

Evaluation of brackets shear bond strengths using two different light-emitting diode curing units

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ABSTRACT

Aims: To evaluate the efficiency of two types of light-emitting diode (LED) curing units in bonding orthodontics brackets. **Materials and Methods:** Three groups, ten teeth each, of newly extracted premolars were used in the study. In the control, the brackets were bonded using a halogen bulb light curing unit, while in the other two groups the brackets were bonded using a high and a low intensity LED curing unit, respectively. The brackets were bonded to the teeth using Transbond® light-cured orthodontic adhesive. The bonded brackets were tested for their shear bond strength using a universal compression machine. **Results:** The mean bond strength of brackets bonded with the high intensity LED curing unit was above the clinically accepted value and it was comparable to that of the halogen bulb light curing unit group. Meanwhile, the mean bond strength of brackets bonded with the low intensity LED curing unit significantly differed from the other two groups and was below the clinical acceptance level. **Conclusion:** The high intensity LED curing units can be used successfully in bonding orthodontic brackets. The bond strength was sufficient to consider these units as good substitutes for the halogen bulb-based units. The low intensity LED curing units are not recommended to be used in orthodontics.

Key Words: Light-emitting diode, light curing unit, shear bond.

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INTRODUCTION

With the introduction of photosensitive (light-cured) restorative materials in dentistry, various methods were suggested to enhance their polymerization including layering and the use of more powerful light-curing devices.⁽¹⁾

Visible light-curing units are an important part of modern adhesive dentistry. They are used to cure resin-based composite restorative materials, resin-modified glass ionomers, preventive pit and fissure sealants, certain bases and liners, core build-up materials and provisional restorative materials, and, most important to the orthodontist, to bond orthodontic brackets to teeth.⁽²⁾

Visible light-cure adhesives have several advantages over two-paste and one-paste self-cured resin systems because they offer adequate time for precise bracket positioning and immediate curing. Light-cured orthodontic adhesives have been cured almost exclusively with light emitted from a halogen light. However, halogen te-

chnology has several shortcomings. Only 1% of the total energy input is converted into light, with the remaining energy generated as heat. The short life of halogen bulbs and the noisy cooling fan are other disadvantages.⁽³⁾ In addition, the halogen bulb, reflector and filter degrade over time due to the high operating temperatures and the large quantity of heat which is produced during the duty cycles. This results in a reduction of the light curing units effectiveness over time.⁽⁴⁾

To overcome these problems, solid-state light-emitting diode (LED) technology has been proposed for curing resin-based dental adhesives.⁽⁵⁻⁹⁾ LEDs are solid-state light sources that have a potential lifetime of over 10,000 hours and can be subjected mechanical shock and vibration with very low failure rates. Furthermore, the LED has no bulb or filter that requires routine maintenance.⁽¹⁰⁾

The LEDs are manufactured by metal-organic chemical vapor deposition of different semiconductor materials in films

that are layered one on top of another. The latest blue LEDs use indium gallium nitride technology and can generate photons of a particular wavelength by varying the band gap. A wide band gap material produces high-energy photons near the blue region of the visible spectrum.⁽¹¹⁾ The LEDs can have wavelength peaks of around 470 nm, so negating the need for filters.^(6, 12-14) In addition, the thermal emission of the LED light-curing units is significantly lower than that of halogen light curing units.⁽¹⁵⁾

Individual LEDs have a relatively low light irradiance output compared to a halogen bulb, therefore multiple diodes are often arranged into an array, the combined output of which, when appropriately channeled through a light guide, can approach that of halogen light curing unit values.⁽¹³⁾

So, this study was conducted to evaluate the efficiency of two types of light-emitting diode (LED) curing units in bonding orthodontics brackets.

MATERIALS AND METHODS

Thirty newly extracted premolars extracted for orthodontic purposes in patients aged 12-16 years were collected from orthodontic clinics, washed and polished, and stored in tap water at room temperature. The teeth selected should have intact buccal enamel, free of caries, and not subjected to any pretreatment chemicals agents like hydrogen peroxide. Any tooth with caries, fractures, cracks, or hypoplastic enamel was excluded from the study.^(1, 2, 16) The teeth were stored in ethyl alcohol 70% to inhibit bacterial growth.⁽¹⁷⁾ Then, they were stored in distilled water to prevent dehydration.

The teeth were randomly divided into three groups with 10 teeth for each and as follows:

1. Control group (halogen bulb), in which the orthodontic adhesive was polymerized with a halogen light curing unit.
2. The second group (high intensity LED), the adhesive of which was polymerized with high intensity LED curing unit.
3. The third group (low intensity LED), in which the adhesive was polymerized with low intensity LED curing unit.

The teeth in each group were mounted in dental stone in an upright position with the help of a surveyor. A plastic ring was placed around each tooth, which was already fixed on a glass slab using soft wax at the root apex. Using the analyzing rod of the surveyor, the teeth were uprighted, and the dental stone were poured around. Then the samples were kept in distilled water until bonding day to prevent dehydration.

On the day of bonding, the teeth were cleaned and polished with rubber cups on low-speed hand piece using non-fluoridated dental pumice. Then, the teeth were rinsed with an air water spray for 5 seconds and dried with oil-free compressed air for 10 seconds. A 37% phosphoric acid etching liquid was applied on the buccal surfaces of the teeth for 30 seconds. The teeth were then thoroughly rinsed with an air-water spray for 15 seconds and dried with oil-free compressed air for 20 seconds giving the enamel a white chalky appearance.

Transbond[®] adhesive primer was applied to the etched surfaces with a brush. Gentle oil-free compressed air was blown to evenly distribute the primer. The Transbond[®] adhesive paste was applied to the bracket bases, and then the brackets were positioned on the middle third of the buccal surface of the teeth with a clamping tweezers and pressed firmly with finger pressure until no excess adhesive was coming out from underneath bracket bases. All excess adhesive around the brackets was removed with an explorer.

Light curing of the three groups was done using Coltolux 50[®] light curing unit (HB), Ultra-Light[®] high intensity LED curing unit (HIL), and lastly Optilight LD 200 E Plus[®] low intensity LED curing unit (LIL). The adhesive was cured for 10 seconds from each of the four directions: Mesial, distal, occlusal and gingival to ensure complete polymerization. The samples were then re-kept in distilled water for 24 hours. After that, the samples were tested for their shear bond using universal compression machine. The sharpened end of the machine rod was applied at the bracket-tooth interface in an occluso-gingival direction. The ultimate magnitude of bond failure force was recorded in Kilograms, then

converted to Newtons and divided by bracket surface area to obtain the shear bond strength in megapascal (MPa).

The collected data were statistically analyzed using Statistical Package for Social Sciences (SPSS) program. The tests used include:

1. Descriptive analysis including mean, standard deviation, minimum and maximum.
2. One-way analysis of variance (ANOVA) test followed by Duncan's Multiple Range Test were conducted to estimate the presence or absence of significant differences

RESULTS

Descriptive analysis including mean, standard deviation, minimum, and maximum, of the shear bond strength of the three test groups were shown in Table (1).

The results showed clinically accept-

ed mean bond strength (over 8 MPa) for the halogen and high intensity LED curing unit groups. While the low intensity LED curing unit group showed mean shear bond strength below the clinical acceptance bond strength.

One-way ANOVA test analysis was carried out to reveal the presence or absence of significant differences among the test groups (Table 2). A significant difference appeared to exist among the groups, so Duncan's Multiple Range analysis was conducted to identify the location of this difference (Table 3). The Duncan's test showed no significant differences in shear bond strengths between the halogen light curing unit group and those of high intensity LED curing unit groups. Meanwhile, it was shown that the shear bond strengths of the low intensity LED curing unit group was significantly different from both halogen light and high intensity LED curing unit groups.

Table (1): Descriptive statistics

Group	No.	Mean	±SD	Minimum	Maximum
HB	10	10.04	2.001	5.41	11.91
HIL	10	9.79	2.248	7.36	13
LIL	10	3.74	1.124	2.24	5.63

No.: Number; SD: Standard deviation.

HB: Halogen light curing unit group (control group).

HIL: High intensity LED curing unit group.

LIL: Low intensity LED curing unit group.

Table (2): One-way ANOVA analysis for the three groups

	Sum of Squares	df	Mean Square	F-value	p-value
Between Groups	254.396	2	127.198		
Within Groups	92.944	27	3.442	36.95	.000
Total	347.340	29			

df: Degree of freedom.

Table (3): Duncan's Multiple Range Test for the three groups

Group	No.	Mean	± SD	Duncan's Grouping*
HB	10	10.04	2.001	A
HIL	10	9.79	2.248	A
LIL	10	3.74	1.124	B

No.: Number; SD: Standard deviation.

*Means with the same letter were statistically not significant ($p > 0.05$).

HB: Halogen light curing unit group (control group).

HIL: High intensity LED curing unit group.

LIL: Low intensity LED curing unit group.

DISCUSSION

It was found that the bond strength of brackets bonded with high intensity LED curing unit was sufficient to withstand clinical forces and not significantly different from that of halogen light curing unit. These findings correspond to the findings of other studies.⁽¹⁻³⁾ Therefore, the high intensity LED curing can be recommended as superior substitute for halogen light curing unit having the same curing efficacy with all advantages of LED curing units.

Meanwhile, the shear bond strength of brackets using the low intensity LED curing unit revealed significant difference from that of both halogen light and high intensity LED curing units. The shear bond strength of the low intensity LED group was under the clinically accepted value (8 MPa). For that reason, it is recommended for clinical purposes to bond orthodontic brackets using a low intensity LED unit.

CONCLUSION

It was concluded from this study that the high intensity LED curing units had proved efficiency in bonding orthodontic brackets comparable to that of the halogen light curing units. For that reason, with the advantages of the LED over the halogen light curing units, the study can recommend the high intensity LED curing units as good substitute for the halogen light units. Hence, the low intensity LED curing units did not fulfill the clinical bonding requirement, they are not recommended for orthodontic clinical use.

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