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INDIRECT BONDING ACCURACY BY 3D PRINTED TRANSFER TRAY

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Abstract:

Introduction: *Indirect bonding is a procedure that involves transferring orthodontic attachments from dental casts (working models) and bonding them to the teeth with the help of a transfer tray. Indirect bonding is a preferred approach for many orthodontists since it takes less time than direct bonding. The merging of computer-aided design and computer-aided manufacturing (CAD/CAM) allowed for the digital formation of transfer trays. This study aimed to determine the accuracy of CAD/CAM indirect three-dimensional printed bonding trays.* ***Materials and methods:*** *١٤٠ teeth were planned to be bonded by 3D printed transfer tray. The intraoral scanner was first used to produce a stereolithographic (STL) file for virtual brackets location, and then another scan was taken after the brackets were bonded. Software was used to measure position deviation of bracket placements by superimposing virtual STL files and post bonding STL files.* ***Results:*** *To see if the mean transfer error was statistically within the selected accuracy limits of 0.5 mm for linear measurements, a one-sample t-test was used. For linear measurements, P-values of less than 0.05 indicated differences within the accepted deviation limits.* ***Conclusions:*** *CAD/CAM transfer trays for indirect bonding have high transfer accuracy in all kinds of teeth.*

Key words

Indirect bonding, CAD/CAM, transfer tray,

Introduction

The first straight wire appliance was developed since long time ago. An appliance made up of attachments (brackets) that have unique features for each tooth, including a pre-set tip, in and out, and torque prescription.(1)

It used to take a long time for direct brackets bonding to their positions. An orthodontist will place the bracket in a certain location and orientation, which may vary from case to case, in order to produce desired tooth movements. Many orthodontists favor indirect bonding because the more accurate the bracket insertion, the more probable the ideal teeth positioning will occur. Indirect bonding is a procedure in which orthodontic attachments are transferred from dental casts (working models) and bonded onto teeth using a transfer tray, first reported by Silverman et al in 1972.(2)

Brackets were often bonded to plaster (physical) models before being moved to a patient's mouth using an indirect bonding transfer tray made of silicon or vacuum formed sheets.(3–6)

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Currently, technological advancements enable for digital bracket planning and bonding. This technique comprises a desktop scanner scan of the patient's models or an intraoral scanner scan of the patient's mouth. After the brackets are put on the digital models, a transfer tray is created or printed to keep the brackets in their proper position before being inserted in the patient's mouth for the bonding operation. In 2018, Christensen was the first to employ an indirect bonding transfer tray created using computer-aided design/computer-aided manufacturing (CAD/CAM). (7,8)

Materials and methods

Before beginning the study, ethical approval of the Faculty of Dentistry ethical committee was obtained and all individuals were told about the study's nature and benefits. Also a signed informed consent was acquired from each paticipant.

Seven individuals with good dental hygiene who needed fixed orthodontic treatment were chosen from the Orthodontic Department's outpatient clinic. Hypocalcified teeth or huge restorations extending to the tooth's facial surfaces, poor dental hygiene, active periodontal disease, and several missing teeth were all ruled out.

This study included 140 teeth for indirect bonding (all upper and lower incisors, canines, and premolars in all patients).

After taking complete orthodontic records, all participants had their teeth polished. Standard Tessellation Language (STL) data for both dental arches were obtained using an intraoral scanner.

The STL file was imported into the 3Shape Orthoanalyzer software, where virtual models were created. Virtual bracket placement according to desired treatment plan was completed, and another STL file for the final bracket position design was obtained and utilized as a reference for superimposition.

Ortho appliance designer was used to plan the transfer tray by defining its extensions. After that, a transfer tray was 3D printed from biocompatible flexible resin Ortho IBT, which was loaded with brackets, checked for firrting and ready for bonding (Figure 1).

Figure 1 printed transfer tray with brackets

Indirect bonding procedure:

All teeth were polished with a brush and pumice, and then etched for 20 seconds with 37 percent phosphoric acid. Drying by air with special attention to the lingual and palatal surfaces of the teeth, as well as isolation, was carried out. With a bonding brush, the etched surfaces were covered with single bonding agent. Inside the transfer trays, light cured composite was applied over the mesh of bracket bases. Gentle pressure was used to place transfer trays loaded with brackets on teeth, followed by 20 seconds of light curing for each bracket. The tray was removed with a dental probe from the lingual surface to the labial or buccal surfaces. After complete bonding, teeth were scanned by the same intra oral scanner for superimposition.

Superimposition:

Superimposition was carried out by reverse engineering software (Geomagic qualify) according to technique described by El-nigoumi in 2016.(9)

Mesio-distal and occluso-gingival linear and angualr deviations were measured as the linear distance**.**

Statistical analysis:

P-values of less than 0.05 indicated differences within the limits of 0.5 mm for linear measurements.(10)

The mean and standard deviation values were calculated. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, data of accuracy showed parametric (normal) distribution.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Results:

One-tailed t-tests were performed to determine whether the mean transfer error was statistically within the selected acceptable

limits of 0.5 mm for linear measurements, and 2° for angular measurements. P-values of less than 0.05 indicated differences within the limits of 0.5 mm for linear measurements and 2° for angular measurements.(10)

All one-sided t-tests reached statistical significance (P < 0.05) for all linear dimensions in all tooth types in both arches, indicating that the brackets were transferred with acceptable translational error in the MD and OG dimensions, regardless of tooth type or arch. Also, all one-sided t-tests reach statistical significance (P < 0.05) for torque angular dimensions in all tooth types in both arches.

Figure 2 Bar charts representing relation between different arches

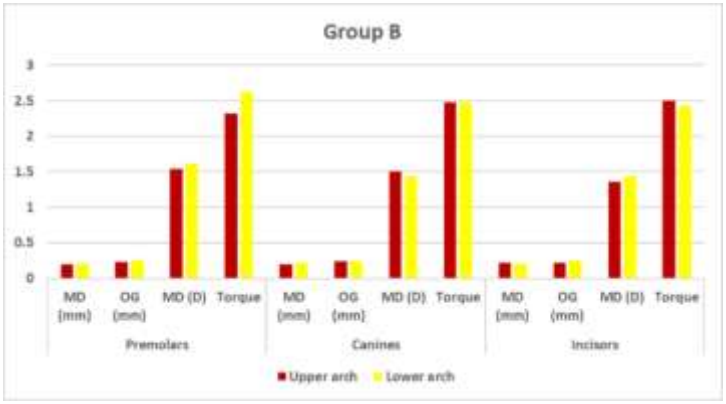

Table 1 The mean, standard deviation (SD) values of tranferred brackets

Variables				p-value
		Mean	SD	
Premolars	**MD (mm)**	0.20	0.07	<0.001*
	OG (mm)	0.32	0.12	<0.001*
	MD (D)	1.73	0.60	0.045*
	Torque	2.28	0.71	0.072ns
Canines	**MD (mm)**	0.23	0.06	<0.001*
	OG (mm)	0.32	0.12	<0.001*
	MD (D)	1.61	0.49	0.011*
	Torque	2.41	0.68	0.040*
Incisors	**MD (mm)**	0.21	0.06	<0.001*
	OG (mm)	0.32	0.08	<0.001*
	MD (D)	1.55	0.44	<0.001*
	Torque	2.52	0.61	<0.001*
Total	**MD (mm)**	0.21	0.06	<0.001*
	OG (mm)	0.32	0.10	<0.001*
	MD (D)	1.63	0.51	<0.001*
	Torque	2.41	0.66	<0.001*

Discussion

The purpose of this study was to determine the accuracy of CAD/CAM indirect three-dimensional printed bonding trays. In this study, a total of 140 brackets were bonded. While removing the transfer tray, 16 brackets were debonded, accounting for 11.4 percent of total bonded brackets. This figure is slightly lower than that reported by Zachrisson and Brobakken, who found a bonding failure rate of 14 percent with indirect bonding.(11)

For transfer accuracy, 134 brackets were measured. One-sided tests revealed that brackets were transferred within the accepted range (0.5 mm) in linear measurements (occluso-gingival and mesio-distal), as well as within the transfer error range of 2 degrees in angular measurements (mesio-distal rotation and torque). The 0.5 mm and 2° thresholds were selected because they are generally recognized professional standards limits. For teeth that are 0.5 mm or more out of alignment, the American Board of Orthodontics Cast-Radiograph Evaluation allocates points. The allowed angular deviation threshold was determined because a 2° crown-tip deviation error causes a marginal ridge discrepancy of 0.5 mm in an average-sized tooth. Several studies have used these levels to evaluate tooth and bracket transfer accuracy in model superimposition.(12–14)

According to Armstrong *et al*, 0.25 mm transfer deviation in the incisor brackets positions and 0.5 mm for canines, premolars and molars is considered clinically accepted. (15)

The results demonstrated that the transferred brackets' linear and angular control were within acceptable limits except torque measurements in premolars. Previous studies of digital indirect bonding techniques have yielded similar results.(14,16)

Previous studies compared the actual bracket positions with the virtual setup through superimposition or direct measuring to determine the accuracy and precision of digital indirect bonding, and they concluded that CAD/CAM indirect bonding is an accurate and efficient technique for orthodontic bracket bonding, which is consistent with the findings of this study..(12,17–19)

The type of material utilised, lack of elasticity, distortion, wrong tray fit, and pressure are all examples of indirect bonding typical problems that affect transfer trays construction. Appropriate pressure would enable appropriate tray seating, but excessive pressure could result in gingival deviation or bracket rotation.

With technology evolution and further researches, standardization of printing settings and resin specification will be set and range of errors through the whole procedure will be reduced to minimum and CAD/CAM indirect bonding will be more popular in every orthodontist daily practice.

Conclusions:

CAD/CAM indirect bonding transfer trays had high transfer accuracy in linear measurements in all types of teeth.

Angular measurements showed accepted transfer accuracy in all teeth except premolars regarding torque measurements.

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