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Effect of Ceramic Shade on the Degree of Conversion of two shades of Light Cured Resin Cements under different Lithium Silicate based Ceramics

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Abstract:

Aim: With an increase in social demand for aesthetic natural looking restorations, all ceramic restorations have gained outstanding popularity. The aim of this study is to evaluate the effect of two different ceramic shades (A2 and B1) on the degree of conversion of two different shades of light cured resin cement through three lithium silicate-based ceramics materials.

Subjects and Methods: 84 specimens were divided into 3 groups according to the type of ceramic into: Group 1: IPS Emax CAD, Group 2: VITA SUPRINITY PC, Group 3: CELTRA DUO CAD. Each group was subdivided into 2 groups according to the ceramic shade into: Sub group I: A2 LT, Sub group II: B1 LT. Each Sub group was divided into 2 divisions according to cement shade into Division I: Bisco choice Veneer cement shade A2.

Division II: Bisco choice Veneer cement shade Translucent.

Results: One-Way ANOVA revealed no significant differences between the different types of ceramic materials on the degree of conversion of resin cement at $P \leq 0.05$. A significant difference was revealed between different shades of the ceramic material on the degree of conversion

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of resin cement at $P \leq 0.05$, in which A2 shade specimens showed higher degree of conversion of resin cement than B1 shade specimens. Moreover, No statistically significant difference between different shades of the resin cements on its degree of conversion at $P \leq 0.05$. Cement with the Translucent shade showed higher degree of conversion than cement with the A2 shade.

Conclusion:

Results of this study showed that in thicknesses up to 0.5 mm of the 3 ceramic materials, ceramic shade had A significant effect on the polymerization of resin cements. Ceramic Shade A2 resulted in higher degrees of conversion than Ceramic Shade B1. Moreover, Resin Cement translucent shades showed higher degree of conversion that Resin Cement A2 shades.

INTRODUCTION

The interest in all-ceramic materials is increasing due to their adequate physical and mechanical properties, excellent esthetics, and biocompatibility which make them suitable for dental rehabilitation.[1]

Resin cements can be classified according to their activation modes. The activation mode can be chemical, physical (by light) or combination of both (dual).[3] When the restoration thickness is above 1.5-2 mm or its opacity hinders the light transmission, the use of dual cured or chemically cured resin cements is advocated to attain proper polymerization of resin cements.[2]

The strength of the bond is largely affected by the degree of polymerization of the resin cement. The term "Degree of Conversion" (DOC), refers to the conversion of monomeric carbon-carbon double bonds into polymeric carbon-carbon single bonds.[3] Increasing the conversion results in higher surface hardness, flexural strength, fracture toughness, and tensile strength. This improvement in properties may be due to the increased cross-linkage.[4]

Inadequate polymerization, characterized by low degree of conversion decreases the mechanical properties of cement and increases water sorption and solubility. Furthermore, it is proved that the increased amount of residual monomers may cause pulp irritation and irreversible pulpitis.[5] Insufficient DOC can negatively affect the mechanical properties, alter dimensional stability, and decrease the bonding of resin cements to tooth structures thus impairing the clinical longevity of the restoration.[6]

suboptimal polymerization shows potential for problems involving lower bond strengths, increased microleakage, increased potential for color changes within the composite resin and surface staining, increased wear, and possible recurrent caries.[7]

The aim of this in vitro study is to determine the effect of different ceramic shades on the degree of conversion of light cured resin cement through three different ceramic materials.

Lithium Disilicate ceramics:

IPS E-max CAD is a multicomponent partially crystallized lithium disilicate glass-ceramic. IPS E-max CAD the blocks exhibit an intermediate status ($Li2SiO3$), necessary for the milling procedures. After milling, the restoration undergoes a heat-mediated chemical reaction called sintering resulting in the lithium disilicate crystallization. At the pre-sintering stage, IPS E-max CAD blocks are supplied in a bluish color. E-max CAD restorations have excellent aesthetics and biocompatibility. Two shades were used A2 LT of 32 mm block and B1 LT of 32 mm block.[8]

Vita Suprinity:

It is partially crystallized zirconia-reinforced lithium silicate glass ceramic. Two shades were used Translucent A2 and B1 of 14 mm block. After sintering the fine-grained microstructure improves the flexural strength.[9]

Celtra DUO CAD:

It is fully crystallized zirconia reinforced lithium silicate glass-ceramics. According to the manufacturer, it comprises fine lithium metasilicate and lithium disilicate crystals in a glassy matrix containing zirconium oxide in solution. The inclusion of 10% zirconia in the glass phase ensures particularly high strength. two shades were used A2 LT and B1 LT OF 14 mm block. Celtra Duo can be finished by both glaze-firing and surface polishing but it does not need further heat treatment like Emax and Suprinity as it is fully crystallized.[10]

Light Cured Resin Cement (Bisco Choice 2 Veneer Cement):

Choice 2 is a light-cured luting cement designed specifically for cementation of porcelain and composite veneers. Two shades of cement were used A2 and Translucent.[11]

Construction of ceramic sections:

Eighty-four ceramic slices were machined from their respective blocks by using a low speed diamond saw (Buehler-Isomet LakeBulff, IL, USA) to uniform standard thicknesses of (0.5 mm and 1.0 mm)[12] A digital caliper* was used to verify the thicknesses

Crystallization:

Partially crystallized Lithium disilicate (Emax) was heat treated at 850ºC for 24 minutes. Temperature cycles were: dry time/closing for 1 minute at base temperature 400ºC, then the temperature 30ºC rises per minute, then high temperature 860ºC at holding time for 10 minutes. The vacuum starts at 550ºC and stops at 860ºC. At the end, long-term cooling cycle 700ºC for 6-7 minutes.

Partially crystallized zirconia reinforced Lithium silicate (Suprinity) was heat treated at 840ºC for 8 minutes and the procedure was as follows: initial chamber temperature was 400ºC for 8 minutes then temperature rate increased 55ºC per minute, then crystallization temperature 840ºC for 8 mins, and finally the ending temp was 680ºC.

Fabrication of Teflon moulds:

Two Teflon moulds were fabricated to ensure a standard thickness of resin cement samples, with an external diameter of 20mm×3mm thickness. An inner dimension 14×14 square shape was cut with two different thickness 0.6mm and 1.1mm to accommodate the designated thicknesses of ceramic slices 0.5 mm and 1.0mm respectively and to ensure a 0.1 mm uniform cement thickness.[13]

Curing of the cement:

The glass slab was inverted and the upper opening was used for curing the resin cement through the ceramic disc, making the mold and ceramic slice underneath and Bluephase Ascent ® PX LED curing light with intensity 1500mW/cm^2 was used to cure the resin cement throughout all the samples. A high intensity LED light was applied for 20 seconds through the ceramic slice.[14]

Preparation of cured samples:

Each one of cured samples already prepared, was ground into fine powder and mixed with potassium bromide powder. The mixture was compacted to form a disc shaped specimen for the FTIR spectroscopy.[15]

Measuring the Degree of Conversion:

Cured and uncured cement samples were collected after preparation and scanned at a resolution of 4cm^{-1} and given a blot of wave number from 4000-400cm^{-1} against absorbance peak intensities, using OMNIC 5.1[c] software connected to the FTIR unit (Fourier transform infrared spectroscopy) NICOLET 6700 (Nicolet Instrument Company, USA).[16]

Degree of conversion for each specimen was evaluated using Fourier Transform Infra-Red spectroscopy. In the MIR region, DC is determined by measuring the intensity (or area) decrease of the methacrylate (C=C) stretch absorption band at The absorption peaks of the aromatic double bonds were recorded at 1608 cm-1 (Abs 1608) and the peak of the aliphatic double bonds (C=C) were registered

* Holex digital caliper, Hoffmann Group, Germany,

at 1637 cm-1 (Abs 1637 as the methacrylate monomer is converted to polymer.[17]

The percentage of unreacted aliphatic C=C bonds remaining throughout the polymerization reaction is obtained by the equation:

DC is determined by subtracting the residual percentage of aliphatic C=C from 100% (*DC%=100-(%C=C)*

RESULTS

Effect of ceramic type on degree of conversion of resin cement

One-Way ANOVA revealed no significant differences between the different types of ceramic materials on the degree of conversion of resin cement at $P \leq 0.05$.

Effect of Ceramic shade on degree of conversion of resin cement

One-Way ANOVA revealed significant difference between different shades of the ceramic material on the degree of conversion of resin cement at $P \leq 0.05$. A2 shade specimens showed higher degree of conversion of resin cement than B1 shade specimens.

Effect of cement shade on its degree of Conversion

One-Way ANOVA revealed no statistically significant difference between different shades of the resin cements on its degree of conversion at $P \leq 0.05$. Cement with the Translucent shade showed higher degree of conversion than cement with the A2 shade.

DISCUSSION

The results of the current study revealed that:

1. There was statistically significant difference between different shades of the ceramic material on the degree of conversion of resin cement at $P \leq 0.05$. A2 shade specimens showed higher degree of conversion of resin cement than B1 shade specimens. This may be attributed to the fact that shade B1 had higher chroma values than A2 shade. This results in reduction of light transimission through ceramic and consequent reduction in the polymerization rate.[18]

2. Regarding resin cement shade, there was no statistically significant difference between different shades of the resin cements on its degree of conversion at $P \leq 0.05$; however, Cement with the Translucent shade showed higher degree of conversion than cement with the A2 shade. This may be attributed to the fact that decreasing the translucency of resin cement lead to decreasing in penetration of light energy available to convert monomers to polymers, thus decreasing the DC of cement. Guiraldo et al in 2009[19] showed that resin shade alters polymerization efficacy, and that light transmission through darker shades decreases due to its increased opacity. It was conducted that darker shades had a significant influence on light transmission through dental resin and consequently its degree of conversion. Azer et al in 2013 [20] also showed that darker shades of resin cements exhibit decreased polymerization of resin cement as darker shades attenuate the light transmission through resin cement.

Regarding the ceramic type, there was no statistical significance between the 3 ceramic types used in the study (Emax, Suprinity, and Celtra). This may be attributed to the high translucency of the three ceramics, in addition to the low thickness of the ceramic used in the study (0.5mm). This finding was confirmed by Runnacles 2014[21] who assessed the degree of convergence of resin cement with respect to ceramic type and thickness and revealed that DC of the light-cured cement through ceramics with 0.5 to 1.0 mm thickness was similar to the control ($p>0.05$), regardless of the type of ceramic. This is possibly due to the low thickness which resulted in less attenuation of light intensity. Moreover, Wang 2013[22] assessed the effect of ceramic thickness on translucency and concluded that the translucency of all materials increased exponentially as the thickness decreased. A study by Bansal 2016[23] evaluated the effect of ceramic type, thickness, and time of irradiation on degree of polymerization of dual-cure resin cement and among his conclusions was that the attenuation of light irradiance increased with increasing thickness of ceramic disks. Faria-e-Silva in 2017 [24] showed that increasing the ceramic thickness resulted in a reduction of irradiance and total energy reaching the resin cement and this resulted in decreasing of DC of resin cement.

For the results of this study, null hypothesis was rejected in regards to the effect of the ceramic shade on degree of conversion as it had significant effect on the degree of conversion of resin cement. The null hypothesis was however accepted regarding the effect of the type of ceramic on the DOC as it did not display any significant statistical changes.

Conclusion

From the light of this study based on the results the following conclusions could be drawn:

1- In Thicknesses up to 0.5 mm, ceramic shade has a significant effect on the polymerization of resin cements.

2- Higher degrees of conversion were shown with lighter resin cement shades used rather than darker ones.

3-Fully crystallized zirconia reinforced lithium silicate glass-ceramic Celtra Duo and lithium disilicate ceramic IPS-Emax CAD allow more conversion of monomer to polymer in the underlying cement than Vita Suprinity.

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