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Assessment of shear bond strength of orthodontic brackets bonded by trans-illumination method

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***Abstract*---**Objective: To assess the clinical effectiveness of trans-illumination technique in bonding orthodontic brackets. Materials and method: Forty premolars were arbitrarily divided into 4 groups. Bonding of brackets was done with 40- and 80-s light curing from the buccal or lingual aspect with different intensities. Shear bond strengths of brackets were measured using a universal testing machine. Collected data were analyzed statistically. Result: The highest shear bond was observed in group 2 (high intensity, 40 s, buccal) and the lowest found in group 3 (low intensity, 40 s, lingual). Conclusion: In all experimental groups except group 2, shear bond strength was below the clinically accepted values. Doubling the curing time and increasing the light intensity during trans-illumination are recommended for achieving acceptable bond strengths.

***Keywords*---**bond, brackets, light cure adhesive, Orthodontic, shear bond strength.

Introduction

The use of light-cured composite material for bonding orthodontic brackets has become increasingly popular among orthodontists. The literature reports that labial curing of bracket adhesive for 40 seconds per bracket provides a balance between optimal strength and light-application time. Transillumination directs light through the tooth to the composite material on the opposite side of the tooth. This method has been recommended when metal covers the majority of the composite material on the tooth, such as in cases of bonded fixed partial dentures and metal orthodontic brackets. [1] Bonding with light activated systems is popular because the extended working time, which allows for precise bracket placement.[2]

Light activated resins has Camphoroquinone that absorbs light with wavelengths in the range of 400 and 500 nm light and responds to irradiation by creating free

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radicals and initiates the polymerization process. One most desired result of bonding to any surface is that the attachment should be strong enough to endure the forces of orthodontic treatment and oral functions without any breakage and safe to the tooth surface during debonding. The strength of these restorations depends on the degree of polymerization of composite resins. Incomplete polymerization produces adverse biological effects, increasing water absorption, composite solubility, and reducing hardness. Various factors contribute to the polymerization of the composites, and they include the wavelength and intensity of the output of light curing units, duration of radiation. [3]

Although transillumination has been suggested to cure composite under orthodontic brackets, there is little in the orthodontic literature to confirm its usefulness. [1] It has been observed form previous studies that the microhardness and the degree of composite polymerization were less when the composite was cured from the lingual than when it was cured from the labial. [4]

Various authors have recommended increasing the length of time of light exposure when using transillumination.[5] According to literature, appliances bonded to the enamel must have shear bond strength between 6 and 8 MPa2,5,7 in order to achieve the clinical needs that support orthodontic and occlusion forces.[6] The present study was done to evaluate the shear bond strength of orthodontic brackets after different light curing method.

Materials and Method

Forty extracted premolar teeth for orthodontic reason free from any pathology were included for the study. Then teeth were sterilized and stored in saline until use for testing.

Before bonding, the teeth were randomly divided into 4 groups each containing ten teeth. Specimen preparation was done exactly as was instructed by the manufacturer. The labial surfaces of the teeth were polished using non-fluoride pumice and then rinsed with water and subsequently dried with moisture-free air. The buccal enamel was etched with a 37% phosphoric acid for 30 s and rinsed for at least 15 s, then dried with oil and moisture-free air source. A thin uniform coat of Transbond XT primer (3 M Unitek, Monrovia, CA, USA) was applied to the etched surfaces. A small amount of adhesive paste of Transbond XT was applied to the bracket bases. Stainless steel brackets used in this study were Ultratrim Standard Edgewise (Dentaurum, Ispringen, Germany) in all groups. Immediately after placing the adhesive, the brackets were lightly placed on the tooth surface, adjusted to the final position and then pressed firmly. Excess adhesive material was gently removed from around the bracket base without disturbing it. The adhesive was cured with High Power (800 mW/cm2) and Low Power (650 mW/cm2) programs of Bluephase C8 (Ivoclar, Vivadent, Schaan, Liechtenstein) LED-curing unit in all groups:

- Group 1 (control): 40 s light curing with the Low Power program from the buccal aspect (10 s for each mesial, distal, occlusal, and gingival aspect).
- Group 2 (control): 40 s light curing with the High Power program from the buccal aspect (10 s for each mesial, distal, occlusal, and gingival aspect).

- Group 3 (experimental): 40 s light curing with the Low Power program from the lingual aspect (light cure tip was placed as close as possible to the lingual surface perpendicular to occluso-gingival axis of the tooth).
- Group 4 (experimental): 40 s light curing with the High Power program from the lingual aspect (light cure tip was placed as close as possible to the lingual surface perpendicular to occluso-gingival axis of the tooth).

After bonding, specimens were stored individually in a normal saline solution at 37°C in a dark environment 24 h prior to testing. The shear bond strength of specimens was measured using a crosshead speed of 0.5 mm/min. In order to avoid bias, the bonding and debonding procedures were done by two different operators and the teeth were given codes unrelated to their group numbers. The results of the SBS test were recorded in megapascal.

Statistical analysis

The data was confirmed to be normally distributed using the Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) and Duncan's post hoc tests were used to compare SBS values among groups using SPSS 11.5 software.

Results

The one-way ANOVA test showed that there was a significant difference among shear bond strength amounts in groups ($F(5,10) = 712.235$, $p < 0.05$). Also, as it is shown in Table 1, Duncan's post hoc tests revealed that there was a significant difference between every two groups except for groups 1 and 2 (control group). Mean values of SBS are shown in Table 2. The highest mean bond strength was seen in group 2 (40-s curing from the buccal aspect with the intensity of 800 mW/cm2) and the lowest value was in group 3 (40-s curing from the lingual aspect with the intensity of 650 mW/cm2).

SBS was not significantly different between two control groups; in both groups, the SBS values were above the clinically accepted values according to Reynolds' study[7] and values were significantly higher than experimental groups. Among four experimental groups, the only group with sufficient SBS values for orthodontic bonding was group 6 (80-s curing from the lingual aspect with the intensity of 800 mW/cm2).

Discussion

The polymerization of light-activated resins under metal brackets by transillumination has been shown to be successful, because the tooth conducts visible light well. Light polymerization (command curing) improves the accuracy of bracket positioning and thus minimizes the need for position in grealigning of teeth after debonding. The polymerization of light activated resins under metal brackets by transillumination has been shown to be successful, because the tooth conducts visible light well.[8]

Oesterle et al to determined the transmittance of the curing light through human enamel and the effect of transillumination on the bond strength of orthodontic brackets on one hundred extracted human maxillary incisors. The shear-peel bond strengths were tested at 30 minutes and 24 hours after light application. They concluded that transillumination of maxillary incisors is an acceptable method of curing orthodontic adhesive, particularly if the exposure time is increased from 40 to 50 seconds. [1]

Wei NanWang and Ching-LiangMeng evaluated the effectiveness of a visible light source in curing the resin under a solid metal bracket, compared the tensile bond strength at different exposures, and analyzed the broken interface distribution between light-cured resin with various light exposure times and self-cured resin. They found that bond strength of light-cured resin of Transbond, except in cases of light exposure of 20 seconds, is stronger than that of the self-cured resin of Concise. [9]

Mathew et al evaluated the shear bond strength (SBS) of metallic brackets bonded to enamel by Conventional Bonding System using six different light curing units. They concluded that Polymerization with all the six LED curing lights resulted in SBS values that were clinically acceptable for orthodontic treatment in all groups. Curing with 3MESPE EliparTM Deepcure gave a higher bond strength than other groups cured for a short time. [3]

Priya and Jain evaluated the shear bond strength of the brackets bonded with two different orthodontic light cure adhesives. They concluded that the mean shear bond strengths of two adhesive systems showed no significant differences. [8]

Abdullah et al assessed the shear bond strength of orthodontic brackets and adhesive remnant index (ARI) of an adhesive cured with two different orthodontic light sources i.e. LED and halogen. They concluded that the shear bond strength of orthodontic adhesives cured with a LED was statistically equivalent to those cured with a halogen light curing unit.[2]

Vicente et al compared the shear bond strength and the quantity of adhesive remaining on the tooth after the debonding of brackets bonded with two light-cured orthodontic resin adhesive systems (Transbond XT and Light-Bond) and a dual-cured resin cement (RelyX Unicem). They observed that the bond strength produced by Light-Bond was significantly greater than that of Transbond XT. [10]

Ribeiro et al evaluated the bond strength of orthodontic brackets in resin restorations with surface treatment. They concluded that the best technique for bonding of orthodontic brackets on composite resin restorations is the performance of surface detritions.[6] Increasing the light intensity can improve the bonding. Further studies are needed to verify the results on larger sample size.

Conclusion

Within the limitation it can be concluded that, doubling the curing time and increasing the light intensity to 800 mW/cm2 during trans-illumination with the LED light-curing unit can be done to improve the bond strength.

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Legends for illustrations
Table

Table 1
Shear bond strength values in all six groups

Group	Subset for α = 0.05				
	1	2	3	4	5
Group 1					12.5686
Group 2					12.9856
Group 3	2.8231				
Group 4		3.4643			

Group 1 (control): 40 s, 650 mW/cm2, buccal; group 2 (control): 40 s, 800 mW/cm2, buccal; group 3: 40 s, 650 mW/cm2, lingual; group 4: 40 s, 800 mW/cm2, lingual

Table 2
Shear bond strength values in all six groups

Group	Mean (MPa)	Standard deviation	Standard error	Minimum (MPa)	Maximum (MPa)
Group 1	13.5	0.38	0.12	11.0	12.1
Group 2	13.7	0.53	0.15	12.3	12.5
Group 3	2.6	0.26	0.10	2.1	3.2
Group 4	3.6	0.32	0.10	2.7	3.5

Group 1 (control): 40 s, 650 mW/cm2, buccal; group 2 (control): 40 s, 800 mW/cm2, buccal; group 3: 40 s, 650 mW/cm