Original Research

# Evaluating the effect of ceramic veneer thickness on degree of conversion in three luting resin cements

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## Abstract

**Introduction:** The purpose of this study was to compare the effect of different ceramic thicknesses on degree of conversion (DC) of 3 light-cured resin cements. **Methods:** In this experimental in-vitro study, the degree of conversion of three light-cured resin cements, Variolink Veneer (Ivoclar, Liechtenstein), RelyX Veneer (3M ESPE, USA) and Choice2 (Bisco, USA) were evaluated beneath feldespatic ceramic discs (Vita VMK Master) with a same shade, 2m2, in different thicknesses (0.5, 1, 2 and3 mm) using FTIR. The light curing unit used was Optilux 501, with an intensity of 600 mW/cm$^2$ and exposure duration of 40 seconds. Three specimens of each cement group were examined in each condition. The obtained data was submitted to Kolmogorov-Smirnov and also checked for absence of skewness and kurtosis for normal distribution. After that, ANOVA test was used for comparison between experimental groups (Tukey HSD). **Results:** In all the three used cements, DC decreased as ceramic thickness increased. This reduction was not significant when using 0.5 and 1 mm ceramic discs, however, it was significant between 1, 2, and 3mm discs($p<0.05$). There was no difference within the cements' DC when exposed through ceramic discs of 0.5, 1, and 2mm, but the Rely X Veneer cement had a lower DC compared to Variolink Veneer and Choice2 when the thickness increased to 3mm($p<0.05$). **Conclusion:** It is not advisable to use light-cured resin cements beneath 3 mm thick ceramics and the use of Rely X Veneer is not recommended as the ceramic thickness increases.

**Keywords:** ceramic veneer thickness, degree of conversion, luting resin cements

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## Introduction

Modern restorative dentistry has provided many advanced techniques to restore function and aesthetics with minimum damage to tooth structures. One of the techniques which has attracted considerable attention during the last decades is ceramic veneer (1). These veneers provide an opportunity for the clinician to minimize the harm to the teeth for preparation procedures (2). Ceramic veneers are used in aesthetic areas of oral cavity and have many advantages over the traditional ceramic crowns which lead to a significant reduction in tooth structure loss and further physical strength of the teeth due to less extensive preparation needed for the traditional crowns (2-4). One of the most important considerations for ceramic veneers is the type of bonding system used to bond the veneer with tooth structure (5, 6). Many studies have been done to fabricate bonding systems to provide appropriate physical properties for the veneers (7-9). Luting agents are widely used as the bonding system for ceramic veneers. Resin composites are used as a luting agent in ceramic veneers because of their physical properties (10). Both chemical and light cured resin composites have been successfully used in veneer systems and different clinical outcomes have been reported for each resin luting agent (4, 11). It is proposed that the majority of ceramic veneer failures are due to inappropriate cements. Thus, finding the most suitable luting agent with best clinical properties is of great importance in ceramic veneer restorations (12, 13). Light-cured resin cements are preferred over chemically cured agents due to the lower working/finishing time and a more stable color in-vivo. But the major obstacle in light cured resins is the problems of light conductance in ceramics (2,8, 14-16). It is well established that ceramic veneers attenuate light beams necessary for light cure polymerization and this limits the use of light cured resins for ceramic veneers (17).

Since there are controversies over the use of light cured resins in ceramic veneers, this study was conducted to evaluate the effect of veneer thickness on the degree of conversion in three resin cements widely used in ceramic veneers. The findings of this study provided evidence for the use of light cured resins in ceramic veneers and informs the clinicians regarding the most appropriate light-cured resin cements for ceramic veneer adhesion.

## Methods and materials

This study was approved by Deputy of Research, Kerman University of Medical Sciences; the grant was provided by the Research Centre for Oral and Dental Diseases (Code: 63).

In this in-vitro study, three resin composite luting agents available in Iran's market were evaluated: Varilink Veneer (Ivoclar Vivadent, Germany), Rely X Veneer (3M ESPE, USA) and Choice 2 (Bisco, USA). The rationale for using these three resin cements in the current study was their different composition and filler sizes and their availability in Iran's market.

Feldespatic ceramic discs (7mm diameter) were fabricated in four different thicknesses: 0.5, 1, 2 and 3mm. Ceramic discs were randomly allocated to different resin cement groups (N=3 for each group) and degree of conversion was evaluated in each luting agent group categorized by the thickness of ceramic veneer.

Each resin cement was placed on a thin polyester strip (Dentsply, Brazil; 0.05mm thickness) and then another thin polyester strip was placed on the uncured resin. All the samples were placed under a pressure of 10kg for 15 seconds to achieve a thin layer of resin cement (100-150 µm). Uncured cements were placed on a black paper to minimize light interferences from other sources. Ceramic veneers with different thicknesses were placed on the uncured resin. A light cure device (Optilux 501, Kerr, USA) was used to emit light on the samples through ceramic veneers (600 $mW^2/cm^2$ for 40 seconds) (17).

To evaluate the degree of conversion, an infrared spectrometer (Equinox 55, FTIR, Burker, Germany) was used. This device uses a Fourier Transformation Infrared Spectroscopy (FTIR) method to assess the presence of carbon C=C bands before and after curing as an indicator of the degree of conversion. Infrared absorption value was read at 1638 cm and OPUS software (Bruker, Germany) was used to measure the degree of conversion for each three luting agents at different thicknesses of ceramic veneers. The absorption peak of 1608 cm-1 was also determined as internal standard (18). To reduce any measuring errors each specimen was evaluated three times and the device was also calibrated for each time.

Three specimens of each cement in 4 different thicknesses were measured with a total specimen number of 36 ( 3 cements × 4 thicknesses × 3 specimen of each cement). Also each cement was evaluated before and after curing, leading to a total number of 72 FTIR test results.

Data was analyzed using SPSS v.16 (IBM, USA). The obtained data was submitted to Kolmogorov-Smirnov test and also checked for absence of skewness and kurtosis for normal distribution (data was normally distributed, P-value>0.05). Then ANOVA followed by Tukey's post-hoc test was used to compare the degree of conversion among the three luting agents.

## Results

Increase in ceramic veneer thickness led to a reduction in degree of conversion in all three resin cements. Maximum degree of conversion (DC) was observed in Variolink Veneer in 0.5mm ceramic thickness and minimum DC was measured in Rely X Veneer at 3mm thickness of ceramic veneer. DC of the three studied resin cements were compared with each other at four different thicknesses. There was a significant difference in DC of Rely X Veneer at 3mm as compared to Variolink Veneer® and Choice 2® ($p<0.01$, ANOVA followed by Tukey's post-hoc test) (Figure 1).

To evaluate the effect of ceramic veneer thickness on the DC in different resin cements, pair-wise comparison was made among DC measured at different thicknesses of ceramic veneer for each resin cement (Table 1, 2 and 3).

For the Variolink Veneer resin cement, maximum DC was observed at 0.5mm and minimum DC was observed at 3mm. there was a significant difference in DC among different thicknesses of ceramic veneers. DC at 0.5mm was not significantly different, about 1mm, but the difference between 0.5mm versus 2 and 3mm thicknesses was statistically significant. There was also a significant difference between 1mm versus 2 and 3mm thicknesses (Table 1).

Tables 2 and 3 demonstrate DC percentage for Rely X Veneer and Choice 2® resin cements, respectively. As is obvious in the tables, increase in ceramic veneer thickness led to a significant reduction in DC of both resin cements which was significantly different at some thicknesses (Table 2 and 3).

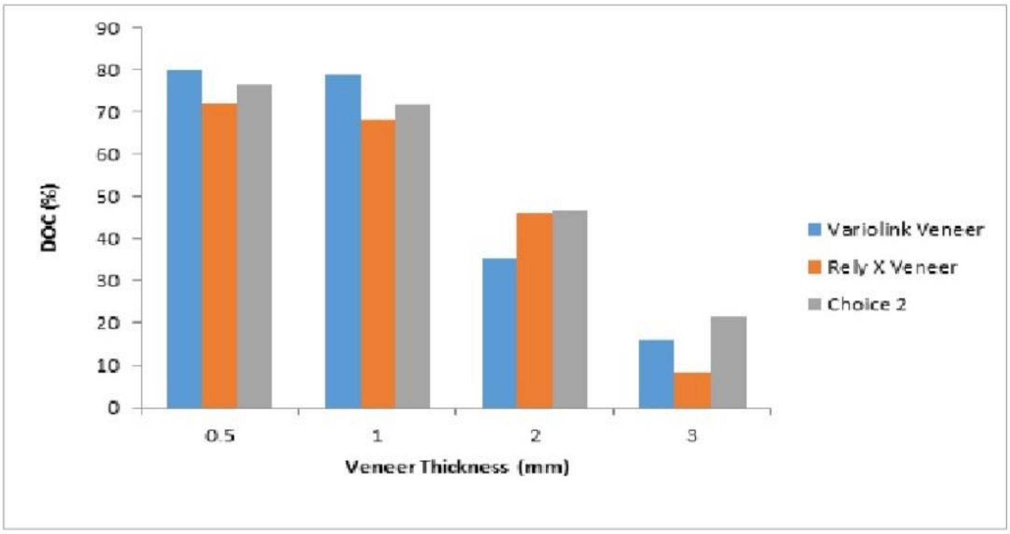


**Figure 1**. Degree of Conversion (DOC) percentage for three luting agents at different thicknesses of ceramic veneer is presented. As expected, DOC was decreased with the increase in ceramic veneer thickness. Maximum DOC was measured in Variolink Veneer ® at 0.5mm and minimum DOC was measured in Rely X Veneer ® at 3mm thickness of ceramic veneer.

* $p<0.01$ as compared to the other two resin cements at 3mm thickness.

**Table 1**. Degree of conversion (DOC) measured for Variolink Veneer at different thicknesses of ceramic veneer. Pair-wise comparison revealed a significant difference of DOC at different thicknesses of ceramic veneer (One-way ANOVA followed by Tukey's post-hoc test).

| Thickness of veneer (pair-wise comparison) | DOC (%) ± S.D. | p-value |
|---|---|---|
| 0.5 vs. | 80.11 ± 3.7 | 0.758 |
| 1mm | 78.7 ± 5.6 | |
| 0.5 vs. | 80.11 ± 3.7 | 0.0001 |
| 2mm | 35.4 ± 6.06 | |
| 0.5 vs. | 80.11 ± 3.7 | 0.0001 |
| 3mm | 16.02 ± 1.98 | |
| 1 vs. | 78.7 ± 5.6 | 0.0001 |
| 2mm | 35.4 ± 6.06 | |
| 1 vs. | 78.7 ± 5.6 | 0.0001 |
| 3mm | 16.02 ± 1.98 | |
| 2 vs. | 35.4 ± 6.06 | 0.0001 |
| 3mm | 16.02 ± 1.98 | |

**Table 2**. Degree of conversion in Rely X Veneer resin cement. Ceramic veneer thickness increase led to a decreased DOC in this resin cement.

| Thickness of veneer (pair-wise comparison) | DOC (%) ± S.D. | p-value |
|---|---|---|
| 0.5 vs. | 72.15 ± 4.62 | 0.475 |
| 1mm | 68.08 ± 5.44 | |
| 0.5 vs. | 72.15 ± 4.62 | 0.0001 |
| 2mm | 46.2 ± 5.68 | |
| 0.5 vs. | 72.15 ± 4.62 | 0.0001 |
| 3mm | 8.35 ± 4.01 | |
| 1 vs. | 68.08 ± 5.44 | 0.0001 |
| 2mm | 46.2 ± 5.68 | |
| 1 vs. | 68.08 ± 5.44 | 0.0001 |
| 3mm | 8.35 ± 4.01 | |
| 2 vs. | 46.2 ± 5.68 | 0.0001 |
| 3mm | 8.35 ± 4.01 | |

**Table3**. Degree of conversion (DOC) for Choice 2® resin cement. Pair-wise comparison among different thicknesses is also provided.

| Thickness of veneer (pair-wise comparison) | DOC (%) ± S.D. | p-value |
|---|---|---|
| 0.5 vs. | 76.65 ± 3.62 | 0.193 |
| 1mm | 71.93 ± 3.84 | |
| 0.5 vs. | 76.65 ± 3.62 | 0.0001 |
| 2mm | 46.62 ± 5.25 | |
| 0.5 vs. | 76.65 ± 3.62 | 0.0001 |
| 3mm | 21.38 ± 3.26 | |
| 1 vs. | 71.93 ± 3.84 | 0.0001 |
| 2mm | 46.62 ± 5.25 | |
| 1 vs. | 71.93 ± 3.84 | 0.0001 |
| 3mm | 21.38 ± 3.26 | |
| 2 vs. | 46.62 ± 5.25 | 0.0001 |
| 3mm | 21.38 ± 3.26 | |

## Discussion

Clinical success of ceramic resins is dependent upon different factors. One of the most important factors which determines the strength of veneer adherence to the tooth structure is the type of cement used for bonding it(8). Two types of resin cements are used in ceramic veneers, chemical versus light-cured resins (19). While the latter has advantages such as a reduced clinical and working time, light conductance through ceramic veneer limits the use of light-cured resins in veneers. This study was performed to evaluate the effect of ceramic veneer thickness on degree of conversion in three brands of resin cements with different physiochemical properties. Results of the study revealed that DC of all three studied resin cements decreased with increase in ceramic veneer thickness which is expected to be so. Furthermore, DC of Rely X Veneer at 3mm was significantly lower than the other two resin cements. According to these findings, use of light-cured resin cements in ceramic veneers with more than 3mm thickness is not recommended; also, Rely X Veneer® resin cement is not advised in ceramic veneer restorations.

It is well-established that physical properties of resin cements is strongly dependent upon the preparation of resin cements and its composition, filler size and percentage and resin type (20). Resin cement polymerization is initiated either chemically or by emission of a specific light (21). Similar to the restorative resin composites, polymerization of resin cements is not complete even in ideal clinical settings and this significantly affects the mechanical properties of resin cements (22). Blackman et al. (1990) evaluated the DC of dual-cure resin cements applied under ceramic inlays. They demonstrated that polymerization ratio of dual cure resin cements is acceptable in ceramic inlay thicknesses up to 3mm which is consistent with the findings of the current study (23). Incomplete polymerization is one of the most important causes of failure of resin cement in clinical settings, thus it is necessary to optimize DC to enhance the physical properties of resin cements (24, 25).

In a study by Imazato et al. (2001), they evaluated the DC of different composites with different fillers using FTIR technique. Furthermore, addition of TEGDMA to the resin matrix increases the DC through facilitation of monomer movement in the resin matrix. In the current study, three different resin cements with different monomers and fillers were evaluated. One of the reasons for differences observed in the current study could be the different composition of these resin cements and different monomers such as TEGDMA, BISDMA and UDMA (18).

A light cure device with high power was used in the current study (600 $mW/cm^2$). This high level of energy provided an opportunity for optimum initiation of polymerization process in the light cured resin cements. Hooshmand et al. (2009) compared the efficacy of LED versus halogen light cure devices in polymerization of resin cements through ceramic veneers. They demonstrated that halogen light cure devices led to better polymerization in comparison to LED light cure devices (26).

Peumans et al. (2000) demonstrated that emission of light through ceramic veneers is associated with a 40 to 50% reduction in light intensity. They also concluded that ceramic thickness is more important in reduction of light intensity passed through the veneer than color and opacity of the ceramic. Furthermore, Linden et al. (1991) showed that the opacity of a ceramic veneer affects light intensity in more than 0.7mm thicknesses. These two studies recommended the use of dual cure resin cement in ceramic veneers with more than 0.7mm thicknesses. Results of the current study confirm their findings and it is suggested that light cure resin cements be used in ceramic veneers with less than 0.7mm thicknesses (27, 28).

In another study by Meng et al. (2006), they showed that light intensity is reduced from 800 to 160 $mW/cm^2$ when emitted through ceramic veneers with more than 2mm thicknesses (29) . This is consistent with the findings of the current study that DC was significantly lower in 2 and 3mm as compared to 0.5 and 1mm thicknesses of ceramic veneers. El-Mowafy et al.(1999) also demonstrated that ceramic thicknesses of more than 2mm significantly reduced polymerization in resin cements which is again confirmed in the current study (30).

## Conclusion

As a conclusion, light-cured resin cements could be used in ceramic veneers with thicknesses of less than 1mm with proper degree of conversion.

Key words: ceramic veneer thickness, degree of conversion, luting resin cements

Conflict of interest:

The authors declare no conflict of interest. This study was conducted using a research grant from Deputy of Research, Kerman University of Mmedical Sciences.

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