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# Comparison of shear bond strength of metal brackets bonded with conventional and high-power led curing lights

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## Abstract

**Objectives:** This study aims to determine the effect of conventional (Ivoclar Ledition), and high-power LED units (Woodpecker i-LED with short curing duration) on the shear bond strength of metal brackets bonded to the tooth surface.

**Materials and methods:** Forty sound maxillary premolars were used for the study. The teeth were divided into two groups (n=20). Teeth surfaces were etched with 37% phosphoric acid for 20 seconds. After applying a uniform layer of adhesive primer on the etched enamel, composite was placed on the base of metal brackets and placed appropriately on the tooth surface. The samples were light cured using high-power LED curing unit in Group 1 and conventional LED curing unit in Group 2. The Shear Bond Strength was measured using Universal testing machine (INSTRON).

**Statistical analysis:** student t test is used.

**Results:** The mean Shear Bond Strength of samples in groups A (high-power LED) and B (conventional LED) was 22.088 and 35.0520 respectively. A high statistical significant difference ($p<0.01$) is found between the mean shear bond strength values of two groups. The metal brackets cured using conventional curing unit showed a statistically significant higher Shear bond strength compared to those cured using high-power LED curing unit.

**Conclusions:** The metal brackets bonded with conventional curing light (Ivoclar) showed statistically significant higher shear bond strength compared to those bonded with the high-power LED (Woodpecker i-LED) curing light. High-power LED curing light also showed adequate shear bond strength for orthodontic bracket bonding.

**Keywords:** High power LED curing light, shear bond strength, orthodontic bracket bonding

## Introduction

One essential requisite for orthodontic treatment is appropriate bond strength between bracket and tooth surface. Bonding of orthodontic brackets to enamel started way in the mid-1960s using the acid etch technique [1]. Previously, only auto polymerizing materials were available. A light-activated adhesive system was introduced with time, which gave orthodontists sufficient time to position brackets and removed the excess material. Tavas and Watts [2] first reported bonding of the orthodontic brackets with visible light cure adhesives. The light-cure adhesives were preferred over other chemical-cure adhesives as they had high primary bond strength, better physical characteristics because of air inhibition phenomenon, user-friendly application, extended working time for precise bracket placement, and better removal of adhesive excess;[3]

The halogen lamp, also known as quartz halogen and tungsten halogen lamp, has been used as a light-curing unit for many years. It contains a blue filter that produces light with a wavelength of 400-500nm [4]. Despite their popularity, halogen light curing units have several disadvantages. Their light power output is 1% of the total electric energy consumed, and the lamp, reflector, and filter wear out gradually. The power density of the light-curing unit decreases with an increase in distance. The other drawback of the application of halogen bulbs is prolonged curing time.[5]

Curing units using Xenon plasma arc, Argon laser, and LED have also been introduced. The shear bond strength values of orthodontic brackets were found the same for the halogen lamps and plasma arc, but plasma light reduces curing time per tooth from 20-40 seconds to 2 seconds. Xenon plasma arc provided better shear bond strength, but it is too expensive [6-9].

Mills introduced LED light curing units as polymerizing light sources in 1995.[10] The use of an LED curing unit reduced the curing time by approximately 60% compared to the Halogen light with the same curing efficiency.[11] Currently, they are the most reliable light source categories for bracket bonding. Light cure resins are set when the light of wavelength 460-480nm within the blue end of the visible spectrum is used within an intensity of 300mW/cm$^2$ that passes through the enamel and produces free radicals disruption of double bonds in alpha diketone initiator [8,12]. LED devices to have advantages like small size, ergonomy, less weight, reduced noise generation, and heat, radiation source having more extended life, low power consumption, and light emission spectrum with total camphoroquinone absorption. Commercially available conventional LED curing units produce light within the intensity of 400-700mW/cm$^2$. Recently, in an in-vitro study comparing the conventional curing units HL – Densply, I - Ledition (Ivoclar), M- Elipar (3M), and Allure, Ivoclar (Ledition) LED was found to have the maximum shear bond strength.[13]. High-power LED curing units can emit light radiation with the intensity of 1600- 2000mW/cm$^2$, allowing shorter exposure times of six seconds for metal brackets.[14]

This study aims to determine the effect of conventional (Ivoclar Ledition), and high-power LED units (Woodpecker i-LED with short curing duration) on the shear bond strength of metal brackets bonded to the tooth surface.

**Materials and Methods**

Forty sound premolars were used in the study. They have divided into two groups 20 teeth in each group. Etching of the tooth surface is done with 37% phosphoric acid for 15 seconds and then rinsed with water and dried with compressed air.

A uniform layer of adhesive primer (Orthosolo primer) is applied on the etched enamel, and the resin cement (Ormco Enlight Orthodontic Adhesive) is applied on the bracket surface.

Brackets (0.022 slot, ortho organizer) were placed appropriately and pressed against the tooth surface. Excess cement was carefully removed with a sickle scaler. Prior to curing, the LED units were tested for their intensity using Woodpecker Intensity meter( fig.1).

Group 1: The adhesive was light-cured with a high-power LED unit (2200mW/cm$^2$; Woodpecker i-LED light, TURBO mode) for two seconds, one second on mesial and for one second on the distal.

Group 2: The adhesive will be light-cured conventionally with a standard LED curing unit (600 mW/cm$^2$; Ivoclar Ledition curing light) for 40 seconds, 20 seconds on mesial, and for 20 seconds on distal.

The bonded teeth were stored in distilled water for 24 hours. All samples are subjected to test the Shear bond strength using INSTRON universal testing machine (fig.2 and fig.3) at a crosshead speed of 1 mm/minute. The results are obtained in Newtons and converted to megapascals (MPa).

**Results**

Table 1 shows the average shear bond strength values (in megapascals) of metal brackets to tooth surfaces using high power and conventional LED light-curing units, wherein the mean value is higher (35.052) for Group II than Group I (22.088).

Table 1: The average shear bond strength values (in megapascals) of metal brackets to tooth surfaces using high power and conventional LED light curing units:

| Groups | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| GROUP-I | 22.0885 | 8.06049 | 11.21 | 37.10 |
| GROUP-II | 35.0520 | 15.22681 | 13.25 | 73.50 |

Table 2 shows the unpaired t-test comparison within the mean shear bond strength values of metal brackets to tooth surfaces using high power and conventional LED light-curing units, wherein the mean value is higher (12.255) for Group I than Group II (10.295). A high statistically significant difference (p=0.000*) is found among the mean shear bond strength values of the two groups.

Table 2: T-test showing the significance level within the mean shear bond strength values (in megapascals) of metal brackets to tooth surfaces using high power and conventional LED light curing units:

| GROUPS | t- value | df | Mean difference | 95% Confidence Interval of the Difference | | *P*-value |
|---|---|---|---|---|---|---|
| | | | | Lower | Upper | |
| GROUP-I | 12.255 | 19 | 22.08850 | 18.3161 | 25.8609 | 0.000** |
| GROUP-II | 10.295 | 19 | 35.05200 | 27.9256 | 42.1784 | 0.000** |

Table 3 shows the paired t-test comparison between the mean shear bond strength values of metal brackets to tooth surfaces using high power and conventional LED light curing units, wherein, a high statistical significant difference ($p<0.01$) is found between the mean shear bond strength values of two groups.

Table 3: Paired sample T-test showing the significance level between the mean shear bond strength values (in megapascals) of brackets to tooth surfaces using high power and conventional LED light curing units:

| | Paired Differences | | | | | t- value | df | P-value |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference: Lower | Upper | | | |
| GROUP1 - GROUP2 | -12.96350 | 13.94840 | 3.11896 | -19.49155 | -6.43545 | -4.156 | 19 | 0.001* |

**Discussion**

Achieving good bracket bond strength is of great clinical significance, as orthodontic brackets are subjected to clinical stresses applied by orthodontic archwires, chewing forces, or even iatrogenic stresses. A successful bracket adhesive must have adequate shear bond strength for its continued attachment during the required clinical period. It has been suggested that bond strength values between 5.9 MPa and 7.8 MPa are sufficient for a clinically effective orthodontic bonding [15]. In this study, we used the shear bond strength test, which is commonly used and has acceptable repeatability. Testing shear bond strength using a universal testing machine has a high similarity to the oral environment in terms of applied forces to samples [16].

In orthodontic treatment, one of the essential factors for bond strength of light-cure adhesives is the curing method. Previous studies have shown that LED light-curing units can polymerize adhesives as efficiently as halogen devices [7]. Despite the lower radiation ability of LED units compared to halogen devices, LED units are more efficient in terms of adequate light transfer [17]. Swanson et al. [18] showed that 40 seconds of curing by LED units results in a stronger bond, but 20 seconds of curing time also creates a bond strength higher than the required amount (>8MPa). With the high technology, the curing time can be reduced with the increased intensity of the curing units. Fleming et al.[14] a systematic review demonstrated that some high-power LED curing units can emit light radiation with the intensity of 1600-2000YmW/cm$^2$, allowing shorter exposure times of six seconds for metal brackets.

Javad et al. [19] conducted an in-vitro study in bovine teeth using both the metal and ceramic brackets with high-power and conventional curing units. The results showed no statistically significant difference among any of the groups. Ward et al. [20], in a randomized split-mouth design study, demonstrated that there was no difference in the bond failure rate of brackets bonded by standard-intensity (1200 mW/cm2) and high-intensity (3200 mW/cm2) LED units. They reported that six seconds of curing by a high-power LED unit is comparable with 20 seconds of radiation with an ordinary LED unit. Mustaffa et al.[21], an in-vitro study compared the woodpecker i-LED curing unit for different curing times (3 seconds and 1 second) for orthodontic bracket bonding and found both the groups had a clinically acceptable shear bond strength.

The present study compared the shear bond strength of metal brackets bonded using conventional and high-power LED curing units. A commercially available high-power LED unit with the shortest curing time was used for comparison with a conventional curing light. Woodpecker i-LED, a high-power curing unit, was used for curing (2 seconds) in Group I and in Group II to maintain the standardization; Ivoclar (L-edition) LED was used for 40 seconds [13]. After bonding, the brackets were stored in distilled water for 24 hours, after which they were subjected to the shear bond strength testing using a Universal testing machine.

The results of the present study showed that Ivoclar LED had a statistically significant higher bond strength compared to the Woodpecker i-LED. Both the groups showed a clinically acceptable minimal shear bond strength required for orthodontic bracket bonding. This result was in contrast to the findings of Javad et al., who found no significant difference in shear bond strength values of both metal and ceramic brackets cured with conventional and high-power LED units. The results of the present study were in contrast to the study conducted by Priyanka verma[22], compared the LED curing units with different intensities and found high power LED unit mm(3200mW/cm$^2$ intensity) with a curing duration of 6 seconds had a better shear bond strength compared to the conventional curing unit.

To assess the heat trauma to the pulp complex [23] since that is a possibility with high-intensity devices, Ramoglu et al., [25] in their in vitro study, compared LED units with an intensity of 3200mW/cm$^2$, 1400mW/cm$^2$ and1200mW/cm$^2$ and observed that all light-curing units generated temperature rises below the critical value of 5.6$^o$C. Hence, high-power LED units, like the one used in this study, can be used with confidence, knowing that they do not cause thermal damage.

## Limitations

The results of the present study might be influenced by the wide range of differences between the curing times in both groups. Further studies are required to evaluate the curing efficiency of the high-power LED units with different curing times.

## Conclusion

1. The metal brackets bonded with conventional curing light (Ivoclar) showed statistically significant higher shear bond strength compared to those bonded with the high-power LED (Woodpecker i-LED) curing light.
2. High-power LED curing light also showed adequate shear bond strength for orthodontic bracket bonding.

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**Legend Figures**


Fig.1

Fig. 3

Fig. 2