

## SHEAR BOND STRENGTH OF LASER CURED COMPOSITE RESIN FOR DIRECT BONDING OF ORTHODONTIC BRACKETS-AN IN VITRO COMPARITIVE STUDY

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### ABSTRACT

**Aim and objectives:** To determine the shear bond strength of laser cured composite resin and compare with that of visible light cure resin and evaluate it's clinical usefulness.

**Materials and methods:** An argon laser with a wavelength of 488-500nm and a power density of  $2.10^4$  mW/cm<sup>2</sup> and an optical diameter of 6mm with a curing time of 10 seconds was employed as against the visible light cure with a wave length of 450-500nm of the same optical diameter and curing time of 40 seconds and tested using a universal instron testing machine.

**Results:** The bond strength between laser cured and visible light composite resin was not statistically significant. However the lesser curing time of laser reduces the chair side time.

**Conclusion:** Laser curing of orthodontic brackets may not be a viable procedure due to the cost factor as the bond strength is clinically insignificant.

**KEY WORDS:** Laser cure, visiblbe light,ceramic brackets,composite resin

### INTRODUCTION

The technique of direct bonding involving composite resins and acid etching has been frequently used in orthodontics since 1955 when Buonocore introduced the acid etch technique.<sup>1,2</sup> It was in 1977 that the first detailed post-treatment evaluation of direct bonding in orthodontics during a full treatment time in a large sample of patients was published.<sup>3</sup> Then came the evolution of visible light activating systems which gave the operator time control for better precision during work. This method of photo initiation has been associated with several disadvantages, such as unpredictability of the quality of light emanating from the visible light source which resulted in improper curing of the composite resin.<sup>4</sup> Laser technology in the past 40 years have led to their increased acceptance by health professionals in the areas of diagnosis and treatment planning. The use of argon laser began to enjoy increased acceptance in restorative dentistry for it's reported physical properties and greater depth of cure and more importantly it's reduced exposure time.<sup>5,6,7,8</sup> A study on the effect of Argon laser beam as a composite light curing agent concluded that it had four wavelengths in blue range between 450-500nm and a power output of about  $2.10^4$  mW/cm<sup>2</sup> that results in higher reaction speed, a higher polymerization rate and a lower polymerization shrinkage. The argon laser is monochromatic and emits light over a narrow band of wavelengths in the blue green spectrum (457.9 to 514.5 nm), making it ideally suited to polymerize composite resins. Although conventional visible light curing units also emit energy centered around

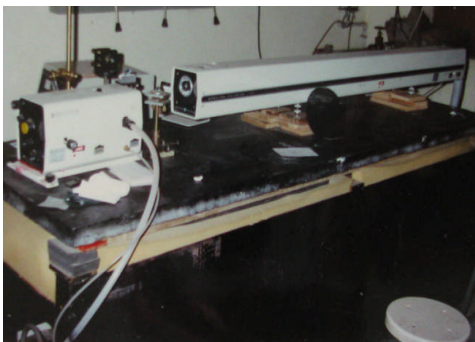
480 nm, the energy is emitted over a much broader range. In addition, light from the argon laser is collimated, which results in more consistent power density over distance.<sup>9,11</sup> In contrast, the power density of light reaching composite from a conventional visible light curing unit decreases dramatically with distance, due to divergence of light from the source.<sup>9</sup> Lasers have not only been used for curing of composite resins but have also for other procedures such as etching and debonding.<sup>15,16</sup> Argon laser verses conventional visible light-cured orthodontic bracket bonding: an in-vivo and in-vitro study was conducted by Hildebrand which showed no statistically significant difference in the bond strength between the two light sources.<sup>13</sup> Diode-pumped solid-state laser for bonding orthodontic brackets and it's effect of light intensity and light-curing time is one of the latest studies conducted in the field of laser bonding.<sup>14</sup>

### Materials and Methods

Fifty freshly extracted maxillary non-carious first premolars without any enamel cracks or fractures from young patients (adolescents) for orthodontic reasons were used for the study. All the teeth were cleared of blood and saliva and stored in a solution of 0.1% (weight/volume) thymol. They were divided into two groups of twenty five teeth each.



**Fig.1 . Light cure adhesive (Transbond XT of 3M Unitek Company)**



**Fig.2 The argon laser**



**Fig. 3  
Universal Instron testing machine: Model No.4467**

The materials used were ceramic brackets(Transcend series 6000, 3M Unitek Company) the light cure adhesive(Transbond XT of 3M Unitek Company)as shown in **Fig.1**. The argon laser and universal Instron testing machine was used from Indian institute of science, Bangalore as shown in **Fig.2** and **Fig.3** respectively.

**Bonding procedure:** The buccal surfaces of each tooth was cleaned with fluoride-free pumice and distilled water and was etched using 37% phosphoric acid for 60 seconds. The tooth surface was then rinsed under running water for 30 seconds and dried using oil-free compressed air. A thin layer of primer was applied on the etched enamel and cured with visible light for 40 seconds. The adhesive was spread on the ceramic bracket base which were positioned exactly at the centre of the crown for proper contour adaptation. The excess material (flash) was removed with a carver and utmost care was taken for proper positioning and precision.

In group 1.the adhesive was cured with an argon laser. A wavelength of 488-514nm with a power density of  $2.10^4 \text{ Mw/cm}^2$  and a optical diameter of 6mm and a curing time of 10 seconds was employed.

In group 2. The adhesive was cured using visible light source. A wavelength of 450-500nm and an optical diameter of 6mm and a curing time of 40 seconds was employed. All samples were then stored in deionized water for 24 hours before debonding.

**Mounting:** Each tooth was clamped onto a mounting jig which consists of a universal matrix retainer with it's ball-end attached to the dentaurem hydrosolder. The tooth was then held at it's cement-enamel junction by the matrix retainer. The jig was placed along the side of the dental surveyor. A plumbline was suspended from the horizontal arm of the surveyor. This arrangement ensures the line of force applied while using the instron testing machine which would be along a tangent to the buccal surface at the point of attachment and shearing in nature.

A suitable mould of 12mm in diameter and 20mm in height was placed on the mounted platform to embed the root portion inside the mould. Auto polymerising acrylic resin was poured upto the level usually covered by the alveolar bone and designed to fit in the instron testing machine. This procedure was repeated for all the 50 specimens.

**Determination of shear bond strength:** The shear bond strength was estimated by using a universal instron testing machine. The specimens were transferred on to the instron testing machine individually and subjected to a shear force. A steel loop which exactly fitted the gingival wing of the bracket was constructed and used so that the forces can be uniformly distributed. A cross-head of 0.1mm was selected and the load was applied till the point of fracture.

The breaking load was then converted into bond strength using the formula:

$$\text{Bond strength} = \frac{\text{Breaking Load (kilograms)}}{\text{Nominal surface area of the bracket base (cm}^2\text{)}}$$

The surface area of the bracket was determined by using a travelling microscope. A student t-test was used to determine any significant difference in the bond strength of the two methods of resin polymerisation.

**Results**

All the fifty samples were tested for shear bond strength using an universal instron testing machine and the breaking load at which bracket failures occurred were recorded and the bond strength was calculated for each specimen. The mean values with standard deviation were calculated and compared. The nominal area of the bracket was found to be 0.11375cm<sup>2</sup>. The mean value of the bond strength of ceramic brackets cured with laser was found to be 16.38MPa with a standard deviation of 1.231.

The mean value of the bond strength of ceramic brackets cured with visible light was found to be 15.28MPa with a standard deviation of 1.235.

The standard deviation was calculated using the formula:

$$S.D = \frac{\sum(X-X)^2}{n-1}$$

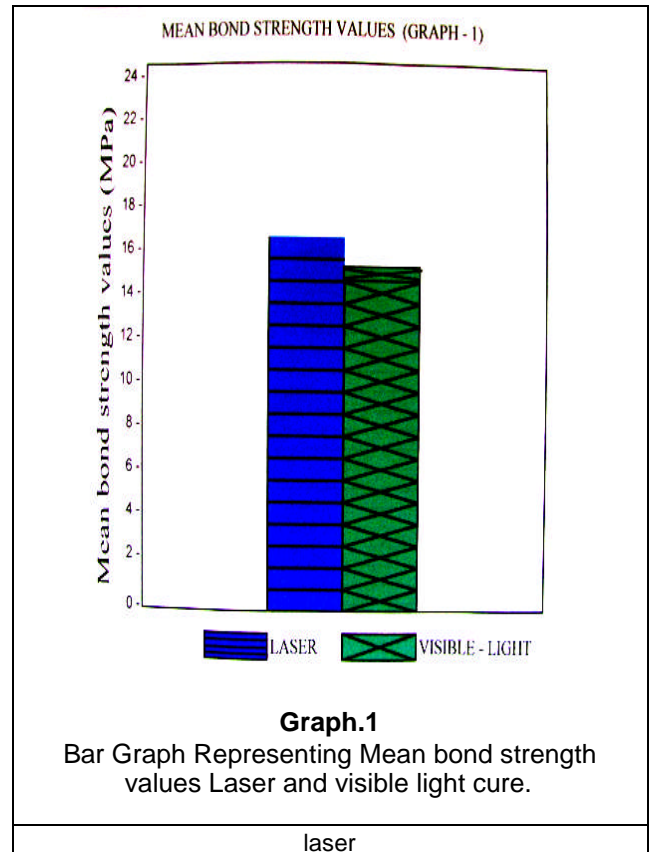
The bond failure site occurred mostly at the resin-bracket interface. No failures were observed within the resin.

The calculated value of t=3.062 is less than the standard value of t=3.67. Hence the t value is insignificant at 0.1% level of significance with P>0.001.

**Discussion**

The guide lines for bonding strength testing was taken in accordance with article of Nigel Fox.<sup>10</sup> The parameters for the use of laser were taken based on the conclusions of Kelsey<sup>9</sup> and exposure time as according to Powell.<sup>6</sup>The common method of statistical analysis employed is t-test. The t-test is an inappropriate method of comparing more than two groups. ANOVA(Analysis of variance) should be used when comparing more than two groups. Since this study contains only two groups the t-test was the chosen method for statistical analysis.<sup>10</sup>

The use of argon laser is enjoying it's increased acceptance in restorative dentistry as a curing agent for it's reported physical properties and greater depth of cure and more importantly it's reduced curing time.<sup>4,5,6,11,12</sup> Powell<sup>6</sup> reported that argon laser samples showed better mean test values than visible light counterparts but were statistically insignificant. The results are in accordance with this study as shown in **Table-1** and **Graph-1**. Also the study conducted on the shear bond strength of Argon



**Graph.1**  
Bar Graph Representing Mean bond strength values Laser and visible light cure.

Laser and conventional visible light-cured orthodontic bracket bonding as an in-vivo and in-vitro study by Hildebrand show statistically insignificant results which coincides with our study.<sup>13</sup> However Blankanau reported that the laser cured resin showed statistically significant difference between the two groups which are contradictory to the results<sup>5</sup>. The present study cannot be compared with the results of Blankanau as he had used two types of materials-microfilled and small particle resins. However, results obtained in- vitro do not always correlate with those achieved in- vivo<sup>13</sup>. Therefore, bond strength values are only meaningful in the context of how they were obtained, and how closely they correlate with results obtained in a well-designed clinical trial. The statistical data in terms of the standard deviation and the t-value infers an insignificant bond strength difference between the laser and the visible light cure sources as shown in Table-2. The results show the site of failure at the resin-bracket interface minimizing the chances of enamel cracks or fractures as shown in Table-3 and Graph-2. The obvious advantage of lasers seems to be the lesser chair side time than the bond strength.

**CONCLUSION**

1. The shear bond strength of the laser cured resin was observed to be statistically insignificant when compared to the visible light cure.

2. The lesser curing time of laser polymerization is an advantage as it reduces the chair side time making it beneficial to the operator as well as the patient.

3. The bond failures occurred at the resin-bracket interface thus minimizing the chances of enamel fractures.

The future of lasers in orthodontic bonding procedures is questionable at this stage due to its cost factor. However, extensive research on semiconductor lasers if proven positive would reduce the cost of equipment and would be less bulkier, thus making it more feasible.

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