

Rapid prototyping: A new method of preparing trays for indirect bonding

Fabio Ciuffolo,^a Ettore Epifania,^b Gianni Duranti,^c Valentina De Luca,^d Daniele Raviglia,^d Silvia Rezza,^d and Felice Festa^e

Chieti, Naples, and Ancona, Italy

This article describes a new method of preparing trays for indirect bracket bonding. Computer-aided technology is used to design the individualized trays, which are then produced with a rapid prototyping procedure. Application in clinical practice and the advantages of time savings and accurate bracket placement are discussed. (*Am J Orthod Dentofacial Orthop* 2006;129:75-77)

Precise bracket positioning expresses the full potential of the straight-wire orthodontic appliance and leads to better treatment results and shorter treatment times.¹ The accuracy of bracket placement with both direct and indirect bonding techniques has been investigated,² and no statistically significant differences have been found between the 2 procedures in regard to angulation, mesiodistal position, or shear bond strength.^{3,4}

Regardless of whether the direct or the indirect technique is used, occasional minor positioning errors in initial bracket placement are inevitable.^{5,6} However, high-tech procedures involving computer-aided design/computer-aided manufacturing (CAD/CAM) processes could help reduce the number of errors.⁷

Rapid prototyping is a high-tech procedure in which a solid object is produced from a computer model. It has been used with CAD/CAM in orthodontics to customize lingual brackets⁷ and in maxillofacial surgery to fabricate custom trays for mandibular recon-

struction after bone loss.⁸ Orthodontists could use this technology to prepare custom trays for orthodontic bonding. This article describes a method of tray preparation for indirect bracket bonding. These trays are individually designed on a computer and produced with a rapid prototyping procedure. They help the clinician save time and achieve more accurate bracket placement.

THE MANUFACTURING PROCESS

The first step in the manufacturing process is to take a silicone impression. The casts produced from this impression are used to prepare the initial model of malocclusion. Noncontact scanning of the initial model is performed with a high-resolution optical 3-dimensional (3D) scanner (Structura s.r.l., Ancona, Italy). The 3D scanner examines the model from various perspectives to create a complete 3D representation, with a resolution of at least 0.02 mm. The result is a surface consisting of many thousands of minute triangles (standard triangulation language surface; Fig 1, A) that can be turned, observed, and processed on a computer with dedicated software (CADental, Structura s.r.l.). At present, acquiring the malocclusion model takes approximately 90 minutes, and a trained operator is needed to ensure correct placement in the scanner.

Next, using the dedicated software, the operator virtually positions the desired commercial bracket (previously incorporated in the software database) onto each tooth at the desired height. Measurements are accurate to 0.1 mm (Fig 1, B). When brackets have been properly positioned, the fabrication of the rapid prototyping trays (RPT) can begin. A special command fills the bracket inlets with virtual clattering material, producing a cubic-like figure that has the same maximal bracket dimensions. A positive of the RPT, in which the real bracket will be placed, has been made. To create the negative of the site, the cubic figure is covered with

^aPhD student, Section of Orthodontic and Gnathology, Department of Oral Science, University G. d'Annunzio, Chieti, Italy.

^bAssociate professor, Department of Oral Science, University Federico II, Naples, Italy.

^cPrivate practice, Ancona, Italy.

^dAssistant to the Dean, Section of Orthodontic and Gnathology, Department of Oral Science, University G. d'Annunzio, Chieti, Italy.

^eDean, Section of Orthodontic and Gnathology, Department of Oral Science, University G. d'Annunzio, Chieti, Italy.

Structura s.r.l., Ancona, Italy, commissioned the Department of Oral Science, University G. d'Annunzio, Chieti, Italy, to develop this procedure and to research the accuracy and shear bond strength of the technique. Structura is patenting the system and hopes to make it commercially available soon. The authors have no financial interest in Structura. More information is available on the Structura web site (www.structuraonline.it).

Reprint requests to: Fabio Ciuffolo, Reparto di Ortodonzia e Gnatologia, Università G. d'Annunzio, Via dei Vestini, 5-66013 Chieti, Italy; e-mail, fcuffolo.alf@virgilio.it.

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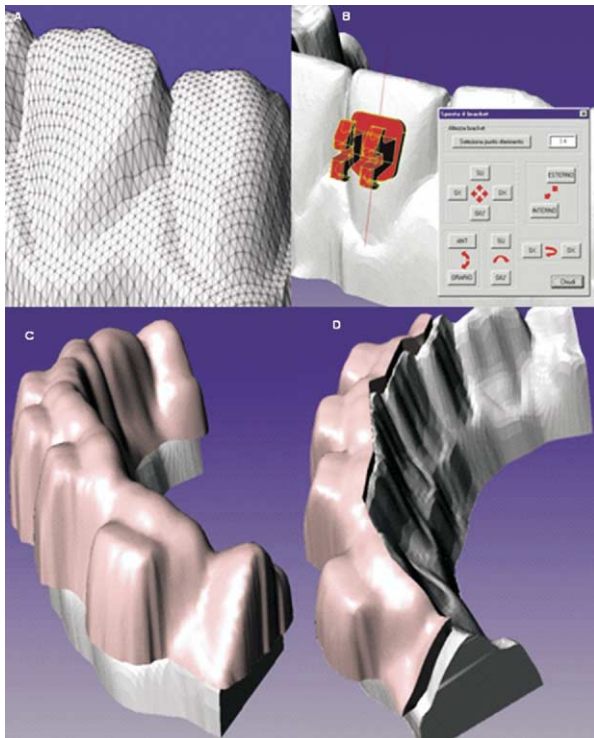


Fig 1. Design process of virtual tray: **A**, scanned malocclusion model; **B**, virtual bracket placement; **C** and **D**, creation of virtual trays.

a virtual acrylic-like material, which represents the tray in a raw state (Fig 1, C).

A software utility trims off the virtual excess material, leaving single, grouped, or unique RPTs, according to arch anatomy and user preference (Fig 1, D). Single trays with adequate mesiodistal dimension are preferable because they prevent interproximal interferences due to, for example, dental misalignment. Moreover, trays for each tooth could be reused in successive treatment phases in which rebonding of some brackets is needed. In contrast, a full-arch tray cannot be reused after the original position of teeth has changed.

To prevent errors in positioning, the RPT should overlap the incisor or cusp margins enough to give a point of reference for the vertical dimension. To have an immediate mesiodistal reference point, the RPT should extend almost to the interproximal space for the incisors, and at least 1 mm laterally from the bracket site for the canines and the premolars. The gingival margin should be cut off from the definitive RPT.

A high-end rapid prototyping machine is used to convert the virtual trays into the final real product, made of a rigid-elastic plastic material (Fig 2, A and B).



Fig 2. Clinical application of RPT: **A**, bracket in RPT with adhesive paste; **B**, RPT placed on tooth; **C**, RPT removal; **D** and **E**, RPT placement on adjacent teeth (full arch bonding can be undertaken); **F**, light-curing.

BONDING PROCEDURE

Once the trays have been produced and delivered, the bonding procedure can start. The buccal enamel surfaces are cleansed and polished with pumice and rubber cups, washed with water, and dried. A 37% phosphoric acid gel (3M Dental Products, St Paul, Minn) is used to acid-etch the teeth for 30 seconds. The teeth are rinsed again and dried, and the characteristic frosted white appearance must be present. Transbond XT primer (3M Dental Products) is applied to the etched surface in a thin film. An adequate quantity of Transbond XT adhesive paste (3M Dental Products) is applied to the bracket bases (Micerium, Genova, Italy), and the brackets are positioned into the RPT sites (Fig 2, A). Then the RPT can be placed in the mouth and pressed onto the dental surfaces according to the anatomy of the teeth (Fig 2, B) and the adhesive cured. When the tray is removed, the bonded bracket remains on the tooth (Fig 2, C). This procedure is continued to bond the full arch (Fig 2, D-F).

DISCUSSION

This method addresses 2 problems traditionally associated with bonding: inaccurate bracket positioning and lengthy chair time.

Commercial brackets in the software database are positioned with utilities that measure height, mesiodistal position, and angulation with a resolution of 0.1 mm. This allows exact bracket placement and reduces the poten-

tial for error. However, this alone is no guarantee of a reduction in mean bracket placement errors. The quality of the initial impression is crucial, and, during the virtual bracket positioning, the user must avoid contact with the dentition of the opposite arch; this could cause accidental debonding.

Compared with direct bonding, indirect RPTs could help the clinician save time by reducing the time needed to check the bracket position on each tooth. The RPT automatically places the bracket in the desired position, as defined on the 3D malocclusion model.

The main advantages of this new methodology, compared with traditional indirect bonding, are the reduction in manufacturing stages and the bracket positioning optimization offered by CAD/CAM technologies.⁷ Furthermore, with this system, bracket positioning can be performed by an orthodontic auxiliary.⁹

Potential limitations of RPTs include the impossibility of correcting the bracket position because of the presence of the tray during the bonding procedure. If the bracket position is wrong on the 3D model, the error will be discovered only after the tray is removed. Furthermore, the presence of light-cured paste around the bracket can be observed only after the tray is removed, so it is necessary to apply an adequate quantity of adhesive paste. Because special equipment and skills are needed to acquire the malocclusion model and fabricate the RPT, these jobs currently should be performed in a dedicated center. However, orthodontists could use the custom software to position the 3D brackets.

CONCLUSIONS

RPTs are a new instrument for indirect bracket positioning. They exploit the advantages of CAD/CAM technologies to optimize bracket placement and can help the clinician place brackets accurately in a shorter time. Randomized controlled trials are needed to compare the effectiveness of this technique with traditional direct and indirect bonding methods in terms of bracket placement accuracy, time, and shear bond strength.

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