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EFFECT OF THREE CERAMIC MATERIALS ON DEGREE OF CONVERSION OF LIGHT AND DUAL CURE RESIN CEMENTS; AN IN-VITRO STUDY

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ABSTRACT

Objective: To assess the impact of various CAD/CAM ceramic materials on the degree of conversion of two resin cements. **Materials and Methods:** For the fabrication of 60 disk-shaped resin specimens with 0.5 mm thickness and 8 mm diameter, a total of 60 ceramic specimens with 0.5 mm thickness were used. These specimens were divided into three groups based on the type of ceramic material: IPS e.max (n = 20), Ultra-translucent zirconia (n = 20), and Vita Enamic (n = 20). Each main group was divided into two equal sub-groups according to the type of resin cement {Rely X Veneer light-cure (n=10) and Rely X Ultimate dual-cure (n=10)}. Degree of conversion (DC) was then measured. Data were collected and analyzed. **Results:** One-way analysis of variance (ANOVA) and Bonferroni's post hoc tests showed that IPS e.max CAD specimens exhibited statistically higher DC values than other ceramics for light-cure resin cement specimens. Ultra-translucent zirconia specimens exhibited statistically higher values than other ceramics for dual-cure resin cement specimens. Vita Enamic specimens presented the lowest values for both resin cements ($P< 0.05$). A significant difference was observed in all ceramic specimens with 0.5 mm thickness ($P< 0.05$). **Conclusion:** All ceramic materials provide clinical acceptable degree of conversion of both light and dual-cure resin cements.

KEYWORDS: CAD-CAM**,** Ceramic materials, Degree of conversion, Resin cement.

INTRODUCTION

Ceramics are frequently utilized in prosthetic restorations because of their realistic look, fluorescence, biocompatibility, durability, chemical stability, high pressure resistance, and thermal expansion like that of tooth structure(1,2). The rapid development of the production techniques of full ceramic restorations increased the use of indirect prosthetic restorations for both anterior and posterior teeth (3). In recent years, the popularity of CAD/CAM technology, which has been developed to improve the quality of restorations and simplify production techniques, has increased significantly(4,5). Aside from enabling the use of a variety of materials, including feldspathic ceramic, leucite reinforced glass ceramic, lithium disilicate glass ceramic, aluminium oxide reinforced ceramic, yttria-stabilized zirconia, and composite blocks, CAD-CAM systems have also improved the quality of restorations(6, 7).

The cementation procedure determines how well an indirect repair performs clinically. The glass-ionomer, zinc phosphate, polycarboxylate, glass-ionomer, resin-modified glass-ionomer, and resin cements are the five primary kinds of luting cement that physicians can utilize(8). Resin cement

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is well recognized for increasing the success rate of ceramic restorations including laminate veneers, inlays, onlays, and crowns (9).

The benefits of chemically cured and light cured resin cements, such as extended working times, a variety of colour possibilities, and continuous polymerization through a chemical catalyst, are combined in dual cure resin cements (10, 11). In cases where the thickness of the restoration is above 1.5-2 mm or when the restoration opacity prevents light transmission, it is recommended to use dual-cure or chemically cured resin cements (12) .Previous studies (13, 14) showed that light-curing enhances the physicochemical properties of dual-cure resin cements, such as surface hardness and indentation modulus, and that they have a higher degree of conversion than they do with chemical polymerization alone(15-17) .The degree of conversion for resin cements represents the percentage of aliphatic carbon double bonds converted to single bonds (9, 18).

Many variables, including the kind, thickness, colour, and translucency of the ceramic utilized in the repair, influence how resin cement polymerizes. Activation mode of the resin cement, power of the light source used for polymerization, duration and distance of the application, are also notable factors for resin cement polymerization (3).Inadequate polymerization means a low conversion rate of monomers to polymer which leads to a physically weak resin cement(17,18).

Polymerization of resin-based products is assessed using direct and indirect approaches. Indirect techniques include scraping, visual evaluation, and surface hardness measurement, whereas direct techniques include chemical techniques including infrared spectroscopy, laser analysis, and Raman spectroscopy(19) .It is frequently used to assess polymerization. Fourier transform infrared spectroscopy (FTIR) is a prominent technique that is based on the interaction between electromagnetic radiation and the organic vibrations of chemical bonds between atoms that comprise the material (18, 20-22).

Using FTIR, this study assessed the degree of conversion of several types of CAD/CAM ceramics under different types of light-cure and dual-cure resin cements. The study's null hypothesis was that the ceramic materials will not alter the resin cements' degree of conversion.

MATERIALS AND METHODS

TABLE (1) Materials used in study.

Material	Trade Name	Manufacturer	Lot No.
Ultra-Translucent Zirconia	Ceramil Zolid ht^{+}	Amann Girrbach, Koblach, Austria	2001001
Lithium disilicate	IPS E.max CAD	Ivoclar Vivadent AG, Schaan, Liechtenstein Germany	Z01SBL
Hybrid Ceramic	Vita Enamic	Vita Zehnfabrik, Bad Sackingen, Germany	91020
Resin Cements	Rely X Veneer	3M ESPE, St. Paul, Minneapolis, MIN	NE36597
	Rely X Ultimate		7824424

Table (1) lists the resources used in this study (1), the materials were chosen in HT and A3 shades to standardize the materials. From the ceramic blocks, a total of 60 discs were cut, 20 of each of the three ceramic materials (20 total), with the exception of zirconia, where the discs were cut 20% bigger to account for shrinkage after sintering. The cuts were produced with a diamond saw (Isomat saw 4000, Buehler, Illinois Tool Works Inc, USA) operating at 2500 rpm under water cooling. According to the manufacturer's instructions, zirconia samples were sintered in the high temperature furnace ceramic (Amann Girrbach AG, Herrcshaftswiesen 16840 Koblach, Austria).

In accordance with manufacturer's instructions, ceramic discs of IPS e.max CAD were crystallized in the Programat P310 furnace (Ivoclar Vivadent AG, Bendererstrasse 2, Fl-9494 Schaan, Liechtenstein) using a specific program. Without additional heat processing, the Vita Enamic discs were polished and cleaned.

Using a Robinson brush and polishing paste, one operator polished each specimen on a single surface (pearl surface). The thickness of the specimens after sawing was verified using a digital caliper (Fisher Scientific Treceable Caliper, USA). All specimens were polished, then washed with distilled water for 10 minutes using an ultrasonic cleaner (Silfradent, Santa Sofia, Forli-Cesena, Italy), after which they were allowed to air dry on absorbent paper. Rely X Veneer (V), a light-cure resin cement, and Rely X Ultimate (U), a dual-cure resin cement, were used for this investigation.

To support the specimens during preparation and reduce the reflection of the underlying surface towards each specimen, a transparent glass slide with a dark backdrop was employed (23).

A mylar strip was positioned on the glass slap to avoid adhesion of formed resin on a glass slap. For standardization of the size of resin cement specimens, a customized cylindrical stainless-steel mold with 8 mm diameter and 0.5 mm depth was placed on a mylar strip on the glass slap. In order to prevent resin cement from adhering to the ceramic discs, the resin cements were dispensed into a stainless steel mould in accordance with the manufacturer's instructions before being coated with a Mylar strip and the ceramic discs. A light-curing equipment (Elipar S10; 3M ESPE, Seefeld, Germany) was used to cure the material for 20 seconds in high intensity mode at a light irradiance of 1200 mW/cm2 and a wavelength range of 430 to 480 nm. After the polymerization operations, the specimens were then kept at 37 °C for 24 hours in a light-proof box to prevent additional exposure to light. (24) As showed in the Figure.

The degree of conversion (DC) of specimens (n=60) was measured using FTIR (spectrum 100, Perkin-Elmer, Waltham, MA, USA). 32 scans overall at 4 cm-1 were obtained in the 400–4,000

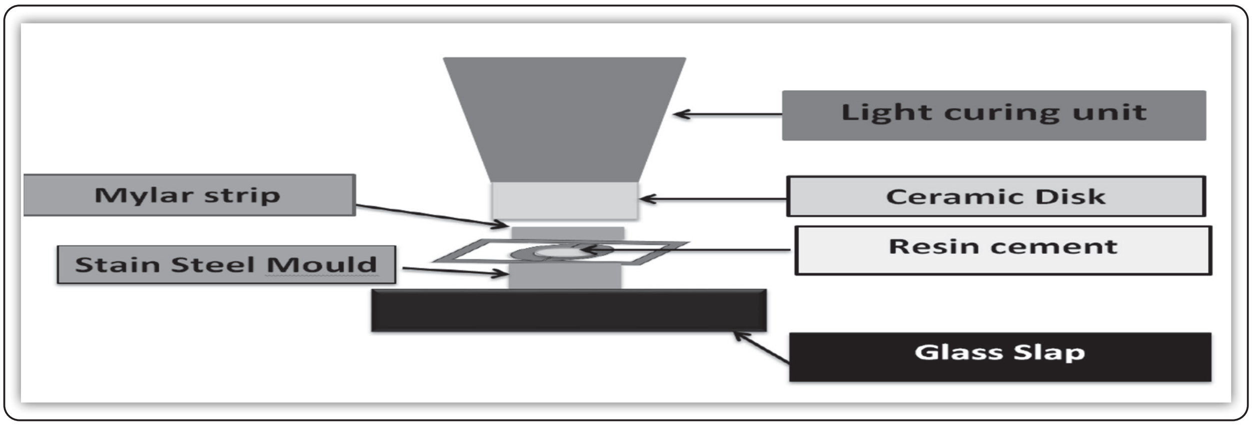

FIG (1) Illustration of the experimental design.

cm-1 range. The absorption peaks of the aromatic double bonds were detected at 1,608 cm-1, whereas the peak of the aliphatic double bonds was observed at 1,637 cm-1. The following equation was used to obtain the% degree of conversion (DC)(3, 9):

$$\mathbf{DC = 100\ (1 - R\ cured/R\ uncured)}$$

where R is the ratio between the absorbance peak at 1,637 cm^{-1} and 1,608 cm^{-1}.

Statistical analysis - SPSS statistical package program (PC version 20) was used for statistical analysis of the data. Kolmogorov-Smirnov normality test was applied in order to examine the conformity of the data to normal distribution. One way ANOVA and Bonferroni's post hoc test were used to compare the effect of different types of ceramic on the degree of conversion of resin cement samples (P< 0.05). The comparison of light-cure and dual-cure resin cement samples cured under the same ceramic and the comparison of the ceramic specimens under the same cement were performed with independent sample t-test or one-way analysis of variance (ANOVA) test followed by Bonferroni's post hoc test.

RESULTS

Degree of conversion of light-cure resin cement under different type of ceramics:

The highest mean value was recorded in IPS e.max group (72.25±4.1), followed by Ultra-translucent zirconia group (59.20±3.15), with the least value recorded in Vita Enamic (54.89±2.87). the difference between groups was statistically significant (P=0.000)

Degree of conversion of dual-cure resin cement under different type of ceramics:

The highest mean value was recorded in Ultra-translucent zirconia group (63.37±3.21), followed by IPS e.max (60.82±4.7), with the least value recorded in Vita Enamic (57.29±1.93). The difference between groups was statistically significant (P=0.002) as show in (Table 2).

TABLE (2) Mean (SD) for degree of conversion (%) of both light cure and dual cure resin cements under different ceramic types.

Types	Light cure resin cement	Dual cure resin cement
IPS Emax CAD	72.25 ^{a} (4.10)	60.82 ^{b,c} (4.70)
Ultra-translucent zirconia	59.20 ^{c} (3.15)	63.37 ^{b}(3.21)
Vita Enamic	54.89 ^{d} (2.87)	57.29 ^{c,d} (1.93)

* *Different superscript (upper case for rows and lower case for columns) indicates statistical significance (P < 0.05).*

Comparison between different resins cements using the same type of ceramics:

In Zirconia (Z): Rely X Ultimate (U) recorded a significantly higher value (63.37±3.21) in comparison to Rely X Veneer (V) (59.20±3.15), with a difference (4.17±1.42), (P=0.009).

In e.max CAD (E): Rely X Veneer (V) recorded a significantly higher value (72.25±4.10) in comparison to Rely X Ultimate (U) (60.82±4.7), with a difference (11.43±1.97), (P=0.000).

In Vita Enamic (V): Rely X Ultimate (U) recorded a significantly higher value (57.29±1.93) in comparison to Rely X Veneer (V) (54.89±2.87), with a difference (2.41±1.09), (P=0.041).

DISCUSSION

The goal of this study was to compare the degree of conversion of two types of resin cements light-cure and dual cure that hardened under various CAD/CAM ceramics. The null hypothesis was rejected because the type of ceramic used has an impact on the degree of conversion for both types of resin cement. The degree of conversion, which is the expression of the monomer-polymer transformation, is related to the amount of energy that the material is subjected to during polymerization(24). It is expressed as the ratio of the double-carbon bonds present in the polymerized resin-based material to the total double-carbon bonds in the non-polymerized material(20). Light intensity and irradiation duration have a direct impact on this quantity of energy for resin cements. According to Ozyesil et al.25, the degree of conversion of resin-based materials varied from 55 to 80%. In the current investigation, the degree of conversion for the dual-cure resin cement ranged from 54.52 to 68.06% and for the light cure resin cement from 50.8 to 78.46%.

Ozyesil et al.(25) evaluated the degree of conversion of a dual cure resin cement with samples cured under 2 mm thickness of IPS Empress 2 ceramic immediately after the polymerization and after 24 hours using FTIR. According to the results of the study, the degree of conversion values was higher after 24 hours. In the light of these findings, resin cement samples in our study were kept in darkness at 37°C for 24 hours before the measurements.

The crystalline phase of the ceramics affects the degree of conversion as light scattering and diffraction occurs (17) .As the scattering of light in the material increases, the transmission and the degree of conversion decreases and a restoration with an opaquer appearance is obtained. The optical properties of indirect restorations are influenced by their inorganic contents, matrix compositions, particle sizes and pores formed during the processing of the material (26) .De Souza et al(11) compared leucite-reinforced and lithium disilicate-based ceramics and reported that lithium disilicate-based ceramics have a more opaque appearance due to the crystal structure and cause lower degree of conversion values than leucite-reinforced ceramics; this result complies with others (19).

When compared to other ceramics of the same thickness in the investigation, the light cure resin cement samples that were cured under IPS e.max CAD discs of 0.5 mm thickness displayed better degree of conversion values. This can be explained by the fact that IPS E.max CAD ceramics have different translucency and microstructure properties compared to other ceramics. This finding was confirmed by Mustafa & Munir(12) and Awad et al(27).

Followed by the light cure resin cement samples cured under Ultra-translucent zirconia in which the crystalline phase affects the degree of conversion, as light scattering and diffraction occurs. Although zirconia with high translucent nature has been used, but it still opaquer than high translucent e.max CAD. Monolithic zirconia restorations' opacity may limit the amount of light that can pass through the material, Zohdy (17), who evaluated the impact of various thicknesses and two shades of two ceramic materials on the degree of conversion of a light-cure resin cement, came to the same conclusion.

Between IPS e.max and Ultra-translucent zirconia ceramics, the degree of conversion of dual cure resin cement does not significantly differ. This may be explained by the fact that e.max CAD ceramics and Ultra-translucent zirconia let the necessary amount of light to pass through them in order to enhance the monomer to polymer conversion of dual cure resin cement and to permit a full chemical reaction to take place (28).

The least degree of conversion was recorded in resin cement cured under Vita Enamic. This could be due to the hybrid structure of Vita Enamic that cause more light scattering, so the amount of penetrated light was not enough to initiate polymerization and the chemical component of dual cure resin cement alone can't yield the maximum degree of conversion of monomers (29, 30).

The limitation of the present study is that in vitro, one thickness of CAD/CAM ceramic material was used, and the obtained degree of conversion values cannot be compared with resin cements with different filler ratios. Further studies including different resin cements, light curing units, curing time, CAD/CAM ceramic materials with different shades, thicknesses and translucency are necessary to comprehensively investigate and understand the degree of conversion.

CONCLUSIONS

Within the limitations of this in vitro study the following conclusions can be drawn:

1. Within thickness of 0.5mm, all ceramic materials provide clinical acceptable degree of conversion of both light and dual cured resin cements.
2. The used ceramic materials within thickness of 0.5mm can be cemented with light or dual-cure resin cements.
3. IPS Emax CAD ceramic show higher degree of conversion for light cure resin cements.
4. Ultra-translucent zirconia ceramic shows higher degree of conversion for dual-cure resin cements.

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