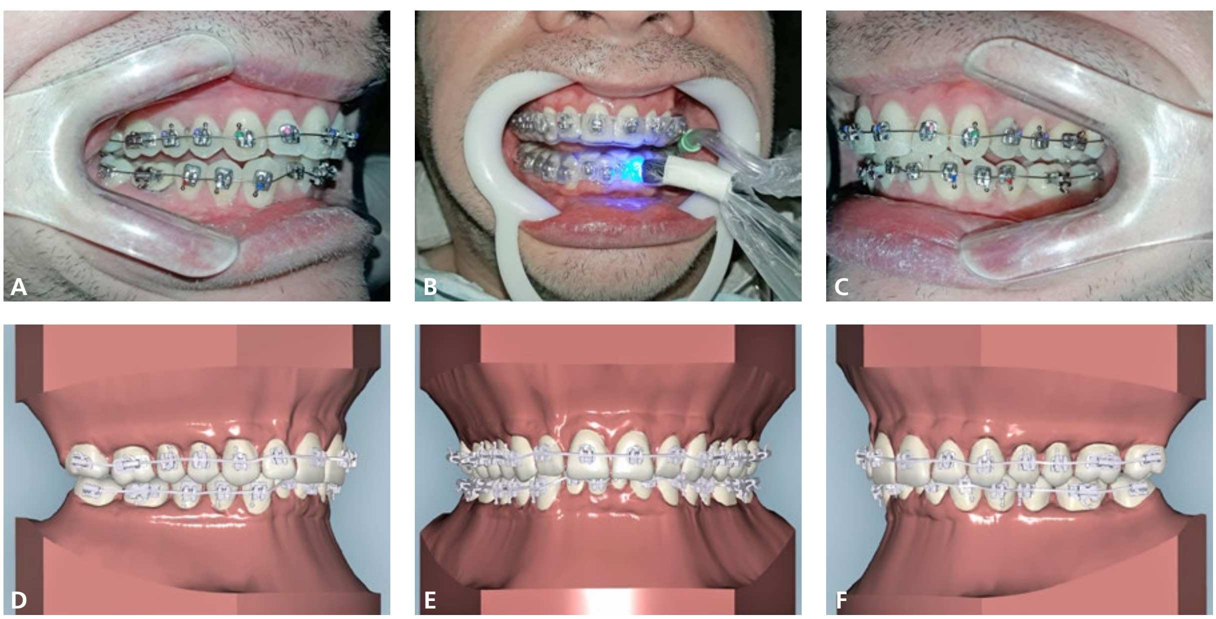

Figure 3 (A-F) - A,C,E) Fixed orthodontic device after indirect bonding in the right and left frontal views and **B,D,F)** the respective orthodontic setup images provided by the eXceed™.

Alignment and leveling started with the following sequence of nickel-titanium wires 0.014", 0.018", 0.017"x0.025" and 0.019"x0.025", totaling 8 months for the complete alignment of the dental arches. For "ideal" arch manufacturing on the steel wires, the eXceed™ system provided the diagram of the patient's dental arches available for printing on the patient's virtual medical record. The 0.019"x0.025" diagrammed steel wires were inserted in the arches and kept for 3 months to allow the expression of the bracket angulations created by the eXceed™. The final refinement of the occlusion was performed using a 0.017"x0.025" braided steel wire and 3/16" intraoral elastic inter--arc for dental intercuspation. After 18 months of treatment, the fixed device was removed and an upper Hawley plate and lower 3-3 bar as a retainer were installed (Figure 4).

Figure 4 - Dental arches after the end of orthodontic treatment.

RESULTS

Alignment, leveling and correction of the deep bite allowed correct occlusal engagement. Analysis of the 3D models demonstrated that there was a small increase in the perimeter of the upper dental arch from 103.00mm to 104.41mm and of the lower one from 87.00mm to 93.71mm (Table 1). The diagram provided by the eXceed™ made it possible for the wire made on it to determine the individualized perimeter of the arc. The increase in perimeter was the result of the inclination of the crowns. This gain of space had a relevance in the correction of the accentuated Spee Curve in the lower arch, which allowed extrusion of the premolars with consequent correction of the deep bite.

Overjet did not change, the eXceed™ system programmed incisor torques to maintain a trespass value within a normal range (Table 1). Class I molar and canine relationships obtained by orthodontic mechanics provided balance and occlusal stability with recovery of function in mandibular excursive movements.

DISCUSSION

Dental morphology has been considered an important factor in the correct brackets, in alignment, and leveling[16]. However, brackets DB performed by most orthodontists is performed inaccurately and subjectively[3]. When a bracket is bonded in a position other than "ideal", rebonding procedure will be inevitable or the implementation of corrective procedures to compensate for error sometimes becomes a necessity[4,6,13,17]. Due to this, orthodontists rarely manage to finish treatment with straight-wire prescription in compensation folds due to variations in the dental morphology[13,] errors inherent to the bonding technique and deficiency in orthodontic mechanics used[4,6,13,17].

DB and IB have been compared in studies by several authors in relation to the adhesive bonding strength of the brackets to the tooth[10,19], adhesive failures[5,18] positioning precision[1,9,10,11,18,] treatment time[5,18] and time to complete the laboratory and clinical stages[1,18]. In general, these studies have not shown differences between the two methods[8,11,18], in bracket adhesive bonding strength rates[1,5,18] and in treatment time[5]. Despite the advantages of IB over DB1.8,laboratory and clinical studies have shown contradictory results[1,9,18]. The IB requires more time and team training for the laboratory stage, such as the positioning and assembly of brackets on the models. In addition, the technique can become extremely difficult, when there is complex malocclusion, teeth with short clinical crown and turned teeth and also, which may require the use of a specific adhesive[15.]

The use of IB associated with eXceed™system technology aimed to obtain precision, decrease of variables that cause errors and the need for finishing folds in the steel wire, consequently reducing clinical time. A prerogative of the eXceed™ is the possibility of predicting final occlusion by means of orthodontic setup. Another benefit that the system allows is the possibility of rebonding with the maintenance of the spatial position of the accessory programmed by the software[7]. During the treatment, it was necessary to perform rebonding of the second lower molars tubes due to breakage. The IB device was sectioned in the region of interest and a new tube was repositioned and it was rebonded.

In this clinical report, there was no difference between the end of orthodontic treatment and the virtual setup provided by eXceed™ (Table 1). The intermolar distance of the arches at the end of treatment was about 2mm larger than the orthodontic setup. The perimeter of the upper and lower arches increased, respectively, 4mm and 2mm in relation to the orthodontic setup. The eXceed™ allowed teeth alignment (8 months), correction of the deep bite keeping the overjet (Table 1). The diagrammed 0,019”x0.025” steel wire was kept in the bracket's slots of the fixed device for 3 months for stabilization. No additional folding was required in the steel wires for torque implementation. Occlusion refinement in some cases becomes necessary due to the inherent muscle action, parafunctional habit, occlusal interference in mandibular movements or due to the patient's own skeletal-muscular pattern.

CONCLUSION

The virtual planning and orthodontic setup associated with the production of an accurate bracket IB device by the CAD/CAM system has showed efficiency and effectiveness in orthodontic treatment. The eXceed™ system allowed teeth movement to the planned position of the orthodontic virtual setup with consequent correction of malocclusion, improvement of the aesthetics and function in a shorter clinical time without the need of finishing folds.

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CLINICAL PROTOCOL FOR ATTACHMENT INSTALLATION IN CASES TREATED WITH ORTHODONTIC ALIGNERS - TECHNIQUE DESCRIPTION

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ABSTRACT

Orthodontic treatment with aligners is something increasingly desired by patients. It is known that these devices carry with them advantages and disadvantages when compared to conventional fixed device. In an attempt to potentiate planned movements virtually, in the vast majority of cases attachments are required. So, it is paramount a safe protocol of attachments installation, thus giving a greater stability and aesthetics for them. The aim of this article is to describe the moment of attachment installation in a patient, highlighting the materials used.

Descriptors: Orthodontics, corrective orthodontics, removable orthodontic appliances.

RESUMO

O tratamento ortodôntico com alinhadores é algo desejado cada vez mais pelos pacientes. Sabe-se que esses dispositivos carregam consigo vantagem e desvantagens quando comparados ao aparelho fixo convencional. Em uma tentativa de potencializar os movimentos planejados virtualmente, na grande maioria dos casos *attachments* são necessários. Nesse sentido, é de suma importância um protocolo seguro de instalação dos *attachments*, conferindo assim uma maior estabilidade e estética desses. O objetivo desse artigo é descrever o momento de instalação dos *attachments* em uma paciente, destacando os materiais utilizados.

Descritores: Ortodontia, Ortodontia corretiva, aparelhos ortodônticos removíveis.

INTRODUCTION

The demand for aesthetic orthodontic treatments is increasing. That is a fact. It is clear that the greatest demand for dental treatment is not the one caused by caries. Today, what most motivates patients to seek dental services is the desire for the “perfect” smile. Thus, the demand usually lies in aligning, leveling, and relating, improving proportions, shapes and dental bleaching.

It seems reasonable to understand that Orthodontics is one of the leading specialties within the aesthetic rehabilitation treatment. However, many patients no longer see themselves as candidates for the use of the conventional fixed metallic aesthetic devices. It is clear that patients seek more comfortable and aesthetic treatments, and in this context, orthodontic aligners are gaining increasing importance, especially for treating mild and moderate malocclusions. It is evident that when comparing orthodontic aligners with fixed aesthetic devices – whether conventional or self-ligating – in terms of aesthetics and comfort the difference is noticeably perceived.

Treatment with orthodontic aligners has evolved a lot in recent years. This evolution can be attributed basically to science, experience of professionals with such devices and continuous improvement of softwares and quality of the “plastic” from which aligners are manufactured. Despite great developments, lack of friction between aligners and teeth makes some movements require extra support. This support and friction come from attachments. The use of attachments with specific drawings increases the correction power of malocclusion by aligners. In other words, in the vast majority of cases, attachments are essential.

When considering the importance of attachments in treatments with orthodontic aligners, the aim of this article is to describe a safe clinical protocol for the installation of these resources, in order to provide good aesthetics and stability.

CASE REPORT

In a treatment with orthodontic aligners, after diagnosis is made and treatment intentions are defined, a virtual planning is carried out. In virtual planning, in addition to a simulation of the desired movements, specific attachments are planned according to the type and magnitude of movement of each tooth. After the virtual planning, usually in consensus with the patient, the aligners are manufactured (Figure 1).

The first step of treatment with orthodontic aligners usually involves the attachments installation. These are manufactured from a 0.3-0.5mm acetate plate (depending on the manufacturer) stamped on the initial model of the patient (Figure 2). For better understanding of the clinical protocol for the attachments installation, follows the step-by-step procedure.

Step 1: ***template isolation***

First, the template (acetate plate) is isolated with Cel-Ac insulator for at least 40 minutes before the procedure to facilitate guide removal and decrease the chance of loosening attachments after photoactivation.

Step 2: prophylaxis + acid conditioning + adhesive

After the isolation of the template, prophylaxis was performed with pumice stone and Robinson brush. After washing and drying all teeth, an expandex lip retractor was installed and the conditioning was performed with phosphoric acid 35% (Ultra-Each, Ultradent), restricted to the place where attachments were planned in the respective teeth (Figure 3). After 30 seconds, the acid was removed and washed with air and water consistently. Then, the teeth were properly dried (Figure 4) and the Single Bond Universal Adhesive (3M) was applied with the aid of an adhesive applicator (Microbrush), rubbing for 20 seconds on each tooth. A light jet of air for solvent evaporation was performed and, subsequently, photoactivation with the Valo light curing (Ultradent, Sandy, Utah, USA) for 3 seconds of exposure (Figure 5).


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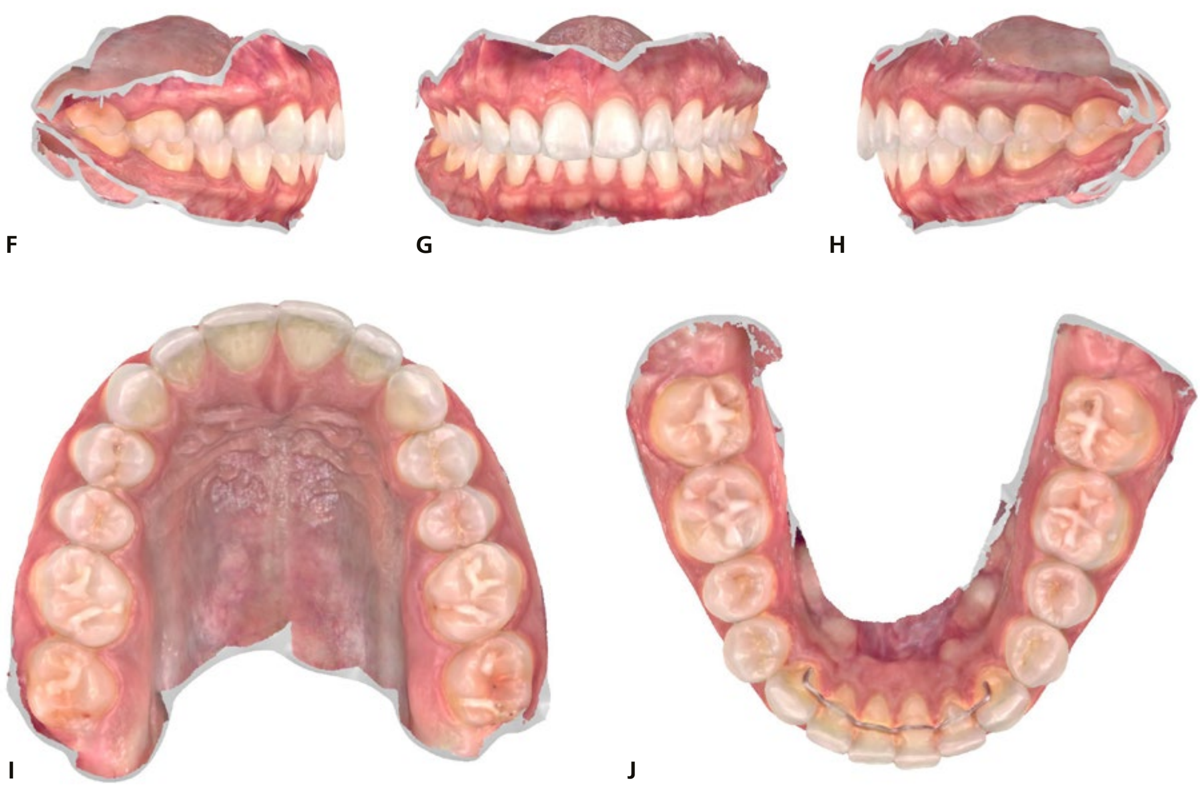
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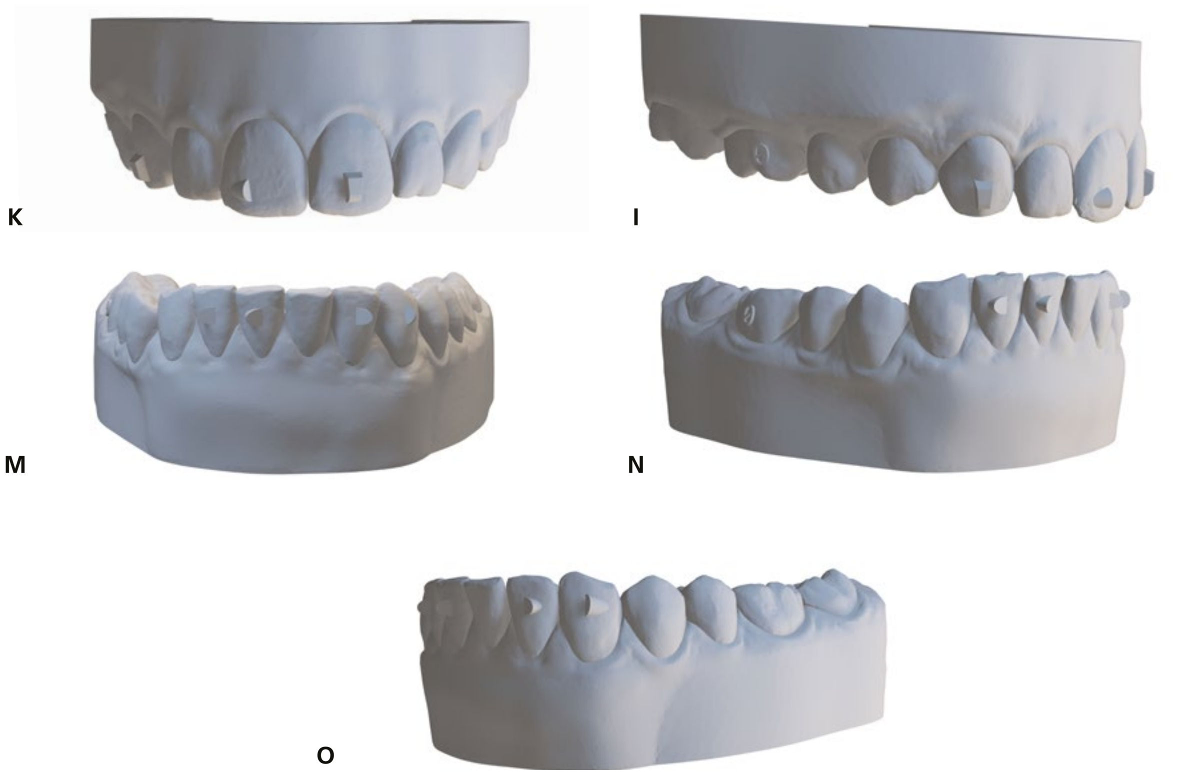


Figure 1 (A-O) – Once the therapeutic goals were defined, the virtual planning was carried out from the intraoral scan of the patient. Then, attachments were planned according to the teeth individual movement.

Figure 2 - Top and bottom templates stamped from the original printed templates

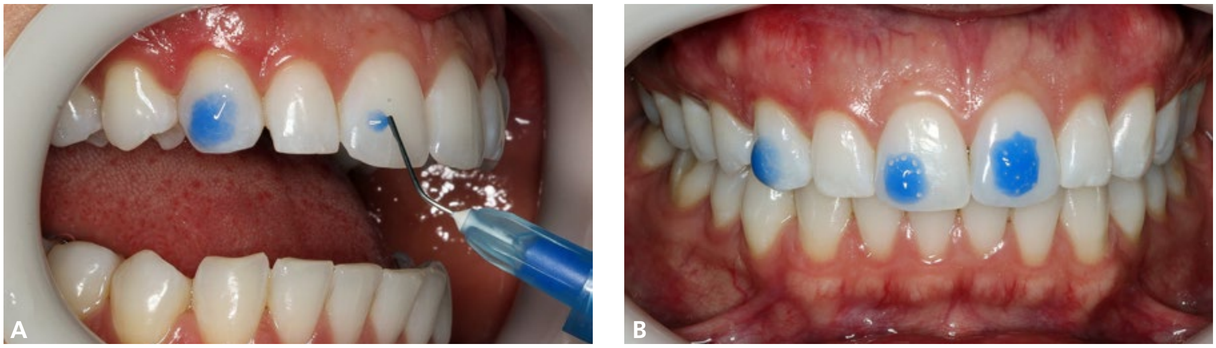


Figure 3 (A-B) – Note that 35% Ultra-etch phosphoric acid (Ultradent) was applied only in the region where the attachment was planned. It is worth saying that this acid, due to its good viscosity allows greater safety and less biological damage, because it does not flow easily, which allows protection to areas that are not of interest.

Figure 4 - After good washing of the acid in order to remove all excess of the phosphoric acid, the teeth were dried. At that moment, an opaque aspect of enamel could be observed.

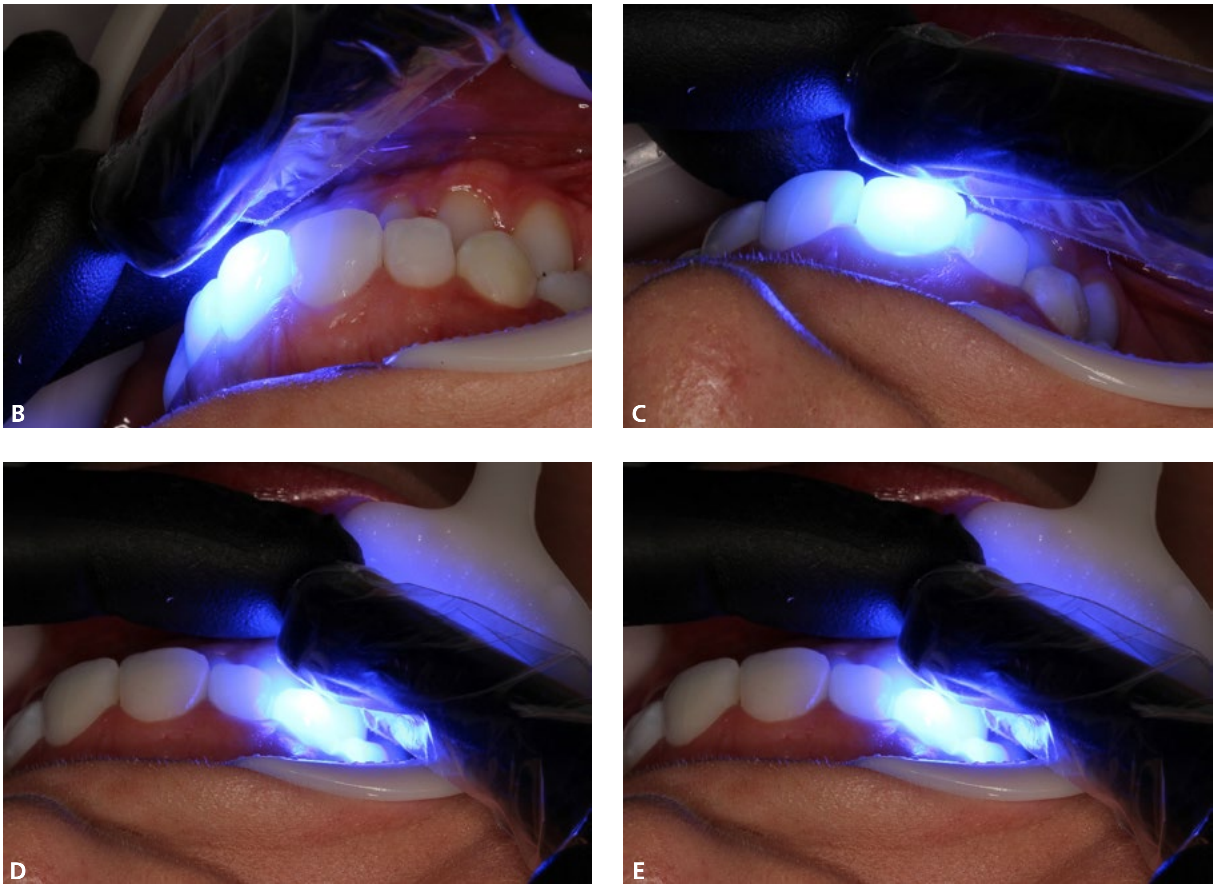
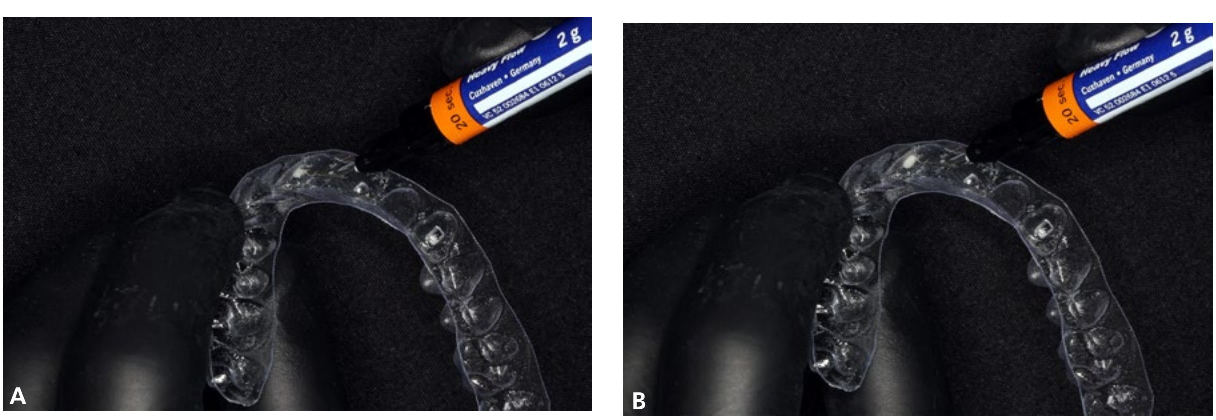


Figure 5 (A-D) – Application of Single Bond Universal Adhesive (3M) in the areas conditioned by phosphoric acid. It is worth saying that this adhesive has a catalyst for several types of surfaces, such as metal, zirconia, and alumina. After applying the adhesive, photoactivation was performed.

3rd Step: composite resin application

At that moment, the compound resin Grande Heavy Flow (Voco) - for facilitating the insertion of the material, having the possibility of choosing ideal color according to the patient's tooth and having very high load content, greater than 83% w/w - was inserted in the respective niches of the template attachments. This insertion was performed slowly, with the applicator tip touching the bottom of the attachment niche, being removed gradually, so that the resin was filling the same, thus reducing the chance of having bubbles (Figure 6).



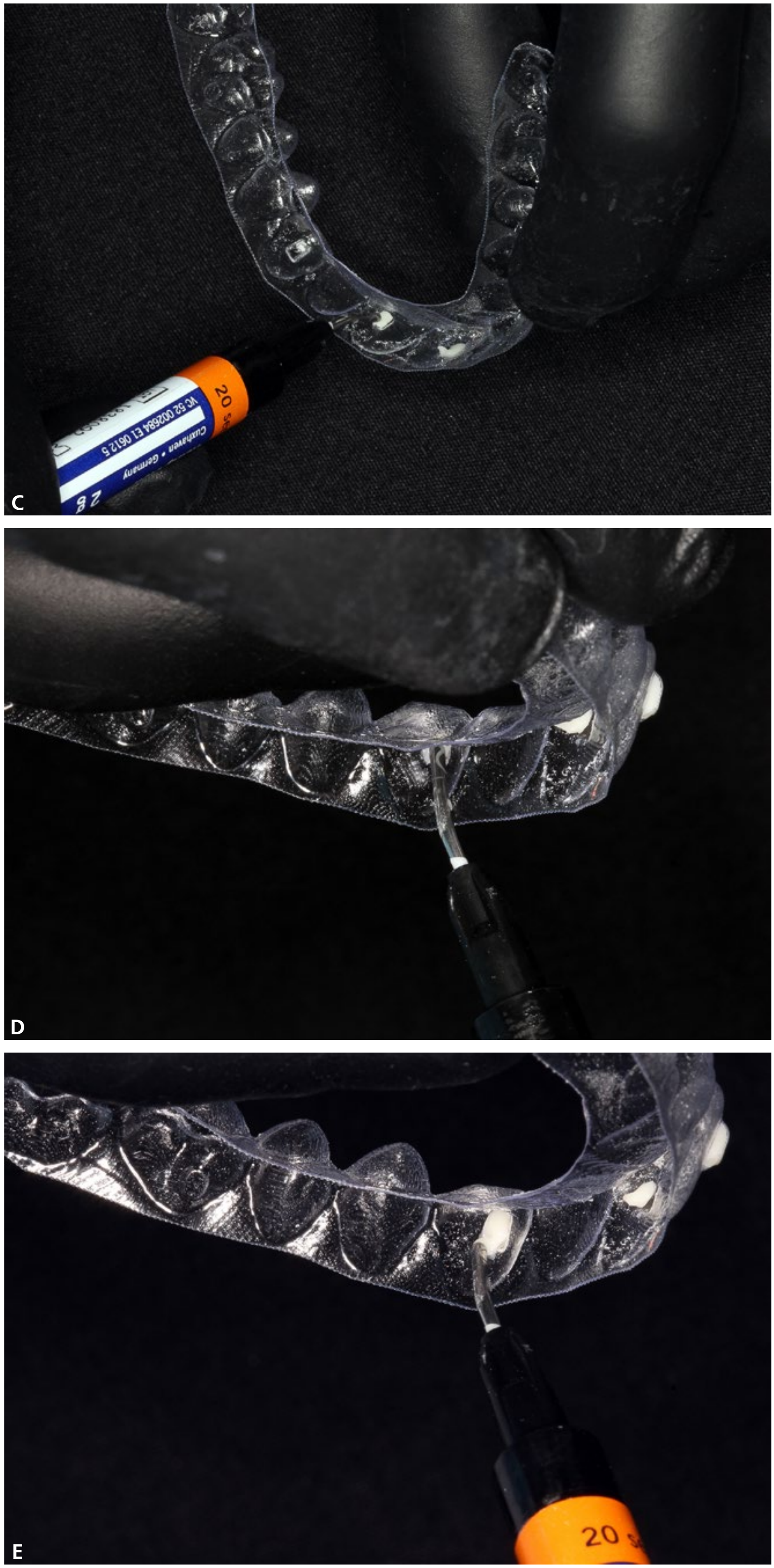


Figure 6 (A-E) – Insertion of Flow resin in attachments niches.

Step 4: photoactivation of attachments through the template

After inserting the resin into the respective attachment niches, the template was transferred to the patient's oral cavity, making sure that the resin was fully in contact with the teeth (Figure 7). When well adapted with a slight apical pressure, attachments were photoactivated with the Valo light curing for 3 seconds (Figure 8). High-power photopolymerizers are recommended for this purpose, such as Valo itself or the Led-X 2400 or 3200 (Orthometric, Marilia, São Paulo)

Then, the template was removed in the direction of the palatine/lingual for the vestibular. Once this was done, the same process was repeated for the lower arc (Figure 9).

Figure 7 - Template adaptation in the patient's mouth. At this point it is paramount to note that the resin is in contact with the vestibular face of the teeth that will receive the attachments.

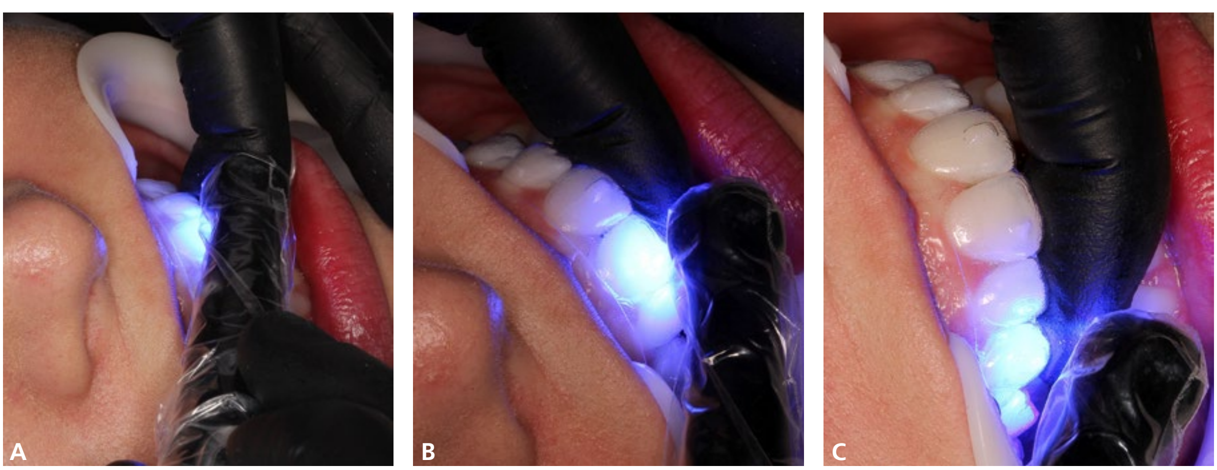
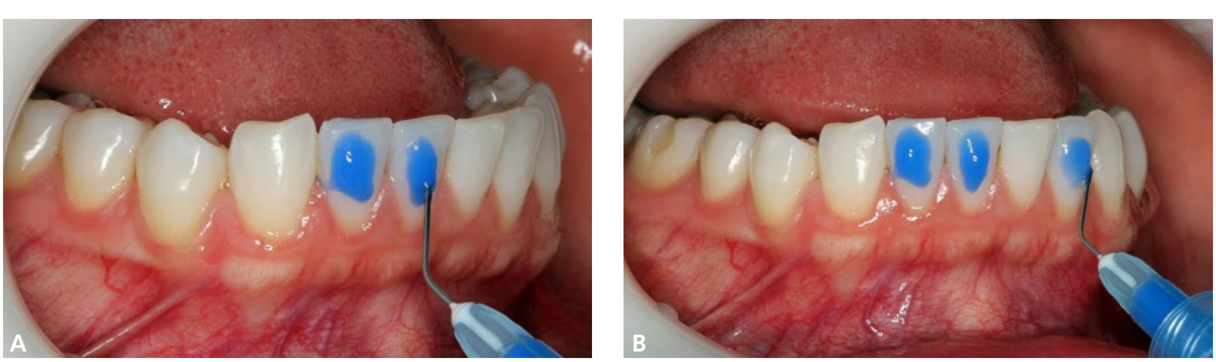
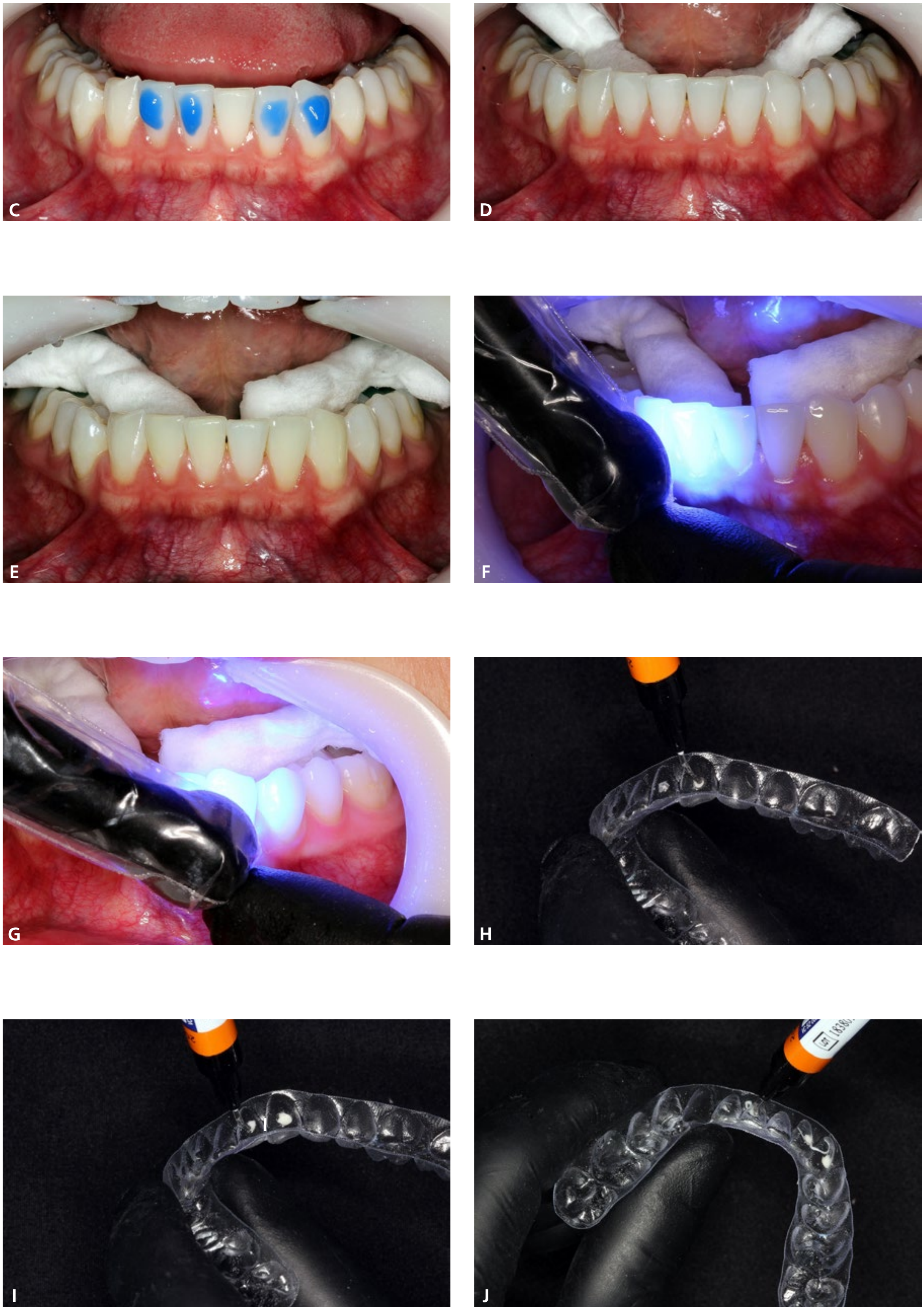


Figure 8 (A-C) – Photo-activation of resins with Valo light curing (Ultradent) for 3 seconds for each tooth.

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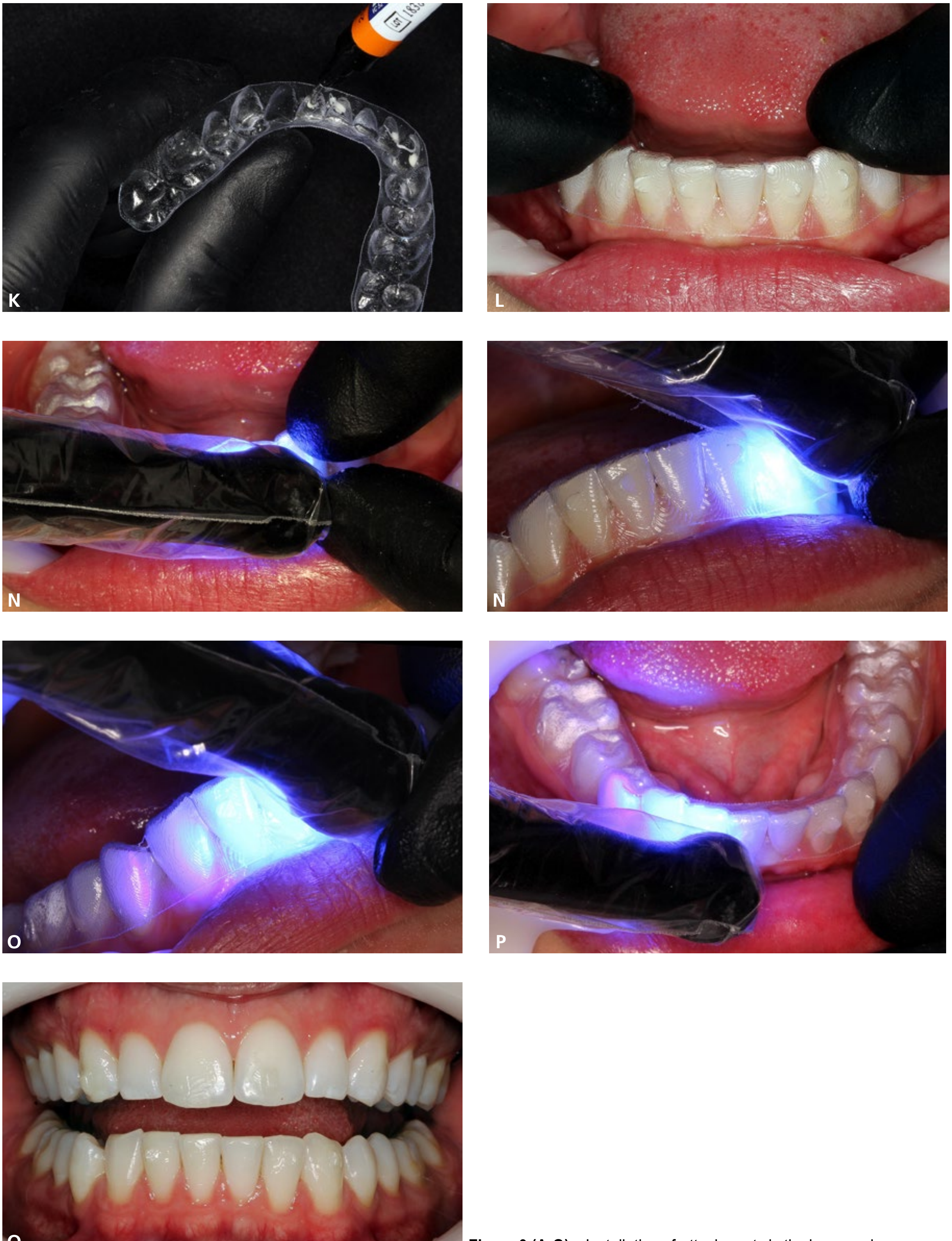

Figure 9 (A-Q) – Installation of attachments in the lower arch.

Step 5: excesses removal

As much as sufficient amount of resin is placed to manufacture the attachment, a minimum excess can be expected. Therefore, at that moment, these excesses were removed with the aid of a handle and a scalpel blade number 15, which confers a lower risk of damage to the enamel surface (Figure 10).

Figure 10 (A-B) – Cautious removal of excesses with the aid of a handle and a scalpel blade n 15.

6th Step: aligners proof

Finally, the aligners for movement are installed and their adaptation is checked, as well as the stability of attachments after their removal (Figure 11).

Figure 11 (A-E) – First aligners adaptation.

FINAL CONSIDERATIONS

Attachments are devices commonly used in cases treated with orthodontic aligners. In order to ensure their good stability and aesthetics from the beginning to the end of treatment, a safe installation protocol must be adhered to. In the protocol described, it is clear that when all possible care is taken, it is possible to guarantee a desirable outcome.

THREE-DIMENSIONAL DIGITAL MODELS ACCURACY AND RELIABILITY: EXCEED™ SOFTWARE VALIDATION

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ABSTRACT

Introduction: CAD/CAM systems help orthodontists in the manufacture of aesthetic aligners and indirect bonding (virtual bracket positioning) in three-dimensional digital models. This study assessed the accuracy and validity of eXceed™ software. Methods: Twenty plaster models of patients were digitized using a table scanner and the obtained files were converted into stereolithography by the OrthoAnalyser™ software. Using the plaster and digital models, six measurements were performed: Intertermolar Width (IMW), Intercanine Width (ICW), Posterior Arch Length (AL), Premolar Crown Diameter (PD), Canine Crown Height (CH) and Overjet (OJ). Intraobserver systematic errors between the replicas were described as differences in absolute means and standard deviations (SD), they were statistically compared with the Student's t-test for paired data. The differences between the methods were evaluated using the Student's t-test. The random errors were quantified using the Method Error () and the Intraclass Correlation Coefficient (ICC). Results: Two of the measurements of the replicas in digital models (AL) and plaster models (ICW) showed statistically significant systematic errors. The ICC ranged from 0.916 to 0.997. The Method Errors were all less than 0.41mm (0.22mm). Bland-Altman graphs showed that the differences in repeatability between the two methods were within the limits of agreement. The values DP (0.253mm), ICW (0.396mm), CH (0.314mm) and AL (0.359mm) were higher in plaster models than in digital models. Conclusion: The measurements performed in both methods were reliable and reproducible, and the measurements of the plaster models were slightly higher than those of the corresponding digital models.

Descriptors: Orthodontics, computer-aided design, dental models, dimensional measurement accuracy, dental technology.

RESUMO

Introdução: Os sistemas CAD/CAM auxiliam ortodontistas na confecção de alinhadores estéticos e na colagem indireta (posicionamento virtual de bráquetes) em modelos digitais tridimensionais. Este estudo avaliou a precisão e validade do software eXceed™. Métodos: Vinte modelos de gesso de pacientes foram digitalizados utilizando um escâner de mesa e os arquivos obtidos foram convertidos em estereolitografia pelo software OrthoAnalyser™. Utilizando os modelos de gesso e digital, seis medidas foram aferidas: Largura Intermolares (LM), Largura Intercaninos (LC), Comprimento do Arco posterior (CA), Diâmetro da Coroa do Pré-Molar (DP), Altura da Coroa do Canino (AC) e Overjet (OJ). Os erros sistemáticos intraobservador entre as réplicas foram descritos como diferenças das médias absolutas e desvios-padrões (DP), foram comparados estatisticamente com o teste t de Student para dados pareados. As diferenças entre os métodos foram avaliadas usando o teste t de Student. Os erros aleatórios foram quantificados usando o erro do método [√Σ(d2/2N)] e o Coeficiente de Correlação Intraclasse (ICC). Resultados: Duas das medidas das réplicas em modelos digitais (CA) e de gesso (LC) demostraram erros sistemáticos estatisticamente significativos. O ICC variou de 0,916 a 0,997. Os erros do método foram todos inferiores a 0,41 mm (0,22 mm). Os gráficos de Bland-Altman mostraram que as diferenças de repetitividade entre os dois métodos estavam dentro dos limites de concordância. Os valores DP (0,253 mm), LC (0,396 mm), AC (0,314 mm) e CA (0,359 mm) foram maiores em modelos de gesso do que nos modelos digitais. Conclusão: As medidas realizadas em ambos os métodos foram confiáveis e reprodutíveis, e as medidas dos modelos de gesso foram ligeiramente maiores do que os dos modelos digitais correspondentes.

Descritores: Ortodontia, projeto auxiliado por computador, modelos dentários, precisão da medição dimensional, tecnologia odontológica.

INTRODUCTION

Traditionally, orthodontists perform diagnosis and treatment plan with the aid of clinical, radiographic examinations and plaster model[1]. The analysis of plaster models allows the clinician to view the occlusion from different perspectives that are not possible by clinical examination. In addition, linear distance measurements are easier to perform in physical models than in vivo[2]. Plaster models have important limitations and may suffer physical and chemical damage resulting in wear, especially when measured repeatedly. In addition, they are susceptible to distortions in volume over time due to weather conditions [3,4].

In order to address these issues, including additional storage-related costs, three-dimensional digital (3D) models were introduced in the late 1990s by OrthoCAD™[5]. So, digital models can be stored and accessed electronically from anywhere, facilitating sharing and communication between professionals[5,6]. In addition, they can be used by an orthodontic software, allowing measurements, assisting in the diagnosis, generating orthodontic setup[1,5,7], assisting in the production of aesthetic aligners and in brackets positioning and in the bonding procedure that is still a critical procedure for both the orthodontist and the patientperimeter, overjet, and overbite[8].

Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) systems applied to Orthodontics have allowed to improve the inaccuracy of accessory positioning during brackets bonding procedure[8]. Stereolithography (STL) files generated from intra or extraoral dental scanning on models of dental arches decreased or eliminated possible inaccuracies, enabling the use of these in computers, including mobile devices. Currently, some softwares available in the market have enabled orthodontists to position the brackets digitally with greater efficiency on the teeth of 3D models[8]. However, there are many doubts related to the reliability and accuracy of these softwares[6,8], leaving the clinician insecure in relation to the use of these systems.

Currently, orthodontic softwares are increasingly automated systems, simplifying the method and steps of planning and manufacturing orthodontic indirect bonding devices. Previous studies have demonstrated the accuracy and reliability of orthodontic software[5,6,8-13]. Some studies have demonstrated the accuracy and reliability of 3D virtual models when compared to the respective plaster models[10,13], while other studies showed less consistent results between the two methods[10,14-17]Copenhagen, Denmark. The purpose of the eXceed™ system is to turn the orthodontic office more efficient, aiding in orthodontic planning, simplifying processes, and assisting clinicians and laboratories in the manufacture of accurate devices for applications in the indirect bonding procedure (such as positioning and personalization of brackets virtually) and aesthetic aligners.

The eXceed™ system allows orthodontic setup and the choice and positioning of orthodontic brackets, in order to obtain the best results in the shortest possible time, minimizing the need for accessories repositioning and finishing folds in orthodontic arches. However, there are no previous studies that support the use of this system in the daily clinical practice. The aim of this study was to assess the accuracy and precision (reproducibility) of the eXceed™ measurement and diagnostic tools and compare with measurements obtained from the corresponding plaster models.

MATERIAL AND METHODS

Twenty patients aged between 15 and 38 years (eight male and twelve female patients) were selected and treated at the Dentistry University, Araraquara, /Unesp. The inclusion criteria of the cases were Angle Class I malocclusion, crowding or mild to moderate spacing (≤ 5mm), absence of transverse discrepancy and open bite, complete permanent dentition (excluding the 3rd molars). Exclusion criteria were dental anomalies in size and shape, severe gingival recession, erosions and abrasions in the dental crown that could influence the measurements. The research project was approved by the institutional Ethics Committee (# 2.451.252) and the Informed Consent Form was signed by all patients.

Plaster Models versus Digital Models

The models were obtained by molding the patients' dental arches with alginate Jeltrate® Plus (Dentsply, Rio de Janeiro, RJ, Brazil). The bite recording at the usual maximum intercuspidation was obtained with a dental wax blade no. 7 (Clássico, São Paulo, Brazil) and, later, it was used to cut the plaster models. The dental molds obtained were leaked within 1 hour after molding, with Type III plaster (Asfer, São Caetano do Sul, SP, Brazil). After 24 hours, the blisters and defects in the plaster were removed using a Lecron sculpting instrument (SSWhite Duflex, Juiz de Fora, MG, Brazil). After this stage, the plaster models were cut following standards and the instructions of the American Board of Orthodontics.

Scanning of all plaster models was performed by a 3Shape R700 table scanner (3Shape Ltda, Copenhagen, Denmark). Each of them was individually scanted to record the details of the dental arches and then occluded to record occlusion. The scanning time was 2.5 minutes per arch with scanning accuracy of 20 µm. The obtained images were automatically processed by the software Scanlt version 4.0.1 (3Shape Ltda, Copenhagen, Denmark) which generated a file with a 3sz extension. The files were then imported by the 3Shape OrthoAnalyzer™ software (3Shape Ltda, Copenhagen, Denmark) and converted to stereolithography (STL) files.

Measurements

The STL files were imported by the system software and six different measurements (Figure 1) were performed using the eXceed Pro Software tools (Roosikrantsi, Tallinn, Estonia). The first premolar crown diameter (PD) was measured between the mesial and distal contact points of the tooth on the left side. The Intercanine Width (ICW) was measured between the tips of the incisals of the right and left canines. The Intermolar Width (IMW) was measured between the tips of the mesiolingual cusps of the second molars. The Canine Crown Height (CH) was obtained from the tip of the incisal to the gingival level on the vestibular side of the right canine. The Posterior Arch Length (AL) was measured from the mesial of the first premolar to the distal of the second molar on the left side. Overjet (OJ) was measured from the vestibular surface at the level of the incisal edge of the left lower incisor more vestibularized to the palatine of the upper central incisor. Each measurement was performed twice, with an interval of one week between the first and second measurements by the same examiner (FCM), so that the accuracy and precision of each of the six protocols could be estimated. The same measurement protocol was performed in the plaster models, using a digital caliper with accuracy of 0.01mm (Digimess Instrumentos de Precisão Ltda., São Paulo, Brazil).

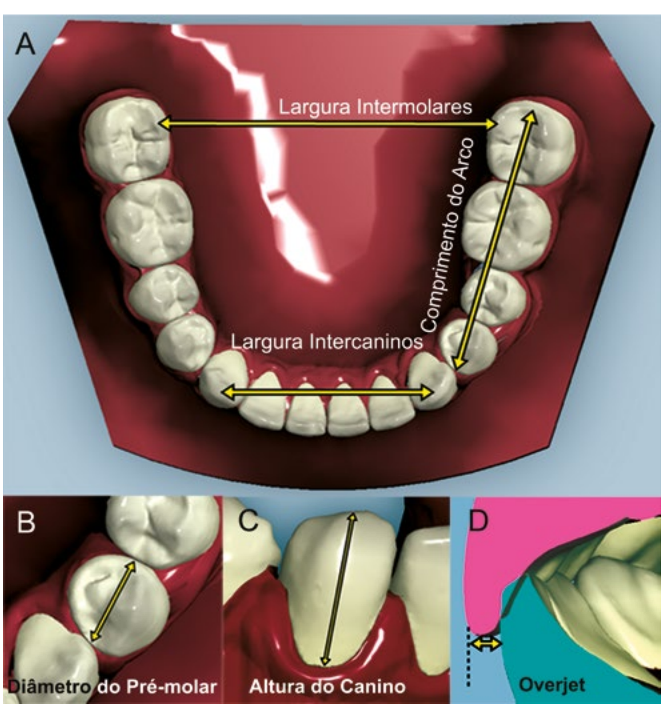

Figure 1 - Six measurements obtained in digital and plaster models. One can see the Intertermolar Width, Arc Length and Intercanine Width **(A)**, Premolar Diameter **(B)**, Canine Length **(C)** and Overjet **(D)** between the right upper central incisor and the right lower central incisor.

Statistical analysis

A sample size of 19 models per group would be necessary to detect a difference of 5% between the measurement in plaster model and in digital model in relation to the canine width, establishing a power of 80% and assuming a probability of 5% for a canine width of 7.20mm and a standard deviation of 0.38mm[11] (G*Power, Dusseldorf, Germany). The Shapiro-Wilk normality test was performed to verify the normal distribution of the data. Intraobserver systematic errors between the replicas were described as differences in absolute means and standard deviations and compared statistically with the Student's t-test for paired data. The intraobserver random error was estimated by the Intraclass Correlation Coefficient (ICC) and the Method Error . The differences between analog and digital measurements were evaluated by Student's t-test. In addition, Bland-Altman analysis was obtained to verify the agreement between both methods. Statistical analyses were performed by IBM SPSS™ software (version 25.0, SPSS, Armonk, NY) with a significance level of 0.05.

RESULTS

The results showed that systematic intraobserver errors in both methods were similar (Table 1). Of the twelve differences obtained, only two were statistically significant ($p<0.05$). The first measurement of the Arc Length performed in the plaster models was 0.313mm lower than the replica and the first measurement of the Intercanine Width performed in the digital models was 0.366mm larger than the replica. The Method Error ranged from 0.104mm to 0.414mm (Table 2). The mesio-distal distance of the first premolar and the Overjet showed the smallest difference (0.042mm) and the Arch Length showed the greatest difference (0.310mm) between the measurements of both methods.

	Modelos de gesso			eXceed™		
Medidas	Dif. (mm)	DP (mm)	Sig.	Dif. (mm)	DP (mm)	Sig.
Diâmetro do Pré-molar	-0,024	0,226	0,647	-0,015	0,166	0,691
Largura intercaninos	0,018	0,350	0,821	0,366	0,359	***<0,001***
Largura intermolares	-0,185	0,417	0,063	-0,110	0,357	0,186
Altura do canino	-0,056	0,227	0,288	0,056	0,339	0,473
Comprimento do arco	-0,313	0,509	0,013	0,047	0,142	0,156
Overjet	-0,010	0,229	0,855	0,054	0,159	0,148

***Italics* + bold** indicates significant statistical difference between the replicas (p<0.05).

Table 1 - Systematic intraobserver errors (mm) and significance (Sig) between the first and second replicas for each of the six protocols measured.

	Plaster models		eXceed™	
Measurements	ME (mm)	ICC	ME (mm)	ICC
Premolar Diameter	0,157	0,916	0,115	0,960
Intercanines width	0,242	0,994	0,358	0,987
Intermolars width	0,316	0,996	0,258	0,997
Canine height	0,161	0,990	0,237	0,978
Arc length	0,414	0,959	0,104	0,997
Overjet	0,158	0,987	0,116	0,992

Table 2 - Intraobserver random errors, estimates between replicas with Method Error (ME) and Intraclass Correlation Coefficient (ICC).

The plaster models presented four of the six measurements slightly higher than the digital method (Table 2). The ICC values ranged from 0.916 to 0.997 (high and consistent values), showing a slightly better correlation for the digital method (Table 2). Bland-Altman graphs showed that the differences in repeatability between the two methods were within the limits of agreement (Figure 2).

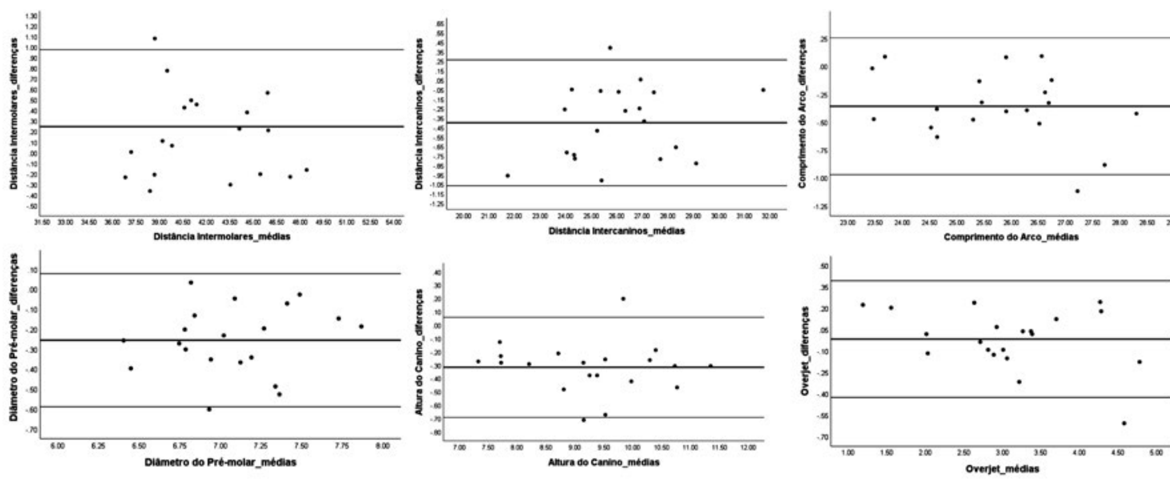

Figure 2 - Bland-Altman analysis of the six measurements of plaster and digital models. The differences were calculated from the subtraction between the replicas of the eXceed™ and manual methods.

When the two methods were compared, four of the six measurements showed statistically significant differences (Table 3). The differences in the measurements obtained were DP=0.253mm, ICW=0.396mm, CH=0.314mm and AL=0.359mm, values were higher when measured in the plaster model than when measured in the digital model.

	Plaster models		eXceed™		Plaster - eXceed™		
Measurements	**Average**	**DP**	**Average**	**DP**	**Dif.**	**DP**	**Prob.**
Premolar Diameter	7,206	0,382	6,951	0,408	0,253	0,170	***<0,001***
Intercanines width	26,298	2,162	25,902	2,253	0,396	0,391	***<0,001***
Intermolars width	41,978	3,583	42,102	3,515	-0,124	0,437	0,219
Canine height	9,432	1,154	9,118	1,136	0,314	0,192	***<0,001***
Arc length	25,931	1,132	25,572	1,335	0,359	0,313	***<0,001***
Overjet	3,091	0,992	3,077	0,919	0,014	0,208	0,759

Italics + **bold** indicate significant statistical difference between replicas ($p<0.05$).

Table 3 - Descriptive Statistics (mm) and systematic differences (mm) between measurements performed directly between plaster models and the corresponding 3D digital models, negative values indicate overestimated measurements in the digital method.

DISCUSSION

The values of manual and digital measurements proved to be accurate and precise representations. Although the measurements performed in both methods were subject to intraobserver variability, only two of the measurements showed statistically significant differences between the replicas and had approximate magnitude (AL=0.313mm and ICW=0.366mm). The systematic error was slightly higher than the previously reported errors[11,18,19], but clinically acceptable. Previous studies have reported that differences in measurements with values below 0.20mm have been shown to be clinically acceptable[20]we aimed to assess accuracy, scan time, and patient acceptance of a chairside oral scanner when used for full-arch scans; these are critical factors for acceptance of this technology in the orthodontic setting.\nMethods Fifteen patients had digital models made from both intraoral scans (Lava COS; 3M ESPE, St Paul, Minn. Systematic intraobserver differences should not occur if the individual is adequately calibrated and if the measurement method is standardized.

The measurements performed on digital models in the eXceed™ system were highly accurate. The eXceed™ produced smaller random errors than the conventional method performed in plaster models with the digital caliper. The lowest values obtained from ICC were 0.960 and 0.916 for the digital model and plaster model, respectively. Jacob et al[11] (2015) used intra and extraoral scanners and demonstrated similar ICC values. Other studies have shown high coefficient values of ICC based on virtual models[13,21–23]. Considering that the reliability coefficient above 0.75 was considered optimal[24], the values of ICC substantially higher obtained in this study indicated excellent precision and accuracy in both methods.

Both methods (caliper and eXceed™) showed high agreement. The Bland-Altman graph showed that more than 95% of the differences between the two methods were within a standard deviation with the differences in agreement limit ranging from 0.67mm to 1.70mm (Figure 2). The differences were relatively low and it can be suggested that the digital method can safely replace the analog method. Akyalcin et al.[21] showed almost perfect agreement between intraoral scan and measurements obtained using a caliper. Jacob et al[11] (2015) evaluated three scanners (two intraoral and one table) and compared with the measurements obtained from the caliper and found high agreement between the scanners. Literature clearly shows that scanners and digital measurements can replace conventional plaster models and measurements obtained by paquimeters[9,10,13-18,20-22,25,26]reliability, and reproducibility of digital models obtained from the Lava Chairside Oral scanner (3M ESPE, Seefeld, Germany.

The measurements obtained from digital models were compared with the same measurements obtained directly from the plaster models. On average, digital measurements were slightly lower than manual measurements, with differences ranging from 0.01mm to 0.40mm. The eXceed system™ was not previously evaluated, making comparisons difficult. Comparative studies between plaster and digital models found significant differences between the methods, but without restrictions for clinical use[14–17,23,26]maxillary and mandibular. Müllen et al[17] and the time to perform a Bolton analysis for each patient by using software (emodel, version 6.0, GeoDigm Corp, Chanhassen, Minn found differences in Arc Length between plaster models and emodels™ software, the authors showed greater Arc Length in plaster models than in digital models[17]and the time to perform a Bolton analysis for each patient by using software (emodel, version 6.0, GeoDigm Corp, Chanhassen, Minn. According to previous studies, the discrepancy in measurements below 0.4mm are not clinically significant[5,18,23]. Our results showed that only the measurements of Intermolar Width in digital models were slightly higher than those performed in plaster models, but without clinical significance ($p>0.05$). Jacob et al[11] (2015) found that most measurements in dry jaws were overestimated when compared to the same measurements in digital models of three different scanners. Interestingly, the authors found a statistically significant difference when the measurements were performed in dry jaws (two out of fifteen) and were higher than the same measurements obtained in digital models. Although the operator can view the models at different angles, the differences between the digital and plaster models may be related to the difficulty in measuring a 3D object in two dimensions on a computer screen[20]we aimed to assess accuracy, scan time, and patient acceptance of a chairside oral scanner when used for full-arch scans; these are critical factors for acceptance of this technology in the orthodontic setting.\nMethods Fifteen patients had digital models made from both intraoral scans (Lava COS; 3M ESPE, St Paul, Minn. Depending on the operator's training, skills and preferences, the measurement performed on a computer screen may be more or less accurate than the conventional method with the use of a caliper in plaster models[14,16].

Although no reference marking has been created in plaster models to enable greater credibility in relation to possible errors, the results of this study have limitations due to the use of plaster models and table scanner instead of dry jaws and/or measurements directly from the mouth and use of intraoral scanners. It is possible that the plaster models may have suffered some involuntary marking by the tip of the caliper. For this reason, the demarcated point would facilitate access to new measurements due to wear, although the measurements were performed with a time interval between the replicas. Therefore the observer when comparing the measurements of both methods may have been more accurate. In addition, table scans are more accurate than intraoral scans[27], because there is no interference of soft tissue and saliva in the region to be scanned and the object remains static, avoiding distortions in the generated image. Another limitation was the use of a version of a specific software, although the objective of this study was the validation of eXceed™ software for clinical use, as it allows a quick and easy to understand management by clinicians.

CONCLUSIONS

Based on the results obtained and within the limitations of this study, we conclude that:

1. The measurements obtained from the plaster models were slightly higher than the digital ones, excluding Overjet which was practically zero; the Intermolar Width in digital models was slightly higher than in plaster models.

2. The measurements performed in both methods were reliable and reproducible, although the digital models were slightly more accurate.

3. The validity of the measurements obtained from the eXceed™ digital models, compared with those obtained from plaster models, indicated that both methods are acceptable for daily clinical practice.

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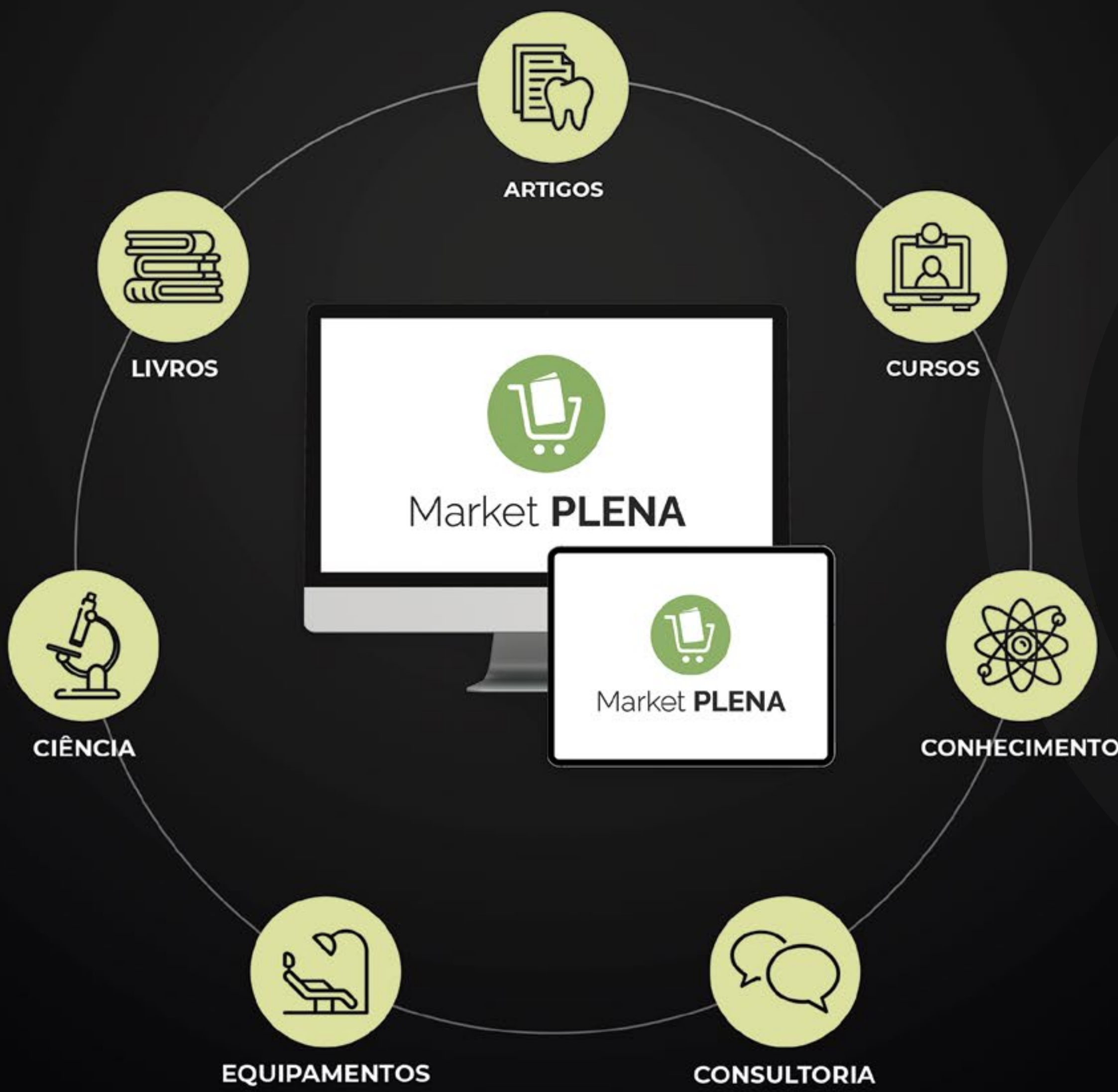

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