Original Research

"A Comparative Evaluation of The Surface Roughness of Lithium Disilicate After Air Abrasion with Silica and Alumina Particles – An in Vitro Study"

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Abstract

The purpose of this in-vitro study was to evaluate and compare the surface roughness of IPS e.max Press lithium disilicate after air abrasion with silica and alumina particles. Thirty lithium disilicate specimens of dimensions 5×5×7 mm, were fabricated by heat pressing ingots. The specimens were divided into 3 groups (n=10). Group A consisted of untreated specimens, group B of specimens air abraded with 50 µm silica particles and group C of specimens air abraded with 110 µm alumina particles. Surface roughness of specimens were analyzed using Stereomicroscope and image software. One way ANOVA revealed that, the higher mean surface roughness was recorded in specimens treated with alumina particles. The difference in mean surface roughness among the groups was statistically significant ($p < 0.05$).

Key Words: Silica, Alumina, Lithium Disilicate, Stereomicroscope, Surface Roughness.

INTRODUCTION

An increasing number of all ceramic materials and systems are currently available for clinical use. The most widely used pressable ceramics is IPS e.max lithium disilicate. It can be traditionally pressed or contemporary processed via CAD/CAM technology. Bonding the ceramic restorations to tooth structure relies on treatment of the ceramic surface. An important requirement for successful function of these ceramic restorations is adequate adhesion between treated ceramic and tooth structure. The adhesion of a luting agent to a ceramic surface requires pretreatment of this interface. A variety of ceramic surface treatments have been advocated like grinding or abrasion with diamond rotary instruments, air-borne particle abrasion, thermal silica coating or tribochemical coating process and acid etching which produce different surface topographies and bond strengths.5 Surface roughness promotes mechanical retention of the composite resin cement, which penetrates into these irregularities maximizing the bond strength between treated ceramic and resin cements.6 Air-borne particle abrasion with silica and alumina are used in this study with the intention of creating surface roughness and microporosities on the ceramic surface which is expected to enhance the bond strength. Little information is available to identify the interaction between the resulting surface topography and bond strength which is to be evaluated.7 Hence its important to evaluate the mechanical properties of these new materials in vitro.

AIMS AND OBJECTIVES

Aim of this study was to compare and evaluate the surface roughness of IPS e.max pressable lithium disilicate pre-treated with silica or alumina particles.

MATERIALS AND METHOD

Table 1 : Armamentarium used for the study

Materials	Purpose
Heat Pressing machine	Heat pressing of specimen
IPS e.max Press ingot	For fabrication of specimen
Sandblasting unit	For air abrasion of specimen
Silica particles - 50 µm	For air abrasion of specimen
Alumina particles - 110 µm	For air abrasion of specimen
Stereomicroscope	To capture image of tested surface
Image software	To evaluate average surface roughness

FABRICATION OF LITHIUM DISILICATE SPECIMEN:

A standardized specimen of dimension 5×5×7 mm was fabricated in cold cure acrylic resin, which was used to prepare silicone mould. Wax patterns fabricated using these moulds were sprued and invested using investment powder and liquid (IPS Press Vest Speed, Ivoclar-Vivadent). Silicone casting ring was used to fill the investment material. Once the investment was set, wax elimination was done in a burnout furnace (Type 5640, Kavo, Germany). Simultaneously, heat pressing machine (Programmat EP 3000, Ivoclar-Vivadent) was pre-heated to 650ºC. After the wax burnout, the investment ring, aluminium oxide plunger and ingot (IPS e.max Press) were transferred to heat pressing machine. Plunger separator was applied to alumina plunger for the easy separation of pressed material. IPS e.max Press ingots and the alumina plunger were heated to 920°C, held for 15 minutes to melt the ingot and vaccum pressed into the mould. After cooling to room temperature, specimens were divested with 50 µm glass bead particles (Kavo) at 2-bar pressure, ultrasonically cleaned in a special liquid (Invex liquid) for 10 minutes, washed in running water, and dried. Rotary stone burs (Syndent) were used for the finishing of lithium disilicate specimens.

EVALUATION OF SURFACE ROUGHNESS:

Thirty specimens were divided into three groups.

Group A: 10 untreated specimens.

Group B: 10 specimens air abraded by silica particles (Perlablast) of 50 µm for 20 seconds at 2.8 bar pressure.

Group C: 10 specimens air abraded by alumina particles (Korox) for 20 seconds at 2.8 bar pressure.

To measure the surface roughness of the abraded surfaces, a stereomicroscope (Magnus) at 40x

magnification was used to visualize and capture the images of the treated surface (Figure 1).

The average roughness (Ra) value was calculated using image software (SPIP 6.0.9 software).

Statistical analysis:

Comparisons were carried out with one-way analysis of variance. Multiple comparisons were carried out with Tukey's post hoc test.

Statistical software:

The statistical software namely SAS 9.0, SPSS 15.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

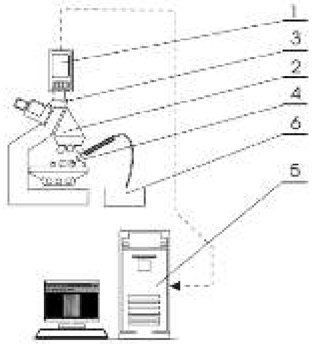


Figure 1: Evaluation of surface roughness by Stereomicroscope and image software

RESULTS

EVALUATION OF SURFACE ROUGHNESS :

Table 2: Average surface roughness (Ra) recorded in nm

Specimen	Group A	Group B	Group C
1	57.03	58.92	58.77
2	54.12	57.94	57.24
3	56.21	55.51	61.21
4	54.76	56.59	58.35
5	55.64	57.35	57.83

Ra : arithmetic average of the 3D roughness.

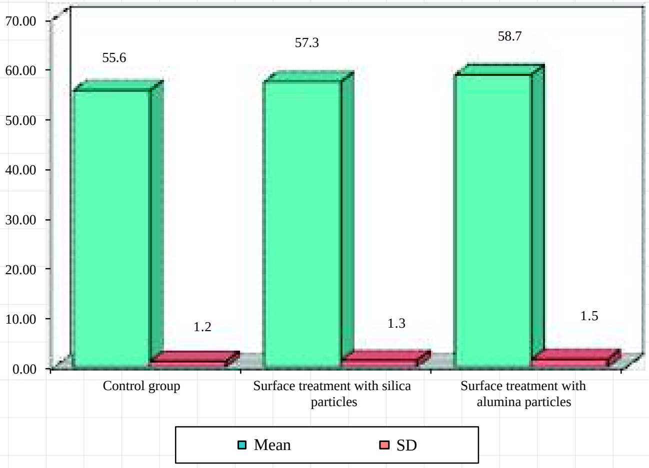
Above table represents the average surface roughness values (Ra) in nm of 5 specimens in each group.

SURFACE ROUGHNESS ANALYSIS :

Table 3: Mean and SD of surface roughness according to three

Groups	Mean	SD	Std. error	Coefficient of variation
Control group	55.55	1.15	0.51	2.07
Air abrasion with silica particles	57.26	1.30	0.58	2.27
Air abrasion with alumina particles	58.68	1.53	0.68	2.60

Graph 1: Comparison of Mean and SD of surface roughness in three groups



Above table and graph represents the mean and SD of surface roughness according to three groups in which, the surface roughness values are higher in air abrasion with alumina particles group followed by air abrasion with silica particles group and control group.

Table 4: Comparison of three groups with respect to surface roughness values by one-way ANOVA

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	P-value
Between groups	2	24.53	12.2660	6.8928	0.0102*
Within groups	12	21.35	1.7795		
Total	14	45.89			

*p<0.05

A significant difference was observed between three groups with respect to surface roughness values (F=6.8928, $p<0.05$) at 5% level of significance. It means that, the surface roughness values are different in three groups.

If F is significant, to know the pair wise comparisons of three groups with respect to surface roughness values, we use Tukey's multiple posts hoc procedures and the results are presented in the following table.

Table 5: Pair wise comparison of three groups with respect to surface roughness values by Tukey's multiple posts hoc procedures

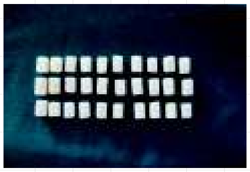
Groups	Control group	Air abrasion with silica particles	Air abrasion with alumina particles
Mean	55.55	57.26	58.68
SD	1.15	1.30	1.53
Control group	P=1.0000		
Air abrasion with silica particles	P=0.1482	P=1.0000	
Air abrasion with alumina particles	P=0.0079*	P=0.2522	P=1.0000

*p<0.05

From the results of the above table, it can be seen that,

- A significant difference was observed between control and air abrasion with alumina particles groups with respect to surface roughness values ($p<0.05$). The surface roughness values are significantly higher with alumina particles group as compared to control group.
- A non-significant difference was observed between control and air abrasion with silica particles groups with respect to surface roughness values ($p>0.05$). The surface roughness values are similar in control group and with silica particles group.
- A non-significant difference was observed between surface treatment with silica particles group and surface treatment with alumina particles group with respect to surface roughness values ($p>0.05$). The surface roughness values are similar in air abrasion with silica particles group and with alumina particles group.

Photographs



Photograph 1 : Lithium disilicate specimens

Photograph 2 : Untreated specimen (40x)

Photograph 3 : Air abrasion with silica (40x)

Photograph 4 : Air abrasion with alumina (40x)

DISCUSSION

Metal ceramic restorations have been available for more than three decades. This type of restoration has gained popularity from its predictable performance and reasonable esthetics. Despite its success, the demand for improved esthetics and the concerns regarding the biocompatibility of the metal has led to the introduction of all-ceramic restorations .

Since their introduction as cosmetic restorations in the early 1980s, ceramic veneers have gained wide acceptance with dentists and patients.1 All-ceramic restorations have gained popularity in recent years due to their excellent esthetic quality and biocompatibility.3

All ceramic restorations are fabricated by CAD-CAM or heat pressing technique. Various pressable ceramics in the market are Vitablocs (Vita), Super Porcelain Ex-3 Press (Noritake Dental International), IPS Empress 2 (Ivoclar-Vivadent), Authentic Pressable All-Ceramic Porcelain (Jensen Dental). The “pressed” restorations are generally considered to be denser, hence stronger and have a better fit when compared with metal ceramic restoration10. They are considered as monochromatic restorations which can be surface characterized to the desired shade and produce comparable esthetics to the layering techniques. Lithium disilicate have good translucency.

Pressable ceramic used in the present study is IPS e.max Press which is a lithium disilicate glass ceramic ingot, that is heat pressed using the lost wax technique.3 The microstructure of IPS e.max Press consists of approx. 70% lithium disilicate crystals ($Li_2Si_2O_5$), embedded in a glassy matrix. Lithium disilicate, the main crystal phase, consists of needle-like crystals. The crystals measure 3 to 6 ʍm in length. They are recommended in situations where average to high translucency is needed. Its increased flexural strength makes it suitable for the usage for fabrication of 3-unit FPD's in the anterior region.14 As they are brittle in nature, they are contraindicated in posterior region.

The longevity of all ceramic restorations depends on many factors such as the prepared tooth, treated surface of ceramic and cementing medium. Morphology modifications on the ceramic surface may be performed to promote a better bond strength.5 To obtain reliable mechanical retention between the composite resin cement and ceramic materials, surface roughening of the ceramic restoration is essential.2 Various measures used to enhance bond strength of resin cement and silica based ceramics are etching with hydrofluoric acid and/or gritblasting which provides micro-mechanical attachment and chemical bonding by a silane coupling agent. According to Valandro et al5, airborne particle abrasion, thermal silica coating (Silicoater; Heraeus Kulzer) or a tribochemical coating process (Rocatec system) can be used to improve the bond strength for these types of ceramics.

Various measures available to evaluate the surface roughness are, the use of scanning electron microscope, Profilometry or Stereomicroscope. In the present study, stereomicroscope was used to visualize and capture the images of the treated surface at 40x magnification. The disadvantage of using stereomicroscope is the lesser magnification at which the treated surface is visualized when compared to SEM, where in the surfaces can be better appreciated at a magnification of 2000x. With the stereomicroscope, surface features like the depth of the irregular pits cannot be appreciated. To evaluate the surface roughness various imaging softwares are available. A specialised image analysis software (SPIP 6.0.9) was used to measure average surface roughness in 3D, where the average roughness were calculated from three regions using an inspection box of standardised size and expressed in nm. On evaluation, a significant difference was observed between three groups with respect to surface roughness ($p < 0.05$) at 5% level of significance. The superior performance of alumina over silica particles with regard to surface roughness in the present study may be explained by the fact of using larger (110 µm) alumina particle when compared to smaller (50 µm) silica particles.

With the advent of newer ceramics, it has become imperative to evaluate their surface topography, its effect on the bond strength and also the effect of these materials in clinical conditions in order to select the appropriate one.

LIMITATIONS OF THE STUDY:

- Limited sample size.
- By using stereomicroscope at 40x magnification, surface roughness were not appreciated well enough when compared to use of scanning electron microscope at 2000x magnification in other studies.

SCOPE FOR FURTHER RESEARCH:

- Further studies can be undertaken to assess the surface roughness and tensile bond strength of lithium disilicate using hydrofluoric acid or silane coupling agent

CONCLUSION

Within the limitations of this study, it can be concluded that the air abrasion with alumina produced higher surface roughness when compared to silica particles.

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Source of Support : NIL
Conflict of Interest : NOT DECLARED
Date of Submission : 10-01-2016
Review Completed : 10-05-2016