Original Article

Shear Bond Strength of Composite to Dentin following Light Curing with Light Emitting Diode and Quartz Tungsten Halogen Light Curing Units

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Abstract

Background and Aim: The use of light emitting diode (LED) light curing units has recently increased due to optimal properties such as longer durability, no need for filter and less heat generation compared to quartz tungsten halogen (QTH) devices. The aim of this study was to assess the shear bond strength of composite to dentin following lightcuring with QTH and LED light curing units for different time periods.

Materials and Methods: In this experimental study, 60 sound extracted human molar and premolar teeth with no decay or restorations were collected. The buccal surface of the teeth was ground to expose adequate amount of dentin. The teeth were randomly divided into six groups. After acid etching and bonding, composite was packed in plastic cylindrical molds and placed on dentin surface. Groups one, two and three were cured by a LED unit (Wood Pecker) with ramp method for 20, 30 and 40 seconds, respectively. Groups four, five and six were cured with a QTH unit (Optilux 501) with a light intensity of 500 mW/cm^2 for 20, 30 and 40 seconds, respectively. After keeping the samples for two weeks in distilled water at room temperature, shear bond strength was measured by a universal testing machine at a crosshead speed of 1mm/minute. The data were analyzed by Two-way ANOVA, one-way ANOVA and Tukey's HSD test.

Results: One-way ANOVA showed a significant difference among the groups and the mean shear bond strength was the highest following light curing by LED device for 40 seconds (18.63 MPa). Pairwise comparisons by Tukey's test showed significant differences in shear bond strength of groups cured with LED unit (P= 0.059 for the difference between 20 seconds and 40 seconds and P=0.004 for the difference between 30 seconds and 40 seconds).

Conclusion: Use of LED units (ramp method) yielded superior results in terms of shear bond strength compared to QTH. Also, 40 seconds of curing is recommended in use of LED devices.

Key Words: Shear Strength, Composite Resins, Curing Lights, Dental

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Introduction

Dental science has greatly advanced in the past century and introduction of light cured composite resins revolutionized esthetic dentistry [1]. In the recent years, use of composite resins especially light cured composites for anterior and posterior restorations has greatly increased due to high esthetic demands of patients [2]. Shear bond strength is an important mechanical property with regard to clinical durability of tooth-colored restorations. It is believed that the degree of conversion of composites depends on the hardness of their components, innate strength of composite, color shade of composite, curing time, type of light curing unit, and type and wavelength of curing light [3]. Adequate polymerization and curing of composite resins is highly important to ensure optimal physical and mechanical properties of restorations. Polymerization shrinkage is a major problem of composite resins. Inadequate polymerization results in greater water sorption, lower mechanical properties, less hardness, greater wear and microleakage, secondary caries and eventual failure of restoration [4,5]. Higher bond strength does not necessarily decrease microleakage but it has a direct association with polymerization shrinkage, which is the major drawback of composite restorations. Several methods have been suggested to increase bond strength such as the application of flowable composite on the cavity floor of composite restorations, use of dentin bonding agents with higher bond strength and use of new light curing units that enhance mechanical properties of composites since they enable greater penetration of light into the composite mass [1]. On the other hand, light intensity is an important factor in the process of polymerization and affects the mechanical properties of composite resins.

The QTH light curing units are most commonly used in dental practice. These devices produce high levels of infrared light, which increases the temperature, decreases the intensity of output light and decreases the durability of lamp [6]. Dynamics of polymerization reactions depends on the activation of photosensitizer, which is often comphorquinone. This molecule is capable of absorbing light at 400-500 nm wavelengths [7,8]. It has been shown that LED devices convert higher amounts of composite monomers to polymer compared to QTH because the wavelength of output light completely matches the range of absorbance of comphorquinone [9]. The first generation of LED units had a relatively low output power and it was shown that their irradiation rate was similar to that of conventional light sources [10]. The second generation of these devices used high power LEDs and showed better efficacy in shorter curing time compared to the first generation. Recently, third generation of LED curing units were introduced to the market. The manufacturers claim that the third generation LED units have higher light intensity; however, this topic is in need of further investigation [10]. Curing depth depends on the filler content and chemical composition of composite, its color and translucency, intensity of light source and duration of light exposure [11]. This study aimed to assess the shear bond strength of composite to dentin after light curing with QTH and LED light curing units for different periods of time.

Materials and Methods

This in vitro, experimental study was conducted on 60 sound human posterior teeth without fracture, anatomical defects, caries or previous restorations. The teeth were cleaned with a curette, pumice paste and rubber cup with a low speed hand piece and disinfected by immersion in 0.5% chloramine T solution at 4°C for one week. The teeth had been extracted within the past three months. Prior to preparation, the teeth were rinsed with water and were then mounted in blocks containing auto-polymerizing acrylic resin such that the tooth crown was completely out of the acrylic resin. The buccal enamel was removed parallel to the longitudinal axis of the teeth using a cylindrical diamond bur (Diatech, Coltene/Whaledent, Altsatten, Switzerland) at high speed under water and air spray. Exposed dentin was ground using 600-grit silicon carbide abrasive paper (3M ESPE, St. Paul, MN, USA). A new bur was used for every five teeth. The teeth were randomly divided into six groups of 10. Dentin surfaces were etched with 35% phosphoric acid (3M ESPE, St. Paul, MN, USA) for 15 seconds followed by 10 seconds of rinsing. Etched surface was then gently air dried for five seconds. Single Bond (3M ESPE, St. Paul, MN, USA) was applied in two layers and cured for 20 seconds. In group one, after applying the etchant and bonding agent, 2mm of A2 shade of Valux microfilled composite (3M ESPE, St. Paul, MN, USA) was applied in a cylindrical plastic mold measuring 3mm in diameter and 2mm in height by a spatula. The composite was packed such that it well contacted the dentin surface and minimized void formation at the composite-dentin interface. Next, composite was light cured from the buccal side for 20 seconds using a LED light curing unit (Wood Pecker, Guangxi, China) in ramp mode. In group two, after applying etchant and bonding agent, 2mm of composite was applied into the transparent cylindrical mold by a spatula and packed on dentin surface. Light curing was done using a LED light curing unit 3red Generation in ramp mode for 30 seconds. In group three, the same procedure was performed but curing was done for 40 seconds. In group four, the same procedure was done except that light curing was performed using a QTH light curing unit (Optilux501, Kerr, CA, USA) with a light intensity of 500mW/cm^2 for 20 seconds. In group five, light curing was done using the same QTH light curing unit for 30 seconds. In group six, light curing was done using the same QTH light curing unit for 40 seconds. After light irradiation, excess material and the plastic mold were gently removed using a scalpel. All samples were the incubated (Kavosh Mega, Tehran, Iran) at 37°C and 100% humidity for 24 hours while immersed in distilled water. The teeth were then subjected to 1500 thermal cycles between 5-55°C and were then underwent shear bond strength test in a universal testing machine (Zwick Roell, Ulm, Germany) with a crosshead speed of 1mm/minute; 100N load was applied vertically by a blade at the closest point to the composite-tooth interface. Shear bond strength was recorded in Newtons. The obtained values were then converted to megapascals (MPa). Data were analyzed using two-way ANOVA. Since the interaction effect was significant, one-way ANOVA, Tukey's HSD test and Bonferroni test were then applied.

Results

A total of 60 samples in six groups were evaluated. The results showed that the mean shear bond strength in groups cured with LED unit for 20, 30 and 40 seconds was 14.84, 12.99 and 18.63MPa, respectively. The mean shear bond strength in groups cured with QTH unit for 20, 30 and 40 seconds was 14.42, 15.65 and 14.87MPa, respectively (Table 1, Diagram 1). Two-way ANOVA showed that the interaction effect of the light source and time on bond strength was statistically significant ($P<0.01$). Analysis of the results using one-way ANOVA showed a significant difference among LED groups ($P=0.005$).

Tukey’s test was used for pairwise comparisons of the groups. The results showed a significant difference in bond strength of LED groups between 20 and 40 seconds ($P=0.059$) and 30 and 40 seconds ($P=0.004$). No significant difference was noted between 20 and 30 seconds of curing in LED groups ($P>0.05$). No difference was noted in pairwise comparison of QTH groups ($P>0.05$).

Discussion

Tooth Advances in photo-activation of dental composites and the manufacturers’ claims regarding bulk curing of composite have captured the attention of many researchers. The quality of curing and degree of polymerization can be assessed using direct and indirect techniques.

Direct methods that assess the degree of conversion of monomer to polymer such as infrared spectroscopy and laser Raman spectroscopy are complex, costly and time consuming. Also, these methods are mainly qualitative rather than quantitative. Indirect methods include visual hardness and scratch tests; among which, hardness testing is extensively performed to assess the efficacy of polymerization and curing by a device and is relatively simple and efficient compared to other methods. Physical properties of composites are also clinically important. Hardness of resin materials at different levels of polymerization can indicate the degree of conversion of monomer to polymer [12] because the greater the polymerization and curing, the higher the degree of conversion. However, for comparison of different resin materials, hardness number cannot be used alone for prediction of degree of conversion of monomer. On the other hand, inadequate curing of composite can cause changes in restoration margins. Properties of the adhesive layer affect marginal integrity. This layer in composite restorations has the lowest hardness and is considered as the weakest area [13,14]. The current results showed that method of light curing affected the shear bond strength. Data analysis revealed a significant increase in shear bond strength in use of LED compared to QTH device. Similarly, Oberholzer et al, in 2005 showed that LED was more effective than other devices for increasing the bond strength [13]. Also, Nomoto et al, in 2003 reported that LED unit required shorter curing time to reveal mechanical properties of composite and was superior to QTH in this regard [15]. Moreover, Korkmazand Attar in 2007 reported that the bond strength of microhybrid and nanofilled composites was comparable in use of LED and QTH devices and LED had the advantage of shorter curing time to obtain the required properties of composites [16].

Table 1. The mean, standard deviation, minimum and maximum shear bond strength (in MPa) of composite resine to dentin after curing with LED and QTH light curing units for different time periods

Unit	Curing time	Mean±standard deviation	Minimum	Maximum	Groups	df	Mean square	F	P value
LED	20	14.84±4.59	8.70	21.81	Between groups	2	82.71	23163	0.005
	30	12.99±1.68	9.66	15.65	Within group	27	46.46		
	40	18.63±3.67	14.09	23.97	Total	29			
QTH	20	14.42±3.28	11.08	21.40	Between groups	2	32.98	0.199	0.821
	30	15.65±4.16	8.23	20.69	Within group	27	19.70		
	40	14.87±5.56	7.86	23.16	Total	29			

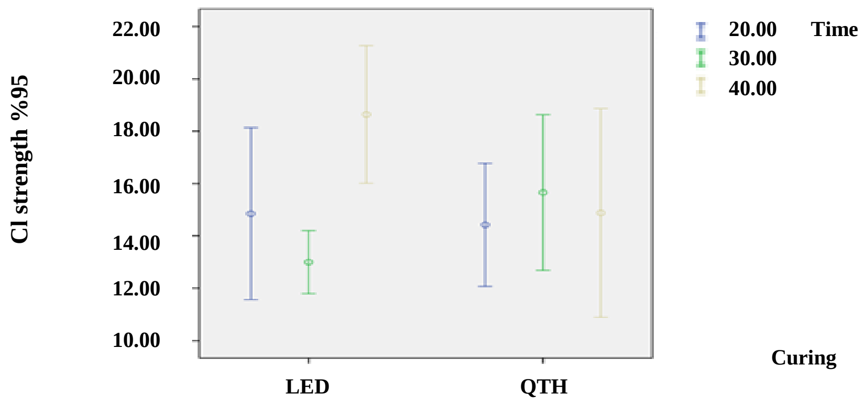

Diagram 1. The mean shear bond strength of composite to dentin (in MPa) in the six groups

The higher mean shear bond strength of composite following curing with a LED curing unit was mainly attributed to the fact that the output light wavelength of device (450-470nm) corresponded to the maximum absorbance peak of comphorquinone (470nm), which is the main photo initiator for composite resin polymerization. Instead of the hot filament used in QTH lamps, LED technology is based on the use of gallium nitride semi-conductive for light radiation [17]. In fact, output light of a LED unit results in more complete and more efficient polymerization while QTH devices are out of the efficient curing range. Price et al, in 2003 evaluated the function of LED2 light curing unit compared to a QTH device for curing of 10 composite resin samples with 20 and 40 seconds of curing time. After 24 hours, assessment of samples showed that the efficacy of LED2 for five composite samples with 20 seconds of curing time was equal to the efficacy of QTH device with 40 seconds of curing time. They also concluded that LED2 light curing unit cannot polymerize all types of composites as does the QTH device [18].

Conclusion

Based on the results, it can be concluded that LED light curing unit in ramp mode and 40 seconds of curing time yields superior results compared to QTH device**.**

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