Sato et al. Applied Adhesion Science 2013, 1:7
http://www.appliedadhesionscience.com/content/1/1/7

Applied Adhesion Science
a SpringerOpen Journal

RESEARCH **Open Access**

Flexural strength of a pressable lithium disilicate ceramic: influence of surface treatments

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Abstract

The aim of this paper was to evaluate the influence of different surface treatments on the flexural strength of a pressable lithium disilicate ceramic. Sixteen bars (16x2x4 mm) were made, divided into subgroups (n = 10), and the following surface treatments were done: C - no treatment; H - etching with 5% hydrofluoric acid; HC - etching with 5% hydrofluoric acid, silanization, and cementation; N – etching with 5% hydrofluoric acid, neutralization with supersaturated solution of sodium bicarbonate, silanization, and cementation; U – etching with 5% hydrofluoric acid, ultrasonic cleaning in distillated water, silanization, and cementation; NU - etching with 5% hydrofluoric acid, neutralization with supersaturated solution of sodium bicarbonate, ultrasonic cleaning in distillated water, silanization and cementation. The three points flexural strength was performed 24 h after cementation and the data were analyzed using one-way ANOVA and Tukey's tests (p-value = 0.05). The results showed that the surface treatment had a significant effect (p-value < 0,05) on the flexural strength of the studied ceramic. The N and NU groups showed lower flexural strength than other groups. Thus, it was concluded that neutralization with supersaturated solution of sodium bicarbonate, followed or not by ultrasonic cleaning results in lower mechanical strength of a pressable lithium disilicate ceramic. The etching with 5% hydrofluoric acid did not reduce the flexural strength of this ceramic type.

Keywords: Dental ceramic; Flexural strength; Surface treatment; Hydrofluoric acid

Background

The dental ceramic are widely used and studied in dentistry. Processing methods of these materials are varied and can be categorized by different laboratory techniques. which results in different distribution of flaws, translucency degrees, and marginal and internal fit [1]. The pressable method technique can be used for IPS e.max Press, which is a lithium disilicate glass ceramic with the improvement of mechanical and optical properties and adequate fit [2].

For luting lithium disilicate ceramic, the surface treatment is etching with hydrofluoric acid (HF), which generates microporosities because of the glass phase and silica oxide dissolution. This treatment produces topographical changes, which increases the micromechanical retention and chemical bond with the silane and resin cements, reflecting on the values of bond strength between the ceramic and cement [3]. The lithium disilicate ceramic must be etching with HF, with an application of silane prior to cementation, but the etching generates acid precipitates that may affect the bond between ceramic and cement [4]. Therefore, it is necessary to use some protocols such as post-etching ultrasonic cleaning bath or neutralization [4-6].

The neutralization after etching does not recommended, but if the clinician prefer to do it, it is necessary to do ultrasonic cleaning bath after the neutralization [4]. The ultrasonic cleaning bath with distilled water appears to increase the bond strength between the resin cement and ceramics, because of the precipitates removal [7]. But there is not any study in literature that evaluate the post-etching protocols influence in ceramic mechanical properties. So, the aim of this study was to evaluate the influence of some surface treatments in the flexural strength of a lithium disilicate ceramic.

Methods

The ceramic bars (IPS e.max Press, Ivoclar Vivadent, Schaan, Liechtenstein) were prepared using a metallic matrix with dimensions of 2.2 mm × 16.2 mm × 4.2 mm [8]. To produce the ceramic bars this matrix was placed on a glass plate, and thin wax layers were poured, in order to prevent distortion, until the complete filling with a slight excess that was removed with a sharp instrument. The wax bars (N = 60) were sprued, and attached to a muffle base. Then, they were invested with phosphate-based material (IPS PressVES, Ivoclar Vivadent, Schaan, Liechtenstein), following the manufacturer's recommendation. The heating and injection protocols were also indicated by the manufacturer using oven model P5000 (Ivoclar Vivadent, Schaan, Liechtenstein). After the cooling process at room temperature, the specimens was polishing with 800 and 1200-grit diamond papers. Before the surface treatment, they were cleaned in ultrasonic bath for 4 min in distillated water.

Then, the bars were aleatory separated in six groups (n = 10) (Table 1).

The HF (Formula e Ação, São Paulo, Brazil) etching was perfomed for 20 s. Then, the bars were washed with air-water spray for 40 s and dried for 30 s.

In the groups N and NU, the bars were submerged in supersaturated solution of sodium bicarbonate (SB) (Portuense, Juiz de Fora, Brazil) for 40 s and washed for 5 s.

In the groups U and NU, the ultrasonic cleaning bath was performed in a ultrasound (Cristófoli Equipamentos, Campo Mourão, Brazil) with distillated water for 4 min.

In groups submitted to cementation, silane (Monobond S, Ivoclar Vivadent, Schaan, Liechtenstein) was applied and, after 60 s, an air spray was applied for 5 s. Then, equal parts of base and catalyzer pastes of the resin cement (Variolink II, Ivoclar Vivadent, Schaan, Liechestein) were mixed for 10 seconds and applied on the bars. They were

Table 1 Surface treatment groups

Group	Surface treatment
C	No treatment
H	Etching with 5% HF
HC	Etching with 5% HF, silanization, and cementation
N	Etching with 5% HF, neutralization with SB, silanization, and cementation
U	Etching with 5% HF, ultrasonic cleaning bath in distillated water, silanization, and cementation
NU	Etching with 5% HF, neutralization with SB, ultrasonic cleaning bath in distillated water, silanization and cementation

Legend: Surface treatments used in this study (n = 10).

kept under constant load of 750 g. The light curing unit (RadiiCal Polimerize, SDI, Victoria, Australia) with light intensity of 1200 mW/cm^2 light cured each face for 2 seconds to facilitate the removal of excess of cement. Forty seconds of light activation was performed on each side of the bars. After the cementation, the samples were stored in distilled water at 37°C for 24 h.

In the mechanical testing, the bars were placed in a three-point bending test, in a metallic device, supported on two cylinders (2 mm diameter) with a distance of 16 mm between centers. Only the extremities of the samples were used for support, so the central area remained free to receive the load. The load was applied to the cementation opposite surface, by cylindrical rod (2 mm diameter) that was attached to universal testing machine (EMIC DL 1000, São José dos Pinhais, Brazil). The compressive load (v = 1 mm/min, load cell of 50 kgf) was applied until catastrophic failure [9,10]. All mechanical testing occurred immersed in distilled water at 37°C.

The flexural strength (MPa) was calculated based on the formula: $3\ PL/2\ WT^2$, where P is the load recorded at fracture, L is distance between supports, W is specimen width and T is the specimen thickness [10].

The values obtained for the fracture of the specimens were submitted to descriptive statistical analysis and the parametric one-way analysis of variance (ANOVA) and Tukey test (p-value < 0.05).

Results and discussion

There were a statistical difference between the groups (p-value = 0.00). The results are represented at Table 2. The flexural strength of monolithic lithium disilicate is represented by the structure of this material can resist masticatory stress, dissipating it throughout the entire restoration [2]. It was observed a decrease in the mechanical strength of groups submitted to SB neutralization process, with or without ultrasonic cleaning bath. The process of neutralization appears to cause reduction in adhesion between dentin and ceramic, since the reaction between HF and neutralization salt produces sodium fluoride and unstable carbonic acid [4]. These precipitates remain on the ceramic surface, avoiding the penetration of resin materials and hindering the creation of micro-retentions [5]. It could explain the lower flexural strength in the group U. For these precipitates removal, the ultrasonic cleaning bath is one of the mechanisms indicated [5]. The ultrasonic cleaning bath with distillated water increased the bond strength between ceramic and resin cement, because of effective removal of precipitates, since it F ions are not completely removed only with air-water spray [7].

Table 2 Flexural strength results

Treatment	Mean ± standard deviation
C	256,72 ± 71,32[a]
H	264,80 ± 33,99[a]
HC	317,28 ± 42,82[a]
N	180,86 ± 63,65[b]
U	317,86 ± 40,86[a]
NU	166,09 ± 43,65[b]

Legend: Mean and standard deviation of flexural strength (MPa). The same superscripted letters indicate no significant differences.

However, there was no visible improvement in the mechanical properties in this study. So, only air water spray has been sufficient to remove residual ceramic surfaces etched with HF [11]. There is few studies about the effects of neutralization and ultrasonic cleaning bath in bond strength and mechanical properties of lithium disilicate ceramic. The mechanical properties of lithium disilicate ceramic is related to considerable glass percentage in its composition. So, the etching could not weakening its structure to cause strength decrease in the H group compared to the group C. Additionally, maybe the precipitates formation in this ceramic type was lower when compared with another ceramics, like feldspathic ceramics. So, the neutralization and ultrasonic bath cleaning are unnecessary, because did not increased the flexural strength and results in more clinical steps for the clinicians. For this reason, the neutralization and ultrasonic cleaning bath could be eliminated as surface treatment for a lithium disilicate ceramic in terms of mechanical properties. But, it should be emphasized that bond strength between ceramic and cement could be better after these post-etching protocols.

Conclusion

The neutralization with supersaturated solution of SB, followed or not by ultrasonic cleaning results in lower mechanical strength of a pressable lithium disilicate ceramic. Etching with 5% HF did not reduce the flexural strength of this ceramic type.

Abbreviations

HF: Hydrofluoric acid; SB: Supersaturated solution of sodium bicarbonate.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

TPS prepared and cemented the samples and wrote the paper. CC planned the project and methodology, supervised the literature review and the tests and prepared the final version. LTY did the literature review and performed the strength test. NRR prepared and cement the samples and discussed the study. VCM got the idea, supervised the practical phase and corrected the final version. ETK guided the conception idea, the project planning, the methodology, the statistical analysis, and raised funds to do the study. All authors read and approved the final manuscript.

Acknowledgements

The authors acknowledge support from Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP (2011/11301-6, 2012/12082-9 and 2013/00924-8).

Received: 22 August 2013 Accepted: 1 November 2013
Published: 23 December 2013

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doi:10.1186/2196-4351-1-7
Cite this article as: Sato *et al.*: Flexural strength of a pressable lithium disilicate ceramic: influence of surface treatments. *Applied Adhesion Science* 2013 **1**:7.