

An Evaluation of a Light Cure and Dual Tray Technique For Indirect Bonding of Orthodontic Brackets

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Objectives: The aim of this study were to evaluate (1) the bond strength of a light cured resin cement and (2) the effectiveness of a double transfer tray technique in indirect bonding of orthodontic brackets. **Methods:** A total of 150 bovine teeth were mounted in blocks of 6 and distributed to test (indirect bonding) and control (direct bonding) groups. Brackets were bonded using the total etch technique for the control group. For the test group, a 1mm hard and 1mm soft double tray with the addition of a light cure resin (Filtek Flow) was used for bonding. Tensile bond strength was recorded 20 minutes following bonding. **Results:** No significant difference in bond strength was found between any two teeth or between the test and control groups. Bond strength was 8.13 (0.44) and 7.76 (1.82) MPa for the test and control groups respectively. **Conclusion:** The light cure material provided clinically acceptable bond strengths and is recommended for indirect bonding. In addition, the double tray technique provided an effective method for indirect bonding.

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1. Introduction

The efficiency and outcome of orthodontic treatment are affected by two major factors: first, the clinician's ability both to choose the correct treatment for the patient and to effectively manipulate the appliances to reach the desired result and second, the materials used for treatment. With the advent of direct bonding of orthodontic brackets to enamel (Newman, 1964) and the introduction of the straight wire appliance by Andrews (1972), it became widely recognized that accurate and effective bracket placement was of critical importance.

In an attempt to improve bracket placement clinically, Silverman *et al.* (1972) developed the indirect bonding technique. In this technique the clinician first attaches the brackets in the desired position to a stone model with full visual and physical access to all teeth. Brackets are then transferred via transfer trays to the patient's teeth where they are bonded.

The many advantages of indirect bonding such as accuracy of bracket placement, reduced clinical chair side time, reduced patient and doctor stress, and easier cleaning following debonding, have made this technique more attractive to practitioners in recent years (McCrostie, 2003; Vijayakumar *et al.*, 2014). This interest resulted in the introduction of many modifications in the technique including the use of light cured adhesives to bond the brackets to the teeth

and the use of different types of transfer trays during indirect bonding (White, 2001; Mazzeo *et al.*, 2013). Light cured adhesives are the most widely used materials in direct bonding. In addition, there has been an increased interest in the use of self-etching primers with direct bonding which have been reported to produce comparable bond strengths to traditional bonding (Arnold *et al.*, 2002; Aljubouri *et al.*, 2004).

The purpose of this study was to investigate the *in vitro* tensile bond strength associated with the use of a light cured resin when used in indirect bonding of orthodontic brackets in association with a double transfer tray technique.

2. Materials and Methods

A total of 150 freshly extracted bovine incisor teeth were used for this study. Each tooth was without caries, attrition, or other obvious defect. The teeth were mounted in blocks made of cold cure acrylic (Orthodontic resin, Great Lakes Orthodontics, LTD., Tonawanda, NY, USA). Each block contained 6 teeth numbered from one to six and arranged similarly to represent crowding in the anterior region of the upper arch (Fig 1). A hole was placed behind each tooth in the acrylic to help orient the blocks during the bond-testing phase. Blocks were stored in a saline solution at room temperature until used. Alginate impressions were taken, and yellow stone models were fabricated. A thin layer of separating medium (Great Lakes

Orthodontics, Tonawanda, NY, USA) was painted on the models and allowed to dry. Mesh base, lower incisor, stainless steel brackets (Catalog #85-311-00, GAC International, Bohemia, NY) were attached to the model using the total etch technique and a light cure composite resin (Transbond™ XT, 3M Unitek, Monrovia, CA) following to the manufacturer's instructions. Brackets were positioned at the center of the flat surface of the tooth and pressed against the model. Excess composite was then removed. The models were then placed in a Triad light curing oven (Dentsply International Inc, York, PA, USA) for 10 minutes to allow curing of the composite. Blocks were then randomly assigned to the test (15 blocks/90 teeth) and control (10 blocks/60 teeth) groups.

In the indirect bonding groups, transfer trays were formed using a Biostar machine (Great Lakes Orthodontics, Tonawanda, NY, USA). A 1mm soft Essix material was formed first (Catalog #25-200-21, GAC International, Bohemia, NY, USA). Silicon spray was then sprayed over the material. A second 1mm hard biocryl material (Catalog #021-025, Great Lakes Orthodontics, Tonawanda, NY, USA) was then formed over the first layer extending, however, only to the lower margin of the brackets. After soaking the models in water for 30 minutes, transfer trays were removed with the brackets embedded in them. The bracket bases were rinsed and dried.

After pumicing and cleaning, the teeth were etched with 37% phosphoric acid for 15 seconds, rinsed with running water for 15 seconds and finally dried with air. One liberal coat of Transbond moisture insensitive primer (MIP) was then painted over the tooth. A small amount of Filtek Flow (Filtek Flow, 3M ESPE Dental Products, St. Paul, MN) was applied to the bracket base. The trays were then placed over the teeth, held in place and the adhesive was cured using an LED (Ortholux LED, 3M Unitek, Monrovia, Ca, USA) light for 20 seconds on each bracket.

In the direct bonded control groups, a slight modification was required to mimic the test group but performing the bonding directly. The same protocol used for indirect bonding was followed except that the transfer trays holding the brackets which were sectioned for each tooth and only the 1mm soft material was used. This resulted in each tooth having its own transfer tray covering only the incisal edge of the tooth to guide the bracket to its correct position.

During the bonding procedure, pressure was applied to the bracket directly while the adhesive resin was being cured. This process was completed for each tooth individually. The modification helped eliminate errors caused by possible tray distortion when used as a whole and at the same time allowed the principles of direct bonding to be applied.

Tensile bond strength testing was conducted 20 minutes following bonding using an Instron universal testing machine (Model 1125, Instron Corp., Canton, MA, USA). For the testing procedure, a 0.012 inch ligature wire (GAC International Inc, Bohemia, NY, USA) was tied to the wings of the bracket. A tensile force at 90° to the bracket base was ensured by attaching the wire to a universal joint on the testing machine while the block was attached to arm of the testing machine through the hole in the acrylic block behind the tooth to be tested. The tensile test was conducted at a rate of 2 mm/minute. The load for adhesive failure was recorded in newtons and then converted into megapascles (MPa) by dividing the force by the surface area of the bracket which, measured 9mm². Brackets that came off during removal of the transfer trays were given a value of zero for the bond strength.

Data were analyzed using one way ANOVA followed by a Scheffé test for pairwise comparison between the teeth within the groups. The student *t* test was used to compare mean bond strengths between the control and test groups. All statistics were performed at the 0.05 level of significance.

3. Results

The mean bond strength (MBS) and standard deviation (SD) for each group is shown in Table 1. No significant difference was found between the test and control groups. Comparison of the individual teeth bond strengths within the indirect test group (Table 2) showed no significant difference between any two teeth in bond strength.

Table 1. Mean tensile bond strength and standard deviation for the test and control groups.

Test Group		Control Group	
Mean	±SD	Mean	±SD
8.13	0.44	7.76	1.82

Table 2. Mean tensile bond strength and standard deviation for the teeth within the test group (MPa)

Tooth number	Tooth Number					
	1	2	3	4	5	6
	8.26	8.02	8.19	8.60	7.90	7.80
	± (1.62)	± (1.33)	± (0.82)	± (1.40)	± (1.37)	± (1.36)

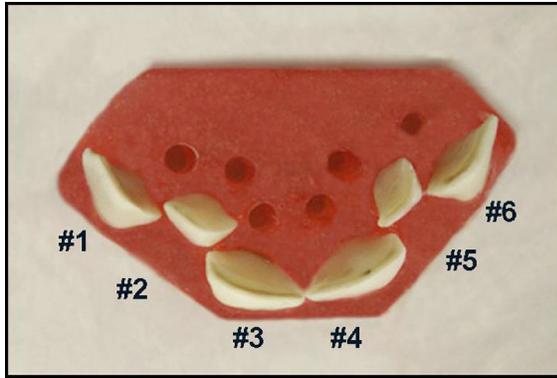


Fig 1. Block design and teeth arrangement.

4. Discussion

The literature is not very clear on what the range of acceptable bond strength is, for this study a range from 3.00 to 9.70 MPa was used as the range of acceptable bond strength as 2.86 MPa was the lowest tensile bond strength reported to be acceptable and 9.70 MPa was the strength at which enamel fracture was reported upon debonding (Retief, 1974; Keiser *et al*, 1976). Both the test and control groups, therefore, had produced bond strengths within the acceptable level.

Results from comparing the bond strengths of different teeth within the indirect test group revealed no significant difference between any two teeth. This result indicates that crowding, to the degree used in this study, did not affect the double transfer trays in providing good adaptation of the brackets to the teeth during bonding. While other *in vitro* studies have used various different materials on aligned teeth (Yi *et al*, 2003; Polat *et al.*, 2004), this study is the unique in that it used the double tray technique in association with crowding.

The use of the flowable composite and the production of acceptable bond strength are in support of the findings by Miles (2005). Further, this resin material provided ease of use and manipulation. It is, however, expected that the clinical bond strength would increase with time as it has been shown that the bond strength increases up to 50% more 24 hours after bonding (Oesterle *et al.*, 1995). In the current study testing was conducted 20 minutes after bonding which is more representative of a real clinical situation where brackets are subjected to forces as the first wire is inserted, occurring about 5 minutes after bonding.

Several other studies used different materials when comparing direct to indirect bonding. However, this study confirms the results reported in a study by Vijayakumar *et al.* (2014) that used the same material for both direct and indirect bonding and found no difference between the two techniques. In addition, the results obtained here further confirm that the

bonding procedure was not influenced by the transfer trays used for the indirect bonding thus confirming that the double tray technique is an accurate method for indirect bonding and that the tensile bond strength obtained was due to the adhesive resin material itself and not the technique.

Conclusion

1. The light cure Filtek Flow flowable composite not only provided high tensile bond strength within the upper limits of the clinically acceptable tensile bond strength, but also provided ease of use and manipulation and is therefore a good choice for indirect bonding of orthodontic brackets.

2. The double transfer tray technique provides accurate adaptation of brackets to the teeth in indirect bonding even in the presence of malalignment.

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