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Evaluation of a New Curing Light on the Shear Bond Strength of Orthodontic Brackets

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ABSTRACT

With the introduction of photosensitive (light-cured) restorative materials in dentistry, various methods were suggested to enhance their polymerization and to shorten the curing time including layering and the use of more powerful light-curing devices. The purpose of this study was to determine the effect of using a new light-curing apparatus that uses a light-emitting diode (LED) on the shear bond strength of an orthodontic adhesive. The new light-curing apparatus used in the study was UltraLume 2 (Ultradent USA, South Jordan, Utah) that has an 8-mm footprint and can simultaneously cure two orthodontic brackets. Forty teeth were etched with 37% phosphoric acid, washed and dried, and sealant applied, and then precoated brackets with the Transbond adhesive (APC II, 3M Unitek, Monrovia, Calif) were placed. The teeth were randomly divided into two groups according to the curing light used. In group I (control), 20 brackets were cured using an Ortholux (3M Unitek) halogen curing light for 20 seconds. In group II, 20 brackets were cured using the new LED light for 20 seconds. The findings indicated no significant ($P = .343$) differences in the shear bond strength between the Ortholux halogen light (5.1 ± 2.5 MPa) and the UltraLume 2 LED light when the two groups were compared using Student's *t*-test ($t = -0.961$). In conclusion, the advantages of the new unit include the ability to cure two brackets at a time and a smaller light-emitting apparatus for the clinician to handle.

KEY WORDS: Curing lights, LED/halogen, Shear bond, Orthodontic brackets.

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INTRODUCTION Return to TOC

With the introduction of photosensitive (light-cured) restorative materials in dentistry, various methods were suggested to enhance their polymerization including layering and the use of more powerful light-curing devices. Orthodontics has benefited from the introduction of these materials, and manufacturers have introduced numerous light-cured adhesive systems to bond orthodontic brackets. The greatest advantage of light-curing adhesive systems is that they provide the clinician with ample time to accurately position the bracket on the enamel surface before using light to polymerize the adhesive. A disadvantage of the light-cure approach is the time it takes to expose each bonded bracket to the light (10–40 seconds). This is needed to ensure adequate polymerization to sustain the orthodontic forces that will be immediately applied to the teeth at the time of insertion and initial ligation of the archwires.

With photoactivated orthodontic adhesives, clinicians have difficulty in determining the depth of cure and the time it takes for complete polymerization. Ruyter and Gyorosi,[1] using infrared spectroscopy, demonstrated that commercially available sealants exhibited different degrees of conversion 24 hours after the start of polymerization. They found that under conditions comparable with an optimal clinical situation, the quantities of the remaining unpolymerized methacrylate ranged between 15% and 35%.

Fan et al,[2] Ruggeberger et al,[3] and Johnston et al[4] found a number of factors that affect the depth of photoactivated cures including duration and intensity of irradiation, filler type and shade, the reflective characteristics of the backing, the mold size, and the optical configuration of the experimental setup. Leung et al[5] have demonstrated that postirradiation hardening of a visible light–activated composite resin continued for up to one day.

As a result, clinicians have attempted to ensure the complete polymerization of the total thickness of these photoactivated materials regardless of whether they are used as sealants, composites, or adhesives.[6] More efficient light sources have been suggested to significantly decrease the curing time including the use of an argon laser[7] and more recently a xenon plasma arc bulb.[8] The latter light source reduces curing time to between two and five seconds.[8] One of the concerns that surround the xenon plasma arc bulb is the potential increase in pulpal temperature by as much as 6°C when tested on a molar tooth.[9] A 5–6°C increase in pulpal temperature could result in irreversible pulp damage.[10]

Until these new, more efficient, but experimental, light sources are proved safe to the pulp tissues (particularly to the less protected hence more vulnerable mandibular incisors), there is still a need to investigate the efficiency of other sources of curing lights such as the use of a Turbo Accelerator Light Guide.[11,12] The Turbo Tip was said to provide an increased light intensity output from a conventional light-curing unit. The enhanced intensity had the potential to provide a marked increase in both the extent of resin composite cure and the depth to which adequate polymerization is obtained,[6] as well as significantly decrease the cure time.[11,12] The reduced light-curing time resulted in a significantly lower bond strength in the first 30 minutes after bonding.[13]

Mills et al[14] were among the first to suggest the use of solid-state light-emitting diode (LED) for the polymerization of light-sensitive dental materials. The use of LED technology has two major advantages, namely, avoiding the use of the heat-generating halogen bulbs and the fact that they have 10,000 hours life time with little degradation of output.[15,16] Furthermore, the LED lights are resistant to shock and vibration.[14]

According to Mills et al,[14] the newer gallium nitride LEDs produce a narrow spectrum of light (400–500 nm) that falls closely within the absorption range of camphorquinones that initiate the polymerization of resin monomers.[14]

Dunn and Taloumis[17] compared the shear bond strength of orthodontic brackets bonded to teeth with either halogen or LED curing units. They found that the LED unit functioned as well as the halogen ones. The size of the tip of the LED unit tested in their study was able to cure one bracket at a time.

A second-generation LED UltraLume 2 curing light (Ultradent USA, South Jordan, UT) was recently introduced in the market. The new light has an equivalent depth of cure as halogen lights but produces more effective curing with an 8-mm footprint that might eliminate the need for multiple curing cycles during operative procedure. From an orthodontic perspective, this light unit can simultaneously cure two brackets because the LEDs in the UltraLume 2 offers a bidirectional curing light. The UltraLume 2 is considered a second-generation light because it does not rely on an array of small, low-power outputs from single LED elements but instead uses a combination of very high-intensity chips, each made of many small LEDs.[18] When used under heavy clinical conditions, the UltraLume 2 light maintains near maximal intensity thus providing a more consistent cure.[18]

The purpose of this study was to determine the effect of using a new LED curing light on the shear bond strength of an orthodontic adhesive within half an hour after bonding, when the initial archwires are tied.

MATERIALS AND METHODS Return to TOC

Teeth

Forty freshly extracted human molars were collected and stored in a solution of 0.1% (wt/vol) thymol. The criteria for tooth selection included intact buccal enamel, not subjected to any pretreatment chemical agents like hydrogen peroxide, with no cracks due to the pressure of the extraction forceps, and no caries. The teeth were cleansed and then polished with pumice and rubber prophylactic cups for 10 seconds.

Etching

The buccal enamel surface of each tooth was conditioned for 20 seconds with 37% phosphoric acid gel. Each tooth was then rinsed with a water spray for 20 seconds and dried with oil-free air for 10 seconds. The buccal enamel surfaces of the etched teeth appeared chalky white.

Brackets

Precoated maxillary central incisor brackets APC II were used (3M Unitek, Monrovia, Calif). The average surface area of the bracket base was 11.8 mm^2.

Curing light

Forty teeth were randomly divided into two equal groups that were bonded in exactly the same manner with one exception.

- Group I—20 teeth were sequentially bonded and light cured using Ortholux XT Visible Light-Curing Unit (3M Unitek) for 20 seconds without allowing the light-curing unit to cool. Ortholux is a halogen light (Figure 1a through c).
- Group II—20 teeth were sequentially bonded and light cured using UltraLume 2 (Figure 2a through d) for 20 seconds without letting the light-curing unit cool.

Before starting the procedure, both light sources were tested using a Curing Radiometer Model 100 (Demetron Research Corp, Danbury, Conn). Both light sources registered values of 400+ mW/cm^2.

Shear bond strength

All teeth were embedded in acrylic up to the level of the cement-enamel junction in phenolic rings (Buehler Ltd, Lake Bluff, Ill). A mounting jig was used to align the facial surfaces perpendicular with the bottom of the mold. Each tooth was oriented with the testing device as a guide such that its labial surface was parallel to the force during the shear strength test. A steel rod with one flattened end was attached to the crosshead of a Zwick test machine (Zwick GmbH, Ulm, Germany). An occluso-gingival load was applied to the bracket producing a shear force at the bracket-tooth interface. A computer electronically connected with the Zwick test machine recorded the results of each test. Shear bond strengths were measured at a crosshead speed of five mm/min. The time frame for debonding simulated the clinical conditions for tying an initial archwire, ie, within 30 minutes from the time of bonding.

Statistical analysis

Descriptive statistics, including the mean, standard deviation, minimum and maximum values, were calculated for each of the two groups of teeth tested. Student's *t*-test was used to determine whether significant differences existed between the two groups evaluated. Significance for statistical tests was predetermined at $P = .05$.

RESULTS Return to TOC

The descriptive statistics on the shear bond strength for the two groups are presented in Table 1. The results of the Student's *t*-tests ($t = -0.961$) comparing the two groups indicated no significant differences in the bond strengths ($P = .343$) between the group cured with the halogen light (5.1 ± 2.5 MPa) and the group cured with the LED light units (6.0 ± 3.1 MPa).

DISCUSSION AND CONCLUSIONS Return to TOC

To more effectively photoactivate and cure dental adhesives, various types of light guides have been used including the newly introduced Turbo Tips.[11–13] These turbo tips were not too effective for orthodontic purposes.[13] Ideally, the early, ie, more effective, cure should result in less stress at the enamel-adhesive interface during the initial ligation of the archwires. Therefore, any enhancement to the initial curing by a more effective method of photoactivation is intended to help bond the adhesive to the tooth faster.[12]

The present findings indicated that the shear bond strength of the orthodontic adhesive obtained when using the LED light-curing device for 20 seconds was not significantly different from that obtained when the brackets were cured with the standard halogen light for 20 seconds. In this study, debonding occurred in the first half-hour after bonding the orthodontic brackets to the teeth, which is the time period within which the clinician ligates the initial archwires.

Therefore, it can be concluded that the halogen and LED curing lights provided comparable shear bond strengths when bonding orthodontic brackets. The advantage of the new LED light-curing device is that the clinician is able to light cure two orthodontic brackets with the same light exposure (Figure 3) without significantly influencing the shear bond strength. This approach reduces the total curing time by half when bonding orthodontic brackets with photosensitive adhesives.

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TABLES Return to TOC

TABLE 1. Descriptive Statistics (in MPa) and the Results of Student *t*-Test Comparisons of the Shear Bond Strengths for the Two Groups Tested ($t = -0.961$, $P = .343$)

Groups Tested	Mean	Standard Deviation	Range
Ortholux (Halogen)	5.1	2.5	1.5–10.1
UltraLume (LED)	6.0	3.1	2.1–13.8

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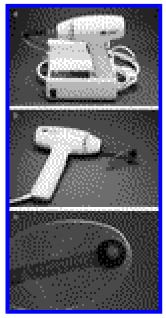

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FIGURE 1. Ortholux light-curing unit that uses a halogen lamp. The apparatus is illustrated in a and b, whereas the tip of the light guide that is placed over the bracket is illustrated in c

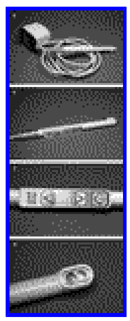

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FIGURE 2. The UltraLume 2 light-curing unit that uses LED elements. The apparatus is illustrated in a and b, whereas the control side of the handpiece is seen in c, and the bidirectional dual light that is placed over the brackets is illustrated in d

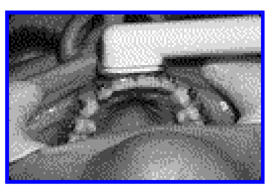

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FIGURE 3. Using the new LED light, two brackets can be cured simultaneously.
