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ORIGINAL RESEARCH

Surface Roughness Analysis of Dental Ceramics Treated with Hydrofluoric Acid and Aluminum Oxide Jet

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ABSTRACT

The aim of this study was to evaluate the surface roughness of 5 indirect restorative materials treated with hydrofluoric acid to 10%, with aluminum oxide jet and a combination of both. The specimens was prepared with 10 mm in diameter and 2 mm thickness, divided into five groups: (1) Ceromer (CeseadII-Kuraray), (2) Leucite crystals ceramics (IPS EmpressII-Ivoclarforcasket), (3) glass ceramic with fluorapatite (IPS D. Sign-Ivoclar), (4) lithium disilicate ceramic (IPS Empress II-Ivoclar restorations), (5) ceramics (Cergogold-Degussa). For all groups were performed the controls, and the surfaces with the 3 types of treatment. For testing roughness used the rugosimeter Taylor/Hobson-Precision, model form tracerSV-C525 high sensitivity. After confirmation of variance analysis with a significance level of 1% ($p < 0.01$), there was equality between the average roughness of materials from groups 1, 3 and 5, and the group 2 was different from the others. It was also found that the ceramics of the group 5 behaved similar to group 4. However the lowest average roughness was observed in group 2 ceramic. In the evaluation between the types of treatment, the aluminum oxide jet and associations and blasting with hydrofluoric acid were similar, and different isolated hydrofluoric acid, and 3 types of treatment significantly higher than the control group. All treatments promoted superficial alterations in all tested materials.

Keywords: Laboratory research, Hydrofluoric acid, Aluminum oxide.

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INTRODUCTION

Unquestionably the fact that, in recent decades, restorative dentistry is one of the most wide spread in dentistry, mainly through research for innovations esthetic materials that can successfully replace the tooth structure.[1] The great challenges, both in clinic procedures on how many surveys are adequate to achieve micromechanical retention of restorations and surface smoothness compatible with the dental tissues.

In the last decades has been used very esthetic restorative materials such as ceramics and polymers because are materials that exhibit excellent optical properties such as absorption, refraction, transmission and reflection of light, and good mechanical properties.

The surface treatment of materials allows uniting different structures or providing similar distribution of occlusal loads.[1]

A way to enhance the retention of esthetic restorative materials to the tooth is getting microretention by physical and chemical methods, and among them the aluminum oxide jet and hydrofluoric acid, complemented by silanization of the restorative material.[2-4]

Various surface treatments have been used in ceramic to enhance the bond strength between resin cement and the inner surface of ceramics.[2,5-8]

The shear strength can be influenced by the bonding agent (silane) and etching. The silanization of porcelain associated with hydrofluoric acid treatment is able to determine consistent bond strength between resin cement and porcelain.[5,9] According Proenca,[10] conditioning and silanization treatments are essential for bond of the resin to a lithium disilicate ceramic, regardless of the resin cement used.

Studies have also detected that the best conditions of the porcelain and microretentions ceromer were obtained by treatment with an association of 10% hydrofluoric acid and aluminum oxide jet.[9,11] Both the hydrofluoric acid treatment how the use of sandblasting produce rough surfaces required for bonding, but the composition of the ceramic and the surface microstructure are important components to a substrate adhesion effective.[12] This information is referenced in the literature by several studies developed within the context of creating microretention surface of esthetic materials.[3,4,13,14]

Other studies have been developed to obtain information about the surface roughness of esthetic materials. Motro[15]

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correlated the surface roughness with the ceramic color stability after different surface treatments. They concluded that the ceramics coloring may be related to changes in surface roughness after different surface treatments. Shimoe,[16] after evaluate the influence of two surface treatments in indirect composite resins and zirconia, found an increase in surface roughness, therefore influencing the bond strength of zirconia with indirect composite studied.

Adhesive and mechanical retention to silica based on ceramics have been employed for bonding. A strong bond depends on the interconnection micromechanics created by surface roughness and by chemical bonding between the silane cement and ceramics. Currently there are techniques such as abrasion with diamond instruments rotating, abrasion with particles of aluminum oxide, hydrofluoric acid treatment, and even combination of techniques. The chemical composition and structural ceramics with high resistance, specifically alumina and zirconia, are not easily affected, methods requiring more aggressive mechanical abrasion to increase the surface roughness.[2]

Based on information from the literature, this study evaluated through rugosimeter, the effect of surface treatment of indirect esthetic materials, depending on some factors: Material (M): (M1) ceromer-II Cesead; (M2) for IPS Empress II skull caps; (M3) IPS D. Sign; (M4) IPS Empress II restorations; (M5) Cergogold; and surface treatment (T): (C) control; (T1) of 10% hydrofluoric acid; (T2) of aluminum oxide jet; (T3) combination of both.

MATERIALS AND METHODS

The materials used were:
- Ceromer (Cesead II—Kuraray)
- Lithium Disilicate Ceramic melting at 920ºC (IPS Empress II—Ivoclar-Vivadent) for prosthesis casket to three elements
- Glass Ceramic with fluorapatite and leucite crystals melting at 900°C (D. Sign—Ivoclar-Vivadent)
- Leucite Crystals Ceramic melting at 1075ºC (IPS Empress II—Ivoclar-Vivadent) for indirect restorations (inlay, onlay, overlay and facets)
- Ceramics (Cergogold—Degussa) for prostheses casket until three elements.

Preparation of Specimens

The specimens were fabricated with the dimensions: 10 mm diameter and 2 mm thickness.

Preparation Technical of Ceromer Specimens

The specimens were prepared in stainless steel matrix, with the measures mentioned in the item 'a'. Small layers of material were overlapped and polymerized for 90 seconds each in an oven light to the mark model UNIXs Kulzer, reaching a thickness of 2 mm—second manufacturer's specifications—after it was cured for 180 seconds. At the end, the specimen obtained tablet form.

Technique of Obtaining Lithium Disilicate Ceramic (IPS Empress II), used to Casket Prostheses until Three Elements

Initially wax buttons were obtained to using matrix of stainless steel. The wax buttons was included in the coating ring (special for Empress ceramics), to be brought to the oven at 850°C for 1 hour to complete elimination thereof.

In the inject oven ceramic Ivoclar model 2.9 the ring was placed at a temperature of 700°C and raised to 920°C (melting temperature of the ceramic) and 60°C for minute from 700°C initial. The temperature was maintained at 920°C for 15 minutes before the injection of the ceramic, remaining the same temperature for an indefinite period depending on the amount to be injected.

After removal of the ring from the oven, the porcelain was cooled to room temperature and opened the coating with aluminum oxide jet to avoid damaging the material. The specimen also obtained the same dimensions mentioned above.

Preparation Technical of Specimens of Glass-ceramic with Fluorapatite and Leucite Crystals (D Sign)

It was made a refractory of coating in pastille form in original dimensions and within the matrix was applied to the first ceramic layer and EDG burned in the oven at 900°C for 1 minute and 30 seconds. The temperature was gradually increased 60°C per minute until reaching 900°C. Immediately after another layer was applied and the same procedure done so that there is compensation for the ceramic undergoes contraction.

Technique of Obtaining Specimens of Leucite Crystals Ceramic (IPS Empress II), used for Indirect Restorations

The technique used for the fabrication of specimens with this type of porcelain was the same as previously mentioned in item 'a.2'. The only difference is the melting temperature, which in this case was of the order of 1075°C.

Technique of obtaining Specimens of Ceramic (Cergogold—Degussa)

The technique used for the fabrication of specimens with this type of porcelain was the same as previously mentioned in item 'a.2'. The differences are located at the initial temperature was 600°C and raised to 60°C for minute until the melt temperature of approximately 980°C.

Surface Treatment of the Specimens

Etching with Hydrofluoric Acid to 10%

The surface of the specimens were etched with hydrofluoric acid 10% by time of 1 minute and then washed thoroughly with water to neutralize the acidic effect.

Aluminum Oxide Jet—Bio Art

The surface of the specimens was submitted to the aluminum oxide jet with equipment manufactured by Bio-Art. Were used at 50 microns particle blasted for 10 seconds with a distance of 1 cm and pressure 60 cm libras/polegadas. The purpose of your job is to create micro-retentions on the surface of the tested materials.

Etching with 10% Hydrofluoric Acid and Aluminum Oxide Jet

In this treatment, the surface of the test specimens were subjected to conditioning the association of 10% hydrofluoric acid and aluminum oxide jet, as described above.

Establishment of the Experimental Groups

Group 1: Ceromer (Cesead II—Kuraray)—M1
- Control (no treatment).
- Treated with 10% hydrofluoric acid.
- Treated with aluminum oxide jet.
- Treated with aluminum oxide jet and hydrofluoric acid 10%.

Group 2: Lithium Disilicate Ceramics melting at 920°C (IPS Empress II) used for prosthesis casket until three elements—M2.
- Control (no treatment).
- Treated with 10% hydrofluoric acid.
- Treated with aluminum oxidejet.
- Treated aluminum oxide jet and hydrofluoric acid 10%.

Group 3: Glass Ceramic with fluorapatite and leucite crystals melting at 900°C (D Sign—Ivoclar-Vivadent)—M3.
- Control (no treatment).
- Treated with 10% hydrofluoric acid.
- Treated with aluminum oxidejet.
- Treated with aluminum oxide jet and hydrofluoric acid 10%.

Group 4: Ceramic leucite crystals melting at 1075ºC (IPS Empress II), used for indirect restorations—M4.
- Control (no treatment).
- Treated with 10% hydrofluoric acid.
- Treated with aluminum oxide jet.
- Treated with aluminum oxide jet and hydrofluoric acid 10%.

Group 5: Ceramics (Cergogold—Degussa)—M5.
- Control (no treatment).
- Treated with 10% hydrofluoric acid.
- Treated with aluminum oxide jet.
- Treated with aluminum oxide jet and hydrofluoric acid 10%.

Surface Evaluation of the Specimens through Tests Roughness

The equipment used in this study was rugosimeter Taylor/Hobson-Precision, Model SV-C525 Form tracer high sensitivity. This equipment consists of a metal platform on which rests the specimens. It also has an indent horizontally adjustable, coupled to a vertical rod which approach allows measuring tip surface roughness of the specimen. In the measurements, the measuring point adjustment was performed using a computerized automated device allowing, through sensitivity, adequate contact of the tip with the surface of the specimen. The slip tip measuring the surface of the specimen, was also triggered by another device attached to the computer program.

RESULTS

The original values of surface roughness (Ra) obtained are 80 measurements performed twice on the two axes of the specimens. Therefore four measures were made on each specimen. Analysis of variance reveals that all values were significant at the 1% level, with $p < 0.01$. The result of the analysis of variance shows that:

1. There was not effect of equal levels of factor material. It is conceded that the roughness variations in the context of various materials tested. In the check where variations roughness occurred for materials tested, applied the Tukey test, as follows in Table 1.

   Based on the critical value of Tukey (0.12695), the Table 1 shows that there was equality (M3) IPS-D.Sign (M1) Cesead-II (M5) Degussa. Moreover, the average found for (M2) for IPS Empress casket was different from the others. It was also found that the ceramic (M5) Degussa behaved similar to (M4) IPS Empress for indirect restorations. However, it can be noted that the lowest average roughness was observed in ceramics (M2) for IPS Empress casket.
2. There was not equality of factor level effects of treatment. This means that for this factor are the averages of different roughness. So, the Tukey test was performed to compare their averages (Table 2).

Table 1: Average roughness (Ra) for materials (M)

Groups of materials (M)	*Roughness mean (Ra)*
(M1)—Cesead-II	1.33868
(M2)—IPS-Casket	0.88757
(M3)—IPS-D-Sign	1.37334
(M4)—IPS-indirect restoration	1.18288
(M5)—degussa	1.26813

Table 2: Average roughness (Ra) for surface treatment (T)

Groups of surface treatment (T)	*Roughness mean (Ra)*
(C)—Control	0.50197
(T1)—Hydrofluoric acid	1.07734
(T2)—Aluminum oxide jet	1.61257
(T3)—Aluminum oxide jet and hydrofluoric acid	1.64860

Similarly, based on Tukey critical value (0.10837) for treatment, it was found that the averages of (T2) jet aluminum oxide, (T3) jet aluminum oxide and hydrogen fluoride were similar and different of (T1) hydrofluoric acid. It was also observed that the average corresponding to three types of treatment were considerably larger than that shown in the group (C) control group, a fact which shows that all treatments induced variations in the surfaces of the materials.

DISCUSSION

Regarding the materials tested, some significant differences were found between them in the context of surface roughness and should highlight the material IPS Empress II—casket (M2) that showed lower roughness values. Probably this fact has occurred due to the different compositions of these materials. The literature shows porcelains based leucite crystals, lithium disilicate, fluorapatite, feldspar, alumina, zirconia and other components, and even the resin matrix and ceramic particles to ceromer. Moreover, they have also with characteristics of high and low melting point.

In 2003, Borges[12] reported that the composition of the surface microstructure of ceramic and all-ceramic restorations is important components of an effective substrate adhesion. In general, the indirect esthetic materials involved had different levels of roughness and stickiness when subjected to surface treatment in several studies.[4,11,12,17,18]

The treatments also behaved differently. As was expected, the control group, which received no treatment, showed the lowest levels of roughness. This reflects the fact that all types of treatment used were able to promote significant changes in the surfaces of ceramic materials.

It was also found that the action of the aluminum oxide jet (T2) and aluminum oxide jet associated with hydrofluoric acid (T3) were those which provided greater rugosity in relation to hydrofluoric acid (T1) used alone.

The results are consistent with those obtained in other studies, which aimed to create microretentions on material surfaces using various types of cosmetic treatment.[13,14,19-25]

In fact, one way to improve retention and bond strength of esthetic restorative materials is getting microretentions for physical and chemical methods: aluminum oxide jet and hydrofluoric acid supplemented for silanization of the restorative material, according to the information.[5,22,26]

The vast majority of the results found in the literature, are related to bond strength tests, also involving indirect esthetic restorative materials and surface treatments varied: hydrofluoric acid;[12,27-30,33] aluminum oxide jet;[12,31] combination of aluminum oxide jet and hydrofluoric acid,[32,33] in which the combination of the treatments mentioned conditioned best results.

Moreover, Stewart[14] emphasized that the literature is unclear about which cement, ceramic surface treatment and bonding agent would be more appropriate to produce more lasting and high bond strength. In addition other information contained in the literature[34-37] emphasize the need to use techniques or chemicals, or association between them to create microretention surfaces of esthetic materials, in order to obtain better bond strength.

CONCLUSION

With the analysis of the results it was concluded that:

- All treatments promoted superficial alterations in all tested materials.
- The materials tested showed different roughness: IPS Empress II—casket (M2) showed the lowest roughness values while the highest average was shown by IPS—D. Sign (M3), which behaved similar to ceromer—Cesead II (M1) and Cergogold (M5).
- The highest levels of roughness were caused for the association aluminum oxide jet and hydrofluoric acid (T3) followed by the action of the jet of aluminum oxide (T2).

CLINICAL SIGNIFICANCE

The results of this study suggest the use of surface treatment of esthetic materials with hydrofluoric acid, aluminum oxide jet or combining both to create microretentions and consequently better bond strength.

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