

# Evaluation of Different Brands of Led Curing Devices for Bonding Metallic Orthodontic Brackets

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## Abstract

The aim of this study was to evaluate the effect of different light curing devices i.e. Light emitting diodes (LED) for bonding orthodontic brackets, using the shear bond strength and assess the adhesive remnant index (ARI). 75 premolars received brackets bonded with transbond XT. The samples were divided into 5 groups consisting of 15 brackets in each group according to light curing procedures: HL – HalogenDensply (Control), I – Ivoclar(Ledition), M - 3M (Elipar), W - (Woodpecker) and A - (Allure). Light curing was performed for 40 sec. Universal testing machine at a crosshead speed of 3mm/min was used to evaluate the shear bond strength. ANOVA and Tukey's test was used to analyse the data. Stereoscopic magnifying glass was used to assess the ARI scores. Shear bond strength means in MPA and standard deviations were 14.8 (2.2), 18.3 (4.9), 18.2 (6.4), 16.2 (5.6) and 15.8 (6.1) for HL, I, M, W and A respectively. I showed the maximum shear bond strength mean value. No statically significantly difference was observed for the ARI scores among the groups. In conclusion, IvoclarLedition and 3M Elipar LED's showed the highest values of bracket adhesive strength.

**Keywords:** LED curing devices; Bond Strength; Orthodontics; ARI

## Introduction

In 1960's bonding of orthodontic brackets started by using enamel acid etch technique [1,2]. Only auto polymerizing material were then available. With time light activated adhesive system was introduced which gave sufficient time to orthodontists to position bracket and remove excess material.

Quartz tungsten halogen lamps have been long dominated as light curing device [3,4]. Important characteristics of halogen light curing system is wide spectrum of action allowing composites to be cured in different shapes; also it has low cost maintenance and is easy to use. They have disadvantages that the bulb filter and reflectors degrade with time and power density of light decreases with increase in distance. Devices using xenon plasma arc, argon laser and LED have also been introduced. Studies show that shear bond strength produced by halogen lamps and plasma arc are significantly the same but plasma light has an advantage of reducing adhesive setting time per tooth from 20-40 sec to 2 sec [5]. But Xenon plasma arc along with argon laser have the disadvantage of being too expensive.

In Orthodontics, the use of LED was first suggested by Mills in the year 1995 [6]. Light cure resins set when light of wavelength of 460nm and 480nm within blue end of visible spectrum is used with an intensity of 300mW/cm<sup>2</sup> that passes through enamel and produces free radicals by disruption of double bonds in alpha diketone initiator. LED devices have advantages like small size, ergonomics, less weight, reduced noise generation and heat, radiation source having longer life, lower power consumption, and light emission spectrum with total camphoroquinone absorption [7-10]. LED's despite having these exciting characters, it is imperative to know if these devices can keep the mechanical properties of the adhesive materials and photo activate these materials for orthodontic brackets.

The aim of our present study was to analyze the influence of various light emitting diodes (LED) light curing devices for bonding orthodontic brackets using the shear bond strength and analysis of the adhesive remnant index (ARI).

## Methods and Materials

### Inclusion Criteria

- Healthy freshly extracted upper 1st premolars.
- All LED's used in the study were new/1 month old.
- Upper 1s premolar MBT 0.22 slot bracket were taken (3M Unitek Gemini)

### Exclusion Criteria

- Carious teeth
- Tooth with irregular labial anatomy.

Seventy five healthy permanent upper premolars were used for study. After extraction and cleaning they were stored in a container with distilled water. The premolars were divided into 5 groups with 15 premolar samples in each group that were to be cured with one halogen light curing device and 4 different light curing devices (LED).

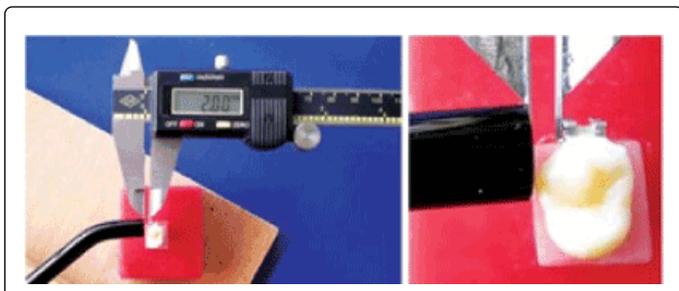
The 5 different light emitting diodes used in the study are as follows:

- HL - Densply
- I - Ledition (Ivoclar)
- M - Elipar (3M)
- W - Woodpecker
- A - Allure

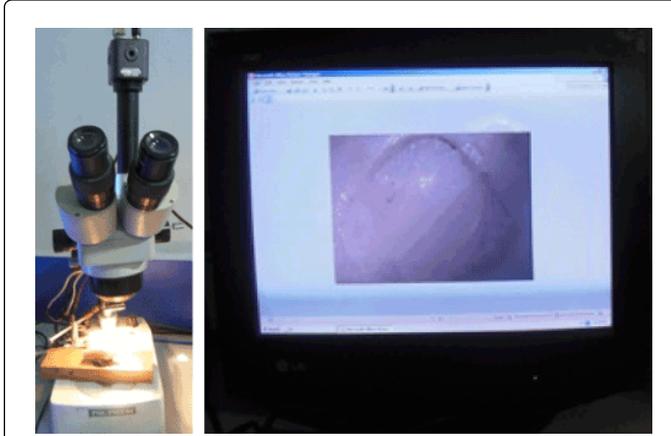
After removal from storage, the teeth were centrally inserted in a cylindrical fibre tube containing activated cold cure resin. Next, the enamel surfaces were etched with 37% phosphoric acid (Ivoclar) for 30s, washed and dried for approximately 20s. Seventy five metallic brackets (Gemini Series, MBT system; 3M Unitek) for upper premolar were bonded to the teeth using Transbond XT composite (3M Unitek) according to the manufacturer's recommendations. Curing was performed with a distance of 2 mm between bracket base and light-curing device for 40 s. In order to stabilize the light curing unit a wooden jig was fabricated with slot to hold the light curing unit. The distance was measured using a digital Vernier caliper (Figure 1). First the mesial side was cured for 20 sec after adjusting light tip to a distance of 2mm as desired. Then the tooth was rotated 180° so that the distal side is facing the tip of the light cure unit. So now each bracket is cured to a total of 40 sec. Light intensity of each device was measured prior to each photo-activation cycle using a curing radiometer (Ivoclar blue phase meter-Figure 2) (Table 1).



**Figure 3:** (a) Universal testing machine, (b) Premolar with bracket bonded and the chisel tip acting in the upper part of the bracket base during shear bond strength test



**Figure 1:** Distance measured using a Digital Vernier caliper



**Figure 4:** Stereoscopic magnifying glass along with its magnified image (10X)



**Figure 2:** Radiometer

All samples were succumbed to shear bond strength test in a universal testing machine (Figure 3a) at crosshead speed of 3 mm/min, with the active chisel tip put on the upper part of the bracket base (Figure 3b). The results were obtained in kgf (Kilogram-force), converted into N (Newton), and divided by the bracket base area (9.806 mm<sup>2</sup>), thus bond strength values in MPa was obtained. After debonding, each sample was evaluated for ARI by using a stereoscopic magnifying glass at ×10 magnification (Figure 4).

The amount of resin remaining on the enamel surface after removal of bracket was classified according to ARI scores established by Artun and Bergland:

- 0 = no adhesive remaining adhered to enamel
- 1 = less than half of adhesive remaining adhered to enamel
- 2 = more than half of adhesive remaining adhered to enamel
- 3 = all adhesive remaining adhered to enamel.

Device Intensity	Light intensity (mW/cm <sup>2</sup> )	
Densply LED(HL)	700*	650**
Ledition LED(I)	1200*	1030**
3MElipar LED(M)	1000*	850**
Woodpecker LED(W)	1000*	830**
Allure LED (A)	1300*	300**
*Informed by the manufacturer		
**Measured with radiometer		

**Table 1:** Information on the evaluated light curing units

The data on shear bond strength were submitted to ANOVA and Tukey's test, whereas Kruskal-Wallis test was used to assess the ARI score. 5% significance level was set for all analyses.

## Results

Shear bond strength data (in MPa), standard deviation and statically analysis are presented in Table 2. Group I showed the maximum shear bond strength with 18.3 MPa mean and least was shown by Group HL with 14.8 mean of all groups. There was no statistically significant difference ( $p > 0.05$ ) between all the groups.

ARI data are shown in Table 3. No statistically significant difference ( $p > 0.05$ ) was found in the ARI scores among the four groups.

Study Groups	Shear Bond strength (MPa)
	Mean $\pm$ SD
Group HL	14.8 $\pm$ 2.2
Group I	18.3 $\pm$ 4.9
Group M	18.2 $\pm$ 6.4
Group W	16.2 $\pm$ 5.6
Group A	15.8 $\pm$ 6.1
Values are Mean $\pm$ Standard Deviation	

**Table 2:** Mean values of shear bond strength (MPa)

Study Groups	Adhesive Remnant Index (ARI)			
	0	1	2	3
Group HL	0	9	6	0
Group I	0	9	6	0
Group A	0	9	6	0
Group M	0	9	6	0
Group W	0	15	0	0

**Table 3:** Distribution of ARI Scores in each group

## Discussion

Studies using shear bond strength tests are frequently difficult to be compared because of several variables such as type of light sources, exposure time, adhesive system used, enamel characteristics, and different methodological approaches. In order to minimize the influence of these variables in the present study, the control group received the same procedures applied to the experimental groups according to the most acceptable methodologies used in the literature (ISO TR 11405) [18].

In the present study, the intensity of light of all the light emitting diodes was measured using a radiometer (Table 1). The intensity of all the devices was above the recommended in previous studies (300 mW/cm<sup>2</sup>) for acquiring an optimum polymerization. Power variation among the devices can justify the difference in shear bond strength. However, the bond strength values recommended by Reynolds were achieved from the curing devices. Interestingly it was found that the

intensity values measured by the radiometer did not correspond to the values provided by the manufacturer (Table 1).

Previous studies have showed that light curing devices such as LED devices display equivalent or even better performance equated to halogen light devices for 40 sec photo-activation time [11-18]. In this study, groups I and M showed higher bod strength than W and A. On the other, Silta et al. [15] studied different polymerization time (20 sec, 10sec, 6sec) for halogen and LED units and found significant differences. The shorter the curing time, lower the shear bond strength. Usemez et al. [13] found significantly reduces values for LED devices compared to halogen light for photo activation time of 10sec.

Artun and Bergand [16] established ARI scores according to these scores the enamel surfaces to which the bracket was bonded were examined after debonding. These scores measure the residual material on enamel and evaluate the area where fracture occurred during the shear bond strength test. In the same way as reported by Silta et al. [15], no significant differences were found among the groups. The present study fractures obtained by debonding procedures were in majority occurring at the enamel composite interface, predominantly ARI score 1 (less than half remaining on enamel). ARI score 0 and score 3 were not found on any of the samples tested in all the groups while all the specimens of group W showed ARI score 1. Regardless of the type of light curing device, ARI classification indicated that most of the material remained adhered on the bracket base, thus affecting the dental enamel surface. This type of failure suggests that the weak link in the adhesive chain was between composite and enamel surface.

Further research is needed to evaluate these and other LED devices before their use in Orthodontics and other dental specialties indicated in reliable manner.

## Conclusion

Ivoclar (lediton) LED showed the maximum shear bond strength followed by 3M (Elipar) LED.

Densply Halogen and Allure LED showed the least shear bond strength followed by Woodpecker LED.

The light sources tested in the present study were all effective for photo activation during bracket bonding.

Most fractures were observed at the enamel-composite interface, with adhesive remaining adhered on bracket after debonding procedure.

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