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Effect of Monolithic Zirconia Thickness on Light Transmission and Microhardness of Resin Cement

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ABSTRACT

Aim of the study: the aim of this study was to investigate the influence of different thicknesses for two types of monolithic zirconia on light intensity and microhardness of underlying resin cement. Material and method: 48 specimens of two types of monolithic zirconia which are Copra Supreme (CSP) and Copra Smile (CSM) were fabricated using CAD CAM machine with three different thicknesses (0.5mm,1mm, 1.5mm). Intensity of light transmitted through the zirconia was calculated using a radiometer. Discs of dual cure resin cement prepared and light activated through the zirconia specimens, all samples subjected to Vickers microhardness test. Data were analyzed using ANOVA, Tukey HSD, Dunnett's tests, and t-test at (α = 0.05).

Results: The thickness and type of monolithic zirconia had a significant impact on light transmission and microhardness (p-value <0.05). Light intensity and microhardness were significantly decreased for both zirconia types. There was significant difference among different thicknesses of each zirconia type. CSP zirconia showed significant fewer values than CSM zirconia in all thicknesses.

Conclusion: The increase in the monolithic zirconia thickness might reduce the intensity of transmitted light and microhardness of resin cement. CSM zirconia had less effect on light intensity and microhardness than CSP zirconia.

Key words: Monolithic zirconia, Light intensity, Cement microhardness

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INTRODUCTION

Zirconia restorations become more attractive in comparison to metal-ceramic ones because of their improved esthetics and their chemical and biological compatibility [1]. Yttria tetragonal zirconia polycrystal (Y-TZP) was introduced in dentistry, as a framework material which must be veneered with either glass-ceramic or porcelain due to its high opacity [2]. Unfortunately, clinical throwbacks raised with the use of Y-TZP because it needs to be covered with veneer layer. The veneering layer is prone to fracture, and this is typically accompanied by chipping and delamination [3]. Monolithic zirconia restorations were developed in order to overcome the issue of a weak veneering layer. The involvement of this unique ceramic material into dental applications improved all-ceramic restoration optical and wear properties [4].

Monolithic restorations are manufactured using computer-aided design/computer-aided manufacturing technology; it's developed by adding various dopants, coloring solutions, and adjusting the sintering temperatures to produce material with higher translucency [5]. Compared to conventionally veneered ceramics and metal-ceramic restorations, these restorations require less tooth preparation because they are not veneered with porcelain. it is more easily processed than bilayer restorations [3]. The luting material, in addition to the zirconia material, plays a critical role in the esthetic quality and longevity of CAD/CAM restorations. Usually, resin cements are used with ceramic restorations because of their characteristics of, suitable esthetic quality, good bond strength with enhanced mechanical characteristics which can reinforce the ceramic restoration [6].

For cementing zirconia restorations, three types of resin cements are available. Which are light-cured (LC), dual-cured (DC), and auto-cured. LC and DC resin cements require sufficient light for optimized polymerization [7]. The lifespan of resin-bonded zirconia restorations depends on adequate polymerization. Incomplete polymerization causes reduced bond strength, color instability, toxicity from leftover monomer, and post-operative sensitivity. Also, it has a negative impact on physical and mechanical characteristics of resin cement [8]. Many factors may influence the polymerization of resin cement, like thickness, translucency and shade of zirconia; composition of the cement; and polymerization type [7].

in purpose to evaluate adequate polymerization of resin cement, Surface Microhardness can be used. Its definition is the material resistance to be indented by a subject and it is utilized as a reliable connection with degree of polymerization, showing that as degree of polymerization raises the microhardness value increases [9]. Resin cement polymerization is affected by ceramic restoration thickness. Lee et al demonstrated that thickness of ceramic has a significant impact on light transmission and polymerization efficiency [10]. It was claimed that increasing the zirconia thickness from 0.5 to 1 mm results in a 10% reduction in translucency which may affect the transmitted curing light [11].

The purpose of this study was that to evaluate the impact of different thickness for two types of monolithic zirconia on the light transmission and microhardness of underlying dual cure resin cements.

MATERIALS AND METHODS

Zirconia specimen preparation

In this study, two types of commercially available presintered monolithic zirconia blocks (Copra Supreme, Copra Smile; Whitepeaks Dental Solutions) were used. A total of 48 zirconia disc samples were designed and milled using CAD software and CAM system (CAD\CAM machine) from zirconia block (24 from each block). They were classified according to zirconia thickness into three subgroups (N=8): 0.5mm, 1mm, and 1.5mm, with standard diameter of 10 mm for each disc. The thickness of each sample was confirmed by utilizing digital Vernia [6]. All discs were ultrasonically cleaned in distilled water for about 10 minutes to eliminate any debris contamination [1].

Light transmission measurement

The light transmittance value of LED curing light unit (Ivocular Vivadent) was measured for each zirconia type and thickness by using radiometer (Optilux, Kerr). This was done by putting the disc on the radiometer aperture and recording the intensity of light which emitted from light curing unit and passed through the disc [6]. An average of three readings was recorded for each disc measured in mw/cm^2. As control value, an unobstructed (without disc) light transmission value was recorded [9].

Resin cement specimens' preparation

A total of 56 Dual cure resin cement (ESTECEM plus, Universal) discs were prepared. They were classified into seven groups (n=8), 6 experimental groups which activated through the 6 zirconia specimens' groups and one control group. Resin cement was placed in a central hole of Teflon mold, measurements of the hole were 10 mm for diameter and 1mm for depth. Celluloid strip was placed over resin cement, this was ensured even surface and provided isolation during polymerization [6,9]. The resin cement specimens were polymerized through the prepared zirconia discs using LED curing unit for about 40 sec [6]. For control croup, specimens of resin cement were directly light-cured under celluloid strip without the existence of zirconia disc [6]. After the procedure of light curing finished, resin cement specimens stored in deionized water in an incubator at 37 for about 24 hours before testing [9] to ensure complete polymerization of dual cure resin cement.

Microhardness test

After storage, the value of microhardness was obtained by using Vickers's microhardness universal testing machine. Indentations were made on the top surface of cement specimens, which is the surface close to light, by using a load of 10 N, dwell time of 10 sec, and 10 indentations. The next formula was used to work out the value of the surface microhardness [12]:

VH= 0.1891 F/d2 (kgf/mm^2).

Where VH is the value of Surface microhardness, F is the loading force which pressed on specimen surface, d is the length of diagonal shape created by the indenter measured in millimeters.

Statistical analysis

Data were analyzed using SPSS software program at 0.05 significance level ($\alpha = 0.05$). ANOVA test and post hoc Tukey's HSD test were made to investigate and analyze differences among different thicknesses of each material. Dunnett's test was performed to compare between control vs all other experimental groups. Also, Independent sample t-test was performed to compare between two zirconia types for each thickness.

RESULTS

For light transmission measurements, as shown in Table 1 which display analysis of light intensity mean values for CSP and CSM zirconia groups, both CSP and CSM zirconia showed significant decrease in light intensity for their all subgroups when they compared with control value (P<0.05). CSP revealed significant lower values than CSM in all thicknesses (P<0.05). Within each zirconia subgroups, CSP zirconia showed significant decrease between all different thicknesses (0.5mm<1mm<1.5mm). In CSM zirconia light intensity was decreased but significant difference was shown only with 1.5 mm thickness.

For Vickers microhardness, as shown in Table 2 which display analysis of microhardness mean values of resin cement for both CSP and CSM zirconia groups, Both CSP and CSM zirconia showed significant decrease in resin cement microhardness when they compared with

Table 1: Light transmission values (mW/cm2) mean ± standard deviation for two types and three thicknesses of zirconia.

Zirconia type	0.5 mm Thick	1 mm Thick	1.5 mm Thick
Copra Supreme (CSP)	711.375 ± 13.45Aa	586.625 ± 47.33Ba	352.75 ± 18.21Ca
Copra Smile (CSM)	825.625 ± 45.19Ab	773.25 ± 18.60Ab	684.25 ± 56.91Bb
Control (Without Zirconia)		1100 ± 0.00*	
Different capital letters in the same row represent significant difference among 3 different thicknesses (P<0.05)			
Different small letters in the same column represent significant difference in each thickness between 2 zirconia types (P<0.05)			
*Indicates significant difference of control from all other groups (P<0.05)			

Table 2: Vickers microhardness values (VHN) mean ± standard deviation of resin cement with two types and three thicknesses of zirconia.

Zirconia type	0.5 mm Thick	1 mm Thick	1.5 mm Thick
Copra Supreme (CSP)	22.5625 ± 1.23Aa	18.7388 ± 0.84Ba	13.2275 ± 0.82Ca
Copra Smile (CSM)	27.1263 ± 0.83Ab	25.225 ± 0.72Ab	20.6563 ± 0.80Bb
Control (without zirconia)		31.3913 ± 0.60*	
Different capital letters in the same row represent significant difference among 3 different thicknesses (*P*<0.05)			
Different small letters in the same column represent significant difference in each thickness between 2 zirconia types (*P*<0.05)			
*Indicates significant difference of control from all other groups (P<0.05)			

control group (P<0.05). CSP also showed significant lower values than CSM in all thicknesses (P<0.05). Within each zirconia subgroups, CSP zirconia showed significant decrease between all different thicknesses (0.5mm<1mm<1.5mm). In CSM zirconia microhardness also showed significant decrease only with 1.5 mm thickness.

DISCUSSION

All ceramic restorations are typically cemented with resin cements. The appropriate resin polymerization produces a good binding between the tooth and the restoration, making it a crucial component in maintaining the durability of a restoration [13,14]. Dual-cured resin cements are preferred in ceramic restoration as its thickness or opacity may affect light transfer and lead to incomplete polymerization of light cured ones [15].

In dentistry, the used zirconia characterized by it's a distinctive structure made up of two phases: tetragonal and cubic. This led to improved mechanical and translucency qualities [16]. New monolithic zirconia ceramic types continue to be released under various brands and with varying degrees of translucency [1].

In this present study, Copra Supreme (CSP) and Copra Smile (CSM) which are two monolithic zirconia ceramics of a single manufacture were used.

These two materials are different in the percentage of Y_2O_3 contents which affect their translucency. CSP consists of 6.93%–6.97% Y_2O_3, 0.05% Al_2O_3 and CSM consist of 9.92% Y_2O_3, 0.15%–0.35% Al_2O_3, respectively. Increasing the amount of Y_2O_3 in the composition of CSM caused a higher translucency due to greater cubic content in its microstructure [1].

Three different thickness of each material were chosen as the thickness of zirconia restoration clinically are varies from cervical to incisal portions. Light intensity and Vickers microhardness of resin cement with each thickness of both materials were measured. Light intensity is considered one of the most essential aspects influencing cement polymerization, and Surface hardness is considered an effective method for assessment the polymerization of resin cement [17].

Light intensity which used in this study was 1100 mw/cm^2 as measured by a radiometer, and it was sufficient to obtain the highest value of surface microhardness of resin cement without presence of zircon disc (control). However, when light irradiating through zirconia discs, light intensity was significantly decreased in both materials (CSP and CSM) with lower values in CSP zirconia. Moreover, as the thickness of zirconia discs increased the light intensity was significantly decreased, especially with CSP material. In conjunction to light intensity, surface microhardness showed related effects. Resin cement samples which received lower light intensity had less Vickers microhardness than those receiving higher light intensity. So, as zirconia thickness increased resin cement hardness decreased. also resin cement which polymerized under CSP zirconia discs had less microhardness than CSM zirconia discs in all thicknesses and all were significantly less than the control.

These results may imply to that all zirconia specimens include an additive like Al_2O_3 which may cause light scattering, also when zirconia thickness increases, the transmitted light becomes low because of light scattering at the zirconia grain boundaries [6]. This low light intensity effects on polymerization of resin cement and illustrate the decrease in microhardness.

CSM zirconia has higher Y_2O_3 contents which mean higher cubic phase ratios. Cubic formation of grains produces larger grains with fewer grain boundaries. This may lead to less amount of light scattering at these small amounts of grain boundaries which improve polymerization and microhardness of resin cement [1].

For CSP zirconia, resin cement microhardness was significantly decreased as the disc thickness increased from 0.5 to 1.5 mm. while in CSM zirconia, microhardness decreased but with less rate. Significant decrease was shown only with 1.5 mm thickness. This may be due to that CSM zirconia is intended to have a more uniform grain size distribution which lead to increase the translucency [1]. High-translucency ceramics are less affected by ceramic thickness than low-translucency ceramics [17].

The results of this study agree with Meng et al. study, which demonstrated that intensity of passed light was decreased when ceramic thickness increased. So, the degree of polymerization reduced and, as a result, resin cement hardness was reduced [18]. Llie, et al. found that curing light can be transmitted, absorbed or scattered through ceramics, dental ceramics can absorb about 40–50% of light intensity [19].

In addition, a study carried out on both light and dual-cured cements by Bansal et al. using various ceramic thicknesses exhibiting the gradual decrease in hardness as ceramic thickness increases [20]. Pishevar, et al. also found that the dual-cured resin cement showed noticeably hardness decrease as ceramic thickness increased, and light transmission decreased proportionately [21].

CONCLUSION

The increase in the monolithic zirconia thickness might reduce the transmitted light intensity and in turn, decrease resin cement microhardness. Zirconia with higher translucency (CSM) had less effect on light transmission and hardness than zirconia with less translucency (CSP).

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