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Fatigue Failure Load of Restored Premolars: Effect of Etching the Intaglio Surface of Ceramic Inlays With Hydrofluoric Acid at Different Concentrations

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Clinical Relevance

Etching with hydrofluoric acid at different concentrations (1%, 5%, 10%) does not affect the fatigue failure load of premolars restored with feldspar inlays (milled by a computer-aided design/computer-aided manufacturing system). Thus, those acids might be used for ceramic etching.

SUMMARY

The aim of this study was to evaluate the effect of etching, with different hydrofluoric acid concentrations at the intaglio surface of feldspathic ceramic inlays, on the fatigue failure load of restored premolars. A total of 60 upper premolars were embedded in plastic cylinders with acrylic resin (up to 3 mm below the cement-enamel junction) and prepared using a device specially designed for that purpose. Teeth were randomly assigned to three groups (n=20): HF1, HF5, and HF10 (etching with hydrofluoric acid for 60 seconds at concentrations of 1%, 5%, and 10%, respectively). Preparations were scanned and restorations were milled by a computer-aided design/computer-aided manufacturing system. The inner surfaces of the inlays were etched and received an application of a silane coupling agent; the dentin and enamel were treated appropriately for the luting system (RelyX ARC, 3M-ESPE).

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The restorations were cemented and the fatigue failure load (in N) was determined using the staircase method (10 Hz; 10^5 cycles in each step). The initial load (585.5 N) was applied on the slopes of the cusps (labial and palatal/lingual, simultaneously) through a cylinder attached to the test machine (Instron ElectroPuls E3000). The tested samples were analyzed under a stereomicroscope for failure analysis. Fatigue data were analyzed by one-way analysis of variance. There was no statistical difference among the fatigue failure loads (in N): HF1 (448.5±79.1), HF5 (360.7±55.4), and HF10 (409.5±121.1). Regarding the fracture mode, there was a predominance of interfacial fracture (50%), followed by cusp fracture (34.6%). It may be concluded that the etching with hydrofluoric acid at the tested concentrations (1%, 5%, and 10%) does not influence the fatigue failure load of feldspathic ceramic inlays cemented on premolars.

INTRODUCTION

Esthetic and minimally invasive restorations are made possible mainly through adhesive dentistry and ceramic advancement. Despite the fact that inlays may be considered a conservative restorative alternative when compared with traditional crowns,[1] their preparation still leads to enamel and dentin loss. This may decrease strength, specifically of premolars, because it increases cusp deflection under occlusal load.[2] Costa and others[3] showed that the cavity size is a significant factor, because it influences the stress distribution and fracture strength of premolars (ie, higher cavity size leads to a higher stress concentration, triggering fracture under smaller loads).

Another factor that may influence the strength of teeth restored with inlays is the type of restoration. According to Lee and others,[4] indirect restorations decrease the cusp deflection due to the absence of polymerization shrinkage of the restorative material in the oral environment. On the other hand, shrinkage in direct restorations results in a large degree of cusp deflection, creating microcracks in the tooth structure. Thus, feldspathic ceramic is widely used for indirect restorations such as inlays, onlays, veneers, and covering ceramics of fixed dental prostheses (FDPs). Furthermore, this ceramic presents increased wear strength, has high survival rates, and withstand high values of compression.[5,6]

The clinical success of ceramic inlay restorations is based on promoting a durable adhesion among resin cement, ceramic, and tooth structure,[7,8] especially because the divergent preparation for such restorations generates a very low friction effect between the preparation wall and the inner surfaces of the restoration. From the adhesion-effect standpoint, the higher the bond strength between the tooth and the restoration, the lower the cusp deflection.[3]

Moreover, feldspathic ceramics are classified as acid sensitive due to the presence of silica in their composition.[9-12] Therefore, the recommended surface treatment is the conditioning of the intaglio surface of the ceramic with hydrofluoric acid, which promotes topographical changes and allows mechanical interlocking of the ceramic with resin cement.[13]

The changes in the ceramic surface topography, however, depend not only on the ceramic composition, but also on the acid concentration and etching time.[14] Venturini and others[15] reported that 3%, 5%, and 10% hydrofluoric acid promoted a higher and a more stable bond strength of resin cement to feldspathic ceramic after long-term aging, in comparison with 1% hydrofluoric acid. These results show that resin adhesion to this ceramic material seems to be dependent on microtopographical changes. Higher acid concentrations produce more intense surface changes, leading to greater mechanical interlocking.[16,17] However, when the flexural strength of feldspathic ceramic was tested with the same hydrofluoric acid concentrations, Venturini and others[18] found a weakening effect, regardless of the concentration used, when compared with nonetched ceramic. Consequently, there is a modification of the "defects" at the ceramic surface and subsurface, which could affect the mechanical behavior of the feldspathic restorations when exposed to cyclic intermittent loading.

When evaluating the effect of hydrofluoric acid at different concentrations on mechanical fatigue behavior of feldspathic ceramic crowns, Venturini and others[19] depicted that 5% hydrofluoric acid had a negative effect on the fatigue failure load of the crowns, whereas 1% and 10% hydrofluoric acids did not change the fatigue resistance. All of these findings highlight that the threshold breakdown during clinical function of ceramic restorations might be caused by micromorphological alterations of the inner surface of the restorations.

Besides, the quality of the adhesive interface may have an impact on bond strength values, leading to a higher or lower cusp deflection.[3] Whereas hydrofluoric acid etching of the feldspathic ceramic

Table 1: *Experimental Design*

Group	Ceramic surface treatment
HF1	Etching with 1% hydrofluoric acid[a]
HF5	Etching with 5% hydrofluoric acid[a]
HF10	Etching with 10% hydrofluoric acid[b]

[a] *Experimentally formulated by FGM.*
[b] *Condac Porcelana, FGM, Santa Catarina, Brazil.*

promoted appropriate bond strength values in previous studies,[17,20] Addison and others[21] showed that this process may weaken the ceramic surface depending on the acid concentration. Thus, it is important to find the hydrofluoric acid concentration that simultaneously enhances adhesion to this ceramic and does not weaken the ceramic material. Moreover, the aforementioned weakening effect associated with the cyclic loading of chewing may lead to fatigue failure of the restoration that occurs when the final loading cycle exceeds the mechanical capacity of the material or restored tooth.[22]

Therefore, with regard to a test setup that simulates the real restorative scenario with ceramic inlays under cyclic mechanical loading, there is no study indicating the optimal concentration of hydrofluoric acid to promote stable adhesion without weakening the restoration. Costa and others[3] reported that the etching procedure has a significant impact on the adhesive interface and that it may influence the fatigue failure load of teeth restored with ceramic inlays.

Thus, the objective of this study was to evaluate the effect of etching the intaglio surface of inlay restorations with hydrofluoric acid at different concentrations on the fatigue failure load of premolars restored with feldspathic ceramic inlays milled by a computer-aided design/computer-aided manufacturing (CAD/CAM) system, as well as to evaluate the mode of failure of the restored premolars. The null hypothesis tested was that the hydrofluoric acid at different concentrations would not influence the fatigue failure load of teeth restored with ceramic inlays.

METHODS AND MATERIALS

Experimental Design

A total of 60 extracted upper human premolars were selected following the inclusion criteria of absence of visible cracks or caries under visual examination. The specimens were randomly assigned to three groups (n=20; Table 1). After tooth randomization (http://www.randomizer.org), buccolingual and mesiodistal measurements for each tooth were performed with a digital caliper (Starrett 727, Starrett, Itu, Brazil), aiming to verify the homogeneity of teeth size in each group through the Levene test, which showed that the randomization had worked properly.

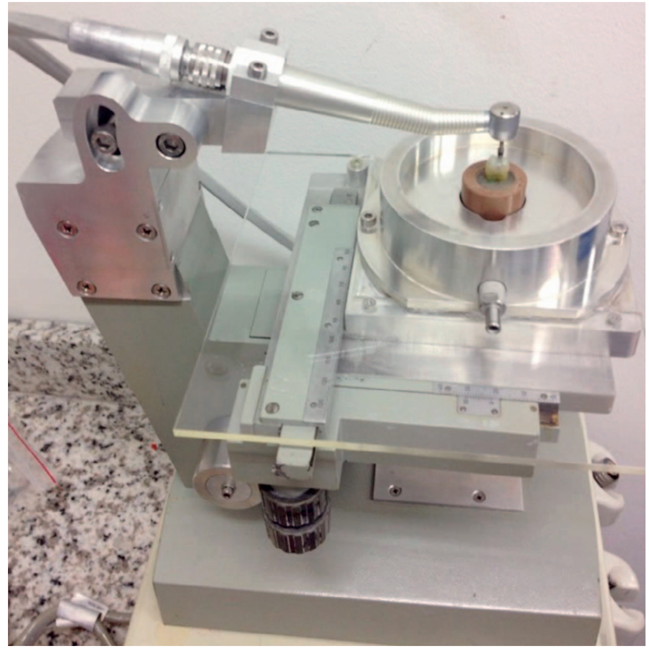

Figure 1. *Adapted device to perform standardized preparations.*

Afterward, teeth were embedded in plastic cylinders (h=14 mm, Ø=25 mm) containing chemically cured acrylic resin (Dencrilay, Dencril, Caieiras, Brazil) up to 3 mm below the cement-enamel junction, with the occlusal surface parallel to the horizontal plane.

Tooth Preparation

Standardized cavity preparations (inlay type) were performed on all teeth, using a conical-trunk diamond bur with rounded angles (KG Sorensen 3131, Barueri, Brazil). Burs were mounted on a high-speed handpiece fixed to a modified optical microscope (Figure 1).

At first, a mesio-occlusal-distal cavity was prepared to a depth of 2 mm under cool water. Then, the proximal boxes with a 2 mm depth were executed, taking into consideration the already prepared pulpal wall. Preparations had the following final dimensions: occlusal box depth = 2 mm; proximal box depth = 4 mm; occlusal isthmus determined by the bur diameter; and rounded internal line angles. Each diamond bur was used to prepare five teeth. Following, all preparations were finished with diamond burs with the same shape as the first one

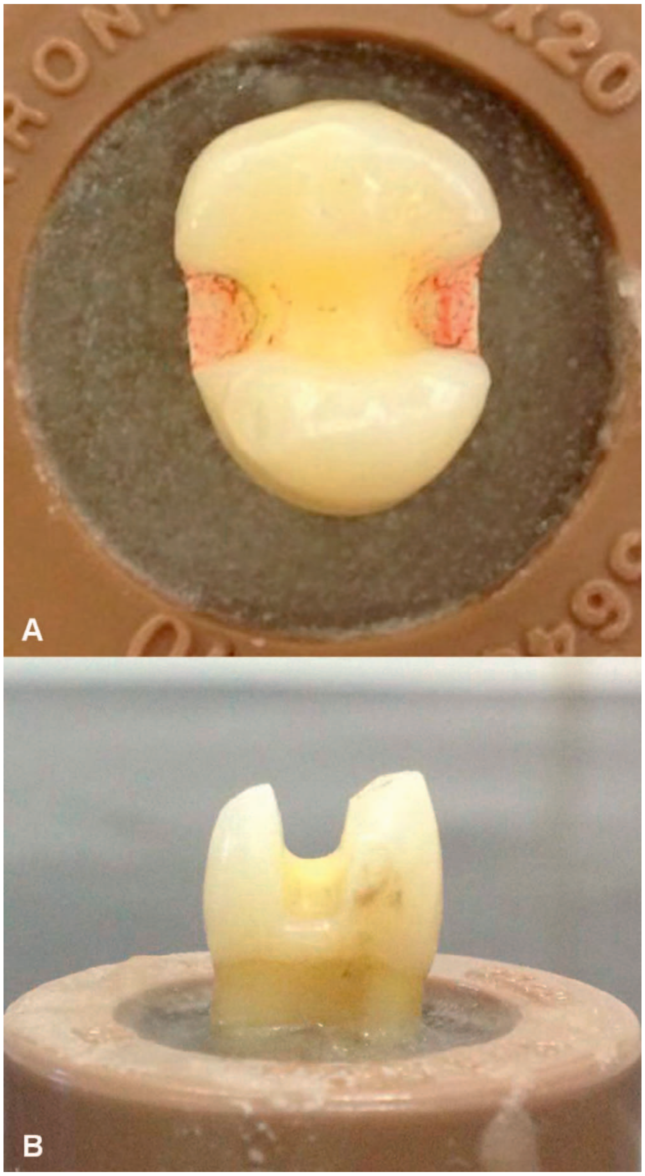

Figure 2. *Prepared teeth for inlay restoration: A) Occlusal view; B) Mesial view.*

but with lower grit size (extrafine diamond bur, KG Sorensen 3131FF) (Figure 2).

Production/Milling of Inlays

Cavities were impressed using polyvinyl siloxane by a one-step impression technique (Elite HD, Batch No. 122842, Zhermack, Badia Polesine, Italy). Impressions were poured using type IV die stone (Durone IV, Dentsply, Petropolis, Brazil). Then, master dies were sprayed with a scanning powder (Optispray CEREC, Sirona, Benshein, Germany) and optically captured by scanning (inEos Blue, Sirona). The generated image was digitally worked in specific software, which formed a three-dimensional virtual model. The cement space in the software of the CAD/CAM system was preestablished and standardized at 90 μm. After inlay design, restorations were milled in the CEREC inLab milling machine (Cerec MC XL, Sirona) from feldspathic ceramic blocks (Vita Mark II for Cerec/inLab, 2M2C/I12, and 2M3C/I12 Vita Zahnfabrik, Bad Säckingen, Germany).

Ceramic Surface Treatment and Cementation

The intaglio surfaces of the inlays were etched by hydrofluoric acid at different concentrations: 1%, 5%, and 10% (FGM, Joinville, Brazil). The etching protocol was the same for all groups: etching time of 60 seconds, rinsing with air-water spray for 30 seconds, and air-drying for 30 seconds. Then, a silane coupling agent (ESPE-Sil, 3M ESPE, Seefeld, Germany) was applied; the surface was kept untouched for 5 minutes (to allow ethanol evaporation, as recommended by the manufacturer). Tooth surfaces were conditioned with 37% phosphoric acid (Atacktec CAITHEC, São José dos Pinhais, Brazil) for 20 seconds, followed by washing and drying. The adhesive system (Single Bond, 3M ESPE) was applied on the surfaces for 20 seconds, lightly air-dried, and then light-cured (Radii Cal, SDI, Bayswater, Australia) for 20 seconds. The resin cement (RelyX ARC, 3M ESPE) was mixed as recommended and applied to the intaglio surface of the ceramic inlay. The restoration was then seated on the preparation, and a load of 750 g was applied over the occlusal inlay surface for 1 minute. The excess resin cement was removed, and photo-curing (Radiical, SDI) was performed for 20 seconds on each surface. After cementation, the specimens were stored in distilled water at 37°C for at least seven days before conducting the fatigue tests (staircase method).

Fatigue Failure Load (via Staircase approach)

First, a monotonic compression test was performed with two teeth in a universal testing machine (DL-2000, EMIC, São José dos Pinhais, Brazil) with the same piston that was later used for the fatigue test; a mean load-to-failure of 975 N was obtained. Then, the fatigue test was conducted under water, at room temperature, according to the staircase (up-and-down) method,[23] in an electrodynamic testing machine (Instron ElectroPuls E3000, Instron Corporation, Norwood, MA, USA).

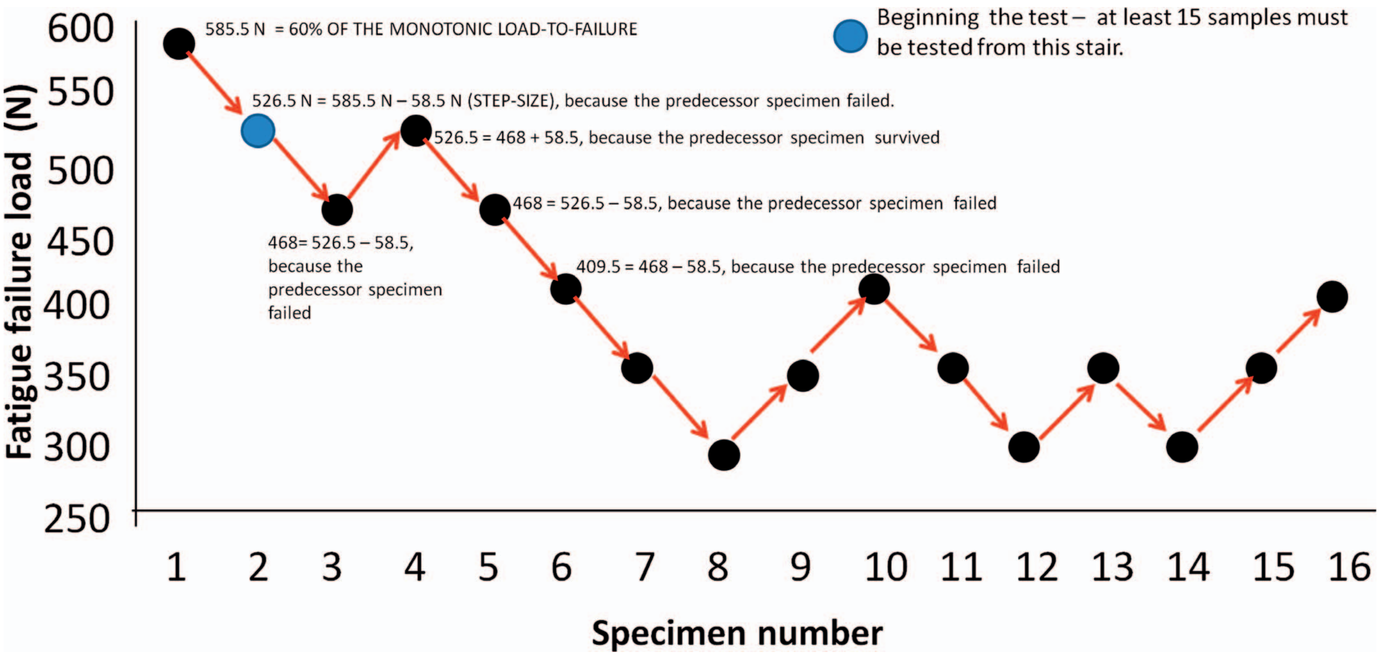

Figure 3. *Illustrative diagram of the staircase test.*

The initial load of the fatigue tests was defined as 60% of the mean monotonic load-to-failure (585.5 N).[23] According to Collins,[23] the initial load should be defined in a range where the fatigue failure load is expected to be. In this sense, previous studies usually assume values ranging from 50%-70% of the mean monotonic load-to-failure. In addition, Collins[23] defined that the staircase test would start only after the first inversion of the stair and that a minimum of 15 samples should be tested after this inversion. So, the first specimen was tested, and depending on the observation of survival or fracture, one increment (step size preestablished at 10% of the initial load; ie, 58.5 N) was increased or decreased, respectively, for the next specimen tested. The test progressed in this manner, with each succeeding specimen being tested at a load level corresponding to one increment above or below its predecessor, depending on whether it survived or fractured, until at least 15 samples were tested after the first inversion of the stair (Figure 3).

For both tests (monotonic and fatigue) the samples were placed on a metal platform at an angle of 90°, in which a cylinder piston (Ø=8 mm) applied a load only on the cusp slope, without contact with the restoration. An occlusal marker (21-μm thick carbon paper film; Accu-S017, Parkell, Farmingdale, New York, USA) was used to ensure that the piston did not touch the inlays.[1,24-26] The fatigue failure load was determined after 10^5 cycles at a frequency of 10 Hz.

Failure Analysis

After visual examination, fractures were classified on a stereomicroscope (Discovery V20, Carl Zeiss, Gottingen, Germany) according to the following criteria: cusp failure, small fractures and/or cracks in the tooth structure; restoration failure, fractures and/or cracks most evident in the restoration, and interfacial failure, fracture and/or crack at the interface with propagation through the restoration.

Topographical Analysis Under Scanning Electron Microscopy

Eight additional milled restorations (n=2) were manufactured and conditioned with 1%, 5%, or 10% hydrofluoric acid, following the aforementioned etching procedures; in addition, two machined restorations remained as milled (control to topographical analysis). Then, a micromorphological analysis under scanning electron microscopy (FE-SEM, Inspect F50, FEI, Hillsboro, OR, USA) was executed in two samples of each group. For that, the specimens were subjected to sputter-coating with gold-palladium alloy, and images were obtained with 500×, 1000×, and 2000× magnification.

Group	Fatigue failure load, N (±SD)
HF1	448.5 (±79.1)
HF5	360.75 (±55.4)
HF10	409.5 (±121.2)

Table 2: *Fatigue Failure Load (Lf) and Standard Deviation (SD) for Different Groups*

Abbreviation: HF = hydrofluoric acid.

Data Analysis

The mean fatigue failure load (Lf) and standard deviation (SD) were determined using equations 1 and 2, respectively, according to Collins[23]:

$$\mathrm{Lf} = \mathrm{Lf}_{X0} + d\left(\frac{\sum in_i}{\sum n_i} \pm 0.5\right) \quad (1)$$

$$SD = 1.62d\left(\frac{\sum n_i \sum i^2 n_i - \left(\sum in_i\right)^2}{\left(\sum n_i\right)^2} + 0.029\right), \quad (2)$$

where Lf_{X0} is the lower load considered in the analysis and d is the fixed increment (step size). In order to determine the fatigue failure load, analyses were based on data of less frequent events (survival or failure). In equation 1, the negative sign was used if the less frequent event was failure, and the positive sign was used when survival was the less frequent event. The lowest load level considered was designated $i = 0$, the next was $i = 1$, and so forth, and n_i was the number of failures or survivals at a given load level.

In addition, a one-way analysis of variance (ANOVA) test ($p<0.05$) was used to analyze the fatigue failure load data.

RESULTS

One-way ANOVA revealed no significant differences among the tested groups ($p=0.14$) (Table 2). Survival was the less frequent event for the HF5 and HF10 groups, whereas failure was the less frequent event for the HF1 group (Figure 4). Most failures had their origin at the interface between tooth and restoration (Figure 5; Table 3). Only one irreparable fracture was observed, 3 mm below the cement-enamel junction in one specimen of the HF10 group.

Topographical analysis under FE-SEM showed noticeably different surface patterns according to the different acid concentrations, especially in comparison to the untreated ceramic surface (Figure 6). However, all surfaces presented a waved pattern that can be seen in the micrographs of 500×

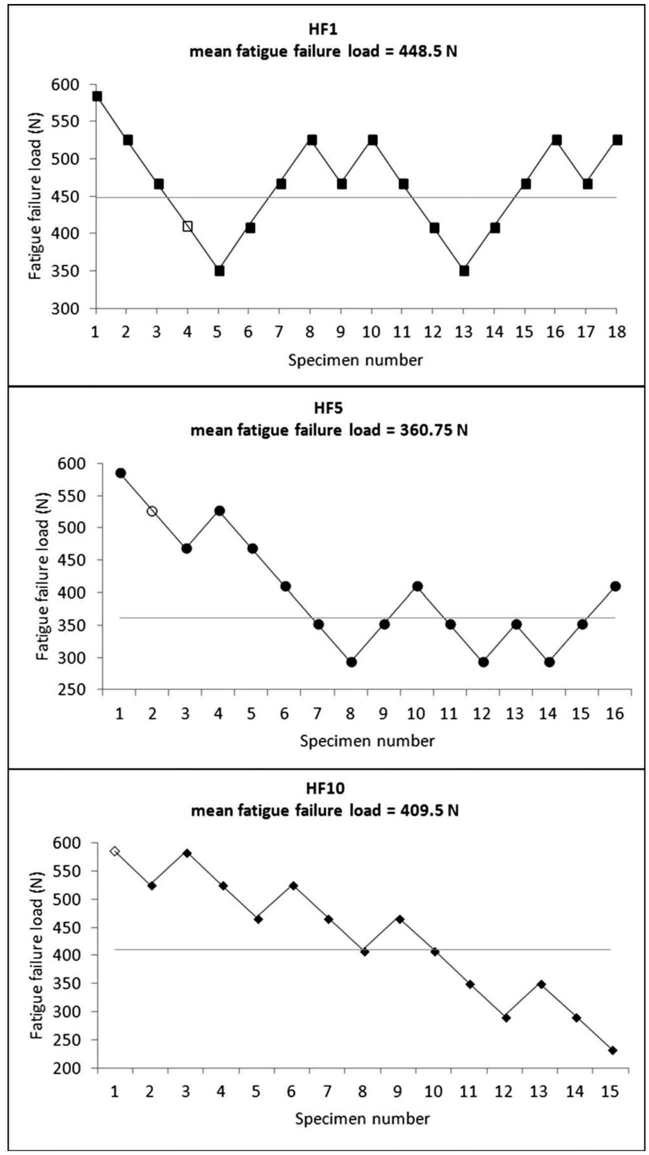

Figure 4. *Fatigue failure load events for each experimental group. The empty scorers refers to the beginning of the test.*

magnification (Figure 6A,D,G). This pattern may have been caused by the machining performed by the CAD/CAM system.

DISCUSSION

Our findings support that the fatigue failure load of premolars restored with feldspathic ceramic inlays was not influenced by etching with hydrofluoric acid at different concentrations (1%, 5%, and 10%), and, therefore, the null hypothesis was accepted.

Plausible explanations for those findings are: 1) the use of a silane coupling agent and 2) the variability in roughness after machining of the glass

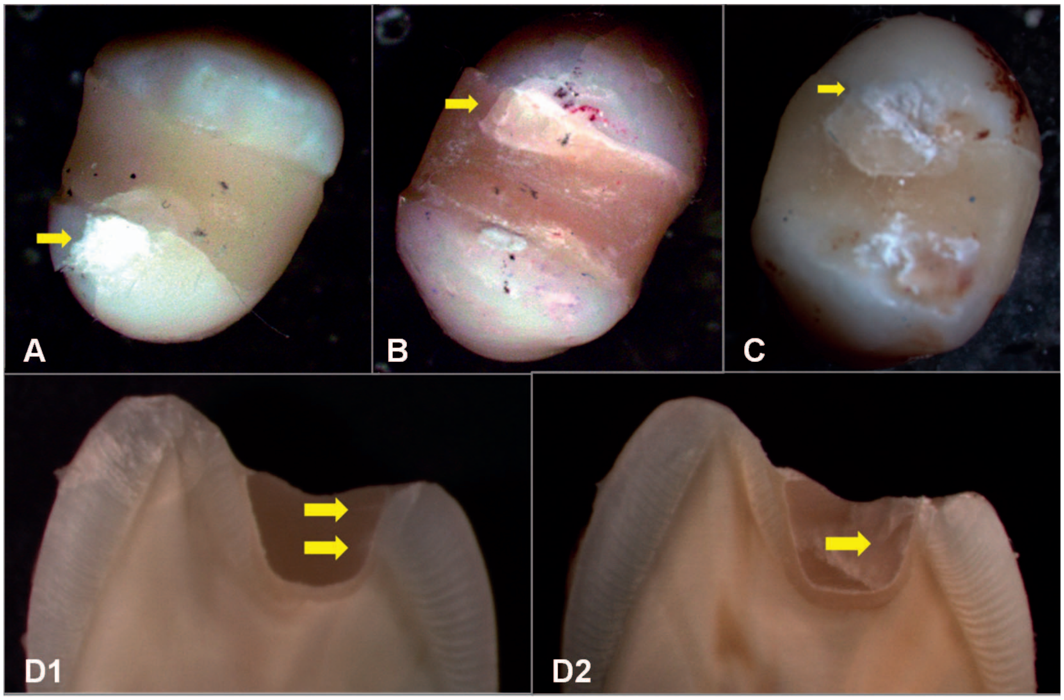

Figure 5. *Representative images of the failure modes obtained with stereomicroscopy. A- Cusp failure: small cracks and/or fractures in the tooth structure; B- Restoration failure: fractures and/or cracks in the restoration; C- Interface failure: cracks and fractures with origin at the interface. D- Cross-section of a restored tooth with interface failure; the indicators show that the origin of the failure seems to start at the interface tooth/restoration.*

ceramic, which may have enhanced mechanical interlocking; consequently, the bond strength via chemical and mechanical bonding between the resin cement and the ceramic material could be improved.[9,10,14] According to Fraga and others,[27] a variability in roughness might be expected after machining, in response to the wear of the grinding tool. In this way, they stated that the differences in roughness generated (ie, the restoration machining order) affected the mechanical properties of leucite glass-ceramics. Moreover, it is known that the use of a resin cement may increase the fracture resistance by means of filling the defects of ceramic restorations, especially the ones introduced by etching.[28,29,30] Thus, the association of those three factors could justify the similar fatigue failure load among the tested groups, given that topographical pattern alterations alone, noticed from the use of different acid concentrations, were not enough to affect the fatigue performance.

Table 3: *Failure Mode Distributions for Each Tested Group*

Group	Failure mode			
	Cusp	Rest	Interf	Total
HF1	3 (50%)	1 (16.66%)	2 (33.33%)	6 (100%)
HF5	1 (11.11%)	1 (11.11%)	7 (77.77%)	9 (100%)
HF10	5 (45.45%)	2 (18.18%)	4 (36.36%)	11 (100%)
Total	9 (34.61%)	4 (15.38%)	13 (50%)	26 (100%)

Abbreviations: Cusp = small cracks and/or fractures in tooth structure; HF = hydrofluoric acid; Interf: cracks and fracture with the origin at the interface; Rest = fractures and/or cracks in restoration.

Besides, cusp deflection is also influenced by an adequate bonding, and the interaction of those factors are also related to the final resistance to fracture.[3] The type of cement used and the quality of the bonding interface (tooth-restoration) may affect the displacement values: the higher the adhesive strength, the lower the cusp deflection.[3] In terms of adhesion, hydrofluoric acid etching is indispensable to promote effective bond strength between resin cements and silica-based ceramic surfaces.[31] Basically, the hydrofluoric acid changes the ceramic surface, increasing roughness and creating a topography for micromechanical interlocking, and the silane coupling agent interacts with the oxides, enabling chemical adhesion when associated with the use of a resin cement.[32-34]

On the other hand, some studies have suggested that hydrofluoric acid at different concentrations and etching times may weaken the ceramic material because they may introduce defects with different sizes and shapes that may not be completely filled by the cement layer.[14,35,36] Those studies[14,35,36] state

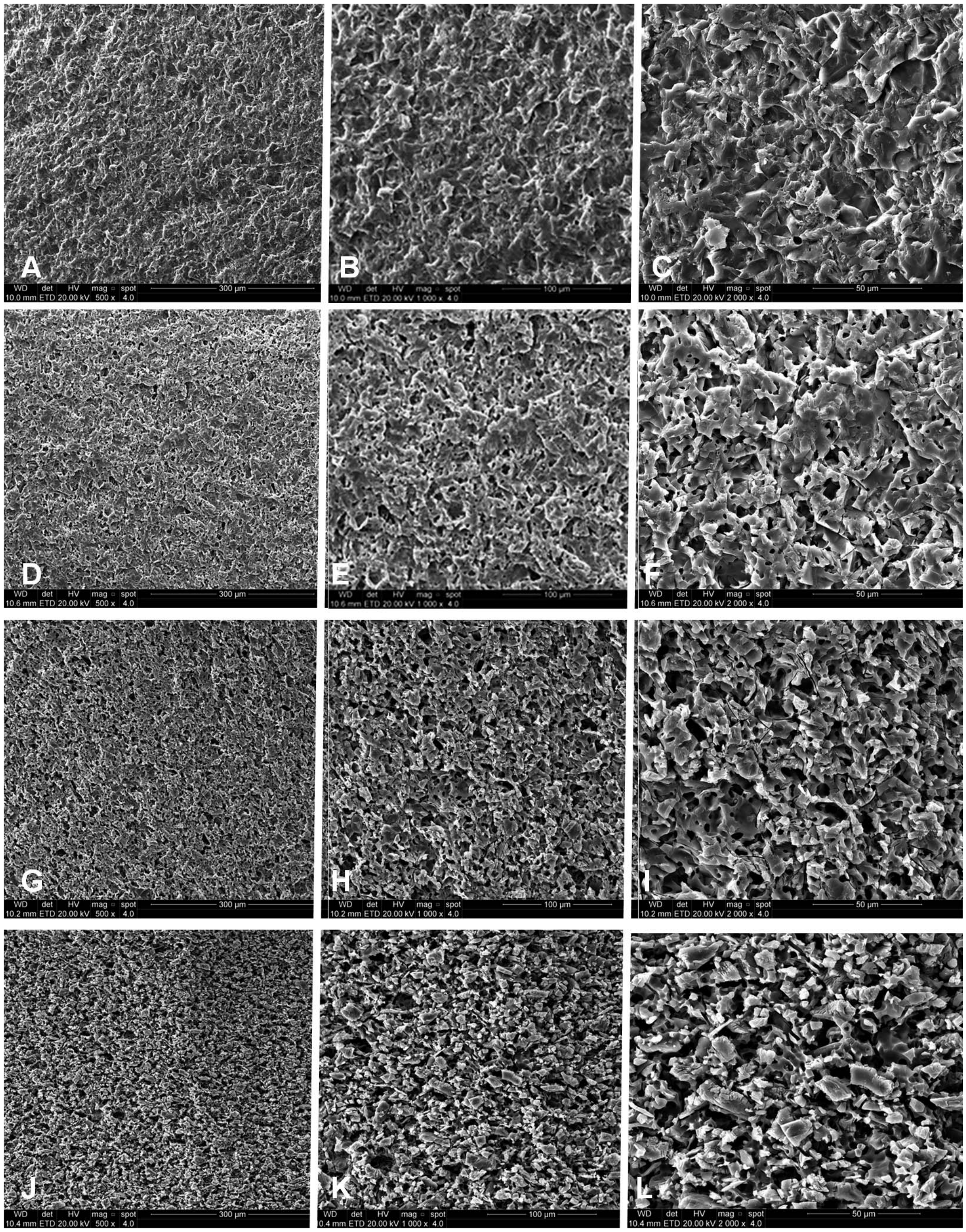

Figure 6. *Representative micrographs of ceramic surface after different acid etching treatments compared with untreated surface. From left to right: 500x, 1000x, 2000x magnifications. (A-C) untreated surface; (D-F) treated with 1% hydrofluoric acid; (G-I) treated with 5% hydrofluoric acid; (J-L) treated with 10% hydrofluoric acid. The surface patterns of the etched surfaces were noticeably different. Higher hydrofluoric acid concentrations promoted deeper and more evident craters and pits, while slight topographic changes were created for the HF1 group (D-F images).*

that when stress is applied on the ceramic material, it will concentrate around those defects, leading to premature failure under smaller loads. However, Venturini and others,[18] who tested the effect of the same acid concentrations used in this study, found no statistical difference for flexural strength among different hydrofluoric acid concentrations, and only a reduction in strength was observed when compared with the untreated ceramic condition. They suggested that the pores promoted after hydrofluoric acid etching could act as a source of crack initiation.

Regarding the failure analysis, we noticed a predominance of interface failure (50%), followed by cuspal failure (34.6%). It should be highlighted that in the HF5 group, more than 50% of the failures were at the tooth/inlay interface, which presented failures where the crack propagated along the restoration interface (77.7%) (Table 3). These results might corroborate the aforementioned concept where etching (in this scenario with 5% hydrofluoric acid) created superficial defects that the resin cement could not fill properly due to its viscosity, creating areas of discontinuity at the interface. These areas might, consequently, act as regions of tensile stress concentration when submitted to mechanical stimuli, and thereby be responsible for the crack initiation and propagation that leads to failure.[19]

As for the incidence of cuspal failures (major failure type for HF1 and HF10 groups; 50% and 45.45%, respectively), they may be assigned to the device setup used for the fatigue testing, which led to stress concentration on the cusp surface[37] through compression load application, given that the piston was near to cusp tips.[1] This is consistent with a previous report[3] which indicated, using finite element analyses, that fractures started on the occlusal surface (at the load point) and propagated in a cervical direction.

SEM images clearly revealed the progressive effect of different hydrofluoric acid concentrations on the ceramic microstructure compared with untreated ceramic surface (Figure 6A-C), showing greater dissolution of the glassy matrix and the presence of pores in the surface after etching. These pores could act as sources of crack initiation. However, although SEM micrographs demonstrated more intense alterations in the ceramic surface topography as a result of higher hydrofluoric acid concentrations, no significant difference in the fatigue failure load of inlays was noted for the tested hydrofluoric acid concentrations.

One of the most-used approaches for inducing fatigue of dental ceramics in an accelerated and precise manner consists of the staircase method proposed by Collins.[23] Therefore, that method was chosen due to its viability and low variability.[29] Collins[23] states that to guarantee a precise estimation, 15 to 30 specimens are required. It has to be emphasized that the test only starts after the beginning of the up-and-down pattern (ie, point where the first reversal occurs) (Figure 3).[23]

The staircase method is a very useful approach for determining the mean and variance of fatigue strength over any specified lifetime; in this sense, the term *fatigue failure load* identifies the maximum load that the material may support with an increased probability of survival (low risk of failure) at the specified lifetime. The term *fatigue limit* represents the stress below which the material supports an infinite number of cycles without failure.[23] So, our data support that none of the hydrofluoric acid concentrations (1%, 5%, and 10%) influenced the fatigue failure loads from the statistical viewpoint, which means that the surface of the feldspathic ceramic may be treated with any of these acid concentrations because they do not seem to weaken the inlay restoration. However, we must highlight that those findings should be taken with caution, given that Venturini and others[15] found a decrease in bond strength values when feldspathic ceramic was etched with 1% hydrofluoric acid, after aging. Also, we did not subject the samples to long-term aging under water, which could lead to degradation of the interface, affecting the bond durability, which could affect the fatigue behavior of restored premolars.

Following the aforementioned concepts, the current research applied an *in vitro* design, approaching parameters to approximate a clinical scenario (load application and testing setup bringing about fatigue), inducing failures that are typically observed clinically.[37] Cautions were taken for the load to be applied to the cusp slopes only (not on the interface), because our aim was also to verify whether the different etching scenarios and the quality of bonding between tooth and ceramic inlay would influence the cusp deflection.

A monotonic test with small-diameter ball indenters creates a stress state that results primarily in surface damage, which is not seen as part of a typical clinical failure.[37] Our study used restored premolars subjected to cyclic loading resembling the clinical situation. This type of load occurs in the mouth and may be simulated in laboratories with controlled parameters such as load, total number of cycles, and frequency.[1,24-26,38] Fatigue load may be considered one of the main reasons for failure of restorations clinically, and its concept is defined as the fracture of a material due to progressive brittle cracking under repeated cyclic stresses of intensity below the material's normal strength.[22,23,37]

Besides, *in vitro* studies have inherent limitations and may not fully simulate some clinical conditions that might damage the restoring assembly, such as bacteria accumulation and its toxins, temperature changes, humid environment, and sliding contact during chewing and clenching. In this sense, in our testing scenario we applied axial loading only; thus, it did not simulate sliding conditions where forces with various incidence angles take place. Thus, the cyclic fatigue method should be viewed as an efficient screening tool for evaluating dental materials rather than as a simulation of actual dental function.[39]

Another important limitation is the difficulty for standardization of the dental substrate regarding functional age of teeth, morphologic variations of the pulp, and abnormalities in dentin composition before extraction.[40,41] Again, we must emphasize that the results of this study require careful interpretation. Further studies could investigate other testing conditions, such as different cavity size, groups of teeth, type of restorations (onlays), ceramic materials, and long-term aging under water, as well as using other methodologies for lifetime prediction.

CONCLUSION

The hydrofluoric acids at the tested concentrations (1%, 5%, and 10%) do not affect the fatigue failure load of the premolars restored with feldspathic ceramic inlays.

Acknowledgement

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Federal University of Santa Maria. The approval code for this study is 1.178.683.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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