INDIRECT BONDING USING CAD/CAM SYSTEMS: DESCRIPTION OF THE TECHNIQUE

COLAGEM INDIRETA POR MEIO DE SISTEMAS CAD/CAM: DESCRIÇÃO DA TÉCNICA

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Resumo

Com o intuito de obter resultados clínicos cada vez mais precisos nostratamentos ortodônticos, as novas tecnologias de colagem indireta têm assumido umpapel relevante na Ortodontia. Com o desenvolvimento dos meios de obtenção emanipulação das imagens digitais, surgiu a possibilidade de realizar o planejamentoortodôntico no ambiente virtual, simulando o resultado desejado, bem como o melhorposicionamento dos acessórios ortodônticos nos dentes para atingir esse objetivo. Apossibilidade de impressão tridimensional a partir da tecnologia CAD/CAM permitiu quea guia para a transferência dos bráquetes, na colagem indireta, fosse confeccionada diretamente no software após planejamento digital da posição dos mesmos. Atualmente, algumas empresas têm disponibilizado programas ou ofertado apossibilidade de executar planejamento digital, bráquetes customizados, arcospersonalizados e guias para a colagem indireta. Este artigo tem o objetivo de realizaruma revisão de literatura reunindo informações recentes sobre colagem indiretautilizando o sistema CAD/CAM em relação à precisão de colagem e tempo dotratamento ortodôntico. Conclui-se que a colagem indireta por meio de sistemas CAD-CAM apresenta confiabilidade em relação à precisão do posicionamento dos bráquetes.Em relação ao tempo de tratamento, diversos estudos sugerem que este foi reduzidocom o método, porém, a variedade de técnicas e softwares existentes, além da diversidade dos métodos científicos, indicam a necessidade de mais investigações. Apesar disso, a colagem indireta digital tem se mostrado uma opção interessante a serincorporada ao tratamento ortodôntico.

Palavras-chave: Aparelhos Ortodônticos Fixos. Bráquetes Ortodônticos. Colagem Dentária

Abstract

New indirect bonding technologies have assumed an important role in Orthodontics to obtain increasingly accurate clinical results in orthodontic treatments. With the development of means of obtaining and manipulating digital images, the possibility to carry out orthodontic planning in the virtual environment arose, simulating the desired result, as well as the best positioning of orthodontic accessories on teeth to achieve this goal. The possibility of three-dimensional printing using CAD/CAM technology allowed the guide for the transfer of brackets, in indirect bonding, to be made directly in the software after digital planning of their position. Currently, some companies have made programs available or offered the possibility of executing digital planning, customized brackets, personalized arches and guides for indirect bonding. This article aims to perform a literature review, gathering recent information on indirect bonding using the CAD/CAM system in relation to bonding accuracy and time of orthodontic treatment. It is concluded that the indirect bonding using CAD/CAM systems presents reliability in relation to the precision of the positioning of brackets. Regarding the treatment time, several studies suggest that it was reduced with the method, however, the variety of existing techniques and software, in addition to the diversity of scientific methods, indicate the need for further investigations. Despite this, indirect digital bonding has proved to be an interesting option to be incorporated into orthodontic treatment.

Keywords: *Orthodontic Appliances, Fixed. Orthodontic Brackets. Dental Bonding*

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INTRODUCTION

Technological advances in recent decades have resulted in the development of new techniques and approaches related to Dentistry. The field of three-dimensional images and prints has undergone major developments in recent years. The introduction of intraoral scanning and models brought several possibilities for changes in all stages of Orthodontics: diagnosis, planning and execution of treatment.

Digital dental models enabled two important technological advances. The first is the manipulation of images using a computer graphics software, leading to the virtual treatment planning, known as setup; and the second is the possibility of customizing orthodontic appliances through the CAD/CAM system (Computer Aided Design/ Computer Aided Manufacturing) (1).

The software and all the virtual tools available aim to increase the accuracy of the orthodontist and make tooth movement more efficient and predictable, improving the final results and even reducing the total treatment time in some cases (2).

Correct diagnosis and planning are essential for the orthodontic treatment success. To obtain increasingly accurate clinical results in orthodontic treatments, the bracket bonding phase has assumed a relevant role in the specialty, since errors in their positioning directly interfere in the final result, as well as increase the time of treatment (3).

Indirect bonding has advantages such as better visualization of the teeth for correct bracket positioning, greater comfort for the patient and less time during the procedure of assembling the appliances (4,5). The positioning of brackets is performed initially in the physical orthodontic study model (traditional indirect bonding), or in the virtual environment (digital indirect bonding). After the virtual planning of the bracket positioning, CAD/CAM technology allows a guide to take the brackets up to the mouth.

Given this context, this study's objective is to conduct a literature review gathering recent information on indirect bonding using the CAD/ CAM system in relation to the bonding accuracy and time of orthodontic treatment, as well as briefly describing the steps for performing the technique by the orthodontist.

LITERATURE REVIEW

Indirect bracket bonding

In 1972, Silverman and Cohen wrote for the first time an article on the technique of indirect bonding, from which variations appeared, mainly in relation to the materials for making the impression trays. Thus, transfer impression trays using silicones, acetate plates and hot glue have already been proposed. In general, all of them are based on obtaining plaster models, in which the orthodontic accessories are positioned and subsequently transferred to the patient's teeth through impression trays (6).

Indirect bonding can provide some advantages, such as reducing the need to make wire bending in the arches, less time on the chair, simplifying the exchange of arches, a more relaxed appliances' assembly consultation, and greater productivity (7,8). Some studies report greater precision in the positioning of the accessories, as the laboratory step allows the elimination of some factors that can hinder bonding, such as saliva, time and impaired visualization by the patient's anatomy (9). Bozzeli et al. (10) observed that, considering the laboratory and clinical phase, indirect bonding requires more total work time, however, the clinical time is considerably less.

Several materials have been proposed for bonding brackets to the working model and later to the teeth. Initially, the use of acrylic based adhesives for bonding brackets to the plaster model was proposed (11). Later, chemical polymerization adhesive materials appeared, followed by Bis-GMA base adhesives, and photopolymerizable composites, concomitant with the advent of more fluid resin composites (11,12).

There are currently many materials with which it is possible to transfer brackets from the working model to the patient's mouth. The most used options are the double system of acetate plates (the interior, with less thickness, and the external, more rigid) or a simple PVS tray (Polyvinylsiloxane) (3,11,13). Trays obtained from hot glue are also widely used because they are simple and quick to perform (14). In 2008, Wendl et al. (15) suggested a method for transferring brackets using the Aptus device (ABD Aptus, Papendrecht, The Netherlands) that uses the bite register as a reference and uses compressed air when attaching accessories.

Hodge et al. (16) conducted a randomized clinical trial with 26 patients, comparing the accuracy of direct and indirect bonding techniques. The method of analyzing the positioning of brackets was carried out using standardized photographs and photocopies for overlay using acetate paper with coordinates. The study concluded that the bracket positioning errors were similar in both techniques, considering them to be accurate.
The professional's experience in the methods also significantly affects the accuracy of the techniques (11).

Nichols et al. (17) analyzed the reproducibility among five orthodontists who performed indirect bonding in ten different plaster models at three different times. Differences in positions were analyzed using cone-beam computed tomography and exported to the Geomagic Studio software where the overlays were made. No statistically significant difference was found between any of the models, confirming the reproducibility of the planning for indirect bonding.

Over the years, interest in indirect bonding has varied. In 1979, Gorelick, cited in the article by Kalange (11), mentioned that 17% of the participants in a national survey in the United States of America preferred the practice of indirect bonding. In 2002, the percentage of professionals who used indirect bonding techniques was around 9.6% (16).

Digital planning and indirect bonding using the cad/cam system

CAD/CAM is an advanced technology that allows the reproduction of 2D/3D digital models and also, the manufacturing of material useful in several areas. It has been a technology of dental interest since the 1980s, with the initial aim of reducing human error in dentistry (13).

Currently, CAD/CAM technology in conjunction with rapid-prototyping technology makes it possible to produce a solid object based on a virtual model. Rapid-prototyping is used essentially to produce customized trays for indirect bonding (18).

In order to provide scientific evidence for the advantages of CAD/CAM, in 2015, Brown et al. (13), carried out a study to evaluate the effectiveness and efficiency of customized appliances with the aid of CAD/CAM technology and indirect digital bonding, with prefabricated appliances directly and indirectly bonded. The study observed a shorter treatment time in the customized appliances with indirect bonding, followed by the prefabricated appliances with indirect bonding and finally, prefabricated with direct bonding. There was no statistically significant difference between the three groups in the final quality of treatment, assessed according to the criteria of the Discrepancies Index of the American Board of Orthodontics (ABO).

The making of the virtual setup and digital planning allowed greater precision in determining the brackets position, including the possibility of overlapping tomographic images on the digital models, checking the position and inclination of the dental roots, thus obtaining a better root parallelism at the end of the treatment (11, 19).

Numerous tools available in the image manipulation software can be used to perform measurements and calculations that will precisely define the exact ideal position for the brackets (13).

In studies that investigated the efficiency of the treatment using the virtual planning technique, shorter duration in the total treatment time was observed when compared to conventional direct bonding techniques or indirect bonding with planning based on plaster models (13, 25).

Garino et al. (20) and Son et al. (19) describe as advantages in virtual planning: less chair time for the assembly of the brackets, less number of bracket rebonding, less need for finishing bends in the arches, and, the possibility to show the patient the case planning on the computer screen. Son et al. (19) also report as disadvantages the lack of assessment of soft tissues and the possible change in lip positioning after planning the orthodontic treatment represented by the virtual setup .

The technique of indirect bonding with virtual planning allows the printing of the bracket transfer guide, allowing the absence of adhesive material in their bases, which is not possible in conventional indirect bonding. This is an advantage, as it reduces the chance of adhesion failures and errors resulting from excess material in the base (21).

There is a variety of software for setup, virtual bonding, and prototyped transfer guides. The orthodontist guides the preparation of the setup according to their planning, and, after the

approval of the virtual simulation result, they can order the desired service. The goal is to provide faster treatment and better results. The software anticipates outcome details that would hardly be noticed so early.

OrthoCAD® (Align Technology, San Jose, California) is a system based on CAD/CAM technology in which after the simulation of the ideal teeth positions, the brackets are inserted in the virtual setup. The system has a tool, with a small video camera and LED lights, in which the position where the brackets are placed on the physical model is marked (22).

Israel et al. (23) studied the reproducibility of conventional and digital indirect bonding with the OrthoCAD® software. After analyzing the results, no statistically significant differences were found in relation to the precision and quality of the alignment and leveling of the arch when comparing the two methods.

The Insignia® system (Ormco Corporation, Orange, CA, USA) is a system that helps to virtually draw the desired occlusion at the end of orthodontic treatment. The company that developed the system also provides patient-specific brackets, transfer guides and personalized orthodontic arches. The main advantage of the Insignia® system, according to Sarver, cited in the article by Aldrees (24), is the ability to develop the most individual treatment possible. After setup, it is possible to manufacture arches and brackets using reverse engineering that move the teeth to the desired result (24).

Weber et al. (25) investigated the possible differences between treatment with appliances made using CAD/CAM technology with Insignia brackets and the conventional appliances in a small group of patients with edgewise brackets. The authors found a statistically significant difference between the total treatment time, which was shorter in the group treated with the Insignia brackets. They also found differences in the scores determined by the American Board of Orthodontics index where the Insignia group was closer to the ideal in its final result.

The Orapix® (Angelinus, Seoul, South Korea) and Incognito® (3M Unitek, Monrovia, CA, USA) software arise in the context of the added difficulties with lingual orthodontic treatments (5). The diverse dental anatomy, impaired visualization and the difficulty in correcting bracket positions make the indirect bonding technique very popular. The Orapix® system allows 3D construction and precise positioning of the brackets in the transfer trays. The Incognito® system produces working models, brackets and orthodontic arches using CAD/CAM programs (5).

Grauer et al. (26) evaluated the effectiveness of the treatment proposed by digital technology, based on a retrospective study with the inclusion of 94 consecutive patients who had malocclusions of different severities. The evaluated technique used the Incognito® system for virtual planning of the accessories' position, three-dimensional printing of the individualized brackets according to the case, indirect bonding and pre-conformed and bended orthodontic wires by a robotic device. From the three-dimensional overlap using a predefined algorithm and a coordinate system they concluded that the discrepancies found were considered clinically irrelevant. Comparing the models of the virtual setup and the ones achieved at the end of orthodontic treatment, the effectiveness and precision of the technique are confirmed.

Son et al. (19) published a clinical case in which the planning was carried out using the 3Txer software (Orapix, Seoul, Korea), by scanning the models of the initial occlusion, making a virtual setup, three-dimensional positioning of the brackets and making individual transfer jigs for indirect bonding for each bracket. The three-dimensional overlap of the virtual planning models and the models after the end of the treatment show agreement and minimal difference in the result, confirming the technique effectiveness. The disadvantage of the method consists in the fact that the guide for transferring the brackets for indirect bonding is not unique for the entire arch, but individual for each tooth, which reduces the stability in the adaptation of the jigs for clinical bonding and increases the time necessary for bonding.

The SureSmile® system (Orametrix, Inc., Richardson, TX, USA) allows the creation of treatment simulations, and, after the result is approved, personalized archwires are made by robotic devices according to the case. In a technology similar to OrthoCAD®, the positioning of brackets is defined in the digital model, with the help of a pen with a video camera and LED lights (11).

Some clinical studies confirmed the accura-

cy of the virtual setup used for the digital positioning of brackets, the indirect bonding with a printed guide and customized orthodontic arches, and the effectiveness of the treatment varied according to the type of tooth and dimension of the tooth movement (9, 27).

SEQUENCE OF INDIRECT BONDING USING CAD/CAM TECHNOLOGY

In the indirect digital bonding technique, we can observe the following phases: making of digital models; virtual planning with bracket positioning; making transfer molds for indirect bonding and the clinical procedure of indirect bonding.

Acquisition of digital models

The process for digital bonding begins with the patient's intraoral scanning for the acquisition of a digital model (Figure 1) and an STL file (stereolithography, used in 3D printing), which can be performed both in the office and in radiological clinics.

Figure 1 - Intraoral scanning for three-dimensional reconstruction of dental arches.

The digital model can also be made from the plaster model scanned by a bench scanner. Despite the precision (10 microns) and being able to obtain working models that generate customized appliances, its application is more intended for study models.

From the STL file, the orthodontist can choose to carry out the digital planning of the orthodontic treatment and virtual bonding of the brackets using their own software, in addition to making the transfer trays, or selecting a company that offers the service.

Virtual planning with bracket positioning

The orthodontist must select which system they will use among those on the market. Some companies offer an online platform where patient data such as treatment plan, intra and extra-oral images, radiographs and STL files of digital models are inserted (Figure 2).

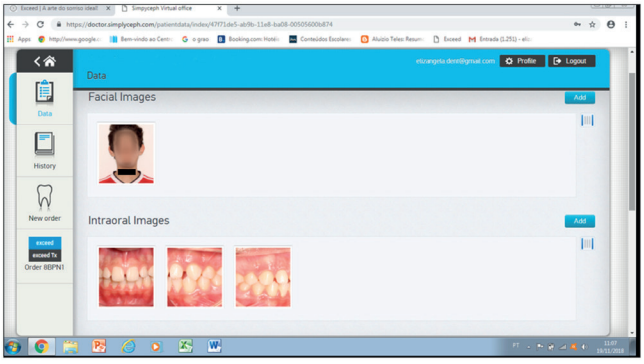

Figure 2 - Online platform where the professional inserts the patient's data and images (files) to make the virtual setup.

On some platforms it is possible to perform the virtual bonding of brackets directly in the malocclusion or through a previous setup, carried out by technicians guided by a specialist in Orthodontics, following the treatment plan discriminated by the professional.

The result is simulated from the collected data. Currently, some companies accept cone beam computed tomography, enabling to visualize the positions of dental roots and the alveolar bone, helping to make the setup.

After the setup approval, the brackets are virtually positioned (Figure 3). The orthodontist selects the desired bracket model from the

company's virtual library. At this point, the professional receives information about possible compensation with resin due to the distance between the bracket base and the crown surface. The visualization of possible occlusal interferences can be verified by the system, leading the professional to choose between moving the bracket or inserting a bite lift (anterior or posterior) in the act of bonding.

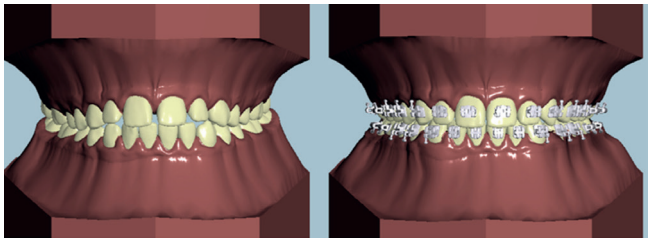

Figure 3 - Presentation of digital models: malocclusion (left) and setup (right) of orthodontic planning with accessories positioned for approval by the orthodontist.

Making and preparing transfer trays for indirect bonding

After the setup approval, the brackets are placed in the ideal arch, and then reverted to the malocclusion, where virtual supports will serve to guide the positioning of physical brackets in the printed model. The models are printed with the addition of these supports that guide the position of brackets. From there, the indirect bonding guide is made using the double stamping technique (two overlapping blades, one silicone inner and one rigid acetate outer). There is also the possibility of printing the positioning guide, without the need to print the plaster model. The type of transfer guide for positioning the brackets in the mouth varies with the software system used.

With the transfer guides in hand, the professional can choose to make the lower and upper bonding in a single attendance or not. The transfer trays can be divided into two or three parts depending on the degree of crowding or the orthodontist's preference. After positioning the brackets on the transfer guide, the bracket base must be cleaned to remove possible dirt that may interfere with the adhesive process. A thin layer of the adhesive system of choice is then applied. From that moment on, it is crucial that the guides remain in a dark environment to avoid the resin's early polymerization (Figure 4).

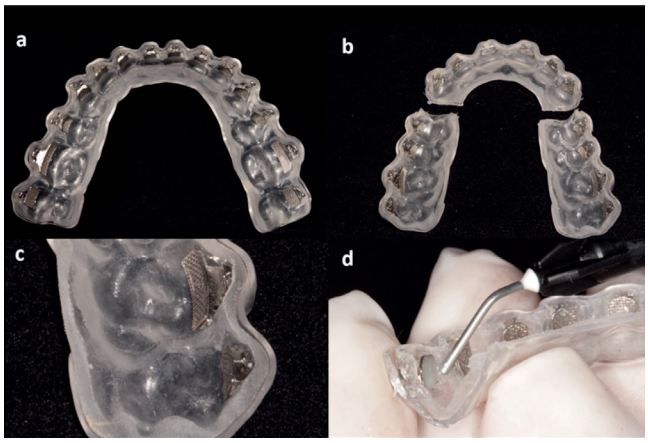

Figure 4 - Transfer trays: A: Entire tray made using the double stamping technique; B: sectioned tray; C: Two overlapping blades, the internal silicone and the other external rigid in acetate; D: insertion of low viscosity adhesive at the bracket base.

Clinical indirect bonding procedure

The clinical bonding phase is divided into two stages: preparation of the enamel and bonding with light-curing material.

The enamel preparation consists of the prophylaxis of all teeth with pumice and water; isolation of teeth with cheek retractors, cotton rollers and suckers; conditioning the enamel with 37% phosphoric acid for 30 seconds washing and drying the enamel (Figure 5).

Figure 5 - Clinical indirect bonding procedure: A: Conditioning the enamel with phosphoric acid; B: adhesive application; C: tray positioning; D: individual light curing of each bracket; E: Careful removal of the outermost tray layer; F: Brackets bonded with the arches already inserted.

After preparing the enamel, a thin layer of adhesive is applied to the teeth followed by polymerization. Then, the tray, with the brackets with resin on the bases, is taken into position in the arch, adapting well to the teeth and pressing lightly, polymerizing each tooth for 40 seconds.

After polymerization, the trays are carefully removed, with the aid of an explorer probe in the direction of the lingual to buccal face, starting with the external tray, and then the internal tray. Without the trays, it is possible to check for excess resin around the brackets. If necessary, the surplus material can be removed with the aid of a multilaminated drill.

DISCUSSION

With the incorporation of new technologies to Orthodontics, companies have launched different systems on the market, including multifunctional software that generally integrate three-dimensional digital models, the possibility of making setup, virtual bonding, and prototyped transfer guides (28). The indirect digital bonding protocols have been improved in order to improve the accuracy of the technique, and the number of researches directed to the refinement of the systems is increasing (23, 28).

The study methodologies converge to assess the quality of the appliances' assembly in a subsequent phase, that is, by quantifying the clinical benefits after treatment (13, 23, 29), as described in a clinical case study, in which two types of malocclusion were successfully treated from planning with the OrthoCAD® software (30). However, the same system, in a laboratory test performed by Israel et al. (23), obtained alignment results similar to conventional indirect bonding techniques.

Digital indirect bonding planning services are available with and without the therapeutic result's simulation (17). Although it increases the possibility of a better result, the creation of virtual setup generates additional cost and demands more time and technical training in the software operation.

The practice of indirect digital bonding is recent and needs further studies (19,32), since those comparing indirect digital bonding methods are scarce and tend to have limitations in terms of sample size and/or discrepancy in the type of malocclusions in the cases included in each group analyzed.

The SureSmile® system, with digital planning and customized arches, produced better finishing results and an average of 25% faster treatments when compared to the conventional fixed orthodontic treatment method. It was observed that SureSmile® patients lost less points in the evaluation of models, following the criteria of the ABO - American Board of Orthodontics (31). The study by Alford (32) demonstrated similar results in terms of better alignment and treatment time, when compared to conventional fixed treatment, but the authors emphasize that the average complexity of the cases selected for the SuresSmile system group was lower than in the conventional orthodontic treatment group. In addition, the SureSmile® system had worse results in root parallelism.

Weber et al. (25) compared similar cases treated with conventional appliances and the Insignia system. The results showed that the treatment time was significantly shorter with the Insignia system. However, the authors admit that the sample was small.

Brown et al. (13), Weber et al. (25) and Alford et al. (32), mentioned the advantage of indirect digital bonding technique with virtual planning, the shorter total treatment time.

According to Son et al. (19) and Redmod et al. (22) the absence of a method that includes the assessment of soft tissues in the virtual setup would be a limitation of the indirect bonding technique by virtual planning. Another disadvantage would be the high cost of obtaining the software.

CONCLUSION

Techniques of indirect bonding using CAD/CAM systems are relatively recent resources in Orthodontics and have been receiving increasing interest and scientific publications. The studies indicate the reliability of the method for bonding precision, suggesting excellent results at the end of the treatment. Studies that compare treatment time are quite variable in relation to the various techniques and software available on the market and the selection of the researched groups. Thus, although many publications suggest a faster treatment, further investigations are still needed. Despite this, indirect digital bon-

ding has proved to be an interesting option to be incorporated into orthodontic treatment.

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