Shear Bond Strength of Orthodontic Brackets Cured with Different Light Sources, LED and QTH

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Abstract

Aim: The aim of this study was to compare the shear bond strength [SBS] of two different light sources, light-emitting diode and quartz-tungsten halogen, under thermal cycle frequencies.

Method and materials: Sixty human premolar teeth were divided into two groups, on which composite (Transbond XT™ adhesive paste) cured with light-emitting diode in group I, and with quartz-tungsten halogen in group II. Samples thermocycled 500 cycles, the exposure to each bath was 10 seconds and the transfer time between the two baths was 10 seconds. 500 cycles between 5°C and 55°C were performed. An Instron testing machine [Dartec Hc.10, England] was used for the shear bond test at a crosshead speed of 1mm/min. Force was applied directly to the bracket–tooth interface. The load at failure was recorded by a personal computer connected to the test machine. SBS values were expressed in mega Pascal [MPa]. T-test was used to compare the shear bond strength between two groups.

Results: The comparison of both groups indicated that the quartz-tungsten halogen groups demonstrated higher mean shear bond strength [p=19.947Mpa] than light-emitting diode groups [19.878Mpa]. There was no statistical difference in the shear bond strength values between the two light sources. [P value =0.918]

Conclusions: Both light sources showed favorable shear bond strength performance and there was no statistical difference in the shear bond strength values between these two light sources.

Keywords: Orthodontic brackets, Light, Shear bond strength, Thermocycling,

In fixed appliance treatment, one of the most important requirements is correct bracket positioning.[1] Since Newman [2] introduced the direct bonding of orthodontic brackets, different kinds of materials have been proposed for this use, mainly composites photo-activated by halogen light.[3]

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Bonding orthodontic brackets with visible light-cured adhesives was first reported by Tavas and Watts.[4] The advantage of a light-cured adhesive system is that it gives the clinician the ideal working time to position the bracket, reduces the risk of contamination, and helps in easy removal of excess material after bonding.[5]Most sources of visible blue light applied in dentistry use tungsten-filament halogen lamps that incorporate a blue filter to produce light of 400–500 nm. The basic principle of light conversion by the halogen technique is inherently inefficient[6] because the light power output is 1% of the total electrical energy consumed. [7, 8] The disadvantages of conventional halogen units are the degradation of the lamp, the filter, and the reflector, leading to reduced curing effectiveness.[9] They have a limited lifetime of 100 hours. Filters can undergo blistering, and reflectors can discolor. The prolonged curing time with halogen bulbs can be uncomfortable to the patient, impractical with children, and inconvenient for the clinician. [9, 10]

In 1990s, rapid light–curing alternatives to the conventional halogen units, such as quartz–tungsten halogen (QTH), plasma arc curing light (PAC), and light-emitting diode (LED) were introduced in orthodontics.[11]

LEDs are junctions of doped semiconductors that generate light when submitted to a low voltage. [12] New light source based on the use of light-emitting diodes are inexpensive, has long lifetime (10,000 hours) with little degradation in light output6, works with low voltage, and can be designed to emit specific wavelengths (430-480nm), in addition to being compact, and resistant to shock and vibration. The high temperatures generated by the high-power LEDs (900 to 1000 mw/cm2) may damage the device, thus requiring maintenance. On the other hand, such a high potency results in faster photo-activation and decreased monomer conversion, which decreases the contraction tension and increases the adhesiveness between brackets and teeth.[12-15]

Introduction

Since the LED technology was introduced, studies have been carried out in order to investigate the LED effect on bond strength of orthodontic brackets. Dunn and Taloumis 3 while evaluating two halogen light-curing units (Optilux 501 and Prolite) and two LEDs (LumaCure and Versalux) with different light intensity, have found no statistically significant difference between them at 40-second exposure time. Bishara et al 16 compared the same curing devices, both types for 20 seconds and also found no significant difference. Üsümez et al17 compared halogen light and LED units at 10, 20 and 40 seconds of curing time and found that only with 10 seconds of exposure the LED light source showed lower values of shear bond strength. Layman and Koyama 12, in a clinical setting, concluded that the LED curing unit produced bond strength as strong as those produced by a conventional halogen light, in addition to being faster and more convenient. Cacciafesta et al 18 compared the photo-activation provided by halogen light, LED and plasma-arc units as well as the effect of the light-tip distance on the shear bond strength of orthodontic brackets. These authors found that the mean values of the shear bond strength regarding these three light sources showed no statistically significant difference at 0 mm distance, but the LED light source had significantly lower mean bond strength values at increased light-tip distances. The aim of this study was to compare the shear bond strength (SBS) of two different light sources QTH and LED under thermal cycle.

Material and Methods

Two different light units for curing an orthodontic bracket adhesive were compared: a QTH light-curing system (Coltolux50.coltene/Whalekent Inc, USA) and a LED light-curing system (LED turbo, Apoza Enterprise.co). The LED and QTH light were calibrated by placing the fiber-optic probe directly on the top of the built-in sensor until the light indicated that the probe intensity was adequate.

Sixty human premolar teeth extracted for orthodontic reasons were cleaned of debris and stored in 0.2% Timol solution. The criteria for tooth selection were intact buccal enamel; no pretreatment of chemical agents, such as derivatives of peroxide, acid, or alcohol; no cracks from forceps; no caries; and no restorations. The teeth were stored in 0.2% Timol solution continuously after extraction. The solution was changed weekly to avoid bacterial growth. Before bonding, the labial surfaces of the teeth in all groups were polished using non-fluoride pumice, rinsed with water, and dried with an air spray. The teeth were embedded in distilled water 24 hours before bonding. A mounting jig was used to align the facial surface of the tooth to be perpendicular to the bottom of the mold and its labial surface parallel to the force during the SBS test. (Figure 1)

Figure 1: aligning facial surface of the tooth to be perpendicular to the bottom of the mold by a mounting jig.

Before bonding, the teeth were randomly divided into two groups, each containing 30 teeth. The bonding surface of each tooth was pumiced for 10 seconds and rinsed for 10 seconds with distilled water (Figure 2).All of the teeth were etched for 30 seconds with 35% phosphoric acid (Figure 3).

Figure 2: pumicing of the bonding surface of each tooth

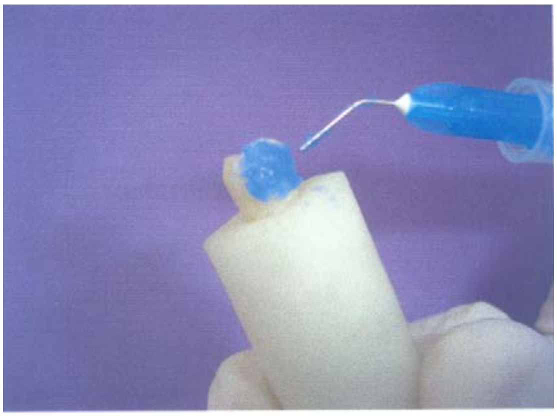

Figure 3: Etching process with 35% phosphoric acid,

washed with a spray for 15seconds, and dried to a chalky-white appearance for 15 seconds, and subsequently, the sealant was applied to the etched surface. The surface was thoroughly dried, and a thin layer of orthodontic adhesive primer (Transbond XT™, 3M Unitek, Monrovia, California, USA) was applied (Figure 4).An orthodontic composite resin (Transbond XT™ adhesive paste) was used for all teeth.
In this study, orthodontic premolar metal brackets (3M Unitek, Monrovia, California, USA) were used. The average bracket surface area of the bracket base was determined to be 14.74 9mm2. Each bracket was placed on the tooth with a constant

force by one operator and brackets were pushed on the tooth surface until no composite rejection was seen around brackets (Figure 5).

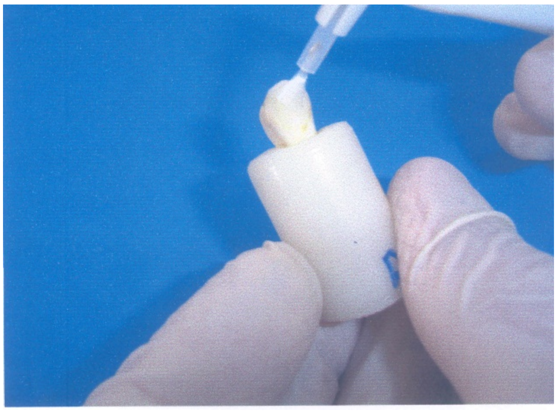

Figure 4: Applying a thin layer of orthodontic adhesive

Figure 5: placement of bracket with a constant force by one operator and brackets were pushed on the tooth surface until no composite rejection was seen around brackets

Group I: Brackets were cured with the LED for 20 seconds from occlusal and 20 second from palatal (Figure 6) and stored in distilled water for 24 hours.Then thermocycled in water between 5°C and 55°C for 500 cycles. . (Figure 7)

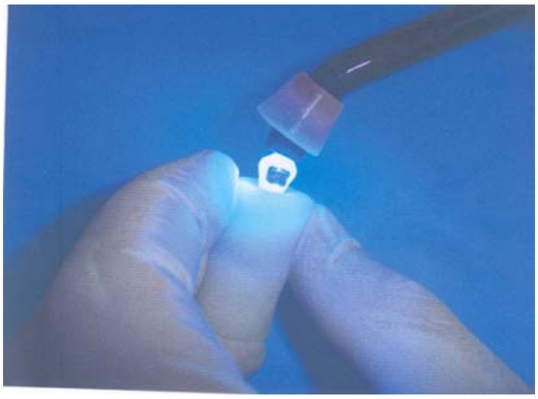

Figure 6: Curing of brackets with the LED from occlusal

Figure 7: Thermocycling baths

Group II: Brackets were cured with the QTH for 20 seconds from occlusal and 20 second from palatal and stored in distilled water for 24 hours. Then thermocycled in water between 5°C and 55°C for 500 cycles.

The exposure to each bath was 10 seconds and the transfer time between the two baths was 5–10 seconds. Each cycle takes 30 seconds.500 cycles between 5°C and 55°C were in accordance with the recommendation of the International Organization for Standardization (ISO/TS 11405).[19]

A universal testing machine (Instron Machine, Dartec Hc.10, England) was used for the shear bond test at a crosshead speed of 1 mm/min (Figure 8). Force was applied directly to the bracket–tooth interface using the flattened end of a steel rod. The load at failure was recorded by a personal computer connected to the test machine. SBS values were calculated as the recorded failure load divided by the surface area (bracket base) and were expressed in Mega Pascal (MPa).

T-test analysis was used to evaluate the differences among two groups.

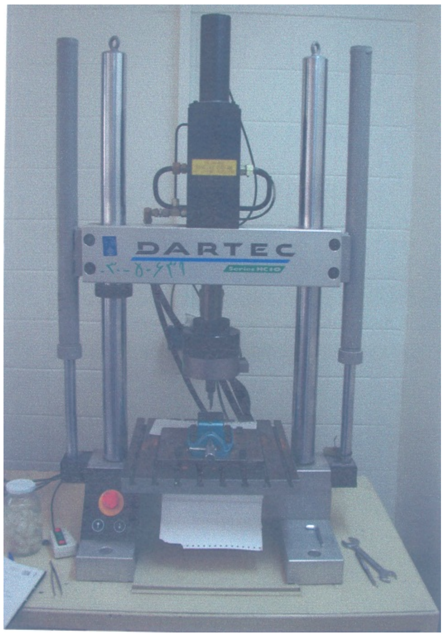

Figure 8: A universal testing machine

Table 1-descriptive statistics and results of T-test comparing shear bond strength (Newton) of the tested groups

group	Number of samples	Mean(Newton)	SD	p. value
LED	30	293.2000	33.8622	0.198
QTH	30	294.2000	40.4870	

Table 2-descriptive statistics and results of T-test comparing shear bond strength (Mpa) of the tested groups

group	Number of samples	Mean(Mpa)	SD	p. value
LED	30	19.8793	2.2559	0.198
QTH	30	19.9471	2.7451	

Results

The statistical results of Shear Bond Strength are presented in Tables I and II. The comparison of both groups indicated that the QTH group (19.9471Mpas) demonstrated higher mean SBS than the LED (19.8793Mpas) group. There was no statistical difference in the shear bond strength values between the two light sources. [Pvalue =0.918]

Discussion

The present study showed no statistically significant differences between the groups, thus demonstrating that type of light-curing device (QTH or LED) had no influence on the shear bond strength of orthodontic brackets bonded to enamel. These findings were in accordance with studies by Dunn and Taloumis 3, who used a 40-second exposure time for four different light sources (two LED units and two halogen light-curing units), and Bishara, et al.[16] who evaluated two devices (one LED unit and one halogen light unit) using a 20-second exposure time and found no statistically significant difference. However, such results are also corroborated by Dunn and Busch. 6

According to Reynolds 20, a given material can be indicated for clinical use if its bond strength values are around 5.0 MPa in in vitro investigations. In the present work, the specimens exposed to LED and QTH unit for 40 seconds showed mean shear bond strength about 19.87 and 19.94 Mpas, respectively, and then achieved such a value. The bond strength values found in the present study can be considered high in comparison to other works 21 using conventional brackets bonded with Transbond XT. Also, the absolute values found in the present study are highly related to those observed by Bishara et al 16, who used precoated and uncoated ceramic and metal brackets.

Dunn and Taloumis 3 compared a 150 mW/cm2 LED unit to two halogen light-curing units, one with 1030 mW/cm2 and other with 400 mW/cm2. They found no statistically significant differences in the bond strength values, thus raising the question of whether high potency is really necessary for light curing the material to bond orthodontic brackets.

Although some pen-shaped LED units have been introduced to the market, these recent devices have been yielding results similar to those obtained with halogen light-curing units if one considers the frequent fractures and debonding regarding the former. Despite the divergent opinions, one of the few advantages of the LED units in comparison to halogen light units [8, 14] is the lifetime of the diodes and the possibility of reducing the photo-activation time.

Üsümez, et al. [17] compared halogen light devices to LED units at 10, 20, and 40 seconds of curing time and found that only the LED at 10-second exposure time showed lower shear bond strength values, which is not corroborated by the Rêgo and Romano study 21 as the shear bond strength values for shorter exposure times (5 and 10 seconds) were similar to those obtained at 40 seconds.

Conclusions

Type of curing system had no influence on the bond strength values of brackets bonded with photo-activated composite using LED source, as the results were similar to those obtained with QTH at 40 seconds.In summary, despite the emergence of novel light source units on the market, the QTH still provides good results when compared to the new light-curing devices LED.

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