Comparison of the Degree of Conversion of Two Resin Cements When using a Fiber Post

Somayeh Kameli * Zohreh Moradi Mohammad Ataei Maryam Ghavam Mohammad Javad Kharazifard

1Postgraduate student, Dept. of Pediatric Dentistry, Dental School, Shahed University, Tehran- Iran.
*2Corresponding Author: Postgraduate student, Dept. of Operative Dentistry, Dental School, Shahed University, Tehran- Iran. E-mail: zo.moradi@shahed.ac.ir
3Associate Professor, Dept. of Polymer, Petrochemical and Polymer Research Center of Iran, Tehran- Iran.
4Associate Professor, Dept. of Operative Dentistry, Dental School, Tehran University of Medical Sciences, Tehran- Iran.
4Dentist,Statistician, Dental School, Tehran University of Medical Sciences, Tehran- Iran.

Abstract

Objective: Tooth-colored non-metal posts are adhered to the canal walls with the use of resin cements and dentin adhesives. Degree of conversion of these cements is especially important to ensure the durability of the restoration. The present study aimed at evaluating the degree of conversion (DC%) of self-cure and dual-cure resin cements at different depths and time points when using a DT. Light Post.

Methods: In this experimental study, metal molds with 5 and 10 mm heights and internal diameter of 0.8 mm were used. Posts were vertically placed in the center of molds. Spectrum of absorption of the dual cure cement was measured before curing using Fourier transform infrared (FTIR) spectroscopy device. The uncured samples were then removed from the device and placed beneath the molds. After light irradiation, samples were transferred again to the FTIR device and their spectrum of absorption was measured. DC% was calculated using the relevant formula. For self-cure cements, spectrum of absorption was measured at 0, 2, 5, 10 and 15 minutes by the FTIR. Results were statistically analyzed using SPSS software.

Results: Self-cure cement had a DC of 5% at 0, 2, 5 and 10 minutes and a DC of 20% at 15 minutes. DC of the dual-cure cement was 44%, 15% and 8% at 0, 5 and 10 mm depths, respectively. Two-way ANOVA and Tukey’s Post Hoc test (HSD) revealed that in the dual-cure cement the DC at 5 and 10 mm depths was significantly different (P<0.05). DC was 20% at 15 minutes which was the highest.

Conclusion: DC% of the dual-cure cement was higher than that of the self-cure cement which is attributed to the optimal characteristics of the dual-cure cement and also the ability of fiber post to pass light.

Key words: Self-cure resin cement, Dual-cure resin cement, DT Light Post, DC%

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Introduction:

Endodontically treated teeth mostly have a severe coronal tooth loss and small residual tooth structure for restorative treatments due to caries, fracture, presence of previous restorations or access cavity preparation. In order to ensure retention and resistance of the final restoration, posts and cores are usually fabricated for these teeth (1). Previously, cast metal posts and cores were the most common method for reconstruction of severely damaged teeth (2). With the development of fiber posts, a new choice was offered to dentists (3). Researchers believe that the modulus of elasticity of these posts is almost similar to that of dentin and they carry a lower risk of vertical fractures compared to metal posts (4). Application of an indirect restoration requires the use of adhesive resin cements. Commonly used adhesive resin materials can have a chemical cure, light cure or
dual cure polymerization. Dual-cure resin cements possess a combination of chemical and light-cure cement properties (5). However, risk of insufficient polymerization of the dual-cure cement at areas far from the curing light source always exists and inadequate polymerization of the cement can affect bond strength (6). DC is defined as conversion of carbon-carbon double bonds to single bonds during the process of polymerization. High degree of conversion usually results in improved physical and chemical properties of composite resins. High degree of polymerization is among the most important factors that affects the clinical efficacy of composite resins (7). Evaluation of DC is important because low DC can lead to release of toxic substances. Inadequate polymerization of resin cements causes problems like postoperative hypersensitivity, microleakage, tooth discoloration, secondary caries and decreased mechanical properties (8). Of several methods used for determination of DC, FTIR is a valid and credible technique that is widely used as a reliable method to directly specify the oscillatory vibration of C-C double bond before and after curing of materials (9). The present study aimed at evaluating and comparing the DC% of two resin cements at various depths and time points used for adhesion of a fiber post.

Methods:

In this experimental study, DC of the post luting cements at different depths was determined as follows. In order to simulate the distance of the light curing tip from the resin cements, metal molds with 5 and 10 mm heights and internal diameter of 0.08 mm were used.

Table 1 - Characteristics of the materials used in this study

<table>
<thead>
<tr>
<th>Composition</th>
<th>Type of product</th>
<th>Manufacturing company</th>
<th>Serial number</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.T. Light</td>
<td>RTD Grenoble France</td>
<td>038160610</td>
<td>Quartz fiber</td>
<td>Quartz fibers and epoxy resin matrix</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>post, translucent, radiopaque</td>
<td></td>
</tr>
<tr>
<td>Multilink</td>
<td>Ivoclar vivadent Germany</td>
<td>G15618</td>
<td>Self-cure resin cement</td>
<td>UDMA, Bis-EMA</td>
</tr>
<tr>
<td>Seal bond dual cement II</td>
<td>RTD Grenoble France</td>
<td>031010606</td>
<td>Dual cure resin cement</td>
<td>HEMA, Bis-GMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39.7% mass percentage inorganic filler</td>
</tr>
</tbody>
</table>

Molds were filled with a self-cure composite resin mixed with a black powder so that light could only pass through the DT Light Post (RTD, Grenoble, France) present in the center of the molds. Afterwards, the posts were cut into 12 and 7 mm lengths and vertically placed in the middle of 10 and 5 mm molds. In order to further simulate the clinical setting, 2 mm of the post length was left out of the composite resin while the remaining length was engulfed in it. On a polyethylene tape, a circle was drawn equal to the diameter of the post with a marker and adequate amount of seal bond dual cement II and seal bond Ultima bonding (RTD, Grenoble, France) were mixed according to the manufacturer’s instructions and placed on the drawn circle. In order to obtain a uniformly thin layer, pressure was applied on the cement after placing another polyethylene tape over it. Afterwards, a circle equal to the post diameter was cut out of a piece of black cardboard and the cardboard was placed over the polyethylene tape in a way that the two circles were matched. Samples prepared as such were placed in FTIR (Burket FTIR, Germany) before curing in a manner that the red laser beam that indicates the path of infrared beam passed through the center of mentioned circles. The pre-curing diagram was then drawn using OPUS software. Uncured samples were removed from the device and placed beneath the 5 and 10 mm molds and light cured with Optilux light curing unit (Optilux-
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501, Kerr dental, USA) for 40 seconds with 650-700 mw/cm² intensity. The important point was that the light cure tip, the post, the hole in the middle of the black cardboard and the circle drawn on the polyethylene tape containing cement were placed all along (Figure 1).

Figure 1- Curing the cement through the mold containing post

After curing, the samples were transferred again to the FTIR device and their spectra of absorption were measured (Figure 2).

Figure 2- The interior of the FTIR device

After data registry and drawing the diagrams by the computer software, degree of conversion of double bonds was calculated using the formula below:

\[
DC\% = \left[1 - \frac{1638cm^{-1}/1608cm^{-1} peakarea(aftercuring)}{1638cm^{-1}/1608cm^{-1} peakarea(beforecuring)}\right] \times 100
\]

Measurement of the value at each depth was repeated three times and the mean of three values was reported as the degree of conversion.

Multilink cement (Ivoclar, Vivadent, Liechtenstein, Germany) was used as a self-cure and self-etch cement that contains two primers of A and B. After mixing of the cement and placing it on the polyethylene tape, its spectrum of absorption was measured at 0, 2, 5, 10 and 15 minutes by FTIR device. Measurement of the value for each depth was repeated three times and the mean of three values was reported as the degree of conversion.

Two-way ANOVA was used to evaluate significant differences between the understudy groups. If the differences were statistically significant, Tukey’s Post HOC test (HSD) would be used to find the group responsible for this difference. Data were analyzed using SPSS software.

Results:

The results showed that the self-cure cement at 0, 2, 5, 10 and 15 minutes had a DC of 5%, 5%, 5%, 5% and 20%, respectively. Measurement of the degree of conversion at various depths of dual cure cement showed that the degree of conversion was 44%, 15% and 8% at 0, 5 and 10 mm depths, respectively. Two-way ANOVA revealed that the mutual effect of the two independent understudy variables was not accidental (P=0.896) and also the DC of the two cements was significantly different (P<0.001). Additionally, DC was significantly different at various depths as Tukey’s HSD revealed that the DC at 5 and 10 mm depths was significantly different that that at 0 mm distance (P<0.05). However, the DCs in the mentioned two depths were not significantly different (P>0.05).

Discussion:

The properties of the resin cement as the adhesive is among the factors that can significantly affect the clinical durability of indirect restorations. High DC results in better physical and mechanical properties (10). Inadequate polymerization of resin cement leads to postoperative hypersensitivity, microleakage, secondary caries, increased susceptibility to destruction, marginal chipping, discoloration and reduced mechanical properties (11, 12). Many studies have used Vickers and Knoop hardness tests to determine the degree of
polymerization. Although hardness has a strong association with DC%, tests that are based on percentage of C-C double bonds are more reliable (5).

FTIR has been proven as a valid and credible technique for the analysis of DC% of dental composite resin monomers which was used in the present study (13). This study aimed at evaluating the DC of two self-cure and dual-cure resin cements when using a fiber post. DT Light fiber post was used for this purpose because in Ghavam et al, study in 2008 it had been observed that due to its translucency, DT Light Post was able to pass light more than other tooth-colored posts (14). In the root canal, when cementing the tooth-colored posts, the ability to pass light for polymerization of the cement is very limited. In fact, the only route for light entry is through the post's cross-section area and the thin layer of resin. In the present study design, the molds were filled with a self-cure composite resin mixed with a black powder so that the light could pass only through the DT Light Post present in the center of molds.

Intensity of the radiated light is among the factors that affect DC% (14). Reduction in the intensity of the radiated light is strongly correlated with the physical and chemical properties of the post and cement. It is clear that the mechanical properties like the modulus of elasticity, flexural strength and compressive strength depend on the degree of polymerization of resin. With the application of resin cements, bond strength of the post is undoubtedly affected by the mechanical properties of resin cement (15). Thus, in the present study, degree of conversion of the dual-cure resin cement in three different depths of 0, 5 and 10 mm was evaluated and it was observed that DC% at 5 and 10 mm depths was significantly lower than that in 0 mm depth which can be due to the reduced intensity of light at farther areas. In a study by Tezvergil-Mutluay et al, in 2007 all the used cements showed a higher degree of conversion when radiated with direct light compared to the situation where light was passed through a restorative material and then reached the cement. This finding is in agreement with the present study result (5). Also, Meng et al, in 2006 demonstrated that the intensity of light equal to 800 mw/cm2 is reduced to 160 mw/cm2 when it is passed through machined ceramic with 2 mm thickness (16). Several studies have claimed that at the time of curing of dual-cure cements polymerization of the chemical part can be delayed due to the quicker light reaction (17). This behavior can be explained by the kinetics of the dimethacrylate matrix polymerization. When the light reaction starts several growth centers are formed and the liquid matrix is converted into a viscous substance through the formation of a large polymer network. The formed polymer network has numerous transverse bonds. Therefore, the process of propagation of polymer network and termination of polymerization activity become limited (12). Considering the fact that chemical reaction occurs in a slower pace than the physical reaction, there is a possibility that the free radicals produced by the chemical component get caught in the polymer network and therefore cannot result in overall increase of DC% (18). Meng et al, in 2008 demonstrated that even with low light intensity dual cure cements have a high percentage of free radicals mostly originated from the chemical component. These radicals get trapped in the set resin matrix and cannot increase the DC. This finding is in agreement with the present study results because the chemical part of the understudy dual cure cement could not increase the overall DC at 5 and 10 mm depths (19). On the other hand, the results of the present study were in contrast to the findings of Caughman et al, in 2001 (20). They reported 50% DC for 6 types of resin cements that received light through a Ceramco feldspathic porcelain disc with 3 mm thickness. This difference can be due to the different light characteristics of feldspathic porcelain and DT Light Post. Another issue to mention is various thicknesses of the used materials in the two studies. The used self-cure resin cement had a lower polymerization speed and lower final DC% compared to dual-cure cement. It seems that lower DC of self-cure cement can be due to the presence of oxygen bubbles produced during the mixing phase that prevent polymerization. Lower DC of self-cure cements is not a natural characteristic of these cements. On the other hand, lower values of DC in self-cure resin cements may be attributed to the lower than optimal concentrations of inhibitors present in
the cement (21). Inhibitors added to the dental cements increase their clinical working time and shelf life. High volume of these materials decreases the degree of conversion (22). An adequate balance should be necessarily maintained between the material’s shelf life and cure rate, concentration of the initiator and inhibitor (21). The present study results indicated lower DC of a self-cure cement compared to that of a dual-cure cement. Also, the DC of dual-cure cement at 5 and 10 mm depths was significantly less than that in the 0 mm depth which is due to the inadequate polymerization of cement at deeper areas.

**Conclusion:**

This study showed that degree of conversion of a dual-cure cement is higher than that of a self-cure cement which is attributed to the optimal properties of the dual-cure cement and also the ability of fiber post to pass light.

**References:**


