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.

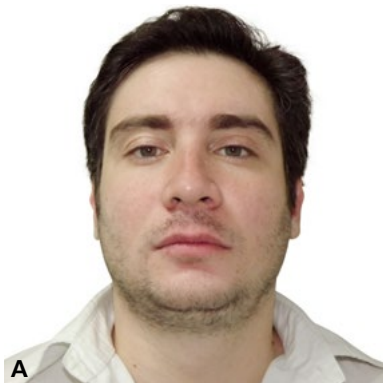
The eXceed™ system has been enabling to orthodontists to perform clinical case diagnosis and planning, brackets virtual positioning and treatment with invisible aligners. This clinical case report aims to present an orthodontic treatment using the IB method with brackets virtual positioning created by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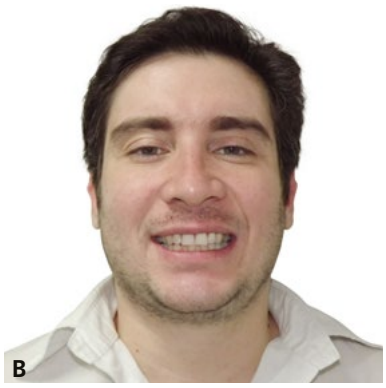
B


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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.

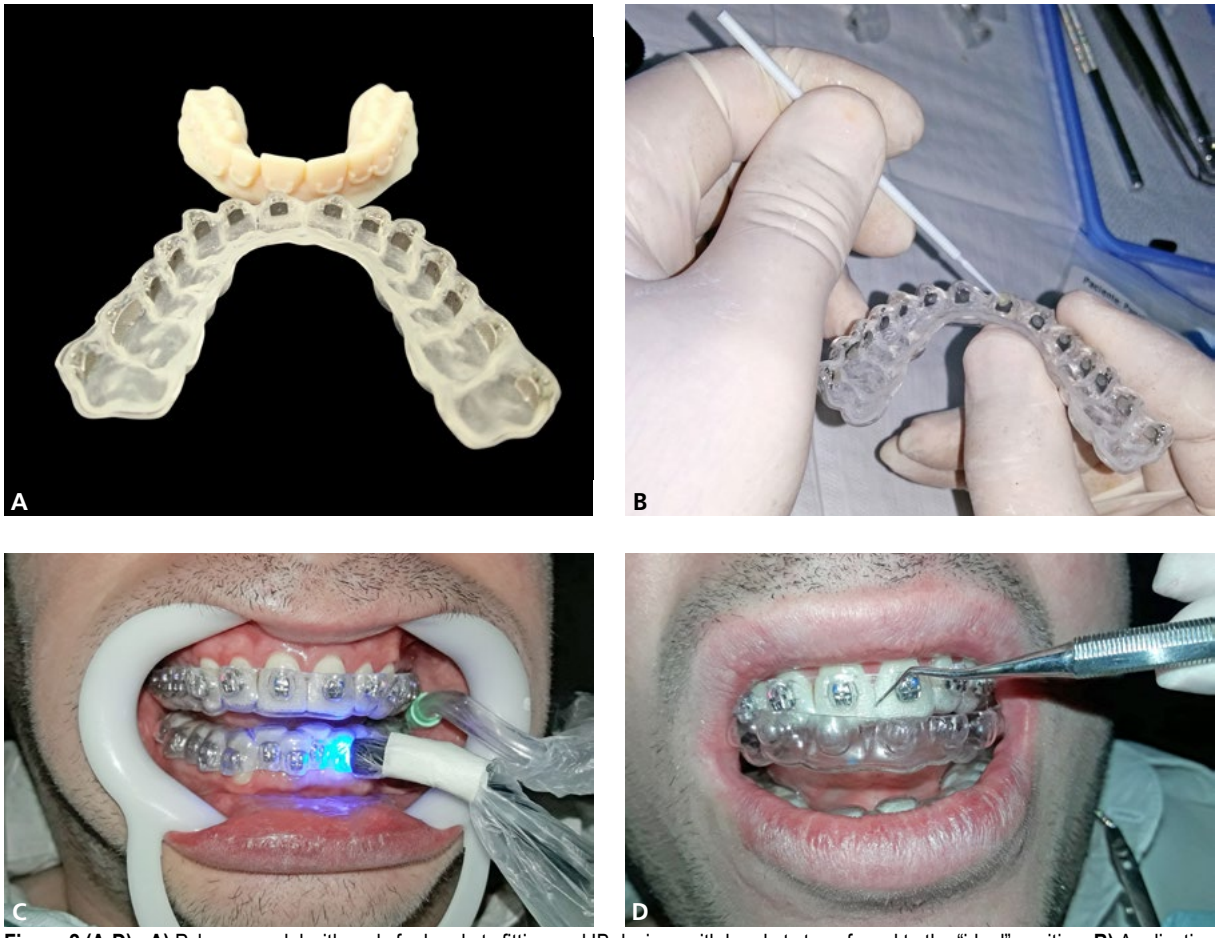

Figure 2 (A-D) - A) Polymer model with pads for brackets fitting and IB devices with brackets transferred to the "ideal" position; **B)** Application of the adhesive on the brackets base; **C)** Positioned IB devices and brackets light curing **D)** Removal of overlapping plates of polyvinyl acetate.

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).

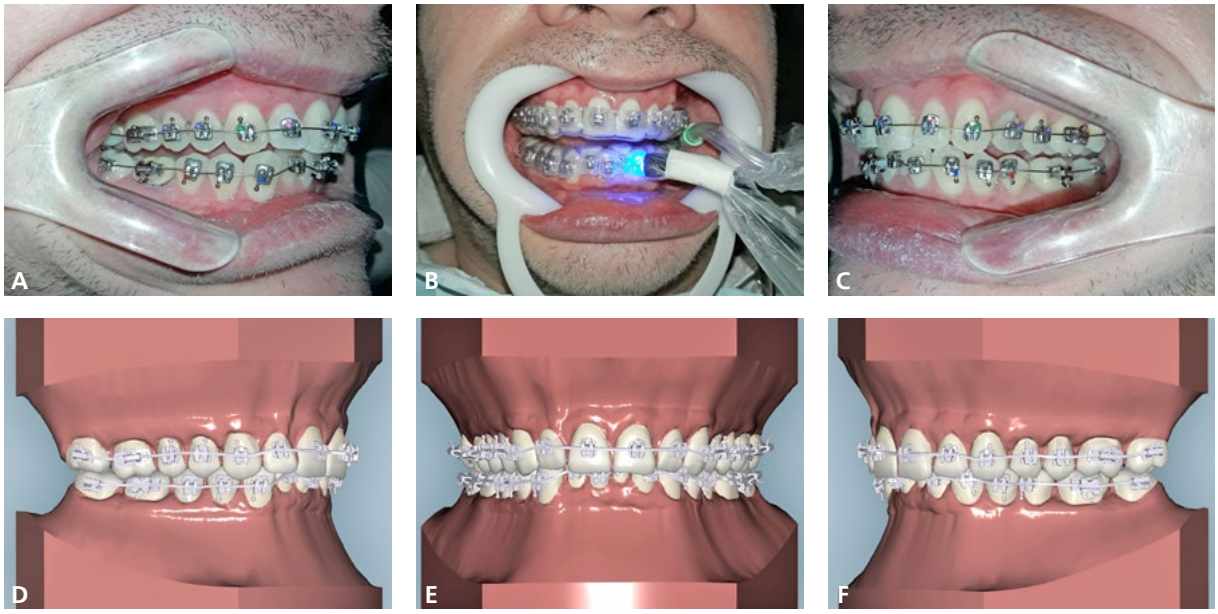

Figure 3 (A-F) - A,C,E) Fixed orthodontic device after indirect bonding in the right and left frontal views and **B,D,F)** the respective orthodontic setup images provided by the eXceed™.

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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