Effect of Dental Chair Light on Enamel Bonding of Orthodontic Brackets Using Light Cure Based Adhesive System: An In-Vitro Study

Anil Tiwari, Tarulatha Shyagali, Sarvraj Kohli, Rishi Joshi, Abhishek Gupta, and Rana Tiwari

1Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, MP, India

Corresponding author: Dr. Tarulatha R Shyagali, Professor and Head, Department of orthodontics and dentofacial orthopedics, Hitkarini Dental College and Hospital, Jabalpur, MP, India Mobile: 07742129768. E-mail: drtarulatha@gmail.com

doi: 10.5455/aim.2016.24.317-321
ACTA INFORM MED. 2016 OCT; 24(5): 317-321
Received: AUG 15, 2016 • Accepted: OCT 10, 2016

ABSTRACT

Aim: The aim of this in vitro study was to evaluate the influence of the Dental chair light on the bond strength of light cured composite resin. Materials and Methods: Sixty therapeutically extracted human premolar teeth were randomly allocated to two groups of 30 specimens each. In both groups light cured composite resin (Transbond XT) and MBT premolar metal brackets (3M Unitek) was used to bond brackets. In group I and II light curing was done using Light-emitting diode light curing units without and with the dental chair light respectively. After bonding, all samples were stored in distilled water at room temperature for 24 hours and subsequently tested for shear bond strength and Adhesive Remnant Index (ARI) scores. Data was subjected to Mann Whitney U statistical test. Results: Results indicated that there was significantly higher shear bond strength (7.71 ± 1.90) for the Group II (composite cured with LED and dental chair light) compared with Group I (composite cured with LED LCU only) (5.74 ± 1.13). The obtained difference was statistically significant. There was no statistical significant difference between ARI scores in between the groups. Conclusions: Light cure bonding with dental chair light switched on will produce greater bond strength than the conventional bonding. However, the ARI score were similar to both the groups. It is advised that the inexperienced orthodontist should always switch off the dental chair light while bonding for enough working time during the bracket placement. Key words: composite resin; shear bond strength, dental chair light, ARI score.

1. INTRODUCTION

Introduction of light curing adhesive is a boon to orthodontist and for the efficient orthodontic treatment requires adequate bracket bonding. As more patients are interested in getting done the orthodontics, the need of the hour is clinical efficiency (1). The inefficient bracket bonding can increase the chances of appliance breakage, which results in prolonged treatment duration, increased chair side time and the greater inconvenience to the orthodontist and the patient.

The initiation of polymerization was done using the visible light in the blue area range of the electromagnetic spectrum to excite the outermost layer of the camphoroquinone that possesses an absorption spectrum in the interval between 400 and 500 nm. The most efficient wavelength for polymerization would be 468 to 470 nm (2).

Number of factors affect the depth of photoactivated cures which include duration, depth and intensity of visible light penetration, filler type and shade, the reflective characteristics of the backing, the mold size, and the optical configuration of the experimental setup (3, 4). While using light cured composite adhesive system, a streamlined bonding process is an important consideration, and the choice of light source is critical. Light curing sources include halogen, plasma arc, argon laser, and light-emitting diode units (5).

During the light cure bonding procedure in dental office, it is a usual routine for orthodontist to switch off the dental chair light. This is done in anticipation that the yellow light of the dental chair may interfere with blue light of the light curing source, this can further influence the bond strength and subsequently increase the bond failure rate. It is stated in the earlier studies that the reduction in the intensity of the polymerizing light source would retard the degree of conversion of the composite material and the mechanical properties of the composite resins are directly in-
Effect of Dental Chair Light on Enamel Bonding of Orthodontic Brackets

Influenced by the degree of conversion (6, 7). If this is true the clinician’s anticipation pertaining to the influence of the yellow light of dental chair on the bond strength must also be true. However, the extensive literature survey on bonding in the field of orthodontics showed that there existed a wide lacuna in the research pertaining to the influence of dental chair light on the bond strength of bracket cured, using light cure composite. A study was planned with the aim to determine whether ambient dental chair light from the overhead light source causes any effect on the shear bond strength (SBS) of light cured composite material.

2. MATERIALS AND METHODS

A total number of 60 therapeutically extracted human premolar teeth were collected. All the selected teeth were checked for the intact buccal enamel, with complete absence of visible cracks resulting from extraction and had no caries or restorations. The teeth were divided into two groups comprising of 30 samples in each group. The samples were prepared in a clinical laboratory. They were embedded in the cold cure acrylic block with the help of square shaped mold prepared in putty material. The teeth in each group were given number of that group. The samples were randomly divided in to two test groups as follows

- Group I - Orthodontic brackets which were bonded to the enamel using light activated adhesive system, keeping the dental chair light in off mode.
- Group II - Orthodontic brackets which were bonded to enamel using light activated adhesive system, keeping the dental chair light switched on.

During the curing procedure the distance between the bracket and LED light was kept at 2 mm and between the bracket and dental chair light, it was kept at 50 cm.

Bonding procedure

To produce a chalky enamel surface, enamel surface was lightly abraded with 600-grit sandpaper for 5 seconds to create a smooth flat surface of enamel, polished for 10 seconds with a rubber prophy cup and fluoride free pumice and water. Rinsed for 10 seconds with deionized water from an air water syringe. Acid-etched for 20 seconds with 37% phosphoric acid gel (3M Unitek, Monrovia, CA, USA), Rinsed for 10 seconds with deionized water from an air water syringe, dried for 5 seconds with air from an air water syringe, coated with a thin layer of Transbond XT primer (3M Unitek, Monrovia, CA, USA). Stainless steel orthodontic maxillary first premolar bracket (MBT 3M Unitek) was bonded to enamel surfaces in group I and II (Figure 1). Each bracket was placed on the bonding surface using bracket holder and fully seated into position. The excess adhesive was removed and the remainder was cured using the light cure composite resin system.

Those enamel surfaces assigned group I, were cured 20 second each, using a lead based light cure composite resin system with the dental chair light switched off, while in group II light curing was done with the dental chair light switched on. After bonding, the teeth were stored in deionised water at 37°C for 48 hours in incubator. Brackets were chosen randomly, were debonded using a universal testing machine (Tinius Olsen H25KS). A load cell carrying 500 Newton’s was attached to the machine. For measuring the shear bond strength, the prepared sample was positioned in lower cross head, with the long axis of the tooth and the bracket base parallel to the direction of load applied. An acrylic jig was made which is gripped in the upper jaw (cross head) and under the gingival wings by adjusting the crosshead. The shear debonding force will be applied to the bracket base in an occlusal-gingival direction at a crosshead speed of 0.5 mm/min (Figure 2). The load was progressively applied till the bracket got detached from the tooth surface and the reading was recorded in Newton for every specimen and then converted into Megapascals (MPa) by using following formula:

\[
\text{MPa} = \frac{\text{Newton}}{\text{Surface Area (mm}^2\text{)}}
\]

The mode of bond failure of each specimen, chosen randomly was examined under a SEM. Based on the amount of adhesive remaining on the tooth, an adhesive remnant index (ARI) score was assigned to each tooth. ARI score was assigned based on Artun J and Bergl (8) and method utilized the

Figure 1. Sample after bonding

Figure 2. UTM during debonding process. (Sample placed in the cross head)

Figure 3. SEM Images of Teeth Surfaces
Effect of Dental Chair Light on Enamel Bonding of Orthodontic Brackets

following scoring system:
- 0 - Indicates that no adhesive remained on the tooth in the bonding area.
- 1 - Indicates that less than half of the adhesive remained on the tooth
- 2 - Indicates that more than half of the adhesive remained on the tooth and
- 3 - Indicates that the entire adhesive remained on the tooth with a clear impression of the bracket mesh.

Statistical Analysis

Data of shear bond strength did not follow normal distribution and the adhesive remnant index (ARI) scores were on ordinal scale, so, it was decided to use Mann Whitney U test for comparison of light curing without dental chair light and with dental chair light groups. P value <0.05 was considered statistically significant. Data analysis was done using Statistical Package for Social Sciences (SPSS) v.21 for windows.

3. RESULTS

The Mean, Standard Deviation, maximum and minimum values of shear bond strength in Group I and Group II samples

| Light curing groups               | Mean ± SD | Median | Min-Max       |
|----------------------------------|-----------|--------|---------------|
| Without dental chair light       | 5.74 ± 1.13 | 6.10   | 3.60-7.40     |
| With dental chair light          | 7.71 ± 1.90 | 6.86   | 5.30-10.70    |

Table 1. Mean, standard deviation (SD), median, minimum and maximum values of shear bond strength in Group I and Group II samples

| Light curing groups               | Mann whitney U test statistics |
|----------------------------------|-------------------------------|
| Without dental chair light       | Mean ranks 21.97              | Test value 194.000 | P Value 0.000 (< 0.001), Significant Difference |
| With dental chair light          | Mean ranks 39.03              | Test value 418.500 | P Value 0.603 (>0.05), Not Significant |

Table 2. Comparison of shear bond strength Group I and Group II Samples.

The comparison of ARI I scores of both groups is shown in the Graph 2 and Table 3. A P value of 0.603 was obtained which was lower than the set P value (0.05). This showed no significant difference between ARI scores in between the groups.

4. DISCUSSION

Type of light curing devices, type of enamel conditioner, etchant, acid concentration, etching time, composition of the adhesive, bracket base design and bracket materials are the few things which can influence the bond strength (9). The peak wavelength and bandwidth of the curing light, the intensity of the light and the irradiation time also have profound effects on the depth of cure.

In the present study all the variables which could have an effect on shear bond strength such as the human teeth, the etchant, acid concentration, etching time, composition of the adhesive, bracket base design and bracket materials, photo activation time were kept constant and similar for both the control and experimental group. Thus the only variable affecting the shear bond strength in this study was the change in intensity due to interference with dental chair light which was the focus of this (in-vitro) investigation.

The current investigation found a significant difference in SBS for the Group I and Group II, due to interference in in-
Effect of Dental Chair Light on Enamel Bonding of Orthodontic Brackets

The shear test result and the ARI results in the current study prove, that both bonding techniques, either in the presence of dental chair light or in its absence, to be efficient, with a statistically significant difference in SBS between both groups (P V< 0.001).

A clinical Observation during the investigation was that the emission from the dental chair operator light would initiate polymerization of the composite adhesive resin earlier and thereby create an hindrance during bracket position manipulation, this might result in high bond failure rates during clinical performance.

It can hence be safely concluded that during light curing of composite adhesive resin the dental operatory light should be switched off. Although if accidently left on it would not adversely affect the bond strength.

The most commonly used traditional Orthodontic Bonding procedure is technique sensitive, as it requires absolute humidity control. Failing to do so will lead to contamination of enamel surface which subsequently can decrease the shear bond strength (22). Apart from this the traditional orthodontic bonding procedure is time consuming too (18). As it required 20 to 40 second time for each bracket curing (23). Probable solution to these constraint is the quickening of the curing time. Quickening of the curing procedure is made possible by using of argon laser and xenon plasma light (18, 24). Although these later curing light reduce curing time by one quarter to one third respectively. But in comparison to conventional light curing units these machines are costly which render the unpopularity of these curing units in private dental clinics (25, 26). Based on the results of current study dental chair light in conjugation with LED seems to increase the rate of polymerization thus quickening or fasting the curing time and providing the solution for above mentioned constraints.

Quickening of the curing time can lead to shrinkage of resin. This problem might be seen in case of sample cured with both LED and dental chair light unit together (group II). However, the thickness of adhesive layer and the excess of resin existing at the edge of adhesive area, can absorb some amount of shrinkage. And the shrinkage itself can pull the bracket closer to the enamel which is probably an advantage rather than a disadvantage (27).

In the present study mean shear bond strength of conventional curing light is 5.59 Mpa and with dental chair light unit in conjugation with LED is 7.71 Mpa, this is less than the mean bond strength obtained by the fast curing light systems like plasma or xenon light (28).

The present study highlights that higher SBS can be obtained with least enamel damage when dental operator chair light was switched on during the light cure bonding procedure. It is recommended that an inexperienced operator should switch off the dental chair light for increased working time, conversely, an experienced operator can keep the dental chair light on for the early initiation of polymerization thus reducing the chances of subsequent salivary contamination.

Though, the study was full proof in controlling all the possible study variables. Nevertheless, it was an in vitro study, the results of study can be more authentic if the same investigation is repeated in an in vivo set up. Further, the study carries the scope to explore the effect of dental chair light on the bonding procedure using the latest light curing units such as...
argon laser, xenon and plasma arc curing light.

5. CONCLUSION

It can be concluded that the LED light curing with dental chair light on (group II) produced higher shear bond strength than the light curing without dental chair light (group I). The dental chair is capable of initiating the polymerization. The AR1 analysis revealed that the adhesive for most specimens from both the groups remained on the tooth surfaces.

REFERENCES

1. White LW. The Past, present and future perfect profession. J Clin Orthod. 2001; 35: 465-70.
2. Santos GB, Medeiros IS, Fellows CE, Muench A, Braga RR. Composite depth of cure obtained with QTH and LED units assessed by microhardness and micro Raman spectroscopy. Oper Dent. 2007; 32: 79-83.
3. Fan PL, Stanford CM, Stanford WB, Leung R, Stanford JW. Effect of backing reflectance and mold size on polymerization of photo-activated composite resin. J Dent Res.1984; 63: 1245-7.
4. Johnson WM, Leung RL, Fan PL. A mathematical model for post-irradiation hardening of photo-activated composite resins. Dent Mater. 1985; 1: 191-4.
5. Powell GL, Kelsey WP, Blankenau RJ, Barkmeier WW. The use of an argon laser for polymerization of composite resin. J Esthet Dent. 1989; 1: 34-7.
6. McCabe JF, Carrick TE. Output from visible light activation units and depth of cure of light activated composites J Dent Res. 1989; 68: 534-9.
7. Ferracance JL. Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. Dent Mater. 1985; 1: 11-4.
8. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment Am J Orthod Dentofacial Orthop.1984; 85: 333-40.
9. Reicheneder CA, Gedrange T, Lange A, Baumert U, Proff P. Shear and tensile bond strength comparison of various contemporary orthodontic adhesive system. Am J Orthod Dentofacial Orthop. 2009; 135: 422-6.
10. Elvebaka BS, Rossovou PE, Miller BH, Buschang P, Ceene R. Orthodontic Bonding with Varying Curing Time and Light Power Using an Argon Laser. Angle Orthod. 2006; 76: 837-44.
11. Jain A, Ray S, Mitra R, Chopra S. Light Cure Tip Distance and Shear Bond Strength: Done It have any Clinical Significance? J Ind Orthod Soc. 2013; 47: 135-42.
12. Cook WD. Spectral Distributions of Dental Photopolymerization Sources. J Dent Res. 1982; 61: 1436-8.
13. Blankenau RJ, Kelsey WP, Caval WT, Blankenau P. Wave-length and intensity of seven systems for visible light-curing composite resins: a comparison study. J Am Dent Assoc. 1983; 106: 471-3.
14. Davis LG, Baker WT, Marshall J, Moseley TT. Optical hazards of blue light curing units: preliminary results. Br Dent J. 1985; 159: 259-62.
15. Yearn JA. Factors affecting cure of visible light activated composites. Int Dent J. 1985; 35: 218-25.
16. Parekh B, Sathe S, Hegde V. Analysis of the Effect of Dental Chair Light on the Knoop Hardness of Composite Resin While Light Curing With QTH and LED light units. World J Dent. 2012; 3: 156-60.
17. Reynolds I. A review of direct orthodontic bonding. Brit J Orthod. 1975; 2: 171-8.
18. Bishara SE, Gordan VV, Vonwold L, Olson ME. Effect of an acrylic primer on shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop. 1998; 114(3): 243-7.
19. Klocke A, Korbmacher HM, Huck LG, Kahl-Nieke B. Plasma arc curing lights for orthodontic bonding. Am J Orthod Dentofacial Orthop. 2002; 122: 643-8.
20. Sfondrini MF, Cacciafesta V, Klersy C. Halogen versus high-intensity light-curing of uncoated and pre-coated brackets: a shear bond strength study. J Orthod. 2002; 29(1): 45-50.
21. Klocke A, Korbmacher HM, Huck LG, Ghosh J, Kahl-Nieke B. Plasma arc curing of ceramic brackets: an evaluation of shear bond strength and debonding characteristics. Am J Orthod Dentofacial Orthop. 2003; 124: 309-15.
22. Sayinsu K, Isik F, Szen S, Aydemir B. Effect of blood and saliva contamination on blood strength of brackets bonded with a protective liquid polish and a light cured adhesive. Am J Orthod Dentofacial Orthop. 2007; 131: 391-4.
23. Kurchak M, DeSantos B, Powers J, Turner D. Argon laser for light-curing adhesives. J Clin Orthod. 1997; 31: 371-4.
24. Ruegggeber FA. State of the art: Dental photocuring- A review. Dent Mater. 2011; 27: 39-52.
25. Talbot TQ, Blankenau RJ, Zobitz ME, Weaver AL, Lohse CM, Rebellato J. Effect of argon laser irradiation on shear bond strength of orthodontic brackets: an in vitro study. Am J Orthod Dentofacial Orthop. 2000; 118(3): 274.
26. Thind BS, Stirrup DS, Lloyd CH. A comparison of tungsten-quartz-halogen, plasma arc and light-emitting diode light sources for the polymerization of an orthodontic adhesive. Eur J Orthod. 1986; 184: 333-40.
27. Oesterle LJ, Newman SM, Shellhart WC. Rapid curing of bonding composite with a xenon plasma arc light. Am J Orthod Dentofacial Orthop. 2001; 119: 610-16.
28. Hoseini MH, Hashemi MH, Moradi FS, T. Hooshmand T, Haririan I, Motahhary P. et al. Effect of Fast Curing Lights, Argon Laser, and Plasma Arc on Bond Strengths of Orthodontic Brackets: An In Vitro Study. J of Dentist. 2008; 5: 167-72.