University J Dent Scie 2023; Vol. 9, Issue 3

Comparison of the Effect of Various Surface Treatments on The Microtensile Bond Strength of Lithium Disilicate Ceramic With Dentin- An In-vitro Study

Abstract:

Aim and Objective: The aim of this study was to evaluate and compare the effect of various surface treatments on the microtensile bond strength of Lithium disilicate ceramic with dentin.

Materials and Methods: A total of 45 human extracted premolars were obtained for the study. The samples were mounted in dental stone blocks having two "V" shaped notch on mesial and distal side of the mounted tooth. The samples were divided into three groups with 15 samples in each. The GROUP-A Control (without any surface treatment), GROUP-B (air abrasion with Al_2O_3 particles for 15 seconds) and GROUP-C (laser treatment for 5 seconds). Standardize tooth preparation was done on samples and lithium disilicate crowns were fabricated with a loop on occlusal surface. After surface treatment crowns were luted with self adhesive resin cement and pull out load test was performed in universal testing machine. The data was analysed using one way ANOVA TEST for multiple group comparison followed by Tusky HSD post hoc test. Level of significance was considered at 5% (p-value<0.05).

Results: The surface treatment considerably increased the retention of lithium disilicate crowns. The air abrasion group showed the highest microtensile bond strength values. There was significant difference between air abrasion and laser treatment groups.

Conclusion: It was evident that microtensile bond strength was adequately increased after both the surface treatments (air abrasion with Al_2O_3 particles and laser treatment) and there was significant increase in bond strength with air abrasion with Al_2O_3 particles group when compared to laser treatment group.

Key-words: Lithium disilicate ceramic, microtensile bond strength, surface treatment, air abrasion.

Introduction:

Ceramics are the most aesthetically pleasing materials available for restorative dentistry[1]. The ceramic systems are having optimal esthetic properties that closely resemble the natural dentition and also include other desirable characteristics such as translucency, fluorescence, chemical stability, biocompatibility, high compressive strength and coefficient of thermal expansion[2]. Because of all these properties full ceramics are now one of the primary choices of dentists as well as patients[3].

One of the most commonly used all-ceramic core materials for conventional and resin bonded fixed partial dentures and complete coverage crowns is Lithium disilicate glass ceramics[2]. Lithium disilicate ceramics (LDC) are a new

Access this article online

Website: www.ujds.in

DOI: https://doi.org/10.21276/ujds.2023.9.3.10

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Received : 26 April, 2023, **Published :** 31 August, 2023

How to cite this article: Shrivastava, A., Sharma, S. K., & Parmar, S. (2023). Comparison of the Effect of Various Surface Treatments on the Microtensile Bond Strength of Lithium Disilicate Ceramic with Dentin- An In-vitro Study. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 9 (special is). 29-33

generation of heat- pressed ceramics that shows higher fracture strength, bending resistance, durability and longevity of ceramics than the first generation of ceramics reinforced by leucite[4]. Lithium disilicate ceramic (LDC) is composed of two components: silica, which serves as a glass matrix and lithium oxide (LiO2). LDCs have an unusual microstructure, consisting of small interlocking, plate or needle - like crystals act as crack stoppers and provides higher strength than the conventional one[3].

With the development of computer-aided design computer aided manufacturing (CAD/CAM) technology, the design and production of lithium disilicate frameworks could be achieved using a digital process[3]. In the late 1990s lithium disilicate crowns were manufactured using this CAD/ CAM technique[2].

To gain bond strength, the ceramic surface can be modified mechanically or chemically which increases surface roughness and reactivity of the ceramic to the luting agent[4]. These strengthened all – ceramic restorations have been indicated for inlays, onlays, crowns and fixed partial dentures[1].

The surface treatment methods include grinding, air abrasion with Al2O3 particles, laser treatment, hydrofluoric acid etching and combinations of any of these methods[4,5,8].

Air abrasion with Al_2O_3 particles is one of the recommended method for surface pre treatment for ceramic because the ceramic has components which are bondable to silane. These agents form chemical bond between the inorganic phase of ceramics and organic phase of resins[3]. The alkoxy groups (RO3 Si-) of the silane molecule react with water to form silanol group (SiOH). The silanol groups further react with hydroxyl (OH) groups on a ceramic surface with available Si and O from siloxane (-Si-O-Si- O-) covalent bonds[2].

Since the development of the ruby laser, it is widely used in medicine and dentistry. Only a few studies have been performed on the laser treatment of lithium disilicate ceramics. The main disadvantage during the laser treatment include stepped local temperature changes during heating and cooling phase, which could create internal tension damaging to teeth and ceramic materials[4].

The purpose of this in-vitro study was to compare the effect of various surface treatments on the microtensile bond strength of lithium disilicate ceramic with dentin.

Materials and Methods:

Forty five extracted human maxillary premolars were obtained for the study. The samples were cleaned with 9.5% normal saline and immersed in 8% hydrogen peroxide solution for 24 hours to clear the tooth from debris and necrosed tissue.

A metal box with dimensions (Length= 1.5”, Width=1.5” and Height= 1.5”) was obtained having two 'V' shaped notches with dimensions (3mm×3mm) . This box was filled with dental stone(Kalabhai one kalstone, India) and 1 specimen tooth was cleaned and mounted in such a way that the 'V' shaped notch came mesial and distal to the mounted tooth and its cement-enamel junction was visible. Forty five such stone blocks were fabricated. Custom tray was fabricated for every stone block with poly methylmetha acrylate (PYRAX-RR, India).

To standardize the tooth preparation and to achieve parallelism between axial surfaces, a custom jig was fabricated which secured the air rotor handpiece on dental surveyor in desired position. Tooth preparation for all ceramic crown was done using an air rotor hand piece (NSK, Japan) mounted on a custom made jig attached to the dental surveyor.

Two step putty wash impressions by addition silicon(AVUE, DENTAL AVENUE, India) in custom tray was made for each stone block poured with die stone(Neelkanth, India) and lithium disilicate (GC, India) crowns were fabricated using CAD-CAM machine (Weiland, Germany). The crowns were fabricated in such a way that a loop measuring 5mm in diameter was attached to the occlusal surface for pull out test.

The lithium di silicate crowns were then divided into three groups based on the surface treatment done.

- **Group A:** Lithium di silicate crowns with no surface treatment
- **Group B:** Lithium di silicate crowns treated with air abrasion(Twin-Pen, China) with 50µm Al_2O_3 particles at 35 psi from a distance of approximately 10 mm for 15 seconds.

- **Group C:** Lithium di silicate crowns treated with laser (Cheese II Den 10B, GIGAA laser, Wuhan Giga Optronics Technology, UK) with wavelength of 980nm for 5 seconds seconds along with a fine water spray acting as coolant.

A uniform layer of self-adhesive resin cement(Maxcem Elite, Kerr Corporation, USA) was dispensed onto the intaglio surface of the crown and cemented on their respective specimen in their respective group, the pull out load test was performed using a Universal testing machine(Samarth Engineering, India) . The test specimen was fixed on the lower jaw of Universal testing machine and the loop of cemented crown was engaged by a stainless steel wire(K.C Smith & CO., UK) fixed on upper jaw of the universal testing machine and test was performed. At point where the crown got separated from tooth, the reading was noted for each specimen.

The data was analyzed using one way ANOVA TEST for multiple group comparison followed by Tusky HSD post hoc test. Level of significance was considered at 5% (p-value<0.05).

Results:

Table 1 showed descriptive statistics for micro-tensile bond strength for various surface treatments which includes mean, median and standard deviation. The greatest bond strength values were observed when the lithium disilicate ceramic surfaces were treated with air abrasion with Al_2O_3 particles.

Table 1: Descriptive Statistics of Groups

Surface Treatment	N	Mean±sd	Median	First Quartile	Third Quartile	Minimum	Maximum	Standard error
Group A	15	3.11±0.57	3.17	2.62	3.56	2.10	3.95	0.15
Group B	15	17.54±0.90	17.66	16.54	18.32	16.11	18.93	0.23
Group C	15	9.64±0.81	9.56	8.97	10.22	8.10	10.90	0.21
Total	45	10.09±6.01	9.56	3.52	16.76	2.10	18.93	0.89

Comparison among groups (Air abrasion with Al_2O_3 particles, Laser treatment)

One way ANOVA test There is a comparison of two groups therefore ANOVA Test was chosen for statistical analysis.

Table 2: ANOVA table for mean microtensile bond strength comparison:

Surface Treatment	Mean±sd	F Value	P Value
Group A	3.11±0.57		
Group B	17.54±0.90	1307.87	0.001
Group C	9.64±0.81		
Total	10.09±6.01		

Table 2: ANOVA detected a statistically significant difference in bond strength between the study groups ($P < 0.005$; Table 2). So we shall apply the Tuskey HSD post-hoc test to determine the amount of significant difference among the groups.

Tuskey's HSD post-hoc test:

This test is performed only after ANOVA test. ANOVA test tells that whether group in the sample differ where as Tuskey's post hoc test clarifies which group among the sample in specific have significant differences.

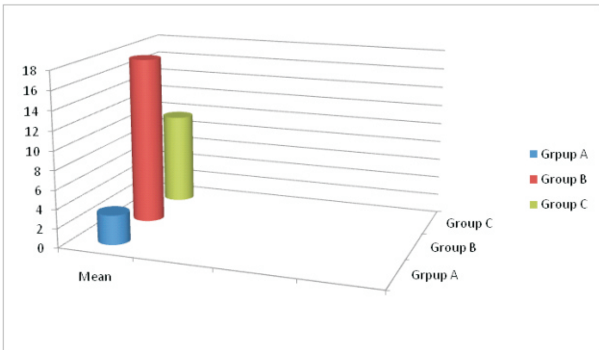
Table 3: Multiple Comparison tables (Tuskey's HSD Post hoc test):

Comparison Group	Mean difference	Standard Error	P Value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group A Vs Group B	14.42	0.28	0.001*	15.11	13.74
Group A Vs Group C	6.53	0.28	0.001*	7.21	5.84
Group B Vs Group C	7.90	0.28	0.001*	7.21	8.58

*. The mean difference is significant at the 0.05 level.

Table 3: The p-value corresponding to one –way ANOVA is lower than 0.01 when Group A was compared with Group B and Group C And Group B was compared with Group C. This suggests that there is significant difference between among these groups.

GRAPH 1: Graphical representation of mean of Control group, Air abrasion with Al_2O_3 particles and Laser treatment.



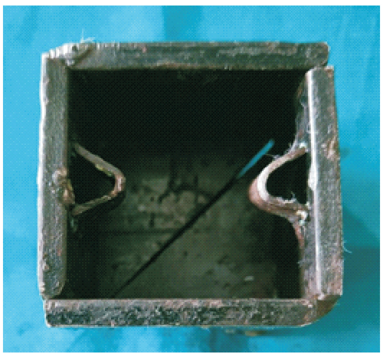


FIG 1: Metal box with "V" shaped notch

FIG 2: Mounted specimen in stone block

FIG 3: Lithium disilicate ingots

FIG 4: Cemented crowns for various surface treatments

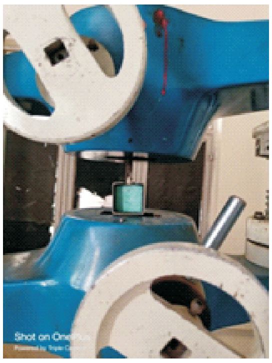


FIG 5: Sample during testing

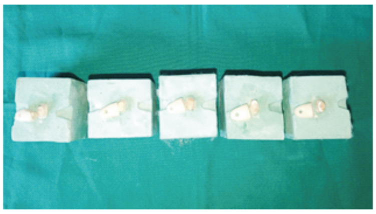


FIG 6: Decemented crowns

Discussion:

The present study investigated the effect of various surface treatment on microtensile bond strength of lithium disilicate ceramic with dentin.

The success of the restoration depends upon the appropriate adhesion between ceramic and tooth structure[1]. A strong bond between ceramic and tooth structure provides good support for the restoration and actively transmits functional loads through the bonded interface[3]. Use of resin cements improves retention, fracture resistance and the marginal adaptation of the restoration to the tooth structure. These cements are known for their high esthetics and high bond strengths[1]. Lithium disilicate glass-ceramics contains a 70% crystalline phase that increases its clinical properties; they bond adhesively to dental tissues, have high esthetics and biocompatible[9]. These properties have made lithium disilicate a good choice for the fabrication of all-ceramic crowns, long span bridges, posts and cores and implant[11]

Air abrasion was proposed in order to increase the micro tensile bond strength of lithium disilicate ceramic. Surface roughening by Al_2O_3 was done by Borges et al[2] , because of its potential for increasing surface energy, surface area for bonding. However it was found by Salvio et al[7] that particles abrasion alone slightly roughens the lithium disilicate ceramic surface but does not always provide reliable resin bond strength.

Different sizes of aluminium oxide particles, between 50 and 110mm, are generally used for air abrasion[2]. These particles altered the morphological structure of the lithium disilicate ceramic , resulting in an increase in the number of potential retention area. However, it was found that different size of particles and the application time may induce discrepancies in the achieved results, as excessively high pressure during blasting may facilitates the micro cracks, thus reducing the mechanical properties of lithium disilicate ceramic[7]. Hence, in the present study, 50 µm Al_2O_3 particles were used which showed the highest micro tensile bond strength values.

In this study, irradiation of lithium disilicate ceramic surfaces with diode laser was done as a surface treatment method. During laser treatment, local temperature changes due to heating and cooling phases create internal tensions that can damage the material[10]. Therefore, in the current study, a lower power setting was selected and the surfaces were irradiated with constant water cooling.

After absorption of laser energy, a process called heat induction produces shell-like ruptures on the ceramic surface, which provided a micromechanical bond between the resin material and the ceramic surface after resin tags penetrate into these cracks and set[3].

Scaly irregularies on the lithium disilicate surface increase micromechanical retention and improves microtensile bond strength of lithium disilicate ceramic with dentin.
However, in the present study, surface analysis tests were not done. Artificial aging methods, such as fatigue, the rmocycling and long-term water storage, were not performed to evaluate the hydrolytic degradation, stability and durability of the lithium disilicate ceramic bond. These may be few of the limitations of this study.

Conclusion:

Improving the retention of lithium disilicate ceramics is desirable in order to avoid the decementation phenomena. Loss of crown retention was found to be the second leading cause of failure of crowns and fixed partial dentures.

Within the limitation of this study, the following conclusions were drawn:

- The two surface treatments (air abrasion with Al_2O_3 particles and laser treatment) used in this study increased the micro tensile bond strength adequately.
- It was evident that bond strength significantly increased in the samples that were surface treated by air abrasion using alumina particles when compared to laser.
- It was also seen that , the laser treated samples showed less significant difference than control group.

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