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The Evaluation of the Depth of Cure During Polymerisation of Belle-Glass Composite Resins Beneath an Alumina Coping Layer

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Abstract: This work aimed to investigate the effect on the polymerisation of Belle-Glass composite resins, through alumina coping layer (Techceram disc). Belle-Glass composite resins were irradiated from the top surface of a Techceram disc, with the Optilux 500 Light-curing unit (Demetron U.S.A) for a determined time. The instrument used in this study consisted of a penetrometer fitted with a digital meter which could be zeroed at any position within its total traverse. At the base of the movable part of the meter; a needle indentor of 0.5 mm diameter was mounted. Five readings of the penetration for each specimen were taken. Results revealed that the mean values, standard deviations and coefficients of variation of the investigated shades of Belle-Glass composite resins demonstrate that the depth of cure of Translucent dentin shade was the greater compared to the other shades. However, one-way ANOVA followed by Scheffe comparison test of curing-depth data showed that there was no significant difference at the level of 0.05. In conclusions, polymerising the resins through the alumina coping layer, resulted in low depths of cure, thus, it is desirable to polymerise the materials further.

Key words: Curing · Composites · Polymerization

INTRODUCTION

Overall, the public has become extremely aesthetic conscious and consequently aesthetic dentistry has evolved to be one of the most important aspects of dental practice today. Many aesthetic materials are available for patients to choose from, including direct and indirect composite resins, porcelain and a whole array of ceramic materials. Direct composite resin restorative materials for posterior restorations are more attractive to the patient because of their low cost and minimal chair time. But, when placing large posterior restorations, direct composite resin materials may present such problems as incomplete polymerisation, inadequate interproximal contact, polymerisation shrinkage, wear and consequently increased recurrent decay [1].

Therefore, indirect/extraoral curing techniques such as light curing, dual curing and heat and pressure curing have been investigated. Disadvantages of these techniques include increased cost, additional laboratory fees and additional appointments for the patient. However, a major advantage of this technique is the fact that any polymerisation shrinkage resulting from curing occurs in the laboratory and can be compensated for at the time of cementation of the restorations, thus increasing the success of the restorations [2]. Prosthetic composite materials are sometimes polymerised with a handheld curing unit for the repair or fabrication of prosthetic appliances in both the intra- and extra-oral environments [3, 4]. Although a number of manufacturers claim that prosthetic composites can be polymerised with both curing ovens and intra-oral curing units, few comparisons of the curing performance of photo-activation units are available, especially as related to the post-curing properties of materials [5-8].

It is important for photo-activated composite materials, that the resin matrix is sufficiently exposed to light in order to result in the generation of their characteristic properties [9, 10]. Several critical factors should be considered for improving resin matrix conversion: the features of the photo-initiator system contained in the resin matrix, the transmission coefficient

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of the composites [11], the spectral energy distribution and output of the photo-curing units and the compatibility of the composite material and photo-curing unit [12, 13]. Since the nature of a particular photo-curing unit depends on the energy of the light source, the properties of photo-activated prosthetic composite materials are influenced by the type of laboratory photo-curing unit [9, 14-16] reported that the use of a high-intensity light source considerably improved properties of composites regardless of resin matrix composition. Post-curing properties of composites are also improved by heating, longer exposure and secondary radiation [7, 17-21].

The advantages of light photo-curing are[22]:

- It is very much less damaging to soft tissues than ultra-violet radiation.
- It is available from simple tungsten filaments (quartz halogen) lamps, rather than mercury discharge lamps. Such lamps are quite stable in their output intensity for long periods of time.
- It is well transmitted by both tooth tissue and by the resin and filler components so that a cure can be effected rather more easily.
- Visible light curing units (VLC) require minimum warm-up period.

The disadvantages of light photo-curing are:

- The chance of possible eye damage (retinal burns with visible light systems, corneal burns with ultraviolet systems). Some procedures, such as close viewing distances, direct view applications and treating the anterior teeth, may increases the exposure to the user. It is recommended that protective eye glasses be worn to avoid this problem [23].
- Difficulty in curing deep areas of restorations.
- Heat generated could be harmful to the pulp.

It is vital to study the depth of cure of polymerization of dental materials used in the oral cavity since the surfaces of these materials may provide an ideal interface for oral microorganism's surface texture [24-26].

Objectives: The purpose of this work was to investigate the effect on the polymerisation of Belle-Glass composite resins, through alumina coping layer (Techceram disc), by measuring the depth of cure with a penetrometer.

Fig. 1: The Radiometer used to measure the light intensity

MATERIALS AND METHODS

Four different shades of Belle-Glass composite resins were examined in this study (Table 1).

The Radiometer Used for Light Intensity Measurements: The light intensity (680 mW/cm^2) of Optilux 500 light-curing unit (Demetron, U.S.A), was measured in mW/cm^2, 20 sec after switch-on of the unit, using a Radiometer Model 100, P/N 10503 (Demetron Research Corp, U.S.A) (Fig 1). The percentage of light (34%), emitted by the Optilux 500 light-curing unit, absorbed by the alumina coping layer was measured using the same radiometer.

The features of the Radiometer used

- No battery required, powered by the curing light source.
- Internal filters admit only useful curing light.
- Rugged solid state circuitry measures optical power density and is calibrated with traceability to the National Institute of Standards and Technology (NIST).
- Measures from 0 to 1000 milliwatts per square centimeter curing power density at the light guide tip.
- Accommodates tip diameters from 8 mm to 13 mm.
- Instant readings, no warm up time and minimal care.

Table 1: The investigated shades of Belle-Glass composite resins.

Code	Shade	Manufacturer	Batch No.
BGTD	Belle-Glass Translucent Dentin (A4)	Kerr Lab, CA 92867 USA	812595
BGOD	Belle-Glass Opaceous Dentin (A3)	Kerr Lab, CA 92867 USA	009339
BGE	Belle-Glass Enamel (Blue)	Kerr Lab, CA 92867 USA	811180
BGC	Belle-Glass, Cervical (R-B)	Kerr Lab, CA 92867 USA	902486

Fig. 2: The penetrometer instrument used to measure the depth of cure of the Belle-Glass composite resins.

Test Procedures: The shades of Belle-Glass composite resins were packed into open ended split stainless steel moulds, 4 mm diameter and 6 mm high. Each mould was pressed between two polythene sheets and two glass slides to remove the excess material. The specimens were irradiated from the top surface of a Techceram disc (0.5 mm thickness), with the Optilux 500 Light-curing unit (Demetron U.S.A) for a determined time (40 sec). The tip of the light output was positioned at zero distance from the top surface of the Techceram disc.

Instrument Used for Measurement of Depth of Cure: The instrument used in this study consisted of a penetrometer fitted with a digital meter which could be zeroed at any position within its total traverse. At the base of the movable part of the meter; a needle indentor of 0.5 mm diameter was mounted. The position of the needle was determined in mm. Initially, the read-out was zeroed when the needle contacted the base of the specimen. One specimen for each shade of Belle-Glass composite resin was prepared for depth of cure measurement. At 5 s from the end of the irradiation period, the specimens within the mould were indented with the penetrometer needle (Fig 2) at the opposite end. The micrometer was used to displace the penetrometer needle within the specimen, until it reached the hardened irradiated surface. Five readings of the penetration for each specimen were taken. The penetration result was subtracted from the mould height to determine the depth of cure. Measurements were randomly made at the centre and at the borders of each specimen.

Statistical Analysis: The data of curing-depth of the four investigated shades of Belle-Glass Composite Resins were statistically analysed using One-way ANOVA followed by Scheffe comparison test.

RESULTS

The mean values, standard deviations and coefficients of variation of the investigated shades of Belle-Glass composite resins are represented in Table 2 and the data also plotted graphically in Figure 3. Table 2

Table 2: Depth of cure measurements of Belle-Glass composite resins taken through the Techceram disc (0.5mm thickness), at a light intensity of 200 mW/cm^2

Materials	Readings No	Mean	S.D	C.V
BGTD	5	2.0418	0.5	24.5%
BGE	5	1.499	0.4	26.7%
BGOD	5	1.7484	0.6	34%
BGC	5	1.1966	0.23	19%

Table 3: One-way ANOVA followed by Scheffe comparison test of the curing-depth data at the level of 0.05

	Sum of Squares	D.F	Mean Square	F	Sig
Between Groups	1.942	3	0.647	3.091	0.057
Within Groups	3.350	16	0.209		
Total	5.291	19			

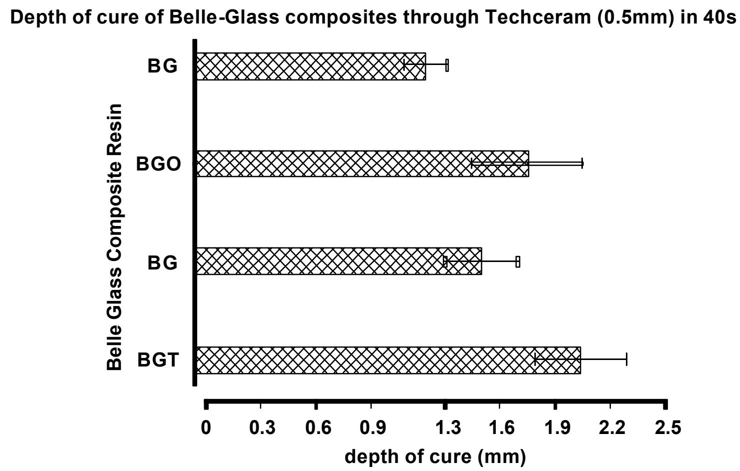

Fig. 3: Depth of cure measurements through Techceram disc.

and Fig. 3 demonstrate that the depth of cure of Translucent dentin shade was the greater compared to the other shades.

One-way ANOVA followed by Scheffe comparison test of curing-depth data showed that there was no significant difference at the level of 0.05 (Table 3).

DISCUSSION

The penetrometer technique was used to measure the depth of cure. Other workers have also used a penetrometer test method [4, 12, 27-29]. Shortall *et al*. [28], argued that this test method is similar to the scrape test used in standards. The main difference is that the penetrometer can apply a constant force allowing consistency of the results. The use of this technique is in agreement with McCabe and Carrick [12] who used a penetrometer technique and found that the depth of cure decreased on moving toward the mould walls and this reduction resulted in the 'bullet-like' shape of the end of the cure material.

The tip of the light curing unit was positioned at zero distance and completely parallel to the top surface of the Techceram disc, to obtain maximum polymerisation of the material beneath the Techceram disc and to avoid the problem of divergence of the light beam. However, the statistical analysis, One-way ANOVA followed by Scheffe showed that there was no significant difference.

The success of this technique depends on obtaining a strong and durable bond between the alumina coping layer and the resin and between the resin and the enamel. The strength of these bonds is dependent on achieving adequate polymerisation of the resin [30]. The results show that the Techceram disc (alumina coping) absorbs 66 or reflects% of the polymerising light. However, this value was determined for a single light source and it is known that light sources from different manufacturers vary in their output spectra [31]. Thus, the absorption values should only be taken as a guide [30].

Like all definitions of polymerisation, the values quoted are dependent on the measuring technique. However, the scrape technique used in this study has been found useful in studying the factors which may affect the polymerisation of resins beneath the alumina coping layer and the variation in performance of curing lights [31]. The results of this study showed that the depth of cure of Belle-Glass composite resins was considerably short, however, it has to be borne in mind that the experiments were carried out at room temperature and not at mouth temperature or in heat-pressure curing ovens. The dual curing material will be beneficial in those clinical situations where it is difficult to illuminate the resin, like the deep interproximal subgingival margin [30].

CONCLUSIONS

The depth of cure experiments showed that polymerising the resins through the alumina coping layer, resulted in low depths of cure thus, it is desirable to polymerise the materials further.

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