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Oral rehabilitation, Prosthodontics, Lithium-disilicate, Bonding, Sandblasting, Adhesion.

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Comparative Evaluation Of Shear Bond Strength Of Resin Cement To Lithium Disilicate By Various Surface Treatments - An In-Vitro study

Abstract

The popularity of all ceramic restorations has increased in recent years. The placement of ceramic inlays, onlays, veneers and complete crowns have gained more demands. This has lead to greater use of composite resin cement to provide strength for all ceramic restoration and to ensure secure attachment to the tooth. To enhance the bond strength of luting cement to the ceramic, a number of techniques have been reported which mechanically facilitate resin-ceramic bonding. Advances in adhesive dentistry have resulted in the introduction of surface conditioning methods such as airborne abrasion with aluminium oxide, glass beads etc to improve bond strength. Etching the inner surface of a restoration with hydrofluoric acid is also a recommended method to increase bond strength. The clinical success of ceramic restoration is heavily dependent on the luting cement and cementation procedure. The present study evaluates improvement of the bond strength between lithium disilicate and adhesive cements by various surface treatments, which include sand blasting with aluminium oxide, sand blasting with glass beads, and acid etching with hydrofluoric acid. The shear bond strength thus obtained using these variables are compared with one another.

AIM

To evaluate and compare the effect of different surface treatments on the shear bond strength between lithium disilicate ceramic and composite resin cement.

MATERIALS AND METHOD

64 Samples of lithium disilicate of size 10×10×2 mm was made. This lithium disilicate block was embedded in an acrylic block. 64 specimens were equally divided into 4 groups. Group A-Without surface treatment, Group B-Sand blasting with aluminium oxide, Group C- Sand blasting with glass beads, and Group D- Acid etching with Hydrofluoric acid. A mould of polyethylene was made for attaining uniform size and shape of composite resin cement. This mould was placed at approximate centre of the lithium disilicate specimen. The base and catalyst paste of composite resin cement were mixed and placed into this mould. Then the resin cement is light cured for 40 seconds and mould gently removed from the test specimen. Shear bond strength between composite resin cement and lithium disilicate was measured by mounting the sample in a jig of universal testing machine.

RESULT

SHAPIRO- WILK TEST was used for testing the normality assumption of quantitative data. One way ANOVA followed by Tukey's post Hoc test was used for association between variables. Probability value ($p<0.05$) was considered statistically significant. The mean and standard deviation of the control group was 187.68±1.37. For specimen treated with aluminium oxide the mean and standard deviation turned out to 228.66 ±3.898, where as for those treated with glass bead it was 175.43±5.24. Specimens treated with hydrofluoric acid showed mean and standard deviation 271.01±3.50. The

result was found to be statistically highly significant as p value obtained was less than 0.001.

CONCLUSION

It was found that shear bond strength of composite resin cement to lithium disilicate was maximum when surface treatment was done with 5 % hydrofluoric acid, followed by surface treatment with aluminium oxide. Surface treatment with glass bead gave mean shear bond strength less than that of the control group. The maximum shear bond strength of composite resin cement to lithium disilicate was obtained by surface treatment with 5% hydrofluoric acid.

INTRODUCTION

The popularity of all ceramic restorations has increased in recent years. The placement of ceramic inlays, onlays, veneers and complete crowns have gained more demands. Dental inlays and onlays are a dental procedure that is used to restore a decayed or damaged tooth to its original condition and can actually strengthen it. A veneer can be used to treat dental conditions such as a slightly crooked tooth, discolored teeth, chipped teeth or they can even be used to cover spaces in between the teeth. A crown can help strengthen a tooth with a large filling when there isn't enough tooth remaining to hold the filling. Crowns are also used to protect a weak tooth from breaking or restore one that's already broken. A crown is a good way to cover teeth that are discolored or badly shaped.

The increased demand of all ceramic restorations has led to greater use of composite resin cement to provide strength for all ceramic restoration and to ensure secure attachment to the tooth. [1] Composite cements are composite materials with higher percentage of resin and smaller particle sizes to reduce viscosity. They are sometimes referred as resin cements. Originally, they had a very high film thickness. Before the development of dentinal bonding systems, leakage of composite cements was common and caused postoperative sensitivity. Modern composite cements have an improved film thickness (thinner). With the use of a dentinal bonding system composite cements are the favourite luting material of many clinicians. They are the material of choice for luting all ceramic restorations. If the ceramic material is properly etched and silanated, composite cement will bond the restoration to the underlying tooth structure. Many types of composite cement systems are available. They come as chemically activated, light-activated, and dual-cure systems.

Shear bond strength is defined as the interfacial adhesion between substrate and the bonded material, mediated by an adhesive layer. This plays vital role in prosthetic dentistry as adhesion to the tooth structure is one of the key factors determining the success and prognosis of the rehabilitation. Here, the luting cement acts as the adhesive layer between the tooth surface and the ceramic.

To enhance the bond strength of luting cement to the ceramic, a number of techniques have been reported which mechanically facilitate resin-ceramic bonding. Advances in adhesive dentistry have resulted in the introduction of surface conditioning methods such as airborne abrasion with aluminium oxide, glass beads etc to improve bond strength. [2] Etching the inner surface of a restoration with hydrofluoric acid is also a recommended method to increase bond strength. [3] The clinical success of ceramic restoration is heavily dependent on the luting cement and cementation procedure. [4]

The present study evaluates improvement of the bond strength between lithium disilicate and adhesive cements by various surface treatments, which include sand blasting with aluminium oxide, sand blasting with glass beads and acid etching with Hydrofluoric acid. The shear bond strength thus obtained using these variables are compared with one another.

Lithium disilicate, a well-known glass ceramic, is highly esthetic, thermal shock resistant material. It has large volume (70% approximately) of long crystals which increase their flexural strength, fracture resistance, and bond strength, thus, making it possible to utilize this material for the fabrication of prosthesis in the anterior region of the mouth and the restoration of premolars. Restorations using this glass ceramic can be fabricated either by lost-wax hot pressing techniques or modern computer-aided design and milling procedures which further helps in improving the mechanical and optical properties of the ceramic. Pressable lithium disilicate is indicated for inlays, onlays, thin veneers, veneers, partial crowns, complete crowns, 3-unit anterior or premolar bridges, telescopic primary crowns, and implant restorations. It can be pressed as thin as 0.3 mm while still ensuring the strength of 400 megapascals (MPa). The flexural strength of zirconia (1000 MPa) is twice the flexural strength of lithium disilicate. Lithium disilicate is used more commonly where esthetics and strength are required simultaneously.

The resin cements were first developed in 1950s and by Dr. Rafael Brown in 1963 and according to the conditioning of tooth before cementation, resin cements are divided into three groups, i.e., total etch and rinse resin cements, self-etch resin cement system, and self-adhesive resin cement system/all-in-one resin cements. The conventional technique for cementation, i.e., total-etch adhesive system, is technique sensitive and involves various steps before cementation. In this technique, the intaglio surface of the restoration is etched with hydrofluoric (HF) acid followed by the application of the silane coupling agent which is responsible for the chemical union between the restoration and the resin cement. Consecutively, the prepared tooth surface is conditioned with phosphoric acid; to increase the surface energy by removing the smear layer; and then, the bonding agent is applied following which final cementation is performed. To reduce the number of operative steps and simplify the clinical procedures self-etch resin cement systems were introduced, which includes the application of self-etching acidic primer followed by the application of resin cement. In 2002, self-adhesive resin cements were introduced those incorporate etchant, primer, and bonding resin in a single solution. Therefore, no treatment of the prepared tooth before cementation is required. They possess no postoperative sensitivity, reduce chairside time, are moisture tolerant, dimensionally stable, and easy to apply, release fluoride ions, offer good esthetics, have optimal mechanical properties, and adhere micromechanically. The adhesion between the cement and tooth is obtained by the chemical interaction between the multifunctional monomer with phosphoric acid groups and hydroxyapatite. Moreover, they act as a permeable membrane after polymerization resulting in mechanical disruption of the coupling between the adhesive and composite resin that can be minimized by selecting a conventional 3step and 2-step resin cement system. Many studies have compared shear bond strength (SBS) of total-etch resin cements with self-etch resin cements or self-adhesive resin cements but few studies compared all the three resin cement systems. However, scarce information is available with regard to the bond strength directly between dentin and indirect substrates.

The integrity and the longevity of the tooth-cement-ceramic interface depend on the luting or bonding procedure, adhesive capacity, and the stiffness of the luting agent being used for the cementation of the restoration to the tooth substrate. Therefore, the luting agent used for cementation can be the "Achilles heel." The desired features of a luting agent are its optical characteristics, improved mechanical properties, low solubility, decreased micro leakage, low incidence of marginal staining, and ability to bond to multiple substrates. Moreover, due to the high strength and glass properties of the lithium disilicate, adhesive cementation is recommended to lute such restorations to the tooth substrate.

Studies conducted by Kim et al in 2005 and Ayad et al in 2008 stated that surface treatment of porcelain with variables increases the surface area and creates micro porosities on the porcelain surface. It enhances the potential for mechanical retention of the luting composite resin [5]

Aim and Objectives

AIM

To evaluate and compare the effect of different surface treatments on the shear bond strength between lithium disilicate ceramic and composite resin cement.

OBJECTIVES

- •To evaluate the shear bond strength of composite resin cement to lithium disilicate without surface treatment
- •To evaluate the shear bond strength of composite resin cement to lithium disilicate by sandblasting with aluminium oxide.
- •To evaluate the shear bond strength of composite resin cement to lithium disilicate by sandblasting with glass beads.
- •To evaluate the shear bond strength of composite resin cement to lithium disilicate by acid etching with hydrofluoric acid.
- •To compare the shear bond strength of composite resin cement to lithium disilicate obtained with various surface treatments among themselves

BACKGROUND

Lithium disilicate ($Li_2Si_2O_5$) is a chemical compound that is a glass ceramic. They are widely used as dental ceramics due to their strength, machinability, and translucency. Lithium disilicate has found applications in dentistry as a material for crowns in the form of $Li_2Si_2O_5$. It has an unusual microstructure that consists of many randomly oriented small and interlocking plate-like needle-like crystals. This structure causes cracks to be deflected, blunted, and/or to branch, which prevents cracks from growing.[6] Lithium disilicate has a biaxial flexible strength in the range of 360 MPa to 400 MPa; in comparison to metal ceramics which is around 80 to 100 MPa, for veneered zirconia it's approximately 100 MPa, and for leucite glass ceramic it's approximately 150 to 160 MPa. It has high hardness (5.92 +/- 0.18 GPa) and fracture toughness (3.3 +/- 0.14 MPa $m^{1/2}$). In addition, it can be made to have an appearance that very closely resembles that of natural human teeth.

Lithium disilicate is also used as a non-conductive seal, enamel or feed-through insulator in nickel superalloys or stainless steel, as it has a high thermal expansion. It has been shown to be superior to other all-ceramic materials with regard to abrasion. When processed correctly, abrasion of glass-ceramic crowns is sufficiently minimal, such that the material's advantages over metal and metal-ceramic restorations prevail. [7 ,8] Lithium disilicate also provides dentists with an option of minimally invasive tooth preparation for thin veneers (as thin as 0.3 mm) and other esthetic restorations, while simultaneously ensuring material/restoration strength and a conservative preparation design. [9] Pressed lithium disilicate restorations demonstrate flexural strength values of 400 MPa in their final anatomic shaped form. Machinable lithium disilicate in full contour restorations demonstrates 360 MPa of monolithic flexural strength throughout the entire restoration. [9] Restorations fabricated from lithium disilicate can be either conventionally cemented or adhesively bonded, providing that a proper retention form demonstrating a taper of 4° to 6° is achieved. Several studies have shown that lithium disilicate restorations demonstrate clinical efficiency with both adhesive and conventional cementation. [10, 11,12]

Shear bond strength is an important parameter to dentists as it helps to ensure that devices are bonded correctly. Long-term retention of the restoration depends primarily on the strength and durability of the bond of the luting composite resin to the tooth and the porcelain substrates to prevent fracture, marginal discoloration, and secondary caries. To achieve this bond, the porcelain surface may be modified chemically or mechanically to promote surface roughness and/or reactivity of the porcelain to the luting agent.

METHODOLOGY

The present study evaluates improvement of the bond strength between lithium disilicate and adhesive cements by various surface treatments, which include sand blasting with aluminium oxide, sand blasting with glass beads and acid etching with Hydrofluoric acid. The shear bond strength thus obtained using these variables are compared with one another.

STUDY DESIGN
IN-VITRO EXPERIMENTAL STUDY

PREPARATION OF THE SAMPLE

Applied formula, n= (Z α/2 +Z 1-β) 2 ×2(σ) 2
d 2
σ = pooled standard deviation obtained from previous study =0.22µm d= accuracy of the estimate = 0.2
Z α/2 = Normal deviate for two tailed hypothesis = 1.96
Z 1 - β = 0.84 (Type II Error) Substituting the values n = 16 is the minimum sample size
4 different groups have to be made

a)Group A-Without surface treatment (n=16)
b)Group B- Sand blasting with aluminium oxide (n=16)
c)Group C- Sand blasting with glass beads (n=16)
d)GroupD- Acid etching with Hydrofluoric acid(n=16)

So the total sample size =64, i.e. 16 in each group

1.64 Samples of lithium disilicate of size 10×10×2 mm made by heat pressing
2.After surface treatments resin cements were bonded to the lithium disilicate.

Table 1: Materials used (Figure 1-2)

SI No	Product name	Manufacturer	Material
1	IPS e.max press	Ivoclar vivadent AG	Lithium disilicate
2	SpeedCEM Plus	Ivoclar vivadent AG	Dental resin cement

Table 2: Auxiliary materials used (Figure3- 6)

SI No	Product name	Manufacturer
1	Glass beads batch no 1218	Delta
2	Metavest Phosphate bonded investment batch no 142047 05/2018	Delta
3	Inlay wax	Hindustan Dental Products
4	Wax wire blue medium hard 2.5mm	RenfertGmbH GERMANY
5	Silicone impression material	Zhermack, Italy
6	Aluminium oxide	
7	5 % hydrofluoric acid	Prevest Denpro
8	DPI Cold cure	Dental Products of India

Table 3: Instrument used for measurement (Figure: 7)

SI No	Instrument	Parameter measured	Manufacturers
1	Universal testing machine	Shear bond	Shimadzu

Figure 1: IPS e.max press ingots

Figure 2: Speed CEM Plus

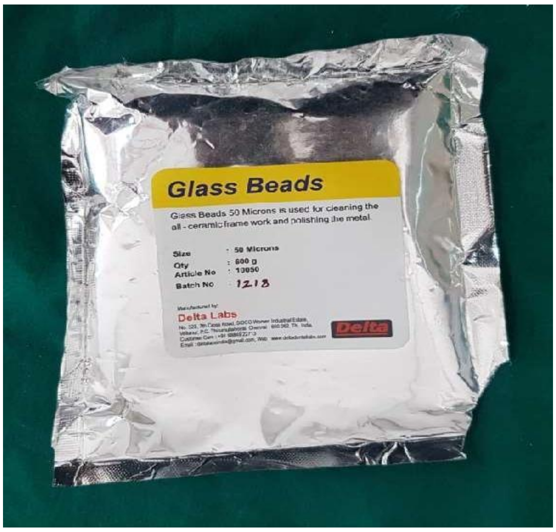

Figure 3: Glass beads

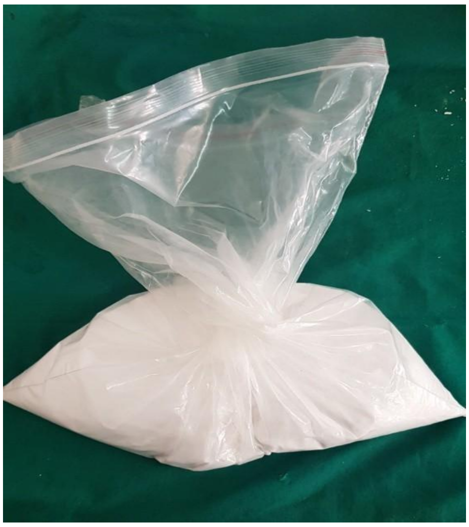

Figure 4: Aluminium oxide

Figure 5: Inlay wax; sprue wax; phosphate bond investment material

Figure 6: silicone impression material ,Cold cure acrylic, , 5% HF

Figure 7: Universal testing machine

ARMAMENTARIUM (Figure: 8)

1.Burn out furnace
2.Ivoclar pressing furnace

3.Abrasive bur
4.Vacuum mixer
5.Wax heater
6.Sand blaster
7.Micromotor
8.Pkt instrument

Figure 8: Armamentarium

METHODOLOGY

PREPARATION OF LITHIUM DISILCATE BLOCK

Test specimens in the form of a block of 10mm length, 10mm breadth and 2mm thickness were fabricated using lithium disilicate(IPS e.max press ingots). The sample size was kept 16 (n = 16) in each group as determined by statistician. Lithium disilicate discs (n = 64) were fabricated using heat-pressing technique.

Putty index (Zhermack, Italy) measuring 10 mm × 10 mm ×2mm was made to standardize the procedure. Molten inlay wax (sculpturing wax yeti dental, Germany) was poured into the putty index. As the inlay wax solidified, the wax pattern was removed from the putty index. One end of the sprue was attached to wax pattern (medium hard 2.5mm RenfertGmbH GERMANY).
The other end of the sprue was attached to the crucible former. Casting ring was placed over it.

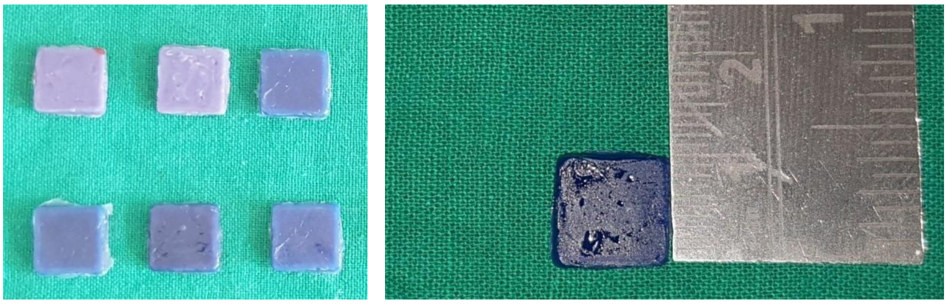

Figure 9: Wax pattern of uniform measurement

Investment of wax pattern along with the attached sprue was done in silicone ring with phosphate-bonded investment material (Metavest Phosphate bonded investment) by vaccum mixing. After proper setting of the investment material, burn out was done to flush out wax pattern and create a hollow cavity. The IPS e.max Press ingot was then kept in hot investment ring. This investment ring with ingot was placed in the centre of hot press furnace (Multimat 2 touch + press) using investment tongs and programming was started. After cooling of the ring, the phosphate bonded investment material was removed and then the sprue was separated from the lithium disilicate blocks. Dimensions of lithium disilicate discs were verified with a digital calliper.

Figure 10: Wax pattern attached to the crucible; invested wax pattern

Finishing and polishing of the lithium disilicate blocks were done. To establish a uniform surface, each specimen was polished with a rotational polishing device using 180-and 320-grit silica carbide abrasive paper under a steady stream of water. The polishing was done by rotating the specimen 90° every one minute with each grit, for a total of four minutes. The specimens were finished with 0.5-µm Al_2O_3 slurry, rotating the specimens 90° every 30 seconds for a total of two minutes. All specimens were subjected to ultrasonic cleaning in distilled water for 15 seconds.

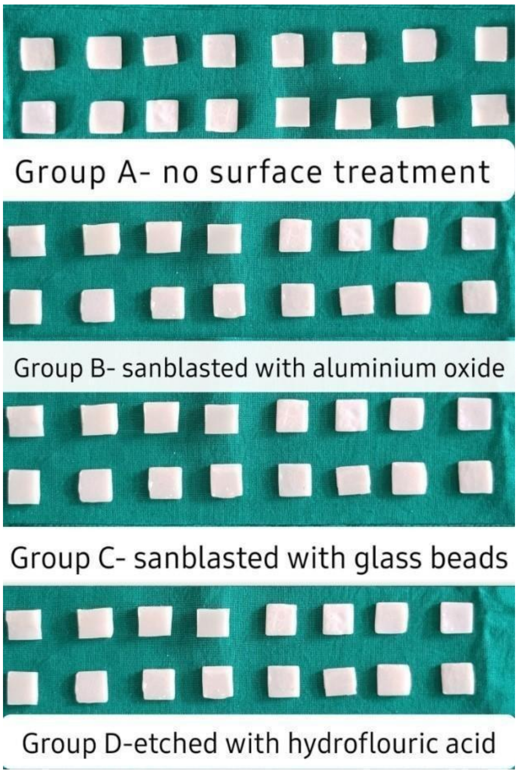

Figure 11: Lithium disilicate blocks after finishing and polishing

Another putty index of uniform size was fabricated. To this putty index, cold cure acrylic resin was poured and the pre-fabricated lithium disilicate block was embedded into one end of the acrylic block. As the acrylic completed its setting, 64 blocks of acrylic with lithium disilicate embedded on it was ready. Now these samples were divided into four different groups. 16 samples from each group were subjected to surface treatment,

a)Group A-Without surface treatment

It was considered as the control group. This group had 16 specimens which were not subjected to any surface treatment after preparation. This enabled the easy comparison of shear bond strength with other groups

b)Group B- Sand blasting with aluminium oxide

These samples, after preparation, were subjected to sandblasting with 50µm aluminium oxide under 4.1-bar air pressure at an approximate 10-mm nozzle-to-porcelain surface distance for 10 seconds. Immediately after treatment, the specimens were rinsed with water spray for 10 seconds and cleaned for 5 minutes ultrasonically.

c)Group C- Sand blasting with glass beads

These samples, after preparation, underwent sandblasting with 50µm glass beads under 4.1-bar air pressure at an approximate 10-mm nozzle-to-porcelain surface distance for 10 seconds. Immediately after treatment, the specimens were rinsed with water spray for 10 seconds and cleaned for 5 minutes ultrasonically.

d)Group D- Acid etching with Hydrofluoric acid

These samples, after preparation, were etched with 5% hydrofluoric acid for 20 seconds.

BONDING PROCEDURE

Primer (MONOBOND S or MONOBOND N) was applied with a micro brush on the lithium disilicate ceramic block and allowed to dry for 60sec. Any excess primer or bonding agent was removed by dispersing a gentle stream of air. A polyethylene mould was used for attaining a uniform size and shape for composite resin cement. The polyethylene mould had an inner diameter of 5mm and thickness of 5mm. The mould was placed at approximate centre of the lithium disilicate block. The base and catalyst paste were mixed in the ratio of 1:1 on a mixing pad for 10 sec (VARIOLINK N).This mixed composite resin cement was applied using composite filling instrument to the conditioned ceramic substrate using the polyethylene mould. Then the resin cement was light cured for 40 seconds and the mould was gently removed from the test specimen. The dried sample was kept in a dessicator at room temperature for 24 hours prior to testing.

MEASURING SHEAR BOND STRENGTH

Shear bond strength between composite resin cement and lithium disilicate was measured by mounting the sample in a jig of universal testing machine and load was applied on the composite resin cement-ceramic interface until debonding occurred. A sharpened stylus applied a shear load to the interface until failure at a crosshead speed of 1 mm/min. The peak failure load and surface area of the composite cylinder was used to calculate the shear bond strength (Mpa).

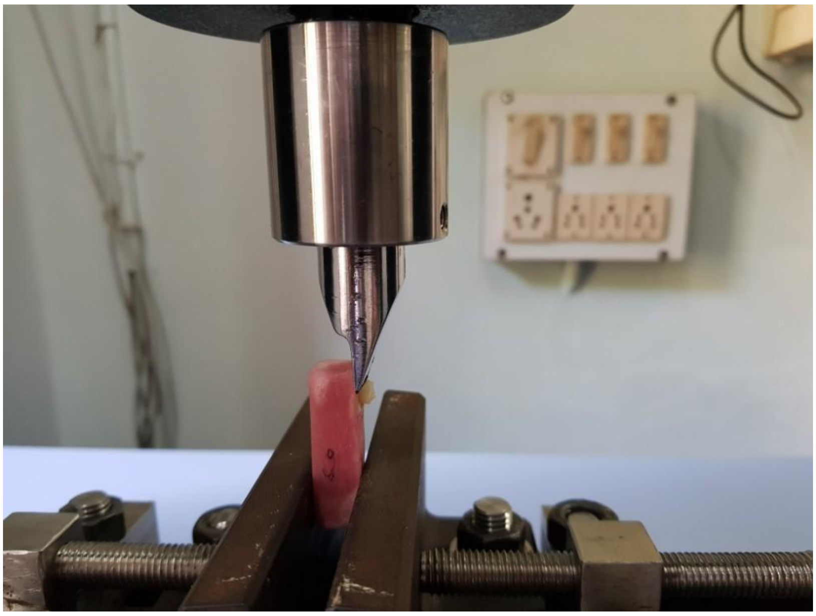

Figure 12: Lithium disilicate block on UT machine

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TATISTICAL ANALYSIS

ANOVA TEST was employed in the present study to compare the shear bond strength of lithium disilicate with resin cement of all four groups

Group A-Without surface treatment (n=16)

Group B- Sand blasting with aluminium oxide (n=16)
Group C- Sand blasting with glass beads (n=16)
Group D- Acid etching with Hydrofluoric acid (n=16)

All data were entered to Microsoft Excel spread sheet for analysis. The descriptive statistics of the recorded measurements are listed and appropriate graphs are drawn. Statistical Package for Social Sciences software, SPSS version 20 was employed in analysis of various data sets collected. The P- value <0.05 was considered statistically significant.

RESULT

All statistical procedures were performed using Statistical Package for Social Sciences (SPSS) 20.0. Calculations for power (80%) of study was performed before the commencement of the study. (All quantitative variables expressed in mean and standard Deviation). Shapiro-Wilk test was used for testing the normality assumption of the quantitative data. One Way ANOVAfollowed by Tukeys post Hoc test was used for association between variables. Probability value ($p < 0.05$) was considered statistically significant

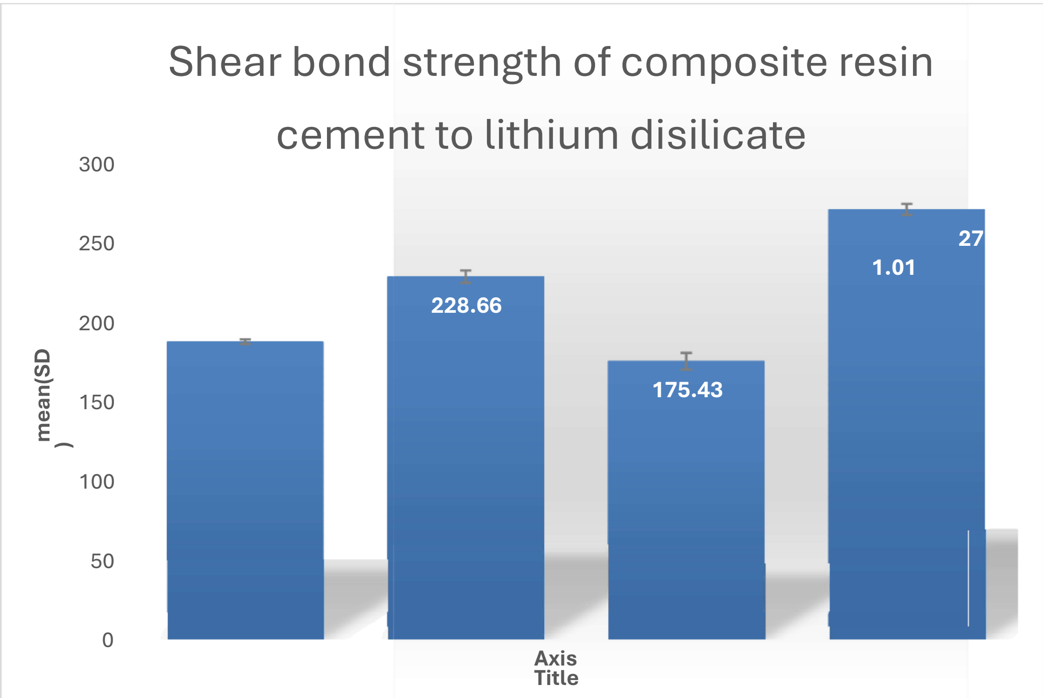
Table 4: Shear bond strength of lithium disilicate with resin cement after surface treatments

Sl No	CONTROL	ALUMINIUM OXIDE	GLASS BEAD	ACID ETCHING
1	189.869	232.450	180.705	266.310
2	186.502	223.249	167.006	272.962
3	186.002	230.350	180.700	270.002
4	188.112	232.441	168.252	271.112
5	187.231	227.032	170.441	268.114
6	189.450	224.411	167.249	270.927
7	186.006	223.122	177.112	272.523
8	187.705	231.230	180.605	271.141
9	186.013	230.112	168.520	267.251
10	188.629	232.005	179.551	266.650

11	189.252	223.106	176.213	270.529
12	186.312	230.252	177.153	270.058
13	186.211	232.123	179.686	271.208
14	188.305	223.112	180.152	270.610
15	188.042	231.525	177.269	279.679
16	189.252	232.050	176.421	277.114

Table 5: Mean and standard deviation of shear bond strength of composite resin cement to lithium disilicate

Groups	Mean	SD
Control	187.68	1.37
Aluminium oxide	228.66	3.898
Glass bead	175.43	5.24
Acid etching	271.01	3.50



Graph 1: Comparison of shear bond strength of composite resin cement to lithium disilicate by different surface treatments

Table 6: Comparison of shear bond strength of composite resin cement to lithium disilicate by different surface treatments along with mean, standard deviation F value and P value

Groups	Mean	SD	F value	P value

Control	187.68	1.37	211.05	<0.001**
Aluminium oxide	228.66	3.89		
Glass bead	175.43	5.24		
Acid etching	271.01	3.50		

#p value <0.05 is statistically significant; ** <0.001 is statistically highly significant #One Way ANOVA followed by Tukeys post hoc test

Table 7: Multiple Comparisons to calculate significance

Tukey HSD						
Groups		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Aluminium oxide	-40.97981*	1.33349	.000	-44.5036	-37.4560
	Glass bead	12.24112*	1.33349	.000	8.7174	15.7649
	Acid etching	-83.33106*	1.33349	.000	-86.8548	-79.8073
Aluminium oxide	Control	40.97981*	1.33349	.000	37.4560	44.5036
	Glass bead	53.22094*	1.33349	.000	49.6972	56.7447
	Acid etching	-42.35125*	1.33349	.000	-45.8750	-38.8275
Glass bead	Control	-12.24112*	1.33349	.000	-15.7649	-8.7174
	Aluminium oxide	-53.22094*	1.33349	.000	-56.7447	-49.6972
	Acid etching	-95.57219*	1.33349	.000	-99.0960	-92.0484
Acid etching	Control	83.33106*	1.33349	.000	79.8073	86.8548

	Aluminium oxide	42.35125*	1.33349	.000	38.8275	45.8750
	Glass bead	95.57219*	1.33349	.000	92.0484	99.0960
*. The mean difference is significant at the 0.05 level.						

The mean and standard deviation of the control group was 187.68±1.37. For specimens treated with aluminium oxide the mean and standard deviation turned out to 228.66 ±3.898, where as for those treated with glass beads it was 175.43±5.24. Specimens treated with HF showed mean and standard deviation 271.01±3.50. The result was found to be statistically highly significant as p value obtained was less than 0.001.

It was found that shear bound strength of composite resin cement to lithium disilicate was maximum when surface treatment was done with 5 % HF , followed by surface treatment with aluminium oxide. Surface treatment with glass beads gave mean shear bond strength less than that of the control group. The study concluded that the maximum shear bond strength of composite resin cement to lithium disilicate was obtained by surface treatment with 5% HF

DISCUSSION

Chemical bonding through silane application plays an important role in ceramic-resin adhesion. The use of silane improves wettability of the ceramic surface and promotes adhesion between adhesives and ceramic/metal. However, the long-term stability of chemical bonding using silane coupling agents is still under debate. The study conducted by Ahrari et al concluded that bonding to glass ceramics revealed no significant differences in bond strength values between different treatment groups (sandblasting, polishing, hydrofluoric acid, or phosphoric acid etching) when a silane coupling agent was applied after surface treatment, whereas in the absence of silane application, hydrofluoric acid -etched and sandblasted groups exhibited the highest micro-shear bond strength. [13]

Hydrofluoric acid was applied as a surface treatment strategy in the present investigation and produced bond strength value that was significantly higher than that in air-abraded specimens. Ceramics with a high glassy phase and a large amount of silica are called acid-sensitive or glass ceramics, generally classified into feldspathic, leucite-reinforced, fluormica glass or lithium disilicate. Etching with hydrofluoric acid could be considered an effective modality for glass ceramics as it dissolves the glassy phase of acid-susceptible ceramics, producing suitable surface texture for bonding and facilitating the penetration of resin into ceramic. The content of silica in lithium disilicate ceramic is approximately 60 wt%, as mentioned by the manufacturer, and could be considered sufficient to obtain reliable bond strength after dissolving in acid solutions. Several studies, [14, 15] demonstrated that the use of hydrofluoric acid on glass ceramics creates higher surface roughness and greater bond strength compared with other acid etchants, surface grinding, or sandblasting techniques. The combination of hydrofluoric acid etching and silane application has been recommended by several authors as a method of choice for surface preparation of feldspathic, lithium disilicate or other types of glass ceramics.

Roughening the surface with 25–50-µ aluminium oxide particles is a traditional way to achieve micromechanical retention on ceramic substrates. Surface roughening increases both the bonding area and the wettability of the ceramic surface. Recent studies indicated higher surface roughness in sandblasted lithium disilicate ceramic in comparison to Er:YAG laser-irradiated or HF acid-treated specimens. However, the ceramic specimens subjected to air abrasion exhibited the lowest shear bond strength in the present investigation. It is possible that the irregularities created by the air abrasion process were not effective in enhancing the bond strength to lithium disilicate ceramic. The deposition of aluminum oxide particles on the surface, which could interfere with the cement-ceramic adhesion,might be another reason for the lowest bond strength in air-abraded specimens. Other authors believe that air abrasion creates surface damage and removes a significant amount of substances from the surface, thus weakening the ceramic and leading to premature fracture.The outcomes of this study are consistent with the results of Colares et al. [16], who reported significantly lower bond strength in lithium-disilicate ceramic blocks treated with sandblasting compared to those prepared by hydrofluoric acid and silane application

In the study performed by Spohr et al, [17] in which the effects of alternative ceramic surface treatments on the bond strength in the bonding of RelyX ARC resin cement to IPS Empress 2 ceramic discs were investigated, it was reported that the application of 10% hydrofluoric acid and silane created the highest bond strength compared to sandblasting only, sandblasting and silanization and hydrofluoric acid application only. These findings supported the results from the present study.

The results from the present study are in agreement with Guarda et al., [18] who reported that etching with 10% hydrofluoric acid showed higher bond strength values than the sandblasting with 50-µm Al_2O_3. Other authors, Salvio et al., [19] Spohr et al, [17] Ayad et al. [20] and Attia et al, [21] also reported that sandblasting with 50-µm Al_2O_3 causes a decrease in bond strength as compared to etching with 10% hydrofluoric acid. Maruo et al. [22] demonstrated that, when evaluating the surface morphology and adhesiveness of lithium disilicate, etching with 5% hydrofluoric acid or phosphoric acid yielded higher shear bond strength than sandblasting between lithium disilicate and self-cure adhesive resin cement. In line with these reports, in the present study, higher resin cement bond strength values were determined in the IPS e.max Press specimens etched with hydrofluoric acid compared to the specimens sandblasted with 50-µm Al2O3 .

Giraldo et al. [23] observed that the active application of phosphoric acid after 9.6% hydrofluoric acid increased the micro-shear bond strength values between the resin cement

and lithium disilicate. In the study of Lise et al., [24] Hydrofluoric acid etching showed higher micro-shear bond strength values than those observed in the control group.

To further explore the effect of surface treatments on the surface of IPS e.max Press, we performed scanning electron microscopy analysis by Özdemir h et al. [25]. The scanning electron microscopy images at 2000 magnification revealed a very smooth surface of the specimen in control group. Uniform and regular retentive areas in the scanning electron microscopy image of the specimen surface were observed in specimens treated with hydrofluoric acid. Various irregular retentive areas that were similar to each other were observed in the scanning electron microscopy images of groups sandblasted with 50-µm Al2O3. These observations support the results from the shear bond analysis.

The quality of the bond should not be just assessed through the bond strength data as the mode of failure also provides valuable information for predicting the clinical performance of bonded restorations. The results of the present study showed that adhesive fracture between the luting cement and porcelain occurred with the highest frequency in all the experimental groups. Despite the significant difference in bond strength between the study groups, the mode of bond failure was comparable among groups, indicating the lack of relationship between shear bond strength and the type of bond fracture. Therefore, factors other than bond strength could affect the mode of failure at the bonding interface.

A limitation of this study was that it used shear bond strength test for evaluating the effectiveness of surface conditioning procedures. This test can produce fracture at a distance from the resin-ceramic interface, leading to misconception of the bond quality. In spite of such limitations, shear bond strength remains a simple and appropriate test to evaluate bonding performance. The bond between ceramic and resin cement is influenced by several factors such as temperature changes, saliva, diet, chewing force and other habits in a complex oral environment. We did not employ thermocycling or any other fatigue cycle in this study because of the diversity of the treatment groups and the controversial results of previous studies regarding the effect of these procedures on shear bond strength.

CONCLUSION

Within the limitations of the study, the following conclusion can be drawn.

1)The maximum shear bond strength between composite resin cement and lithium disilicate was found when the specimens were etched with 5% hydrofluoric acid.

2)The shear bond strength of specimens sandblasted with 50µ aluminium oxide was less than that of those etched with 5% hydrofluoric acid.

3)The shear bond strength of specimens sandblasted with 50µ aluminium oxide was more than that of the control group and those sandblasted with 50µ glass beads

4)Surface treatment with 50µ glass beads gave mean shear bond strength less than that of the control group.

Dentists today have to meet the growing demands for prosthetic rehabilitation due to population aging and higher requirement of quality of life. That means higher demands on the functional reliability of dental appliances, their aesthetic and biological properties should be considered.

Lithium disilicate (IPS E-max crown) is aesthetically superior when compared to other available alternatives such as zirconia and PFM crown. The chemical durability, aesthetic nature, and enhanced translucency make lithium disilicates excellent materials for use in dentistry. The success rate of the prosthesis depends not only on the fabrication but also on the durability of the prosthesis in the patients' mouth. To obtain longevity of the prosthesis proper bonding between lithium disilicate and composite resin is essential.

It was found that shear bond strength of composite resin cement to lithium disilicate was maximum when surface treatment was done with 5 % hydrofluoric acid, followed by surface treatment with aluminium oxide. Surface treatment with glass beads gave mean shear bond strength less than that of the control group. The maximum shear bond strength of composite resin cement to lithium disilicate was obtained by surface treatment with 5% hydrofluoric acid.

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