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Do lithium disilicate ceramic manufacturing techniques affect the degree of conversion of light-cured resin cement?

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Abstract

The aim of this study is to evaluate the degree of conversion of light-cured resin cement subjected to activation through the interposition of lithium disilicate ceramic produced according to two manufacturing techniques. Cylindrical specimens of RelyX™ Veneer resin cement were generated based on each manufacturing technique (CAD/CAM—computer aided design/computer assisted manufacturing, $n = 5$ or pressed ceramic technique, $n = 5$). Next, the specimens were washed in distilled water, dried with absorbent paper and stored in containers filled with distilled water at 37 °C for 24 h. Specimens from each group were subjected to attenuated total reflectance Fourier transform infrared (ATR-FTIR) in order to evaluate their degree of conversion. Data about the degree of conversion (%) were subjected to analysis of variance and to Student's t-test ($\alpha = 0.05\%$). The degree of conversion of RelyX™ Veneer was statistically higher in the CAD/CAM manufacturing technique ($39.83 \pm 0.35\%$) than in the Press one ($37.59 \pm 0.62\%$). The light-cured resin cement activated through ceramic structure reinforced with lithium disilicate generated through the CAD/CAM manufacturing technique showed higher degree of conversion than the one generated through the Press manufacturing technique.

Keywords: Ceramics, Resin cements, Cementation, Polymerization

Introduction

The use of ceramic veneers in Dentistry has increased due to high degree of aesthetic requirements, since lithium disilicate veneers can restore dental aesthetics in a way to make it look very similar to the natural dental structure, besides requiring less invasive or even no cavity preparation [1]. However, the aesthetic quality of the material is not the only criterion to be taken into consideration at the time to assure successful restoration procedures, since ceramic veneers must firmly adhere to the dental structure through resin cements [2]. The commercially available cements for laminate restoration luting may be light or dual-cure activated. Some advantages such as color stability, working time and ease of use make the photopolymerizable cement the material of choice

depending on ceramics opacity [1]. Thus, resin cement is the material of choice in the cementation of ceramic veneers.

The material is available in pre-sintered blocks for chairside milling using CAD/CAM systems [3]. Lithium disilicate restorations can also be manufactured based on the lost-wax, pressed ceramic technique [4]. The pressed system enables a smaller marginal gap between restoration margin and the finishing line in tooth preparation, besides being significantly stronger than other systems [4]. However, there is growing demand for the milled ceramic system, which enables intraoral digital impressions and in-office milling, thus reducing its production time [4]. Resin cement polymerization can be affected by some factors linked to the restoration, among them: ceramic thickness, color and type, crystalline structure, grain size, defects, intrinsic porosity and stratification technique [5–7]. However, few studies [8, 9] have shown that the difference in ceramic opacity influences the properties of resin cements.

Thus, the aim of this study was to evaluate the degree of conversion (DC) of light-cured resin cement subjected to activation through the interposition of lithium disilicate ceramic produced through two manufacturing techniques. The null hypothesis was that the degree of conversion (DC) of light-cured resin cement is not influenced by the two manufacturing techniques (CAD/CAM or Press).

Methods

Specimen preparation

Two discs (10 mm diameter; 0.6 mm thick) were made of lithium disilicate glass ceramics. The first one (pressed ceramic technique) consisted in isostatic injection based on the heat technology (IPS e.max Press, shade LT A1, Ivoclar Vivadent, Schaan, Liechtenstein). The other disc was based on the manufacturing technique applied to indirect restorations made of lithium disilicate ceramics, which followed the automation technique guided by the CAD/CAM system (IPS e.max CAD/CAM, shade LT A1, Ivoclar Vivadent, Schaan, Liechtenstein), whose milled ceramic discs were produced by scanning the pressed ceramic disc with CEREC Omnicam (Sirona, Bensheim, Germany) from and milling it on CEREC MC-XL (Sirona). The resulting discs (both surfaces—top and bottom) were subjected to sequential wet polishing SiC abrasive papers (320, 400, 600 and 1200 grit; Norton SA, São Paulo, SP, Brazil) in a water-cooled automatic polisher (APL4; Arotec, Cotia, SP, Brazil) in order to get to final diameter 10 mm and thickness 0.5 mm. Specimens were ultrasonically cleaned with distilled water for 10 min and dried with compressed air. Disc thickness was measured with 0.01 mm-accuracy digital caliper (Mitutoyo Corporation, Tokyo, Japan).

The LED (light emitting diode) curing unit output (Radii Cal; SDI, Bayswater, Victoria, VIC, Australia) was measured with a power meter [10] (Ophir Optronics Inc., Danvers, MA, USA) at irradiance 1400 mW/cm². The irradiance was measured when the light-guide end touched the surface of the ceramics during exposure at 1260 mW/cm² (IPS e.max CAD/CAM) and 1120 mW/cm² (IPS e.max Press). The RelyX™ Veneer (3 M ESPE, shade A1, St. Paul, MN, EUA) light-cured resin cement was inserted in a matrix (1.0 mm thick; 7 mm diameter) and, then, the ceramic disc resulting from each manufacturing method was placed over the resin cement. The tip of the light curing unit was

placed over the ceramic disc and the resin cement was light-activated for 20 s. Five specimens were prepared for each manufacturing technique.

Degree of conversion measurement

Samples were manufactured in two different ways and divided in two groups: CAD/CAM ceramic group (n = 5) and Press ceramic group (n = 5), for conversion degree analysis. Specimens were washed in distilled water, dried with absorbent paper, placed in black containers filled with distilled water and stored at 37 °C for 24 h.

The unpolymerized resin cement was accessed twice before all ten evaluations in order to set the bonding pattern of its monomeric state before sample analysis. The top of the specimens was analyzed through attenuated total reflectance Fourier transform infrared (ATR-FTIR) (Spectrum 100 Optica; Perkin Elmer, Waltham, MA, USA).

Graphs were generated in the Spectrum software version 6.3.1 (PerkinElmer) for visualization and analysis purposes. The ATR-FTIR spectrometer operated under the following conditions: 300–4000 cm^{-1} wavelength, 4 cm^{-1} resolution and 16 scans. The degree of conversion was based on the peak intensity of the aliphatic C=C bond (1608 cm^{-1})/ peak intensity of the aromatic C=C bond (1608 cm^{-1}) ratio, which was calculated for cured and uncured specimens through the following equation:

$$\text{DC} = (1 - R_{\text{cured}}/R_{\text{uncured}}) \times 100.$$

where R is previously described peak.

These calculations were performed in Microsoft Office Excel 2007 software (Microsoft Office Professional Edition 2007, Microsoft Corporation).

Statistical analysis

Data were subjected to statistical analysis in the SAS System for Windows 9.0 (SAS Institute Inc., Cary, NC, USA). Degree of conversion values were subjected to ANOVA and Student's t-test, at 5% significance level.

Results

Table 1 shows the mean degree of conversion values (power of statistical test, 0.99). The degree of conversion of RelyX™ Veneer was statistically higher in the CAD/CAM manufacturing technique ($39.83 \pm 0.35\%$) than in the Press technique ($37.59 \pm 0.62\%$).

Discussion

Successful cementation and restoration procedures depend on the strong and durable bond among resin cement, ceramics and dental structure [9]. The adhesion strength is directly proportional to the suitable cement polymerization and it is crucial to enable

Table 1 Degree of conversion (%) of resin cement (mean \pm SD)

Ceramic group	Resin cement
CAD/CAM	39.83 (0.35) A
Press	37.59 (0.62) B

Different letters indicate statistically significant differences in the mean values (Student's t-test; $p < 0.001$)

the satisfactory physical, mechanical and clinical performance of resinous materials [11]. Few studies [12, 13] have evaluated the influence of translucency on the degree of conversion of luting materials. Some authors [14, 15] investigated the light transmission and degree of conversion of the resin cement, although based on different ceramic shades and thickness. Thus, this study assessed the degree of conversion of a light-cured resin cement in two different ceramic systems, namely: Press and CAD/CAM.

Proper polymerization is important to determine the longevity of ceramic restorations [12]. Incomplete polymerization can lead to color instability [15], residual monomer toxicity [16], decreased adhesion strength [17] and postoperative sensitivity, as well as to increased risk of micro infiltration and caries [18]. In clinical terms, the correct resin cement polymerization helps maintaining physical properties of the cement and affects ceramic restoration outcomes. Based on our results, the ceramic type (Press or CAD/CAM) significantly influenced the degree of conversion of the resin cement.

It is known that resin cement polymerization can be affected if light does not reach the cement [19]—thickness and shade are some of the factors capable of hindering the polymerization process [20, 21]. Therefore, the current study only used slides with similar ceramic thickness (0.5 mm) and shade (LT A1) to prevent these factors from interfering in the degree of conversion of the resin cement. The distance between the light source and the cement layer, as well as source type, light irradiance and exposure time are other factors capable of influencing the degree of conversion [9, 22]. These factors were standardized in our study to avoid biases. Thus, ceramic sheets were glued to the photopolymerizing apparatus to avoid differences in the distance between the ceramic type and the light; the same light curing unit (1400 mW/cm² LED) and exposure time (20 s) were adopted for the light-cured resin cement. However, irradiance after the interposition of the ceramic discs was attenuated to 1280 mW/cm² in the CAD/CAM ceramic group and to 1120 mW/cm² in the Press ceramic group. It may have been the factor leading to the difference in the degree of conversion observed in our study.

During indirect restoration luting, the ceramic attenuates the light intensity and reduces the amount of photons that reach the resin-based cement [4, 12]. Thus, dual-cured resin cements are indicated to compensate the light attenuation caused by the interposition of an indirect restorative material, as well as to assure proper resin cement polymerization processes [23]. However, the light-cured cement used in the current study has received sufficient energy to enable polymerization. According to Burgess et al. [24], 16 J/cm² is the minimum energy density to be applied; thus, the present study adopted energy density 25.6 J/cm² in the CAD/CAM system and 22.4 J/cm² in the Press system. Thus, energy density was not a limiting factor for Press system. However, it is necessary conducting further studies based on energy density equivalence to validate this assumption.

The degree of conversion was analyzed through Fourier transform infrared spectroscopy—(FTIR); the CAD/CAM ceramic group showed statistically significant higher difference in the degree of conversion than the Press ceramic group when RelyX™ Veneer resin cement was used. Differences in ceramic translucency affect the degree of conversion of the cement; in addition, high-translucency ceramics present higher degree of conversion of the cement than the low-translucency ones [13]. As discs with similar shade, thickness and manufacturer were used in the current study, the CAD/CAM

system appeared to present higher translucency; however, it is necessary conducting further studies to assess this property. Moreover, Alkadi and Ruse [25] reported different crystal sizes formed during the processing of each technique. Thus, material translucency may have been affected by the size of the crystals. Therefore, according to our results, the null hypothesis was rejected because the DC of light-cured resin cement was influenced by the manufacturing techniques.

Conclusion

Based on the herein adopted methodology and materials and on the results obtained in this study, it was possible concluding that:

The light-cured resin cement activated through ceramic structure reinforced with lithium disilicate generated through the CAD/CAM manufacturing technique showed higher degree of conversion than the one generated through the Press manufacturing technique.

Abbreviations

ATR-FTIR: attenuated total reflectance Fourier transform infrared; CAD/CAM: computer-aided design/computer-aided manufacturing; DC: degree of conversion; LED: light emitting diode.

Authors' contributions

ACD, AHMG, and MBL participated in performing the experiments. SBB, GGJ and LLS contributed to the writing of the manuscript. IOFD performed the statistical analysis. RDG conceived of the study, participating in its design and coordination, helping to drafting the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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