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Comparative Evaluation of Shear Bond Strength of Orthodontic Brackets Bonded To Teeth With Conventional Halogen Based Light Curing Units And Light Emitting Diode (LED) Curing Units - An Invitro Study

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Abstract

Background: One of the significant developments in the field of Orthodontics over the past years has been the successful bonding of the bracket to teeth based on the mechanical locking of an adhesive to irregularities in the enamel surface of the tooth and to mechanical locks formed in the base of orthodontic attachment. Successful bonding therefore requires careful attention to three components of the system, the tooth surface and its preparation, the design of the attachment base and type of bonding material. This in vitro study was conducted to evaluate the shear bond strength of orthodontic bracket bonded to teeth with LED curing unit and to compare it with halogen based curing units.

Materials and methods: The total 40 sample extracted teeth were divided into two groups, group A and group B, each group consisted of 20 teeth. Group A is the bonding with conventional halogen based light curing unit (control group), and Group B is the experimental group where Light emitting diode (LED) curing units used in the bonding. The force at which the bond failure occurred was recorded as the measure of bond strength in Newton and tabulated for both groups. The force in Newton was recorded for each specimen and divided by the surface area of the bracket pad to obtain the shear strength value in Mpa.

Results: Control Group shows mean shear bond strength of 169.63 ± 49.34 N. Experimental group showed mean shear bond strength of 256.937± 34.866 N. The results were analyzed by paired t- tests for the comparison between groups. The two groups were statistically significantly different ($p<0.05$) and but there is no significant difference of mean value within the groups.

Conclusions: The light emitting diode cured adhesives showed significantly higher shear bond strength than halogen cured adhesives. Both halogens based curing unit and LED-curing units show shear bond strength above the optimum normal for orthodontic purpose. LEDs are probably the better choice, as light source of energy in situations requiring higher bond strength.

Keywords: bonding; light curing unit; halogen; LED; comparison; extracted teeth

Introduction

The evolution of the concept of bonding orthodontic brackets to the teeth surface by means of an adhesive material has been a monumental step in the progress of Orthodontics. In 1955, Buonocore[1] introduced acid etching of enamel.[1] The technique of bonding was introduced by Newman in 1964.[2,3] Bonding with light activated system is popular due to its extended working time for precise bracket placement. Most dental photo initiator systems use Camphoroquinone as the diketone absorber at a wavelength of 470nm at the maximum.

Halogen based light curing units has several shortcomings which includes Light power output is less than 1% of consumed electric power, Lifetime of approximately 100 hours only, Large and cumbersome and must be frequently replaced due to decrease in output over a period of time.

In 1999 Mills et al[4] proposed solid-state Light Emitting Diode (LED) technology for the polymerization of light activated dental material to overcome the shortcomings of halogen visible light curing units. This has several advantages over the halogen based light curing units. LEDs use junctions of doped semiconductors (diodes) to generate light, Undergo little degradation of output over time and hence lifetime over 10,000 hours, Require no filters to produce blue light, Resistant to shock and vibration , Quiet, and take little power to operate.

These properties were put to test in Orthodontics, for bonding the orthodontic brackets. Robert .J. Gange(2001)[5] compared the curing probes of conventional halogen lights and power slot (Reliance Industries) and concluded that the light intensity was more concentrated on the bracket with a rectangular tapered tip and thus reduces the curing time. Dunn & Taloumis (2002) [6] compared the shear bond strength of orthodontic brackets bonded to teeth with conventional halogen based curing units and LED curing units and concluded that curing by LED was as effective as curing by halogen lamps with a reduced curing time. They recommended further studies on curing by LED units. Thimothy Swanson et al (2004)[7] conducted a study to evaluate the relationship between the shear bond strength of orthodontic brackets bonded to enamel and the duration of photo polymerization with LED units and conventional quartz tungsten halogen based light curing units. (Ortholux XT 3M). There were 1 conventional halogen curing unit and 3 LED-curing units, consisting of 64 LED units (GC-E-light), 19 LED units (Elipar Free Light) and 2 LED units (Ultra Lume). The result of this study showed that, effects of light curing unit type and curing time on the mean shear bond strength of orthodontic brackets to teeth were significant. All experimental groups recorded mean shear bond strength greater than 8 Mpa with 10-second cure.

Hence an invitro study was planned to evaluate the shear bond strength of brackets bonded to teeth with LED cured adhesives, and to compare shear bond strength of orthodontic brackets bonded to teeth with conventional halogen based light curing units.

Materials and methods

This study was conducted in the Department of Orthodontics, Govt. Dental College, Calicut. The shear bond strength of the bonding adhesives was determined at the Department of Biomechanics, N.I.T, Calicut. 40 extracted human premolars; healthy, without any caries, fractures, developmental defects, and hypoplastic enamel, which were collected, cleared of blood and saliva, and stored in distilled water at room temperature. The storage medium was changed periodically to inhibit the bacterial growth and possible contamination. Stainless steel contoured Begg Brackets were used (TP Orthodontics Inc. 256 – 650 series, Curved base on Mini- Mesh Bonding Base). A light cure adhesive (Transbond XT by 3M Unitek) was also used.

Group A (control group): Conventional halogen based light curing unit was used in this study was HILUX (Kulzer). The power density of this halogen light was around 480 mW/ cm sq .

Group B (experimental group): Light emitting diode (LED) curing units used in the study was "HILUX- LED MAX 4" (KULZER). The power density was 1010 mW/cm2. LEDs are solid-state light sources in which doped semiconductors are used to generate light. They are manufactured by metal organic chemical vapor deposition of different semiconductor material in films that layered one on the top of the other. As current flows through this semiconductor chips, electrical energy is converted into light and little energy is emitted as heat. The LED unit used in this study consisted of single large LED.

Sample block preparation

In order to fix the teeth to the lower cross head of Instron Universal testing machine, the teeth were embedded in acrylic blocks with the crown of the teeth exposed. A placement guide was used to align the buccal surface of the tooth specimens perpendicular to the bottom of the acrylic block. The total 40 samples were divided into two groups, group A and group B, each group consisted of 20 teeth.

Enamel surface preparation

The buccal surfaces were cleaned with pumice and dried with oil free air. The dried surfaces of the teeth were etched with 37% phosphoric acid for 30 seconds. The etched surfaces were again cleaned with water for 20 seconds and dried with oil free air.

Bonding of Brackets

The light cure adhesive primer of Transbond XT placed on the enamel surface of teeth of both groups A and B; and polymerized for 10 seconds as recommended by the manufacturer. Group A was cured by conventional halogen light and group B by LED curing unit.

The Transbond XT light cured adhesive paste is applied on the bracket mesh, and placed on the tooth surface. Excess bonding resin are removed by an explorer. The position of the bracket was adjusted so that the bracket would later receive a 90 degree shear force. The resin adhesive then photo activated, samples of group A with conventional halogen based light curing unit and Group B with LED curing unit. The light guide tip was placed as close as possible to the bonding site. The bracket adhesive interface was cured for 20 seconds on the distal and 20 sec on the mesial surfaces; for a total cure time of 40 seconds. Three 60-second exposures, 1 second apart were made with halogen light sources to eliminate any irradiance variations due to a cool bulb. The intensity of the light was checked with a curing radiometer, LED showed 1010 mW/cm.sq. After curing the specimens were stored in distilled water at 37degrees for 24 hours.

Method of shear bond strength evaluation

The shear bond strength of teeth bonded were tested by Instron Universal testing machine at NIT, Calicut. The machine is manufactured by Shimazu Corporation, Japan AG-1 series. The maximum capacity is one ton. For this study, the cross head of Intron machine moved at a constant speed of 1.0 mm/min until the bracket failure occurs. Each acrylic block was stabilized with suitably designed clamp attached to the lower crosshead. The acrylic block was mounted in such a way that the bracket slot was perpendicular to the floor.

The upper cross head of Instron Universal Testing Machine carries a chisel shaped rod, which is placed in the interface between the tooth and bracket. As the upper crosshead moves downward, a shearing force is applied to the tooth bracket interface. The force at which the bond failure occurred was recorded on a computer as the measure of bond strength. The force required for bond failure was recorded in Newton and tabulated for both groups. The force in Newton was recorded for each specimen and divided by the surface area of the bracket pad to obtain the shear strength value in Mega pascal.

Statistical Analysis

Readings obtained were statistically analyzed. Descriptive statistics including mean, maximum and minimum values, range and standard deviation were calculated and tabulated for each group tested. The paired t-test was used to determine whether any significant difference exists in shear bond strength of bonding adhesives cured with conventional halogen light curing unit and LED curing unit. t-test was used to determine the significant difference of shear bond strength within the group.

Results

The values obtained on testing the shear bond strength of the samples in groups were recorded. The raw data of observations with basic statistical constants such as mean, standard deviation, maximum, minimum and range are contained in table I and II. The results were analyzed by paired t- tests for the comparison between groups. The two groups were statistically significantly different ($p<0.05$) and but there is no significant difference of mean value within the groups.

Figure 1: Control group

Figure 2: Experimental Group

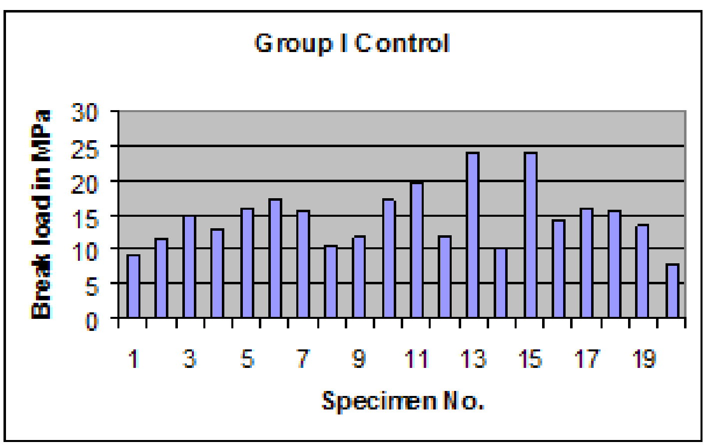
Table 1: The results obtained for each group

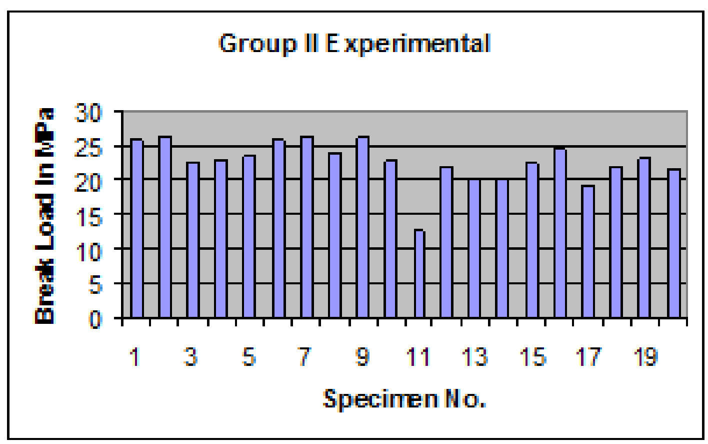
SL No.	Group A			Group B		
	Maximum Load	Break load in Newton's	Break Load in Mpa	Maximum Load	Break load in Newtons	Break Load in Mpa
1.	108.718	104.546	9.3342	290.625	288.906	25.7944
2.	132.07343	129.271	11.5417	303.312	296.109	26.4375
3.	167.9062	167.9062	14.5912	251.750	251.750	22.4770
4.	156.546	154.593	13.0025	257.671	257.640	23.0029
5.	191.6562	180.1093	16.0807	262.406	262.296	23.4186
6.	196.06250	193.5468	17.2805	291.609	291.031	25.9842
7.	174.6875	174.4062	15.5715	295.343	295.343	26.3692
8.	119.218	118.7500	10.6023	270.312	268.218	23.9473
9.	133.5156	131.073	11.7026	294.390	293.734	26.2255

10.	205.359	194.0781	17.3279	254.953	254.953	22.1630
11.	232.921	221.531	19.7790	145.515	139.562	12.4605
12.	129.171	128.796	11.7084	244.953	244.953	21.8702
13.	278.140	269.890	24.0966	227.140	226.656	20.2366
14.	121.093	114.734	10.2430	235.234	225.531	20.1361
15.	268.578	268.015	23.9292	253.093	253.093	22.5969
16.	160.218	160.078	14.2922	276.609	274.546	24.5123
17.	182.703	180.859	16.1476	226.015	213.906	19.0982
18.	175.6093	174.6875	15.5966	245.734	245.734	21.9399
19.	156.5625	150.5937	13.4455	262.750	259.359	23.1564
20.	101.875	89.1718	7.9615	249.343	240.203	21.4461

Table 2: The shear bond strength values were converted in to Mega Pascals (force in Newtons per unit area) and compared between the groups

Groups	Mean shear bond strength			p Value
	Newton	Mpa	SD	
Samples cured with halogen light (control group)	169.6307	14.7317	4.364	1.78×10^{-5} (<0.05)
Samples cured with LED (experimental group)	256.9379	22.6936	3.238	





Graph 1, 2: Break load in Mpa in both control and test groups

Discussion

One of the significant developments in the field of orthodontics over the past years has been the successful bonding of the bracket to teeth eliminating the need for bands. Bonding is based on the mechanical locking of an adhesive to irregularities in the enamel surface of the tooth and to mechanical locks formed in the base of orthodontic attachment. Successful bonding therefore requires careful attention to three components of the system, the tooth surface and its preparation, the design of the attachment base and type of bonding material. Direct bonding with visible light curing adhesive is a popular technique. Since 1970, the halogen light curing unit has been the instrument of choice. With increasing popularity of PEA, where it is crucial to position the bracket precisely, the light curing is a method of choice for bonding to provide enhanced working time and to view the bracket from different aspects before curing. Ability to place arch wire immediately after bonding is another advantage of light cure. The ability of light curing units to deliver enough light at appropriate maximum absorption levels for the respective photo initiator systems is crucial to optimize the physical properties of light activated dental materials.

Inadequate polymerization of dental composites has been associated with inferior physical properties, retention failures, higher solubility, and adverse pulpal responses because of unpolymerized monomers. Maximum conversion of monomer to polymer is necessary to achieve optimal physical properties of adhesive cements and depends on the composite composition, the light source, and exposure time. In orthodontics, the most important factor is whether the adhesive composite has reached a level of polymerization that will adequately retain brackets to teeth when orthodontic forces are applied. The visible light activated resin systems use diketone absorber to create free radicals that initiate polymerization process. Most of the light activated composite resin use camphorquinone as diketone absorber with the maximum absorption in the blue region of visible light spectrum at a wavelength of 470 nm. The most popular method of delivering blue light has been with halogen-based light curing units. Despite their popularity halogen bulbs have several disadvantages.

Most of the electric energy put in to the halogen system is changed to heat, but only a small portion is given off as light; about 1%. The high heat produced by the halogen light would cause blistering of expensive filters and discoloration of reflectors. The cooling fan can be noisy and bulky. The halogen bulbs last approximately 50 hours and should be replaced every 6 months. In order to overcome the shortcomings of halogen bulbs, Mills et al (1995) [2] proposed a solid-state light emitting diode (LED) technology for the polymerization of light activated dental materials. Instead of hot filaments used in the halogen bulbs, LEDs use junctions of doped semiconductors (diodes) to generate light. LEDs have a lifetime of over 10,000 hours and can be subjected to mechanical shock and vibration with a very low failure rate The present in vitro study was intended to evaluate the shear bond strength of orthodontic bracket bonded to teeth with LED curing unit and compare it with halogen based curing unit.

Samples belong to the control group was cured with Halogen light and experimental group cured with LED curing unit. The shear bond strength of bonded teeth were tested. The result of this study shows that the samples cured with halogen based curing units (control group) the mean shear bond strength was 169.6307 $\pm$ 49.34 N. (14.73 $\pm$ 4.36 Mpa.) Samples cured with LED curing unit (experimental group) shows mean shear bond strength of 256. 9379 $\pm$ 34.86 N. (22.69 $\pm$ 3.23 Mpa). The mean shear bond strength of control group was 14.73 $\pm$ 4.36 Mpa and that of experimental group was 22.69 $\pm$ 3.23 MPa. The result of the paired t-test shows that the two groups (control and experimental) were significantly different.

Thimothy Swanson and co workers (2004)[7] conducted a study to compare the shear bond strength of orthodontic brackets bonded to the enamel and duration of photo polymerisation with LEDs and conventional Quartz Tungsten halogen based light curing units. The result of their study showed that with 40 seconds of curing time, the conventional halogen based curing unit exhibited a mean shear bond strength of 15.3 $\pm$ 6.4 Mpa. The other three LED-curing units showed a mean shear bond strength of 12.2 $\pm$ 3.3 Mpa with 64 LED units, 15.6 $\pm$ 5.6 Mpa with19 LED_units and 18.6 $\pm$ 5.8 Mpa with 2 LED units. The result of this study indicated that, as the number of LED decreases the bond strength increases. LED curing unit used in the present study consisted of a single large LED and this may be the cause for the higher value of shear bond strength obtained in the present study.

LED cure the composite to significantly greater depth than halogen unit. This may be due to the maximum conversion of monomer to polymer, thereby achieving optimal physical properties of adhesives. Considering this significantly higher bond strength, it may be recommended that in situations demanding higher bond strength like cases with deep bite, inadequate crown height (lower premolars) etc, LED curing will provide a definite advantage over halogen curing . In halogen based curing units, only a small portion of emission spectrum is actually used for activating the photoinitiator molecule.

But in LED narrow emission spectrum is very close to the maximum absorption potential of the camphorquinone. The LEDs were more efficient in delivering the usable light to photo activate the camphorquinone. Advances in technology are directed at delivering more result, expending less energy as seen in new automobiles and compressor designs. LEDs offer higher strength by spending less energy. Energy wasted in producing heat and uncurable spectrum is minimized.

This further saves energy of the cooling fan. Absence of filter will further render whole of the produced light at the site of action, without dilution. As already stated filter hinders transmission and would require regular maintenance care for clogging and cleaning. Xenon Plasma Arc curing units produce shear bond strength with 6-9 seconds equal to those produced with 40 second exposures to a conventional tungsten quartz halogen light. When compared with conventional halogen based light curing unit and plasma arc light curing unit, the LEDs had certain advantages, they are smaller lighter,and the lifetime is over 10,000 hours. As the semiconductor technology improves, the halogen based light curing units might be replaced by LEDs. The results of this study shows promise for the orthodontic application of LED curing units, but clinical studies are necessary for validation.

Summary and conclusion

This in vitro study was conducted to evaluate the shear bond strength of orthodontic bracket bonded to teeth with LED curing unit and to compare it with halogen based curing units. The results of the study lead to the following findings: Adhesives cured with LED showed quite higher value of shear bond strength. Out of two light curing units tested in this study, the light emitting diode cured adhesives showed significantly higher shear bond strength than halogen cured adhesives. Both halogens based curing unit and LED-curing units show a shear bond strength above the optimum normal for orthodontic purpose. LEDs are probably the better choice, as light source of energy in situations requiring higher bond strength. Clinical studies may be conducted to further validate the above findings. Based on the above findings it can be concluded that, the two light curing units used in the present study produce a shear bond strength above the shear bond strength required for successful bonding. By considering the advantages of LED such as long lifetime, little power supply, maximum photo activation and higher degree of polymerisation, LEDs can be a better choice over halogen-based light curing units.

References

1. Buonocore MG. A simple method of increasing the adhesion of acrylic lining material to enamel surfaces. J Dent Res 1955,34:849–53.
2. George V Newman. Adhesion and orthodontic plastic attachment, Am J Orthod 1969; 56: 573-87.
3. George V Newman. Clinical treatment with bonded plastic attachment, Am J Orthod 1971; 60: 601-10.
4. Mills RW, Jandt KD, Asworth SH. Dental composite depth of cure with halogen and blue light emitting (LED) technology. Br Dent J 1999;186:388-91.
5. R J Gange. Retrofitting curing lights for high-speed bonding. J Clin Orthod 2001 ;35(6):388.
6. Dunn WJ, Taloumis LJ. Polymerization of orthodontic resin cements with light emitting diode curing units. Am J Orthod Dentofacial Orthop 2002;122:236-41.
7. Timothy Swanson, William J.Dunn, Darrell E.Childers and Louis J.Taloumis. Shear bond strength of orthodontic brackets bonded with light-emitting diode curing units at various polymerization times. Am J Orthod Dentofacial Orthop 2004;125:337-41.