Original Research

The Effect of Lithium Disilicate Ceramic Thickness and Translucency on Shear Bond Strength of Light-cured Resin Cement

Mohammad Javad Moghaddas[1], Hamideh Sadat Mohammadipour[1, 2], Roya Amiri Daluyi[1, 2], Azin Jahan Nia[3]

[1] Department of Restorative and Cosmetic Dentistry, School of dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Dental Materials Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
[3]Student of dentistry, Mashhhad University of Medical Science, school of dentistry, Mashhhad,Iran

Received 4 May 2017 and Accepted 9 June 2017

Abstract

Introduction: To achieve acceptable clinical performance, a ceramic veneer must be bonded to enamel by well-polymerized resin cement. Among different factors, thickness and translucency of the ceramic may affect the resin cement polymerization. Thus, the current study evaluated the effect of the thickness and translucency of lithium disilicate ceramic on light-cured resin cement bond strength to enamel. **Methods:** In this laboratory study, 208 sound bovine incisors were equally divided into 16 groups (n = 13). The lithium disilicate ceramic cubes in four thicknesses (0.4, 0.6, 0.8 and 1 mm) with four translucencies (high and medium opaque, high and low translucent) were fabricated and bonded to prepared enamel surfaces using a light-cured translucent resin cement according to manufacturer recommendations. After 5000 cycles of thermocycling, the bonded specimens were placed in a universal testing machine and loaded to the point of fracture. To determine the mode of failure, each sample was observed under a stereomicroscope. Data were recorded and analyzed by Shapiro-Wilk test and two-way analysis of variance (ANOVA). **Results**: The ceramic thickness and translucency could not significantly affect shear bond strength (SBS) of resin cement to enamel (p = 0.17 and p = 0.097, respectively). The Adhesive and ceramic cohesive failures were reported as the maximum and minimum mode of failure, respectively. **Conclusion:** The SBS of the light-cured resin cement bonding to enamel and lithium disilicate ceramic was not affected by the translucency of ceramics having a thickness of less than 1 mm.

Keywords: Dental veneer, IPS-emax press, Resin cement, Shear strength, Translucency.

Moghaddas MJ, Mohammadipour H, Amiri Daluyi R The Effect of Lithium disilicate Ceramic Thickness and Translucency on Shear Bond Strength of Light-cured Resin Cement**.** J Dent Mater Tech 2017; 6 (3): 108-116.

Introduction

The increased demand by patients and dentists for highly esthetic treatments has increased the trend toward metal-free or ceramic restorations (1). Ceramic veneers have been popular esthetic treatments since their introduction in 1983 because of their strength, longevity, conservative nature, biocompatibility and esthetics (2). These restorations are perceived as the most conservative types of ceramic restorations to correct the inappropriate color, shape and position of defective or misaligned teeth (3).

Achieving high strength in small thicknesses for ceramic veneers, the glass ceramic structure should be reinforced by adding the appropriate amount of fillers (1, 2). In lithium disilicate ceramic, the crystal content of a glass ceramic increased to approximately 70% (2). As a result, this moderately strong ceramic with favorable mechanical properties such as high flexural strength (4) can be prescribed not only for ceramic veneers but for use in full-contour restorations (2). A wide range of translucencies from highly translucent to highly opaque, makes the lithium disilicate ceramic as a good option to either simulate natural tooth appearance or mask severe tooth discoloration respectively (2). Moreover, the popularity of this type of ceramic has increased because of its susceptibility to acid, which creates a reliable cement-ceramic adhesion (2).

Non-retentive conservative preparations of ceramic veneer, which commonly have no undercut or retentive points, require strong and stable adhesion between the resin cement, ceramic and tooth structure (5). Achieving this adhesion can be overcome some drawbacks of ceramic such as brittleness and increase clinical success and longevity (6, 7). Resin cements with good mechanical properties, a wide range of esthetic shades, high bond strength to tooth structure (8), superior retention (9) and lower solubility compared with conventional luting agents (8) are suggested for veneer bonding. However, without well polymerization, access to such favorable resin cement characteristics may be impossible (10).

(why occasionally? It seems it is always important), It was highly important for light cured resin cements to deliver sufficient light curing through the ceramic restoration (8). The light delivered to the cement layer through lithium disilicate ceramic decreases by approximately half for less than 1 mm of ceramic thickness (11). If the resin cement is not well-polymerized, the mechanical properties, bond strength and dimensional stability will decrease (8, 9) and susceptibility to water sorption and solubility will increase. Thus, the cement will become more prone to degradation and debonding (5, 12). This event may be more deteriorative in ceramic veneer than in other ceramic restorations which rely only on enamel adhesion. In addition to secondary caries, color changes and post-operative sensitivity (8, 9), non-reactive cement monomers may cause toxicity and (9), pulp irritation .They may also generate local inflammatory responses (5), which reduce biocompatibility.

The polymerization effectiveness of resin cement in the point of ceramic thickness and translucency has remained challenging in clinical situations.

To evaluate the effectiveness of light transmission through ceramic material, researches have mostly focused on the degree of conversion or hardness (3, 8, 9, 11, 13), while few studies have addressed the evaluation of bond strength (7, 14, 15). Akgungor et al. (16) reported that the thickness of lithium disilicate ceramic has no effect on the shear bond strength (SBS) of light-cured resin cement bonded to dentin. Also, previous studies revealed that the degree of conversion of light-cured resin cement did not depend on the thickness and translucency of the ceramic employed when the veneer cemented is less than 1 mm in thickness (9, 10). Although, the negative effect of thickness of the restorative material on the degree of conversion of resin was previously presented (17). While a previous study reported deteriorative effects of the opacity of ceramic on light transmission and the degree of conversion of the luting material (3), Alghaith et al. (13) found no significant differences in the micro-hardness of light –cured resin cement to lithium disilicate ceramic at translucency levels of 0.5 to 1 mm in thickness.

To the best of our knowledge, no study has evaluated the effect of the translucency and thickness of lithium disilicate ceramic on the SBS of resin cement for an enamel substrate. The current in vitro study evaluated the effect of ceramic thickness (0.4, 0.6, 0.8 and 1 mm) and translucency of the lithium disilicate ceramic (high and medium opaque, high and low translucent) on the bond strength of light-cured resin cement bonded to enamel. The null hypothesis was that neither thickness nor translucency has an effect on the bond strength of the enamel-cement-ceramic complex.

Methods and Materials

Sample preparation

Enamel preparation

This in vitro study was performed on 208 sound bovine incisors. The teeth were first cleaned with a rubber cap and slurry of pumice and examined under a ×10 magnification stereomicroscope (Dino lite Pro; Anmo Electronics; Taiwan) and those with cracks, developmental and structural defects were discarded. The teeth were stored in 0.1% Thymol solution at room

Temperature until study initiation. After collecting all the required teeth, the anatomic crowns were separated from the roots on the CEJ level with a slow-speed water-cooled diamond saw (CNC Machine; Nemo; Iran) and they were embedded in self-cured acrylic resin (Acropars; Marlic; Iran) to obtain approximately a 3×3 mm2 enamel window at the center of the buccal surface. To provide flat surfaces suitable for cement bonding and SBS measurement, the enamel surfaces were serially polished with 400, 600 and 800 grit silicon carbide papers (Starcke; Germany) under cooling water flow.

Ceramic preparation

The 208 lithium disilicate based ceramic cubes (IPS e.max; Ivoclar Vivadent; Liechtenstein) having 3×3 mm2 cross-sections were fabricated using the lost wax technique in four translucencies including high opaque (HO), medium opaque (MO), in shade 1 and high translucent (HT) and low translucent (LT) in shade A2, and four thicknesses (0.4, 0.6, 0.8 and 1 mm). No glaze was applied to the ceramic cubes. The specimens were immersed in distilled water to remove surface residues and dried, then examined under a magnifier to discard those with visible flaws, cracks and other surface defects. The ceramic samples were classified into 16 groups of 13 samples each as shown in Figure 1.

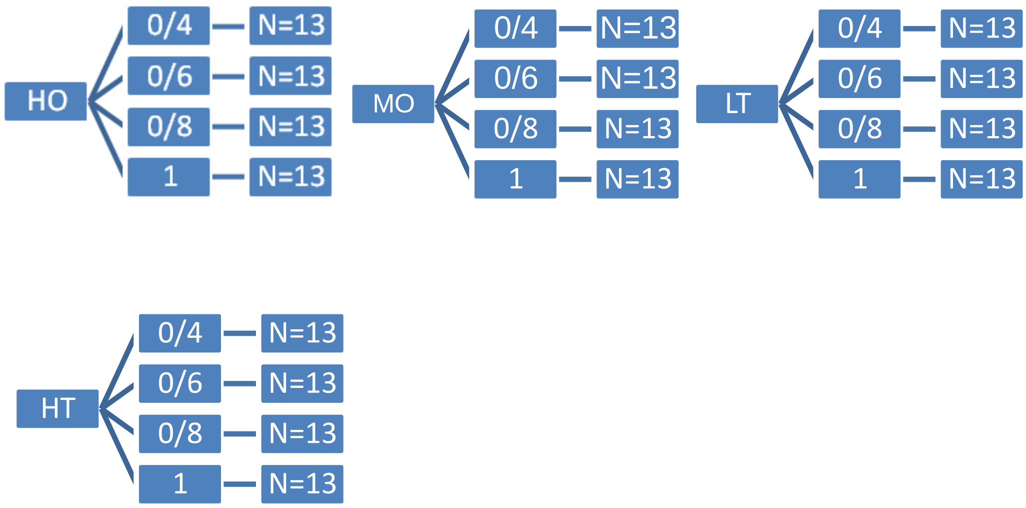

Figure 1. Classification of study groups

Surface treatment

Enamel surface treatment

The exposed enamel surfaces were treated with 35% phosphoric acid (Ultraetch; Ultradent Products; USA) for 30 s, rinsed with copious amounts of water for 5 s and then air-dried to produce a frosted appearance. The bonding agent (All Bond Universal; Bisco; USA) was applied to the etched enamel according to manufacturer instructions. The solvent was gently air-evaporated and then light polymerized for 10 s with a light-curing device (Blue phase C8; Ivoclar Vivadent; Liechtenstein) that was set at a power density of 650 Mw/cm2.

Ceramic surface treatment

Each adherent ceramic surface was treated with 9.5% hydrofluoric acid (Porcelain Etchant; Bisco; USA) for 90 s. The gel was rinsed off with copious amounts of water and the surface was air-dried. Following acid etching, a silane coupling agent (Bis-Silane; Bisco; USA) was applied to the ceramic surface and allowed to remain for 30 s according to manufacturer recommendations. The surface was then gently air-dried with water-free spray. An adhesive resin (Porcelain Bonding Resin; Bisco; USA) was applied in a thin layer to the silane-treated ceramic surface and remained without light-curing as suggested by the manufacturer.

Light-cured translucent resin cement (Choice II; Bisco; USA) was used for ceramic bonding. To ensure that an equal volume of resin cement was applied to each enamel specimen , about 2 mm of resin cement which was extruded from the tip of cement syringe was put on the enamel surface and the ceramic cube was then pressed onto the cement under 200 g of force for 20 s. After removing the excessive cement with a dental explorer, the bonded samples were cured with a light-curing unit (Bluephase C8; Ivoclar Vivadent;

Liechtenstein) from a distance of 4 mm above the specimens for 40 s.

To assimilate the distance of the tip of the light guide from the bonded specimen and avoid surrounding light exposure, a metallic cylinder having the aforementioned height (4 mm) was fabricated and curing was done through the cylinder. All procedures were carried out by one experienced operator. After termination of bonding procedures, the bonded samples were stored in distilled water for 24 h in an incubator at 37°C and 100% humidity. To simulate thermal aging, the specimens were subjected to 5000 thermal cycling between 5 and 55 oC in deionized water with a dwell time of 30 s and transfer time of 20 s. The materials used are listed in Table 1.

Table 1. Materials used in this study

Type	**Material**	**Main Composition**	**Company**	**Lot No**
Ceramic	IPS E.max	Lithium disilicate crystals (Approx. 70%)	Ivoclar Vivadent, Schaan,Liechtenstein	
Dental Etchant	Ultraetch	35% Phosphoric Acid	Ultradent Products Inc., South Jordan, USA	
Porcelain Etchant	Bisco	9.5% Buffered Hydroflouric acid	Bisco,Schaumburg, IL, USA	1600001052
Silane coupling agent	Bis Silane	Ethanol30-95%. Silane 1-10 %(Part A only)	Bisco,Schaumburg, IL, USA	1600001078
Porcelain Bonding Resin	Bisco	Bis-GMA<40 %. Urethane dimethacrylate<40 %. Tri-EDMA<30 %. (HEMA Free)	Bisco,Schaumburg, IL, USA	1600001059
Veneer Cement	Choice 2	Strontium Glass<75 %. Amorphous Silica<25 %. Bis-GMA<10.	Bisco,Schaumburg, IL, USA	1600000840
Dentin Bonding Agent	All Bond Universal	Ethanol>20 %. Bis-GMA>20 %.	Bisco,Schaumburg, IL, USA	1500005510

P

Debonding procedure

For bond strength evaluation, each sample was mounted in a holding device within a universal testing machine (Santam; model STM-20; Iran) to import the shear bonding force to the adhesive interface until fracture occurred. A cross-head chisel was placed perpendicularly to the enamel-cement-ceramic complex and the specimens were loaded at a speed of 0.5 mm/min. The SBS was calculated (MPa) by dividing the load at failure point (N) by the surface area of the enamel-ceramic bonding (9 mm^2).

Fracture analysis

After the specimens were fractured and removed from the testing apparatus, the fracture sites were examined under a stereomicroscope (Dino lite Pro; Anmo Electronics; Taiwan) at ×20 magnification to identify the type of bond failure. The fracture modes were classified according to Irie and Watts (18), who described different failure modes as: adhesive failure (at the interface of the resin cement with ceramic or enamel substrate), cohesive failure (within the resin cement, ceramic bulk or enamel substrate) and mixed failure mode (combination of adhesive and cohesive failure).

Statistical analysis

The normal distribution of the data was checked by Shapiro-Wilk analysis. Two-way analysis of variance (ANOVA) was applied to detect any significant difference in SBS value between groups. A 95% confidence interval was used to evaluate the statistical significance using SPSS software (version 21.0; SPSS; USA).

Results

The assumption of normality was determined by Shapiro-Wilk test ($p > 0.05$ for all study groups). Two-way ANOVA showed no significant difference in SBS values for the interaction of translucency and thickness between groups ($p = 0.19$). Tables 2 and 3 show the descriptive information for mean values, standard deviation (SD) and the maximum and minimum SBS of the study groups with regard to translucency and thickness of lithium disilicate ceramic.

The results of the current study presented no significant difference among study groups for translucency ($p = 0.097$). The maximum and minimum SBS values were revealed in LT and HT groups respectively. The results of the effect of ceramic thicknesses showed that the maximum SBS was for the 1 mm thickness and the minimum was for the 0.4 mm thickness. There was no significant difference in mean SBS between study groups for ceramic thickness variable There was no significant difference between groups for ceramic thickness variable ($p = 0.17$).

The different failure modes between groups for translucency and thickness of lithium disilicate ceramic are presented in Tables 4 and 5, respectively. Adhesive failure was the predominant mode of failure (38.5%) and cohesive failure of ceramic (1.4%) was the least common mode of failure when categorized by translucency. The predominant mode of failure categorized by thickness was adhesive failure (38.5%) and the least common mode was cohesive failure of ceramic (19.2 %) which is similar to that for translucency.

Table 2. Shear Bond Strength of Study Groups with different Translucencies

	Study groups	Mean_+ SD	Min	Max	
Translucency	High Opacity (HO)	20.56 ± 5.39	6.10	35.00	P= 0.097
	Medium Opacity (MO)	20.66 ± 7.70	1.00	38.00	
	High Translucency (HT)	19.35 ± 7.29	1.00	42.15	
	Low Translucency (LT)	22.49 ± 5.19	6.50	33.14	

Table 3. Shear Bond Strength (MPa) of Study Groups with different Thicknesses.

	Study groups	Mean_+ SD	Min	Max	
Thickness	0.4 mm	19.39 ± 6.29	3.10	38.00	P= 0.17
	0.6mm	20.32 ± 6.89	1.00	35.00	
	0.8mm	21.35 ± 5.92	6.50	33.14	
	1mm	22.02 ± 6.88	1.00	42.15	

Table 4. Mode of failures in different translucencies.

Study group	Adhesive (n)	Mixed Failure(n)	Breaking Failure(n)	Cohesive cement(n)	Cohesive ceramic(n)	Cohesive enamel(n)	Total (n)
HO	13	6	7	13	0	13	52
MO	22	9	7	9	1	4	52
HT	23	4	6	10	1	8	52
LT	22	8	5	8	1	8	52
Total	80	27	25	40	3	33	208

Table 5. Mode of failures in different thicknesses.

Study group	Adhesive (n)	Mixed Failure(n)	Breaking Failure(n)	Cohesive cement(n)	Cohesive ceramic(n)	Cohesive enamel(n)	Total (n)
0.4 mm	26	6	6	13	3	3	52
0.6 mm	22	9	13	8	0	7	52
0.8 mm	9	4	16	10	0	16	52
1mm	23	8	13	9	0	7	52
Total	80	22	25	40	3	33	208

Discussion

In the current study, the effect of translucency and thickness of lithium disilicate ceramic on the shear bond strength (SBS) of light-cured resin cement was investigated. To evaluate the effectiveness of light transmission through ceramic materials and polymerization of resin cements, most of laboratory researches have focused on the degree of conversion or hardness of resin cements (3, 9, 11, 13). Although these factors do not directly relate to clinical success, it has been shown that increased monomer conversion is the first step to achieve maximum mechanical properties (19). Also, hardness can provide a good correlation with the degree of polymerization of resin materials. The current study evaluated SBS, because it has been accepted that shear stress is the primary cause of bonding failure of all restorative materials (16).

In clinical cases, inadequate polymerization of resin cement, results in early loss of restoration and lower clinical longevity. Light-cured resin cement, which offers on-demand working time (3, 6) and greater color stability due to the lack of amines, is recommended for veneer cementation (3). Light transmittance can be affected by factors related to ceramic including thickness, translucency, color and type of ceramic (3, 6, 10, 20), to resin cement such as a polymerization mode (8) and factors related to light-curing devices such as curing mode and light intensity (3). According to the aim of the present study, two of the important ceramic- related factors on resin cement bond strength were evaluated.

The outcome of this study revealed that in ceramic groups with the same translucency, the thickness of ceramics did not affect the SBS of the resin cement ($p = 0.17$). The effect of ceramic thickness on the degree of conversion (18), hardness and bond quality of resin cement in the literature is controversial. In a previous study, the Empress 2 ceramic specimens with a thickness of less than 2 mm did not affect the bond strength of light- and dual-polymerized resin cements to dentin substrate (16). The authors used 1, 1.5 and 2 mm ceramics thicknesses which were suitable for crowns and inlays fabrication in clinical settings and attributed this outcome to the longer light exposure time of 60 s (16). The ceramic samples for the current study were fabricated in four thicknesses less than 1 mm (0.4, 0.6, 0.8 and 1 mm) according to conservative tooth preparation for ceramic veneers in clinical situations (21).

It was reported a thickness limit for any types of ceramics in previous studies at which the DC, hardness and polymerization of resin cements suddenly decreased. Ilie and Hickel (11) presented that the limited threshold at which the cement hardness decreased significantly for lithium disilicate glass-ceramics was in 1 mm, while for leucite-reinforced glass ceramic, which is less dense, this effect occurs at a thickness of 2 mm. In agreement with the previous study, Zhang et al. (22) reported a sharp drop in the light intensity curve at 1 mm of lithium disilicate ceramic thickness. Another study reported that IPS Empress ceramic thicknesses above 3 mm can adversely affect the micro-hardness of resin cement (8). Although, total irradiance was transmitted through E.max press ceramic discs significantly decreased from 37% to 9% with increase thickness from 1 to 3 mm (22), it can be sufficient to achieve acceptable cement polymerization and bond strength. These conflicting reports on the effect of ceramic thickness may attribute to the type, nature and fabrication method of the ceramics. Lithium disilicate ceramic is more opaque and denser than leucite-reinforced glass ceramic. The presence of two crystalline phases with different refracting indices offers more light scattering (11).

Regarding to previous literature, it appears that thicknesses of 1 mm or less of lithium disilicate ceramic, despite of adversely limiting light transmission, did not affect the hardness, DC and bond quality of the resin cements (11, 22). In a clinical setting, the thickness of the ceramic veneer is generally at or below 1 mm on the facial surface and can increase to 1.5 to 2 mm on the incisal edge. Thus, a thickness of 1 mm or less, which is applied for veneer fabrication in clinical settings, has little or no effect on light transmission and bond quality. These statements completely confirmed the outcome of this study in which the lithium disilicate ceramic thicknesses lower than 1 mm could not affect the SBS of light-cured resin cement to enamel. Confirming the present study findings, in Cho et al. (9) study, the micro-hardness and DC of light- and dual-cured resin cements could not be affected by the E.max press ceramic thicknesses less than 1 mm. Also, De Souza et al. (5) indicated that the effect of light attenuation on the DC was not significant for ceramic thicknesses of 1.0 mm or less.

In this investigation, maximum and minimum mean SBS without considering translucency variable was respectively recorded for samples which have 1 mm and 0.4 mm thickness. This can be attributed to the difference between cement film thickness and ceramic thickness in each group. For indirect restorations the cement thickness often is considered much less than thickness of restorations. Since the same force and equal amount of cement was used in each sample in this study; the proportion of ceramic thickness to cement film thickness in groups with thicker ceramic (0.8 and 1 mm) was greater than those with thinner ceramic (0.4 and 0.6) (as you used the same force on each specimen, the thickness of cement should be the same, and the proportion has no effect on this subject; if there is no significant difference between thickness groups, it seems better not to try to find a reason for the numbers). It was not unexpected to see higher cement cohesive failure in the groups with the lowest ceramic thickness. Confirming this hypothesis, in the current study, most cohesive failure was recorded in ceramics with a thickness of 0.4 mm.

Within the same ceramic thickness groups, translucency did not affect the SBS of the resin cement (p = 0.09). The translucency of the ceramic may affect the DC of light- and dual-cured resin cements (18). The ceramic translucency is important for clinicians because it affects the color of the underlying tooth structure and decreases the amount of light transmitted through ceramic restorations. It has been reported that 1 mm of glass transmits 13 times more light than 1 mm of IPS Empress Ceramic (17). Numerous factors including ceramic thickness, crystalline structure, number of ceramic firings, repeated ceramic staining cycles, grain size, pigment, number, size and distribution of defects and porosity can affect ceramic translucency (11). As stated, the DC of the cement may decrease with the use of thicker, darker or more opaque restorations (23, 24) while the bond strength between the veneer and tooth structure may not be affected. With the decrease in light transition through opaque ceramics, including alumina and zirconia, compared with more translucent lithium disilicate and feldspathic ceramics, the resin cement failed to properly polymerize. As a result the hardness decreased and the cement solubility and water sorption increased (25, 26).

It could be stated that the similar bond strengths obtained with different ceramic translucencies in the current study may depend on the low ceramic thicknesses used. It is theorized that for greater thicknesses, the role of translucency is more obvious. To support this hypothesis, Linden et al. (27) reported that for veneers with a thickness of 0.7 mm or more, the effect of ceramic opacity on cement hardness was more important. Moreover, Alghaith et al. (13) reported that for highly opaque ceramic material, a small change in thickness significantly affected polymerization efficiency. Which was agree with Illie et al. (11) statements about effect of ceramic thickness on ceramic translucency. They defined translucency as a function of wavelength and revealed that, ceramics were more permeable for higher wavelength. They suggested ceramic translucency increased with rising wavelength and decreasing ceramic thickness. Although they reported, neither translucency nor thickness influences the hardness of resin cement when ceramic thickness was 2mm or less.

In the current study, neither the thickness nor translucency of lithium disilicate ceramic affected the SBS of light-cured resin cements when ceramic thickness was 1 and lower than 1 mm. In agreement with these results, Watanabe et al. (20) found that different translucencies and thicknesses (1 and 2 mm) of feldespathic ceramic did not affect ceramic bond strength, Kilinc et al. (8) reported a more negative effect of ceramic thickness than ceramic shade on polymerization of resin cement, when the ceramic thickness was more than 3mm, but they didn’t mention the reason. (Please mention the reason) Although Chan et al (28) reported a relation between translucency, required exposure time for proper polymerization and ceramic thickness. According to their formula as : t=t 0TC-l/2 ,(which t0 was the time for direct curing of composite , TC was transmission coefficient of ceramic and l was ceramic thickness), when the thickness of ceramic increased , the required exposure time increased too, which indicated the more important role of ceramic thickness than ceramic translucency on required exposure time for efficient polymerization . These considerations may not be valid for modern curing units though (11).

Thermal fluctuations with developing crack propagation and catastrophic failures in ceramic structures and through hydrolyzing silicon-oxygen bonds at the ceramic-cement interface can compromise ceramic bonding over time (29). Hence, thermal aging was applied in laboratory studies to mimic the clinical situations. So, all the specimens of this study endured 5000 cycles of thermocycling to simulate about six months of thermal changes in an oral environment.

Evaluation of the failure mode after debonding in the current study showed adhesive failure to be the main cause of failure, followed by cement cohesive failure. Adhesive failure can contribute to bond hydrolysis, cement degradation during thermocycling, and water sorption. Insufficient polymerization of resin cement resulted from the prevention or attenuation of light transmission through ceramic material may cause resin cement cohesive failure. In addition to the current failure modes, in some mounted samples the enamel separated from the dentin in DEJ. These types of failure, which is here named for the first time as breaking failures, may relate to deep inherent structural defects of the teeth which could not be evaluated by the microscopic measurement.

Regarding the outcome of the present study, translucent light-cured resin cement can be used effectively for thicknesses of 1 mm or less of ceramic veneer at different translucencies. Thus, the null hypothesis could not be rejected. The clinician should be aware that the polymerization and bond quality could be jeopardized if the ceramic thickness employed for a restoration is thicker than 1.0 mm or if another cement or ceramic is applied. It is important to emphasize that different results could be obtained with the application of different ceramic and cement types as well as light-curing devices.

Conclusion

Based on the results and considering the limitations of this in vitro study, it was concluded that the shear bond strength of light cure resin cement to enamel substrate is not affected by the different translucencies of ceramic veneer having a thickness of 1 mm or less.

Acknowledgements

This article was extracted from a master's thesis carried out in 2016 at the Dental School of Mashhad University of Medical Sciences under the advisory guidance of Dr. Moghaddas. The authors would like to extend their gratitude to the Vice-Chancellor of Research of Mashhad University of Medical Sciences for providing the financial support for this project.

References

1. Neville BW, Damm DD, Chi AC, Allen CM. Oral and maxillofacial pathology. Elsevier Health Sciences; 2015.
2. Saghafi S, Zare-Mahmoodabadi R, Salehinejad J, Kadeh H, Afzal-Aghaee M. (2010). Immunohistochemical analysis of p53 and PCNA expression in calcifying odontogenic cyst. J Oral Sci. 52(4):609-13.
3. Habibi A, Saghravanian N, Salehinejad J, Jafarzadeh H. (2011). Thirty years clinicopathological study of 60 calcifying cystic odontogenic tumors in Iranian population. J Contemp Dent Pract. 12(3):171-3.
4. White SC, Pharoah MJ. Oral Radiology: Principles and Interpretation. Elsevier Health Sciences; 2014.5. Motamedi MH, Ebrahimi A, Behroozian A, Kargahi N, Rasouli HR.(2014). Maxillofacial Aneurysmal Bone Cysts in Isfahan 1987-2013: A Clinicohistopathological Study of 16 Casest. Oral Hyg Health. 2(155):2332-0702.
5. Gorlin RJ, Pindborg JJ, Clausen FP, Vickers RA. (1962).The calcifying odontogenic cyst—a possible analogue of the cutaneous calcifying epithelioma of Malherbe: an analysis of fifteen cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 15(10):1235-43.
6. Shear M. Developmental odontogenic cysts. (1994). an update. J Oral Pathol Med. 23(1):1-11.
7. Toida M. (1998). So-called calcifying odontogenic cyst: review and discussion on the terminology and classification. J Oral Pathol Med. 27(2):49-52.
8. Chindasombatjaroen J, Poomsawat S, Klongnoi B. (2012). Calcifying cystic odontogenic tumor associated with other lesions: case report with cone-beam computed tomography findings.Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 113(3):414-20.

9. Oliveira AM, Perez-Atayde AR, Inwards CY, Medeiros F, Derr V, Hsi BL, et al.(2004) USP6 and CDH11 oncogenes identify the neoplastic cell in primary aneurysmal bone cysts and are absent in so-called secondary aneurysmal bone cysts. Am J Pathol. 165 (5):1773-80.
10. Arora SS, Paul S, Arora S, Kapoor V. (2014). Secondary jaw aneurysmal bone cyst (JABC)–a possible misnomer? A review of literature on secondary JABCs, their pathogenesis and oncogenesis. J Oral Pathol Med. 43(9):647-51.
11. Nadimi H, Bronny AT, Singoli A, Gatti WM, Hasiakos P. (1987). Aneurysmal bone cyst associated with a dentigerous cyst: Report of case. J Am Dent Assoc. 115(6):859-61.
12. Öner M, Yurdakul E, Durukan P. (2012). Aneursymal Bone Cyst Causing a Femoral Neck Fracture: A Pediatric Case. JAEMCR.1; 3(4).
13. Devi P, Thimmarasa VB, Mehrotra V, Agarwal M. (2011). Aneurysmal bone cyst of the mandible: A case report and review of literature. J Oral Maxillofac Pathol. 15 (1):105-108.
14. De Fátima Bernardes V, de Lacerda JC, de Aguiar MC, Gomez RS.(2008). Calcifying odontogenic cyst associated with an orthokeratinized odontogenic cyst. Head Neck Pathol. 2(4):324-7.
15. Bonakdarpour A, Levy WM, Aegerter E. (1978). Primary and Secondary Aneurysmal Bone Cyst: A Radiological Study of 75 Cases. Radiology. 126(1):75-83.

Corresponding Author:
Roya Amiri Daluyi
Dental Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.
Department of Restorative and Cosmetic Dentistry, School of dentistry,
Mashhad University of Medical Sciences, Mashhad, Iran.
Vakil-Abad Boulevard, Mashhad, Iran
Office phone: +98 9155207581, +98 513 8829501
E mail: roya_amiri65@yahoo.com