ABSTRACT

To determine the sorption rate of flowable dental composites by using different photo-activation techniques. Ninety specimens of 3 different dental composites were used for study. 7mm in diameter and 2mm thick disc of each material were prepared in the laboratory by using brass moulds. 30 samples were polymerized each by Quartz Tungsten Halogen (QTH), Light Emitting Diode (LED) and Ultraviolet B (UVB) light curing units. Samples were taken out from mould and placed in clean glass tube, immersed in 2 % methylene blue solution and placed in incubator for 24hrs. Absorbance was detected at 590nm by using Visible Spectrophotometer. The significant results were observed by using both Light Emitting Diode and Quartz Tungsten Halogen light units (*P< 0.01). Ultraviolet B narrowband light found to be inappropriate for polymerization purpose. Similarly, composite Clinpro and Bioseal showed significant results in every photo-activation method (*P<0.01). Light Emitting Diode units were as efficient in curing resin composite as Conventional Halogen lamps are. Ultraviolet B narrowband light was not appropriate in activation of dental composite while Clinpro and Bioseal are efficient flowable composites.

Key Words: Resin composites, Ultraviolet B narrowband, Methylene blue, Light emitting diode, Spectrophotometer.

INTRODUCTION

Polymeric composite restorative materials represents one of the many successful dental biomaterials, since they restore biological tissue in both appearance and function.1 Composite resin restorations are widely used nowadays in dentist routine practice due to patient increasing demand for cosmetic reasons.2 Bowen developed Bisphenol Aglycidal methacrylate (Bis-GMA) monomer in 1962 to improve the physical properties of acrylic resin, as their monomer only formed linear polymer chains. These, chemically cured composite were used by incorporating base paste into the catalyst which lead to problems associated with proportions, mixing process and color stability.3 Light cured composite was introduced in dentistry in 1960’s. Its importance is due to several reasons among which aesthetics is considered an essential factor.4 However, composite resins have few limitations. The final properties of light-activated composite resin are regulated by their composition, the intensity of the light source and exposure time. The clinical performance of light-cured composite restorations is markedly related to quality of type of light used.5 With the advent of first self-curing resin composites in 1960’s, light curing systems originated in early 1970’s.6 In view to technological improvements in composite resins, curing lights have also established better properties for entire restoration polymerization.7 Light curing units were originated for the photo-activation of composite resins in 1970’s with the use of...
Ultraviolet light. However, due to the adverse effects caused by this light system it was quickly replaced by Quartz Tungsten Halogen (QTH) lights.\textsuperscript{5} Previously, QTH lamp remained the most widely used light source for photo-activation of dental composites for quite some time, however the major drawback of this type of light was heat generation. Moreover the bulb, reflector and filter degrade over time due to high operating temperatures which is caused by ample amount of heat generated during cycles.\textsuperscript{5}

Currently, Light Emitting Diodes (LED) are being used for curing resin composites. They are compact, cordless and easy to use light curing units. They have a working lifetime of over 10,000hrs, comprising of wavelength peaks of around 470nm. Unlike QTH units, it is not imperative to use filters in them; and can be portable. Comparatively the thermal emission of LED units is significantly less than that of QTH lamps.\textsuperscript{8} An alternative light source is the argon laser, which characteristically produces a high energy beam of light with an accurate controlled wavelength that can be adjusted for each dental composite.\textsuperscript{10} In order to reduce clinical time, high power units such as Plasma arc curing units were introduced in the market.\textsuperscript{11} Plasma arc curing system was introduced in late 1990’s as an alternative for rapid light curing. It employs a high frequency electric field to induce its plasma energy.\textsuperscript{12} The advantage of using Plasma arc lamps for resin composites is very short curing time of 3-5 seconds.\textsuperscript{13} This light was highly popular but the negatives outweighed the positives. The initial cost was three times greater than the QTH or LED curing units. Other disadvantage is the maintenance cost of this type of light curing unit.\textsuperscript{14}

Spectrophotometer is a sophisticated instrument, designed to measure an observed object by reflection or transmission of light. The principle of Ultraviolet and Visible Spectroscopy is based on the ability of molecule to absorb ultraviolet and visible light. The absorption of light is related to the excitation of outer most electrons in the molecule.\textsuperscript{15} There are different types of Ultraviolet-Visible Spectrophotometers; most commonly used in the laboratory being a Double Beam Spectrophotometer which comprise of Ultraviolet-Visible light source, two cells through which light passes and a detector to analyze the amount of light passing through a cell. The term Ultraviolet-Visible is normally used for the radiation having a wavelength in the range of 200-800nm. There are different groups that absorb below 200nm, but this part of spectrum is difficult to examine unless the spectra are recorded in Vacuum Spectrophotometer.\textsuperscript{16}

This study aimed to compare the efficiency of a commercially available LED, QTH and more specifically Ultraviolet B narrowband (NB-UVB) light units by using commercially available dental composites (Nexcomp Flow, Clinpro and Bioseal) and also to measure and analyze the sorption rate of these flowable dental composites.

**METHODOLOGY**

The study was conducted in Department of Biochemistry in collaboration with Department of Dental Material Sciences at Muhammad Bin Qasim Dental College, Karachi; Pakistan. Ninety specimens of 3 different resin composite materials namely Nexcomp Flow, Clinpro and Bioseal were used for study. 7mm of diameter and 2mm thick disc of each material were prepared in the laboratory by using brass mold. The samples were divided into 3 groups and each group consists of 30 specimens. Three light curing units namely Quartz Tungsten Halogen (401\textsuperscript{TM} Demetron).

Research Corporation, Danbury, CT, USA), Light Emitting Diode (Optilight LD III\textsuperscript{TM}, Gnatus, Ribeirão Preto, São Paulo, Brazil) and UltraViolet B narrowband (Solarc 120 UVB-NB, Ontario Canada) were used to polymerize these composite materials. The specifications of these light sources are shown in Table 1.

Following groups and sub-groups were categorized according to the composite materials and light curing units:

**Group I: Nexcomp Flow containing 30 specimens, further subdivided into:**

- **Group Ia:** QTH light treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.
- **Group Ib:** LED light treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.
- **Group Ic:** NB-UVB treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.

**Group II: Clinpro containing 30 specimens, further subdivided into:**

- **Group IIa:** QTH light treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.
- **Group IIb:** LED light treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.
- **Group IIc:** NB-UVB light treated Control and Test (2% Methylene blue); containing 10 specimens; 5 of each group.
Group III: Bioseal containing 30 specimens, further subdivided into:

Group IIIa: QTH light treated Control and Test (2% Methylene blue); containing 10 specimens 5 of each group.

Group IIIb: LED light treated Control and Test (2% Methylene blue); containing 10 specimens 5 of each group.

Group IIIc: NB-UVB light treated Control and Test (2% Methylene blue); containing 10 specimens 5 of each group.

ANALYTICAL METHOD

Preparation of methylene blue staining solution:

2% Methylene blue staining solution was prepared in laboratory by mixing 2ml of methylene blue dye material with 98ml of deionized water. The prepared solution was used for the test.

90 Specimens were treated with QTH, LED and NB-UVB lights for 1 minute. After polymerization the tests samples were taken out from the mould and placed in clean glass tube containing 1ml of methylene blue solution and placed in incubator (Sanfa DNP-9052, China) for 24 hours (37±4°C). The specimens were taken out and washed with distilled water for 1 minute and now transferred into 1ml absolute alcohol containing test tubes and incubated again for 24 hours (37±4°C). The solutions were filtered and centrifuged (Centrifuge Model 800, China) for 3 minutes at 4000rpm and supernatant were used for analysis. Absorbance

TABLE 1: DIFFERENT LIGHT CURING UNITS WITH THEIR SPECIFICATIONS

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Light Source</th>
<th>Light Intensity (mW/cm²)</th>
<th>Wave Length (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optilux 401TM</td>
<td>QTH</td>
<td>450</td>
<td>400-500</td>
</tr>
<tr>
<td>(Demetron)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optilight LD III</td>
<td>LED</td>
<td>650</td>
<td>470-490</td>
</tr>
<tr>
<td>TM (Gnatus)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solarc 120 NB-UVB</td>
<td>NB-UVB</td>
<td>200</td>
<td>311</td>
</tr>
</tbody>
</table>

TABLE 2: EFFECT OF QTH, LED & NB-UVB LIGHTS ON NEXCOMP FLOW, CLINPRO AND BIOSEAL COMPOSITES

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameters</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nexcomp Flow</td>
<td>0.015</td>
</tr>
<tr>
<td>2.</td>
<td>Clinpro</td>
<td>0.001*</td>
</tr>
<tr>
<td>3.</td>
<td>Bioseal</td>
<td>0.009*</td>
</tr>
</tbody>
</table>

TABLE 3: COMPARISON BETWEEN QTH, LED & NB-UVB ON NEXCOMP FLOW, CLINPRO & BIOSEAL COMPOSITE

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Light Source</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>QTH treatment</td>
<td>0.001*</td>
</tr>
<tr>
<td>2.</td>
<td>LED treatment</td>
<td>0.002*</td>
</tr>
<tr>
<td>3.</td>
<td>NB-UVB treatment</td>
<td>0.04</td>
</tr>
</tbody>
</table>

was recorded in Ultraviolet Vis Spectrophotometer (Schimadzu 160 UV-Vis, Germany) at 590nm.
Results were presented as mean ± SD. Statistical significance and difference were evaluated by Kruskal Wallis test by using the SPSS version 19 software by IBM, USA. P-values of P<0.01 were considered to be significant. Significant differences are represented by *P < 0.01.

RESULTS

Effect of QTH, LED & NB-UVB lights on Nexcomp Flow, Clinpro and Bioseal Composites:

Table 2 shows the significant effect of LED and NB-UVB light (*P<0.01) on Clinpro and Bioseal while Nexcomp Flow shows no significant results.

Comparison between QTH, LED and NB-UVB on Nexcomp Flow, Clinpro & Bioseal Composite

QTH and LED treatment on composites (*P<0.01) showed significant results while NB-UVB treatment showed no significant result. Table 3 shows the details.

DISCUSSION

In present study we found that composite Nexcomp Flow showed no significant results when treated with QTH, LED and NB-UVB as shown in Table 2. Previous studies prove that proper polymerization of composites depends upon source of light and its intensity, density, wavelength and time of exposure. All these variables have noteworthy effect on the final set of dental composite material. High degree of conversion improves hardness and strength of dental composite, as well as color stability. Water sorption occurs due to the hydrophilicity of matrix present in composites. As the amount of fillers increases, polymer's volume diminishes so does the sorption rate. Higher the rate of sorption, higher will be the plasticizing and hydrolyzing of the composites; leading to formation of micro cracks and eventually reduced life of the material.

Water sorption rate is inversely proportional to amount of filler content present in composite material. Filler particle size, shape and distribution are other variables. A lower degree of conversion affects the physical and mechanical properties of the composite. Increased cure results in a lower amount of uncured resin. These uncured monomers can act as the plasticizers that eventually reduce the biological, physical and mechanical properties of the resin composite material. Viscosity of Nexcomp Flow sealant was observed higher as compared to Bioseal and Clinpro. This was partly due to higher weight % of Barium aluminium borosilicate filler (less than 60%) particles in Nexcomp Flow and presence of lower weight % of diluent monomer Triethylene glycol dimethacrylate (TEGDMA) about 1-5%. The rate of water sorption depends on the type of filler, filler loading and filler-matrix adhesion. The air-filled voids incorporated in the composite resin during the handling of the material manually, may lead to inhibition zones with unpolymerized materials, which may also result in higher water sorption. A key factor that influences water sorption and solubility of a composite material is the coupling agent. When water comes in contact with siloxane coupling agent, it breaks the bond causing debonding of filler particle and making a void which eventually leads in water uptake. Another cogent reason for water sorption is the coupling of diluent monomer i.e. TEGDMA with hydroxyl group of Bis-GMA.

Table 3 showed that NB-UVB light is inefficient to polymerize the composites. Commercially available Ultraviolet B narrowband handheld light units are available that emit a spectrum of Ultraviolet light wavelength ranging from 300-320nm. These lamps are approved by American Food and Drug Administration (FDA) for medical use for the treatment of skin diseases. NB-UVB light is theoretically safer and more effective than Ultraviolet B broadband, because it emits light over a very short range of wavelengths. This study involved the use of NB-UVB light for polymerizing the composites for the first time and it was observed that all the sealants cured with NB-UVB light were not properly polymerized. The sample discs cured with NB-UVB light were found to tackiness on the surface, showed the sign of un-polymerized polymer. NB-UVB light curing unit was being operated at 200mW/cm² and had a wavelength of 311nm that was not enough to adequately cure the resin.

In this study no significant differences were found in dye penetration between flowable composite resins polymerized by LED or QTH light. Although the irradiance values of the curing units used in this study were different (450mW/cm² for QTH and 650mW/cm² for LED). The reason might be the protocol followed to make specimen preparation in disc shape, with a height of only 1.5mm, is in favor of optimal polymerization for both the groups. We suppose, as long as there is sufficient energy at the appropriate wavelength to reach the conversion of double bonds to form the polymer, the source of photons seems not to matter.

Amaral et al, 2005 depicted similar results of 2% methylene blue dye penetration to conventional QTH lamp in comparison with LED units. But their study did not involve the use of NB-UVB light. Micali and Basting, 2004 also found the LED was as effective to polymerize the composite resin as the QTH lamps are. Borges et al, 2012 found no differences in physical properties of composite resins polymerized by QTH curing-light and LED. This study also testifies that that LED and QTH lamps are both effective means of curing the composites and both of these light systems
Flowable composite materials

have no effect on the physical properties of the set material. The other parameter of this study i.e. NB-UVB light found to be non-effective.

CONCLUSION

Within the limitation of this study following conclusion may be drawn:

LED units are as efficient in curing the polymeric composite resin as the conventional QTH lamps are, while NB-UVB light is not an effective tool for curing down the composite material because of shorter wavelength of light. Light intensity of the curing units doesn’t increase the polymerization of the composites, but it only affects the depth of cure.

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