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Water sorption of light cured resin cement: The effect of Ceramic material and thickness. (In vitro study)

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Abstract

Aim: The objective of the current study is to evaluate the water sorption of resin cement under three types of ceramic material (Lithium di-silicate, Vita Enamic & Cerasmart) Using two thicknesses (0.4 & 1mm).

Methodology: Forty-two specimens will be sliced with two thicknesses (0.4 & 1mm) from Lithium di-silicate (e-max), Resin reinforced lithium di-silicate (vita Enamic), and Cerasmart blocks. Then water sorption of resin cement will be evaluated after curing through each specimen using a digital weight caliper.

Results: Results showed a significant difference in water sorption between different materials, the lowest water sorption of resin cement was found under lithium disilicate (e.max) than that of Vita Enamic and Cerasmart samples. There wasn't a significant difference between different thicknesses of Vita Enamic and Cerasmart blocks, However, in Emax samples, 1.0 mm thick samples had significantly higher water sorption values than samples with 0.4 mm thickness.

Conclusion: Within the limitations of this study it may be concluded that Lithium disilicate ceramic restorations allow more conversion of monomer to polymer in the underlying cement than polymer reinforced ceramic which allows a higher degree of conversion than resin Nanoceramics with the same thickness. Also, Hybrid ceramics with different thicknesses up to 1.0 mm have no significant effect on the water sorption of resin cement.

Keywords: Resin cement; Ceramics; Hybrid ceramics; Water sorption; Polymerization

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Introduction

All-Ceramic restorations are well-known for their aesthetic ability to imitate natural tooth color. The success of all-ceramic restorations in dentistry mainly depends on the strength and durability of the bond between the ceramic restoration and the tooth structure. (1)

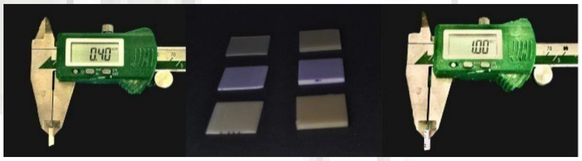
Nowadays, Adhesion plays an important role in dentistry. Adhesive cements are now used for cementation of complete and partial coverage all-ceramic restorations. The popularity of using adhesive resin cements has increased over the years as they provide maximum retention and better bond strength to tooth structure than traditional cements. (2)

Resin cements may be chemically cured, light-cured, or dual-cured. The mechanism of resin cement polymerization is a form of addition polymerization reaction, in which the smaller units (monomers) react together to produce larger cross-linked molecules (polymers). (3)

Incomplete polymerization of resin cements may be related to many reasons, but mainly it's due to the insufficient amount of light that passes through the ceramic restoration material to activate the resin cement monomers. (4) The ceramic material thickness and microstructure are the major factors that affect the light transmission through the ceramic material. (5) Failure of resin-bonded restorations may be explained by water sorption and solubility of resin cements. (6)

Materials and Methods

Forty-two specimens will be sliced using a low-speed diamond saw with two thicknesses (0.4 mm and 1 mm) from Lithium di-silicate (e-max), Resin reinforced lithium di-silicate (Vita Enamic), and Cerasmart blocks. A digital caliper was used to verify the thicknesses (Figure 1).



Two Teflon molds were fabricated with an external diameter of 20 mm×3 mm thickness, and the inner dimension 14×14 square shape was cut with two different thicknesses of 0.5 mm and 1.1 mm to accommodate the designated thicknesses of ceramic slices of 0.4 mm and 1.0 mm respectively and to ensure an 0.1 mm uniform thickness of resin cement samples.

The ceramic discs were seated on the inner stopper of the mold. Light-cured resin cement was then dispensed from the syringe on the ceramic discs, a celluloid strip (Mylar Strip) is placed to allow easy separation of the cement specimens after curing and then a glass slab was applied with pressure to ensure complete seating and uniform 0.1 mm thickness of cement created by the mold.

Light curing was done using a high intensity LED light-curing unit (3M Elipar™ Deep Cure LED Curing Lights with intensity 1470 mW/cm2) for twenty seconds where the tip was in direct contact with the ceramic disc. Figure (2)

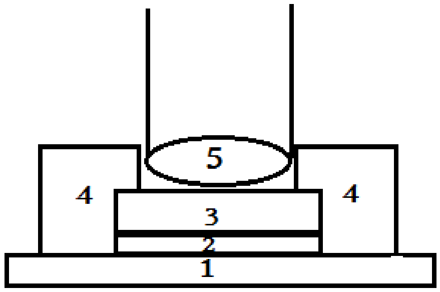


Figure (2): Diagrammatic representation of the resin/ceramic sample preparation: 1. Glass slab 2. Resin cement 3. Ceramic disk 4. Custom-made Teflon mold 5. Tip of the light-curing unit

Cement specimens were then separated from the ceramic discs, left in a black container for one day to prevent further polymerization of the cement, and then placed in a Dessicator containing freshly dried silica gel and placed in an incubator, Cement specimens are repeatedly weighted every Twenty-Four-hour interval until a constant mass (dry weight) was obtained (i.e., the variation was less than 0.2 milligram in any twenty-four-hour period) using an analytical balance of accuracy 0.001 gram.

Water sorption was assessed by weight changes, which were measured in the following manner, the first day, the third day, the fifth day, and one week until equilibrium was reached.

Water sorption was reported in weight percent (%). Wet weight was determined by the procedures described in ADA specification no. 27 for resin-based materials. Samples were removed from the water and then dried using filter paper and waved in the air for fifteen seconds to remove any apparent moisture. The final weight was taken 1 min from the time of removal from the water. The water sorption percentage was computed as follows:

Water sorption = (weight after water immersion - weight before immersion (dry weight).)/ dry weight) x100

Results

The data were collected, tabulated, and statistically analyzed. A two-way ANOVA test was used to study the effect and the interaction of the different tested variables. The significance level was set at p≤0.05 within all tests.

Numerical data were presented in table (1) and figure (3).

Table 1: Mean ± standard deviation (SD) of water sorption (%) for different materials and thicknesses

Thickness	Material (mean±SD)			p-value
	Emax	Vita Enamic	Cerasmart	
0.4 mm	1.10±1.09B	1.89±1.12AB	2.38±0.95A	0.004*
1.0 mm	2.41±1.17A	2.45±1.16A	2.47±0.46A	0.987ns
p-value	0.001*	0.131ns	0.805ns	

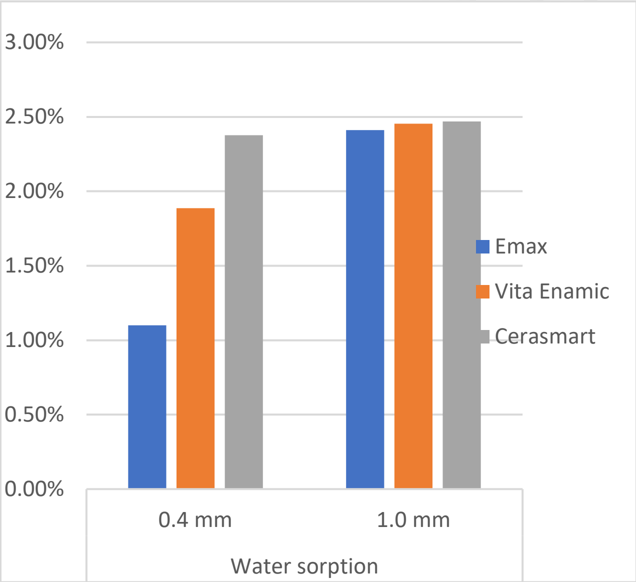


Figure 3: Bar chart showing average water sorption (%) for different materials and thicknesses

1-Effect of thickness within each material:-

A- Emax: 1.0 mm thick samples (2.41±1.17) had a significantly higher value than samples with 0.4 mm thickness (1.10±1.09) (p=0.001).

B-Vita Enamic: There was no significant difference between the samples made with different thicknesses (p=0.131).

C-Cerasmart: There was no significant difference between the samples made with different thicknesses (p=0.805).

2-Effect of Material within each thickness:

A- 0.4 mm:

There was a significant difference between samples of different materials (p=0.004). The highest value was found in Cerasmart samples (2.38±0.95) followed by Vita Enamic (1.89±1.12) while the lowest value was found in Emax samples (1.10±1.09). Pairwise comparisons showed Cerasmart samples to have a significantly higher value than Emax samples (p=0.003).

B-1.0 mm:

There was no significant difference between the samples of different materials (p=0.987). The highest value was found in Cerasmart samples (2.47±0.46) followed by Vita Enamic (2.45±1.16) while the lowest value was found in Emax samples (2.41±1.17).

Discussion

In the present study, three different types of materials (Emax, Vita Enamic & Cerasmart), cut into 0.4-mm & 1-mm slices that simulate the average thickness of dental ceramic veneers. (7) The results of this study have high clinical significance in veneer cementation procedures, compared with other studies investigating greater thickness of the ceramic.

The success of ceramic restorations depends on obtaining a strong, durable bond between the resin cement and dentin/enamel. The magnitude of these bonds is directly proportional to adequate cement polymerization. Complete polymerization of resin cement is crucial for achieving optimal physical properties and satisfactory clinical performance of resin cement. (8)

Inadequate cement polymerization under ceramic restorations is related to an insufficient amount of light radiation to activate monomers. Light intensity decreases in the function of restoration thickness and shade; therefore, ceramic material characteristics, such as microstructure, composition, optical translucency, and refraction index, may determine the amount of light transmitted and, consequently, water sorption of resin cements. (8) Therefore, ceramic material thickness and type were included as variables in this study.

Previous studies investigated the water sorption of resin cements using different curing devices, modes, intensities, tip size, and curing time. These variables showed a great effect on the water sorption of light and dual-cured resin cements. (9) Therefore, in this study, these variables were eliminated for standardization, and only one light cure device, intensity, and mode were used throughout all the specimens, 3M Elipar™ Deep Cure LED Curing Lights with intensity 1470 mW/cm2 was used to cure the resin cement throughout all the samples, the curing tip was placed in direct contact with the ceramic discs to ensure complete light penetration and transmission of maximum energy through the specimens. Curing for 20 seconds was applied to all specimens as recommended by the manufacturer.

Light cure resin cement (RelyX veneer cement) was selected for this study because of its high aesthetic properties and extended working time. Also, light-cured cements provide better aesthetics over the dual and chemical-cured cements due to the absence of aromatic amines. The properties of light-cured cements are affected by the thickness and the chemical composition of the ceramic material used. Light-cured cements are used under thin and translucent restorations where there is adequate light transmission. (10)

The shade of the underlying cement affects the final shade and opacity of restoration. Recent investigations have shown that this is true, especially in the case of thin porcelain laminate veneers where the shade of the resin cement can affect the final color of the restoration. Therefore, a translucent shade of light-cured resin cement was selected and standardized throughout the study.

Teflon mold was fabricated to ensure standardization of resin cement samples of even length, width, and thickness. Resin cements were applied inside the mold above which the ceramic disks were placed, pressed by finger pressure, and then light-curing was done. In this study, the thickness of cements was controlled at 0.1 mm to be similar to the maximum accepted cement thickness which is suitable for fitting the veneer for better stress distribution between ceramic and cement interface (11)

The samples were transferred into a glass desiccator containing dehydrated silica gel (Fischer Scientific, Leicester, UK) maintained at 37 o C ± 1 °C and stored for 1 hour, then they were maintained for another hour at 23±1 °C. The specimens were then weighted using an electronic balance with four digits precision (Sartorius, Biopharmaceutical and Laboratories, Germany). This cycle was repeated until a constant weight was achieved, i.e. dry weight or original weight. Then, each specimen was immersed and incubated in distilled water at 37 °C ± 1 °C in separate containers. Water sorption was assessed by weight changes, which were measured in the following manner, first day, the third day, fifth day, and week until equilibrium was reached (over one week). Water sorption was reported in weight percent (%). Wet weight was determined by the procedures described in ADA specification no. 27 for resin-based materials. Samples were removed from the water, blot-dried using filter paper, and waved in the air for 15 s to remove any apparent moisture. The final weight was taken 1 min from the time of removal from the water.

The results of the present study revealed that there was a significant difference in the water sorption of resin cement between samples of different materials. The highest value was found in Cerasmart samples followed by Vita Enamic, while the lowest value was found in Emax samples, so as for the different ceramic material effect on resin cement polymerization, the null hypothesis was rejected.

This may be attributed to the difference in microstructure between those materials, as the crystalline content, grain size, and shape, chemical nature, homogeneity, distribution of the particles, refractive index and porosity are important factors that have a great effect on the translucency and the optical properties of the ceramic material. [13]

Ilie et al., 2008 [14] studied the relation between translucency of ceramic material and water sorption of resin cement by studying the changes of the translucency parameter as a function of wavelength. He found great differences between samples of different ceramic materials, so he concluded that water sorption of resin cement is affected by the chemical and micro-structural composition of the ceramic materials tested. The microstructure of a ceramic material - especially its crystalline phase- could highly affect the polymerization process of the underlying resin cement due to the variations in the light scattering and the light transmission through different ceramic materials.

IPS e.max CAD (Li2Si2O5) has an approximately 70% crystalline glassy structure which allows more light penetration through it which results in the highest degree of conversion, while Vita Enamic and Cerasmart due to their hybrid structure have a lower degree of conversion. Scanning electron microscope showed that Vita Enamic has a more porous structure than Cerasmart, this structure allows more light penetration, and as a result, higher values of degree of conversion of the underlying resin cement were obtained with Vita Enamic group. These findings were confirmed by Awad et al., 2013 [15] who assessed the translucency of different CAD/CAM materials, and Usman Ashraf in 2015 [16] who studied the effect of light transmission through hybrid ceramic restorations.

Regarding the effect of thickness, for hybrid ceramics (Vita Enamic and Cerasmart), There was no significant difference between the samples made with different thicknesses. Runnacles et al. [17] investigated the degree of conversion of light-cure resin cements under ceramics of various thicknesses, he used ceramic discs with four different thicknesses (0.5 mm,1 mm, 1.5 mm, and 2 mm) and according to the results of his study, the degree of conversion of the resin cements beneath ceramic discs of thicknesses 0.5 mm and 1.0 mm were the same as those of the control group, However, there was a statistically significant decrease in the degree of conversion of resin cement beneath ceramic discs of thicknesses 1.5 mm and 2 mm. Kubilay barutcigil in 2020 [18] studied the effect of thickness and translucency of hybrid ceramic materials on the degree of conversion of light-cured and dual-cured resin cements, he used four different thicknesses 0.5, 1.0, 1.5, and 2.0 mm, and found that the increase in the thickness of hybrid ceramic caused a great decrease in the degree of conversion of light-cured resin cements, especially at thicknesses 1.5 mm and above.

For IPS e.max CAD, there was a significant difference in water sorption between samples made with different thicknesses (0.4 & 1 mm). El-Mowafy et al. [19] found a significant decrease in the light intensity of the curing unit from 700 mW/cm2 to approximately 270 mW/cm2 with ceramic thicknesses over 1 mm. He also found that the decrease in light intensity was more rapid above ceramic discs of thickness 1 mm. Seok Hwan Cho in 2015 [20] studied the effect of different thicknesses of pressable ceramic veneers on polymerization of light-cured resin cement, he used four ceramic thicknesses (0.3, 0.6, 0.9,1.2) and found that the degree of conversion and hardness of the resin cement was unaffected with veneering thicknesses between 0.3 and 0.9 mm. However, the 1.2 mm group has a significantly lower degree of conversion. Lee et al. [21] studied the curing efficiency of different resin cements through different ceramic materials and thicknesses and highlighted the importance of increasing curing time because according to his results the curing time recommended by the manufacturers was insufficient to compensate for the attenuation of light by the restoration thicknesses; he stated that the time recommended by the manufacturers roughly corresponded to the times needed to achieve a maximum hardness of cements directly exposed to light.

Conclusion

Within the limitations of this study, it may be concluded that

1-Lithium disilicate ceramic restorations allow more conversion of monomer to polymer in the underlying cement than polymer reinforced ceramic which allows a higher degree of conversion than resin Nanoceramics with the same thickness.

2-Hybrid ceramics with different thicknesses up to 1.0 mm has no significant effect on the water sorption of resin cements.

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