Flexural strength of dual cured composite resin cements polymerized with different light sources

ABSTRACT

Aim: To determine the flexural strength of dual cured composite resin cements polymerized with LED light and Quartz-tungsten halogen light and to determine the effect of curing and storage time on the flexural strength. Materials and Methods: feldspathic porcelain (IPS InLine) used to produce uniform disc-shaped specimens (10mm diameter and 1.5mm thickness). An electronic caliper was used to confirm precise specimen dimensions. Vita shade 2A was selected. One commercial dual-polymerizing composite resin cement was used (Variolink II; Ivoclar Vivadent). The resin cement was placed in brass molds 8 ×6× 2 mm in size that lined with a teflon used to prepared the specimens to determine flexural strength. After insertion of the resin cements a glass slab was pressed over the mold and removed any expressed materials around the margins of the mold. A mylar strip (0.07 mm) was used to prevent adhesion of the resin cement to ceramic disk. Two types of light source were used: Quartz-tungsten halogen light and LED. The specimens divided into 8 groups (10 specimens for each). For each light source the curing time done for 20 and 60 sec. and the specimens either tested 15min. after curing or after 24hrs. Measurements for the 3-point flexural strength test were performed at a constant crosshead speed of 1 mm/min. Statistical data analysis was performed by three-way ANOVA and Duncan Multiple Range Tests to determine the significant group. Results: three- way ANOVA indicated there is no statistical significant differences between the two light sources (p>0.05), were as there is statistically significance between the flexural strength of specimen cured for 60 sec. and tested after 24hrs more than other groups (p<0.05). Conclusions: adequate curing time with 60sec. and instruction for the patient not to use of the restoration until at least 24hrs after the insertion of the restoration is advocated.

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INTRODUCTION

The use of resin cements has increased considerably in the last years due to a larger application of indirect restorative materials, such as ceramics(1).Dual-polymerization composites were developed in an attempt to combine the desirable properties of chemically polymerizing and light-polymerizing materials, thereby providing adequate polymerization in deeper areas with shorter polymerizing times(2-4).

Adequate polymerization is a crucial factor in obtaining optimal physical properties and a satisfying clinical performance of composite. Inadequate polymerization diminishes the physical properties of composite, affecting strength, stiffness, water sorption, and color stability [5].

Quartz-tungsten-halogen (QTH) are composed of lamps operate on a 450-500 nm wavelength range and are popular visible light sources. However, QTH bulbs have a limited effective lifetime and several factors may contribute to produce an inadequate polymerization output, such as presence of debris on the fiber tip, breakage of the tungsten filaments of the optical fiber and voltage variations. In addition, only little energy of the total energy were input is effectively converted into light the remainder being generated as heat [6].

Blue light emitting diodes (LED) produce blue light in a short-wave emission spectrum (450-490 nm), with peak at 470 nm, coinciding with the absorption peak of camphorquinone (468 nm), which is the photoinitiator present in most composites [7]. LED units have some advantages over QTH lamps due to their potential lifetime of over 10,000 hours without a significant degradation in light output after this period, no need of cooling system or filters, no noise production during function, operation with batteries and direct conversion of electrical energy into light with little amount of wasted energy and minimum heat generation [7]. Factors such as light-curing methods, exposure time, indirect restorative materials, and the luting agents can influence the final quality of restorations [8,9].

MATERIALS AND METHODS

A disk of 10mm diameter and 1.5mm thickness was prepared from feldspathic porcelain with Vita shade 2A was selected. (IPS InLine; Ivoclar Vivadent AG, Schaan, Liechtenstein) with uniform thickness, was fabricated following manufacturers' recommendations. An caliper (Mitutoyo, Tokyo, Japan) was used to confirm precise specimen dimensions.

One commercial dual-polymerizing composite resin cement was used (Variolink II; Ivoclar Vivadent AG, Schaan, Liechtenstein) Fig. (1).

Figure (1): Variolink II.

The resin cement were mixed in accordance with the manufacturers' instructions and placed in split brass mold 8 ×6× 2 mm in size that lined with a teflon used to prepared the specimens to determine flexural strength . After insertion of the resin cements a glass slab of 6mm in thickness was pressed over the mold and removed any excess materials around the margins of the mold. A mylar strip 0.07 mm (Ivoclar Vivadent AG, Schaan, Liechtenstein) was placed between the resin cement and veneer disk to prevent adhesion of the resin cement to the ceramic disk.

Two types of light sources were used: Quartz-tungsten halogen light (QTH) (Australis 5, wave length 400-500nm, light output 530mW/cm², Ivoclar Vivadent AG, Schaan, Liechtenstein) Fig. (2 A) and LED (LEDition, wave length 430-490nm, light output 500mW/cm², Ivoclar Vivadent AG, Schaan, Liechtenstein) Fig. (2 B).

Figure (2): A. QHL curing unit, B. LED curing unit.

A total of eighty specimens prepared. The specimens divided into 8 groups (10 specimens for each):

Curing with LED for 20 sec. and tested after 15 min.
Curing with LED for 60 sec. and tested 15 min.
Curing with QHL for 20 sec. and tested 15 min.
Curing with QHL for 60 sec. and tested 15 min.
Curing with LED for 20 sec. and tested after 24 hrs.
Curing with LED for 60 sec. and tested after 24 hrs.
Curing with QHL for 20 sec. and tested after 24 hrs.
Curing with QHL for 60 sec. and tested after 24 hrs.

The specimens be tasted after 24 hrs were stored in light-proof boxes after polymerization to avoid further exposure to light at 37°C and 100% humidity. The dimensions of the specimens were checked with same caliper used previously to confirm precise specimen dimensions.

All samples were tested for flexural strength with a 3-point bending test with a universal testing machine , A load was applied by a centrally located rod until fracture occurred. The flexural strength in MPa was calculated with the following formula:

$$FS = \frac{3}{2} \times \frac{pl}{bd^2}$$

where FS is flexural strength, p is the peak load applied, l is the span length, b is the sample width, and d is the sample thickness.

Statistical data analysis was performed by three-way ANOVA with regard to the curing time, testing time and light sources factors at a significance level of 5%, and Duncan Multiple Range Test was used, if statistical significance was present to determine the flexural strength variables.

RESULTS

Descriptive statistics for flexural strength values of the resin cement after polymerization through ceramic material with the 2 light units tested are given in Table I, Fig. (3).

Table (I): Descriptive statistics for flexural strength values of the resin cement (Mean± standard deviation)

	20sec./15min.	60sec./15min.	20sec./24hrs	60sec./24hrs
LED	100.4±1.2	135.54±0.8	132.33±.13	155.35±0.88
QTH	102.45±0.9	136.91±1.1	133.35±1.5	157.32±0.99

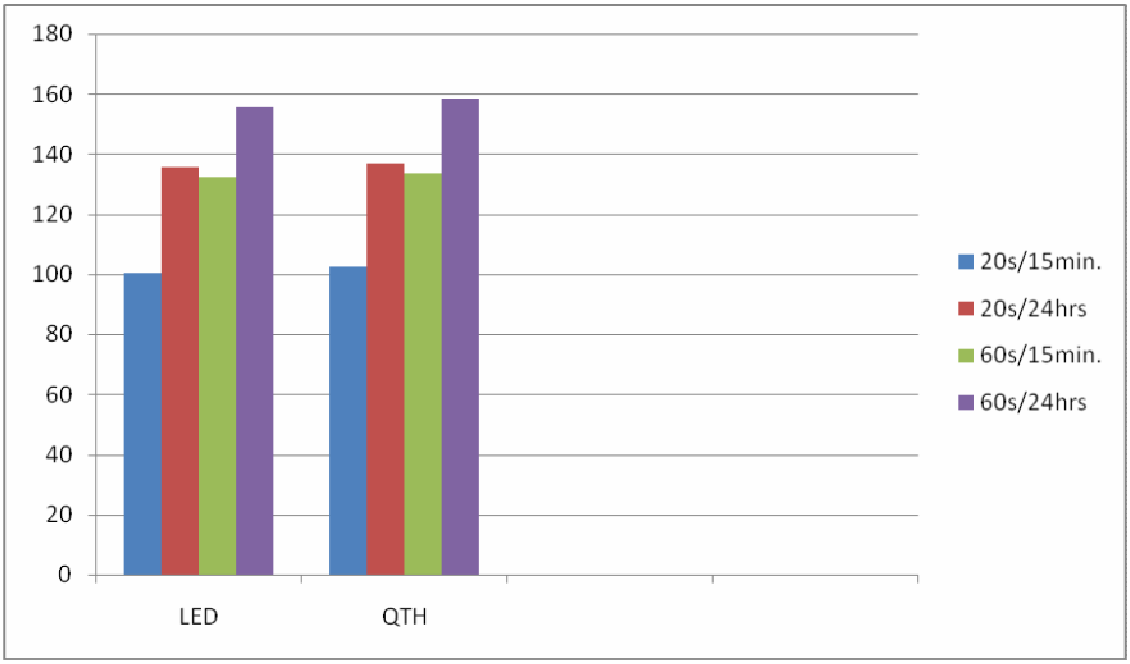

Figure (3): Shows the Flexural Strength of Dual Cured Composite Resin Cement Cured With Either LED or QHL Cured For Either 20 or 60sec. and Tested either after 15min. or 24hrs.

Statistical analysis indicated that flexural strength of dual cured resin cement polymerized by Different light source (TQH and LED) were not statistically significant from each other (p□0.08).

Significant interactions were present between light sources and testing time (P=0.00), light sources and exposure time (P=.007), testing time and exposure time (P=.004) .

Duncan Multiple Range Test indicated that the Flexural strength values were significantly higher for dual-polymerizedresin cement specimens polymerized for 60 sec. and tested after 24 hours (P<.01) . For the lights tested, Flexural strength values were increased with longer polymerization times. (P<.01).

Table (II): Duncan Multiple Rang Test, the groups with the same letter not statistically significant from each other.

Group1 LED 20sec./ 15min.	Group2 LED 60sec./ 15min.	Group3 QHL 20sec./ 15min.	Group4 QHL 60sec./ 15min.	Group5 LED 20sec./ 24hrs	Group6 LED 60sec./ 24hrs	Group7 QHL 20sec./ 24hrs	Group8 QHL 60sec./ 24hrs
D	C	D	C	B	A	B	A

DISCUSSION

Flexural strength describes the amount of force required to bend and break the materials when a test piece of specific thickness is loaded, the flexural strength of a material is a combination of compressive, tensile, and shear strengths. As the tensile and compressive strengths increase, the force required to fracture the material also increases[(10).]

The result of this study showed that the flexural strength of the dual cured resin cement was not affected by the type of light curing unit, which has been found elsewhere [(11, 12)] . Mills et al. [(13)] also found no statistically significant differences in the mechanical properties of dental resin photoactivated with two LED and a QTH lamp.

The result can be explain that the light intensity or output power density or irradiance is expressed in W/cm² and represents the number of photons emitted per second by a light source per unit area of the light-cured point. The energy density for light curing is calculated by multiplying the light intensity by the curing time and is expressed in J/cm² [(14,15).] For both light sources, the light intensity of the QTH was 530 mW/cm² and the exposure duration was 20,60 sec, while the LED source had intensity of 500 mW/cm² with exposure duration of 20, 60sec. Therefore, the energy density used by the QTH and LED were 10.6, 31.1 J/cm² and 10, 30 J/cm², respectively. The closer energy output was used for both light sources could help explaining the non statistical significance of flexural strength obtained.

There were statistical significant between the curing time with greater flexural strength of 60sec. compared with accompanied curing time with 20sec. Peutzfeldt (2) have reported that, when dual-cure cements are adequately light cured there is an increase of the conversion degree and ultimate mechanical properties are obtained compared to dual-cure cements submitted exclusively to chemical activation, also Rasetto et al.,[(16)] found that the increase in the time and intensity of curing sources through veneers were increase the polymerization of the resin Variolink II. This behavior was also observed in this study.

The third variables that related to time of testing, the measurement of flexural strength of dual cured resin cement showed the lowest value when tested the specimens after 15min. compared with specimens tested after 24hrs. the results in accordance with previous studies for various mechanical and physical properties [17-19], that found there were significant degree of conversion between immediate and after 24hrs. The resin cement tested after 24hrs, showed significant higher monomer conversion than the specimens which were tested immediately after light polymerization. Our finding disagreement with Caughman et al.,[20] and El-Mowafy et al.,[21] who reported that Variolink II has a relatively weak chemical polymerizing component and relies mainly on its light-polymerizing capability and the chemical catalyst did not improve the degree of conversion of resin.

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