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Influence of sandblasting distance on enamel and ceramic structure bond strength

Influência do jateamento na estrutura cerâmica e esmalte, alterando a distância na resistência de união

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ABSTRACT

Objetive: The purpose of this study was to evaluate the influence of sandblasting distance on ceramic and enamelbond strength. **Material & Methods:** Sixtythird molars were selected, enamel surfaces were ground flat with wet 600 - 2000 grit aluminum oxide abrasive papers and polished with three, one, and one-fourth micrometer-grit diamond pastes. On hundred and twentylithium disilicate-based core ceramic discs (2 mm diameter; 1 mm thickness) were also obtained and further divided into 7 groups [Group C, no sandblasting, Group SB-E(5-10) enamel sandblasting - 5 and 10 mm of distance, Group SB-C(5-10) ceramic sandblasting 5 mm and 10 mm of distance, Group SB-EC(5-10) enamel and ceramic sandblasting 5 mm and 10 mm of distance]. After treatments,shear and Atomic Force Microscopy (AFM) tests were performed.Data were analyzed by Statistic Tests of normality, one-way ANOVA and Tukey post-test (α: 0.05). **Results:** Group C presented the highestbond strength values(59.2 ± 12.5), while group SB-E 5 mm showed the lowest values (21.7 ± 08.8) ($p < 0.005$). **Conclusion:** The use of sandblasting treatment of enamel surface at 5 mm distance decreases the bonding strength to shear.

KEYWORDS

Shear strength; Aluminum oxide; Air Abrasion, Dental.

RESUMO

Objetivo: o objetivo do estudo foi avaliar influência do jateamento na estrutura cerâmica e esmalte sob resistência de união, mudando a distância. **Materiais e Métodos:** 60 terceiros molares, foram selecionados, superfícies de esmalte foram planificadas com lixa com grão 600 - 2000 lixas e polido com pastas de diamante de um grão -micrômetro. Obtidos 120 discos cerâmica em dissilicato de lítio de (2 mm de diâmetro e 1 mm de espessura), dividido em sete grupos [Grupo C, não jateamento, Grupo SB-E (5-10) esmalte jateamento 5 e 10 mm, Grupo SB -C (5-10) de jacto de areia cerâmica 5 mm e 10 mm, Grupo SB-CE (5-10) e esmalte cerâmico areação 5 milímetros e 10 mm], depois foi realizado o microcisalhamento e a microscopia de forca atômica (AFM), estatística como Teste de Normalidade , após análise de variância one-way e teste de Tukey (α: 0,05). **Resultados:** A força do grupo C apresentou maiores valores de resistência de união (59,2 ± 12,5), o grupo SB-E 5 mm (21,7 ± 08,8) ($p < 0,005$), o grupo SB-E10 (53,6 ± 14,3). **Conclusão:** o uso de jateamento tratamento da superfície do esmalte de 5 mm, de 20 s diminui a força de ligação de microcisalhamento.

PALAVRAS-CHAVE

Resistência ao cisalhamento; Óxido de alumínio; Abrasão dental por ar.

INTRODUCTION

Restorative dentistry faces new challenges in adopting emerging technologies related to dental materials and to meeting patients' demands for esthetic non metallic restoration. Currently, available choices of nonmetallic materials for such restorations include direct and indirect resin composite, porcelain or ceramic. Among these materials, glass ceramic inlay techniques have some advantages such as satisfactory physico-chemical properties, abrasion resistance, and color retention compared to composite resins that lead to some problems when used in stress-bearing areas of the mouth [1]. IPS Empress 2 (IvoclarVivadent, Schaan, Liechtenstein) glass ceramic is a heat-pressed, lithium disilicate–reinforced ceramic. This all-ceramic material has been introduced for single restorations as well as for three-unit fixed partial dentures in the anterior region, possibly extending to the second premolar. The final restoration, made oflithium disilicate–framework ceramic, offers clinical benefits in terms ofadaptability, polish surface, and reduced wear of opposing tooth structure, with the advantages of increased biocompatibility, natural appearance, and superior esthetics [2, 3].

Some clinical studies have indicated that an insufficient luting performance of restorations may result in clinical failure [4,5]. Obtaining desirable adhesion between cement and ceramic surfaces requires surface pretreatment to improve the retention, marginal adaptation, and fracture resistance of restorations [6, 7]. Surface pretreatment of porcelain increases surface area and creates microporosities on the surface, enhancing the potential for mechanical retention of the cements [8].

Many in vitro studies have suggested that sandblasting of the interior surface of all-ceramic crowns enables adhesive bonding [9, 10]. Sandblasting produces a rough irregular surface and facilitates micromechanical retention by increasing the surface area and energy available for the adhesion of resin cements. Fine alumina oxides under pressure (which are used in this method) decrease surface tension, enabling optimal wetting of silane-coupling agents. That sandblasting enamel directly before acid etching may be an effective procedure to prepare teeth and to increase bond strength of lingual orthodontic bracketsm [11]. The purpose of this study was to evaluate the influence of different sandblasting distances on ceramic and enamel structure bond strength.

MATERIAL & METHODS

Enamel specimen preparation.

Sixtythird molars were selected, cleaned, and stored in a 0.5% chloramine T solution at 4 ◦C for no more than a week. Teeth were obtained after informed consent by the patients and under the protocol (00010-0002/2) that was analyzed and approved by the local Ethical Research Committee. The roots were sectioned 1 mm above the cement-enamel junction using a double-faced diamond diskDiscoflex (KG Sorence, Sao Paulo, Brazil). Then, enamel surfaces were ground flat with wet 600, 1,000, 1,200, 1,500, and 2,000 grit aluminum oxide abrasive papers (Carborundum, Bogota, Cundinamarca, Colombia) and polished with three, one, and one-fourth micrometer-grit diamond pastes(Arotec S/A. Cotia, SP, Brazil) on a polishing machine (Aroppol E Arotec S/A. Cotia, SP, Brazil).

Ceramic Specimen preparation

One hundred and twenty lithium disilicate-based (Table 1) core ceramic discs (2 mm diameter;1 mm thickness) in IPS Empress 2 were obtained bywax patterns, which were preparedwith Duralay (Reliance, Illynois, USA) and invested in IPS Empress 2 Speed. The wax was eliminated in a burnout furnace pre-heated to 850ºC with an alumina plunger for 90 min. The IPS Empress 2 ingots were softened at 920 ºC and were automatically pressed into the mold in a furnace (EP 600;Ivoclar-Vivadent). After pressing and cooling atroom temperature, the

specimens were separated with 125 -μm glass beads at 4-bar pressure, ultrasonically cleaned in a special liquid (Invex liquid; Ivoclar-Vivadent, Amherst, New York, USA) for 10 min, washed in tap water, and dried. The enamel surfaces and ceramic specimen were randomly divided into each treatment of sandblasting:

Group C (n = 15) (untreated control). Without microsandblasting on enamel or ceramic.

Group SB-E5 (sandblasting -Enamel). Enamel surfaces were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar,from a distance of 5 mm perpendicularly to thesurface for 20 s.

Group SB-C5, (n = 15) (sandblasting - Ceramic). Ceramic specimens were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar, from a distance of 5 mm perpendicularly to thesurface for 20 s.

Group SB-EC5, (n = 15) (sandblasting – Enamel-Ceramic). Enamel surfaces, Ceramic specimens were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar, from a distance of 5 mm perpendicularly to thesurface for 20 seconds.

Group SB-E10 (sandblasting -Enamel). Enamel surfaces were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar, from a distance of 10 mm perpendicularly to thesurface for 20 seconds.

Group SB-C10, (n = 15) (sandblasting - Ceramic). Ceramic specimens were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar, from a distance of 10 mm perpendicularly to thesurface for 20 s.

Group SB-EC10, (n = 15) (sandblasting – Enamel-Ceramic). Enamel surfaces, Ceramic specimens were abraded with 50-μm Al_2O_3 particles at a pressure of 2.8 bar, from a distance of 10 mm perpendicularly to thesurface for 20 s.

Microshear test

The internal surface of IPS Empress E-Max II(IvoclarVivadent, Schaan, Liechtenstein) cylinders (1-mm diameter, 2-mm thick) was etched for 20 s with 9.6% hydrofluoridric acid (EUFAR, Bógota, Cundinamarca, Colombia) (Table 1), followed by the application of a silane agent Calibra (Dentsply, Milford DE, USA) for 60 s. The adhesive and resin cement (Table 1) were light-cured using a Led lightBluephase Style (IvoclarVivadent, Schaan, Liechtenstein). One ceramic cylinder was cemented on each enamel specimen, and 24 h after the bonding procedure, the cylinders were subjected to a shear test using a thinchiselmetal in a universal testing machine (Kratos; São Paulo, SP,Brazil) at a 1 mm/min crosshead speed. Values were expressed in MPa.

Atomic Force Microscopy (AFM)

Baseline Ravalues were obtained using an atomic force microscopy, based on readings of four ceramic surfaces (1 mm × 2 mm) and four enamel surfaces per group, under an atomic force microscopy (AFM; SPM-9600, Shimadzu, Kyoto, Japan). Imaging was performed with standard geometry silicon nitride (cantilever) and probed with constant elastic (0.01–1.0 N/m). AFM images were collected at a very low scan rate at1 Hz to obtain details of the enamel structure and to avoid damaging the tip. An area of 50.0 μm X 50.0 μm with resolution of 512 3 512 MPx, with operating point of 1.5 V.

Statistical Analyses

Descriptive statistics for the images were used. Forbond strength, values were analyzed by one-way ANOVA and Tukey's test (α: 0.05)

Table 1 - Materials, manufacturers, and batch numbers

Material	Manufacture	Composition	BatchNumber
RelyX™ ARC	3M Espe	methacrylateresin-based, bisphenol-A-diglycidyletherdimethacrylate (BisGMA), triethyleneglycoldimethacrylate (TEGDMA), Zirconia/silicafiller	1224300076
Adper™ Single Bond 2	3M Espe	BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids	N396444
IPS® e.max	Ivoclar-Vivadent	lithiumdisilicatecrystals(approx. 70%), $Li_2Si_2O_5$	R71283
Hydrofluoridricacid	Eufar	9.6% hydrofluoridric acid	120822
Calibra	Dentsply	Ethanol (Ethyl Alcohol) or Ethanol Solution (Ethyl Alcohol solution)	110517

RESULTS

AFM data (Roughness values, in nm) are expressed descriptively in (Table 2). The roughness values increased, after performing microsandblasting procedures (Figure 1,2,3,4,5,6).

The mean shear bond strength (in MPa) and standard deviations are shown in (Table 3)

Bond strength values significantly reduced when sandblasting of enamelwas performed at 5 mm distance ($p < 0.05$), andincreased slightly, although not significant, when done in ceramic sandblasting.

Table 2 - Roughness Ra (nm) enamel and ceramic before sanblasting

Sanblasting		
Distance	**Enamel**	**ceramic**
Group C	013.45	045.62
5 mm	478.76	094.65
10 mm	526.16	338.75

Table 3 - Means (MPa; standard deviations) of the shear bond strength for the groups tested

Sanblasting			
Distance	**enamel**	**ceramic**	**enamel and ceramic**
Group C		59.2±12.5A	
5 mm	21.7±08.0B	64.1±15.4A	44.3±12.4A
10 mm	53.6±14.3A	58.6±17.0A	40.6±17.1A

** Different letters represent significant statistical difference with group C (one-way ANOVA and Tukey test ($p < 0.05$).*

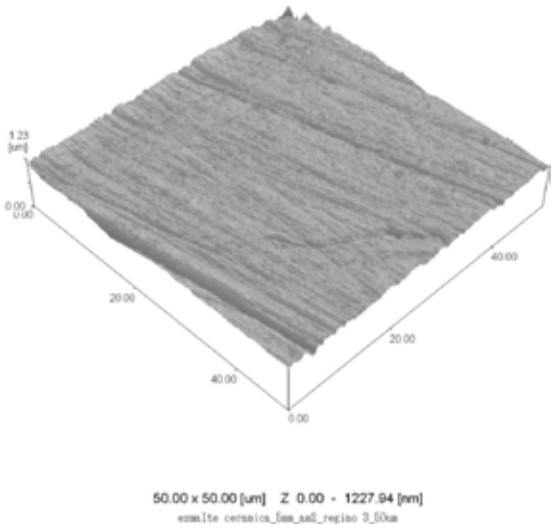

Figure 1 - Enamel- noSandblasting.

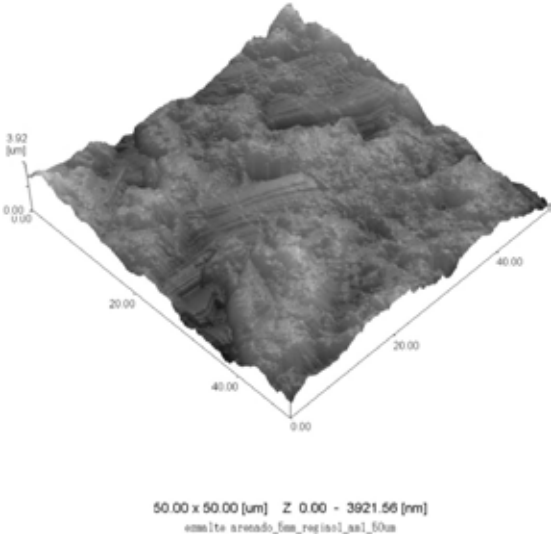

Figure 2 - Enamel - Sandblastingat 5 mm.

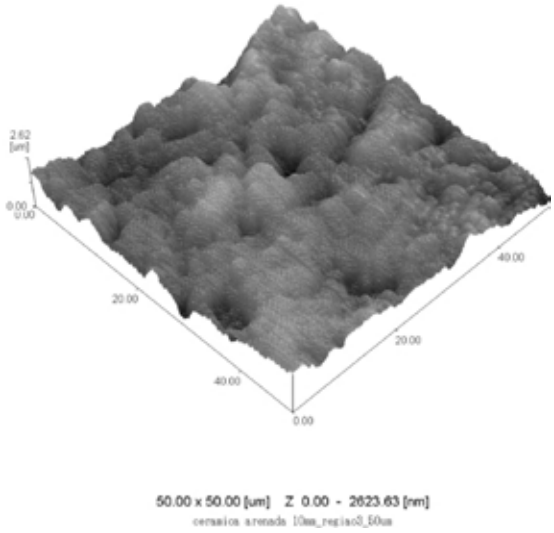

Figure 3 - Enamel - Sandblastingat 5 mm.

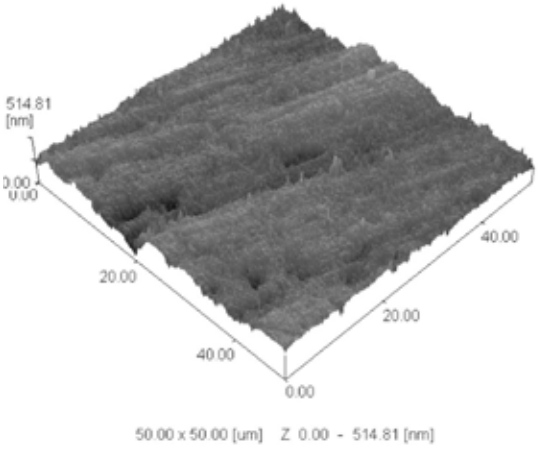

Figure 4 - Ceramic – No Sandblasting.

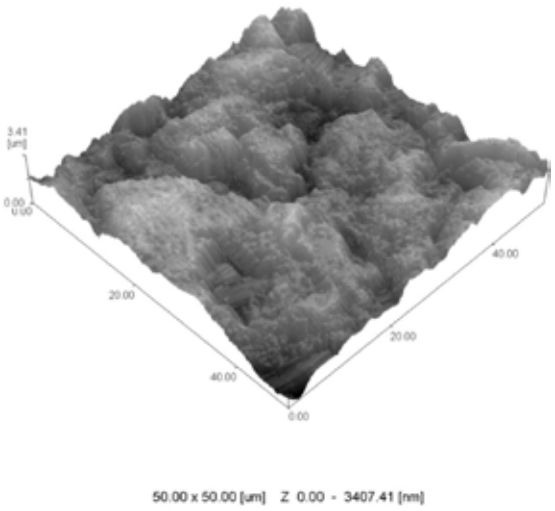

Figure 5 - Ceramic - Sandblasting at 5 mm.

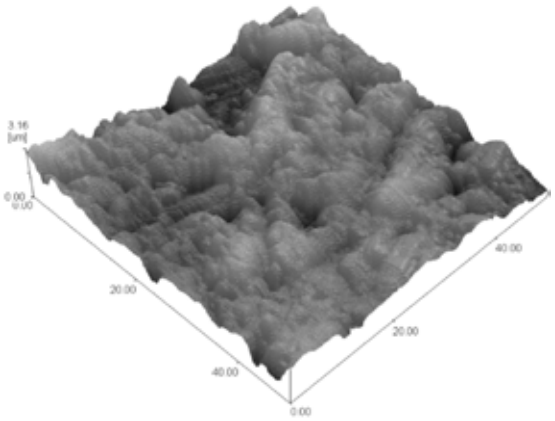

Figure 6 - Ceramic - Sandblasting at 10 mm.

DISCUSSION

When bonding ceramic to the tooth structure, two different interfaces need to be considered: the dentin or enamel/adhesive interface and the ceramic/cement interface [12]. The bond strength at both of these interfaces should be optimized, because the lowest one will determine the final bond strength of the cemented restoration [13].

In this context, the bond strength between resin cement and ceramic depends on many factors, such as the composition of the ceramic material. Studies, such Spohr A. (24), statethe application of Hydrofluoridricacid increasesthe bond strength values, fact also observed for the use ofsilane and resin cement, and also for the surface treatment that the ceramic received. Numerous options have been suggested, and these were overall combinations of various mechanical and chemical conditioning methods used to optimize bond strength at the ceramic/cement interface. Roughening of the surface with aluminum oxide air abrasion or diamond burs is generally regarded as compulsory for reliable bond strength [14, 15].

Creating an effective micro-roughness on ceramic surfaces is crucial for an adequate retention of ceramic [16], leading to resin or cement penetration into this retentive surface [17]. Based on this concept, micro roughness increases both ceramicand enamel surfaces.

There is wide agreement in the literature that acid etching causes iatrogenic damage to the enamel [18], enamel loss and the appearance of cracks from acid etching have been described; on average, these cracks reach a depth of 80 μm (19).The resin probably remains on the enamel after debonding, and this could affect plaque retention, susceptibility to caries, and discoloration. Majier and Smith (20) report that the loss of enamel surface reduces when polyacrylic acid is used instead of phosphoric acid. According to Olsen et al, [21] sandblasting with aluminum oxide results in an irreversible loss of enamel, whereas acid etching shows intact organic components that allow the etched enamel surface to be remineralized [22].

However, enamel loss resulting from sandblasting at low pressure and short exposure time was smaller than acid etching with 37% phosphoric acid. Moreover, the sandblasting technique provides a quick method of conditioning and bonding teeth, so that contamination is easily avoided. It is also possible that the removal of inorganic and organic components of the enamel matrices by means of sandblasting technique prevents resin attachment to the enamel after debonding. In contrast to Reisner et al, [11] who observed that sandblasting did not appear to damage the enamel surface, the present study shows significant differences in enamel loss between different sandblasting methods. Distance alterations resulted in a significantly higher degree of enamel loss. Therefore, it should be noted that when sandblasting with aluminum oxide is used for bonding, the amount of enamel loss can be controlled by the operator. In addition, the operator should be aware of the negative aspects of sandblasting with aluminum oxide in the mouth. The adhesive strength measurements recorded in the present study indicate that bond strength is significantly reduced when sandblasting is used at 5 mm distance fromenamel; this is consistent with the studies of Olsen et al [21] and Reisneret al. [11].

Although no study has been found on the effect of the sandblasting particle size on the bond strength to zirconia, an investigation on the optimal surface treatments for carbon/epoxy composite adhesive joints concluded that the surface roughness, eroded length and eroded depth increased as the particle size of sandblasting augmented [23]. In the present study, particle size was not tested, and microabrasionat5 mm resulted in increasedroughness values.

CONCLUSION

Considering the conditions evaluated in this study, it can be concluded that:

The use of sandblasting treatment of the enamel surface at 5 mm distance decreases the bondstrength values.

The use of sandblasting treatment of the enamel and ceramic surface at 5and 10 mm distance did not increase the bond strength values.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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