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Surface Roughness Evaluation of Two Dental Ceramics Before and After Four Types of Finishing and Polishing

Research Article

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Abstract

Ceramic is a common restorative material for prosthetic rehabilitation, The ceramic surface must be polished and smooth, without pores or microcracks, to avoid plaque accumulation, gingival irritation, discoloration of the ceramic surface, fractures and wear of the opposite tooth. Whenever a clinical adjustment is performed, the finishing and polishing of the surface is still a challenge. The aim of this study was to evaluate the surface roughness of two ceramics subjected to four different finishing and polishing systems. Thus, it were made 100 specimens of ceramic: 50 specimens of Noritake EX-3 and 50 specimens of IPS E.max), divided into Control group (n=10) glaze only, Group 1 (n=10) finishing with Komet diamond burs ; Group 2 (n=10) finishing with Komet diamond burs + polishing with Komet abrasive rubbers ; Group 3 (n=10) finishing with Komet diamond burs + polishing with Shofu rubbers Group 4 (n=10) finishing with Komet diamond burs + polishing with Dh Pro rubbers for ceramics. The average values of surface roughness were found among groups for ceramics Noritake: Control - 0.90 (±0.21), Group 1 - 4.33 (±0.70), Group 2 - 1.37 (±0.67), Group 3 - 1,32 (±0,038) and Group 4 - 1.98 (± 0.11). For ceramics IPS E.max: Control - 0.54 (± 0.06), Group 1 - 2.28 (±0.85), Group 2 - 1.17 (±0.24), Group 3 - 1.34 (±0.67) e Group 4-1.93 (± 0.11). Based on the results, we conclude that: The polishing system DhPro had the worst results of recovering the surface roughness on two ceramics (Noritake and IPS E.max); ceramics polished with polishing systems Komet and Shofu showed similar results regarding the glazed ceramics; after finishing with Komet diamond burs, there was a significant difference between the ceramic types, IPS E.max showed the smoother surface.

Keywords: Surface Roughness, Synthetic Ceramics, Metal Free Ceramics

Introduction

The restorative dentistry has undergone a great advance in recent years, providing the development of new ceramic materials with improved properties. Among the variety of aesthetic restorative materials available, ceramic has the best durability characteristics, wear resistance, biocompatibility, and it is aesthetically similar to tooth structure. The porcelains are widely used in dentistry by having optical properties that make them almost unique, since with them, we can mimic the characteristics of color and translucency of natural teeth and characteristics of aesthetic and biocompatibility [1-3].

In the eighteenth century, ceramics was first used in dentistry for making teeth for dentures. This introduction of ceramic materials in dentistry was described in the year 1728, when Fauchard suggested its use for restoring missing teeth [4]. the first dental ceramics (feldspathic porcelain), had low tensile strength and fracture notwithstanding the mechanical forces required by the stomatognathic system. [1-3,5].

From the twentieth century, ceramics began to be used for making metal-ceramic restorations more precisely in the 60s. The association of metal to porcelain brought the possibility of implementing crowns for posterior teeth and fixed partial dentures with more elements because afforded resistance. This alternative treatment is still used today for making fixed partial dentures, mainly because of its strength and longevity [1-3].

A new revolution in dentistry occurred with the introduction in 1989 of the metal-free systems such as the In-CeramAlumina® system in which a coping is produced with a porous alumina substrate with glass particles being infiltrated at high temperature [6]. A technological improvement over the years, has brought new ceramic materials to build metal-free restorations. Ceramics present a fast progress in the scientific field in order to improve their physical and mechanical properties to meet the aesthetic needs that are increasingly demanded by modern society.

Regardless of the type of ceramic used, an important factor to be observed is the presence of a smooth surface, that provides increasing resistance to fracture, usually achieved with the completion of glaze that is also effective against crack propagation on the outer surface [7,8]. In many daily clinical situations, occlusal adjustment and correction of inappropriate contour of the restoration are quite often. In these cases, the ceramic should be re-glazed, but this is not always possible, as in cases after cementation. The simple adjustment of ceramic restorations produces a rough surface, which may facilitate the bacterial retention, t can generate the wear of antagonistic teeth and decreased the resistance of ceramic, crowns bringing forth crack propagation and pigmentation, compromising aesthetics and resistance. For this reason, it is very important to restore the surface smoothness of these ceramic restorations after performing any adjustment.

Many finishing and polishing systems and techniques are available to restore a smooth surface, with different results, being a still controversial subject in the literature, some authors describe that finish and mechanical polishing can restore an adequate surface smoothness while others report that a new glaze is still the best alternative [2]. Thus, the aim of this study was to evaluate the surface roughness of two ceramics (Noritake EX3 and IPS e.max) subjected to four different finishing and polishing systems.

Materials and Methods

Samples

To perform this laboratorial cross-sectional study, the samples was built usinged a metal and teflon prefabricated device for the building of ceramic specimens. Ceramic was manipulated according to the recommendations of the manufacturers and was inserted in the teflon device. The specimens before sintering have the same dimensions as the metal matrix and after the firing of these undergo contraction of about 20% by volume. The samples Noritake (Noritake Super Porcelain EX-3, Japan, Kota Imports LTDA, São Paulo, Brazil) were subjected to heating in an oven Astromat® (Dekema, Germany), covered with heating rate of 30°C per minute and temperature pre-heating to 450°C for 10min and firing temperature of 660°C, held for 30s and 60s vacuum without vacuum. The glaze was performed with the same oven set at point temperature of 650°C for 90s without vacuum, being considered the control group. Samples of ceramic IPS - e.max (IPS e.max Ivoclar Vivadent Brazil) were sintered at Kermation® oven at an initial firing temperature of 600°C and final of 960°C and held at the glaze 920°C following the manufacturer's instructions.

It Were made 100 specimens, 50 for each type of ceramic: Noritake and IPS e.max as seen in Figure 1. These samples were stabilized for subsequent finishing and polishing and reading with rugosimeter apparatus with a device of colorless acrylic resin in dimensions of 3cm long, 2.5cm wide and 7mm height, having a central hole with dimensions of specimens, as can be seen in detail in Figure 2.

Finishing and Polishing

After glazing, each specimen was subjected to a finishing procedure with diamond bur (Komet-Brasseler, Lemgo, Germany), in order to simulate the adjustment made by the professional in a clinical situation., After, and three types of polishing was conducted in order to simulate the polishing to restore the smoothness and gloss of the surface. Thus, the 50 specimens of each ceramic were divided randomly into five groups (n = 10) as described below:

i. Control: It received no additional treatment, staying with glazed surface.

ii. Group 1: Mounted diamond bur tips (Komet-Brasseler, Lemgo, Germany) for high-wear rotation with plentiful irrigation with nº390EF tips (15μm yellow) and nº390UF (white 8μm) for 30 seconds each, totalling 1 minute of finishing (no polishing).

iii. Group 2: Abrasive Rubber Komet - Application of pre-polishing tips (No. 9679), pre-final (No. 9680) and high-gloss polishing (No. 9457), for 40 seconds each, totalling 2minutes of polishing.

iv. Group 3: Céramiste tips (Shofu Dental Corp., Menlo Park, California, USA) - polishing sequence as recommended by the manufacturer. The "Standard" tips, "Ultra" and "Ultra II" were applied to the surface of the specimens for 40 seconds each, totaling 2 minutes of polishing.

v. Group 4: Dhpro rubber tips for ceramics (Dh System Pro Ceramic-Curitiba- Brazil). The tips of phase 1 (2 points - ceramic removal risk) and phase 2 (1 tip - ceramic glaze) were applied to the surface of the specimens for 40 seconds each, totalling 2minutes of polishing.

For standardization of finishing and polishing procedures, they were performed by a single operator; the high and low speed handpieces and the samples were adjusted to a fixed device and, therefore, the movements were in the same direction, as shown in Figure 3.

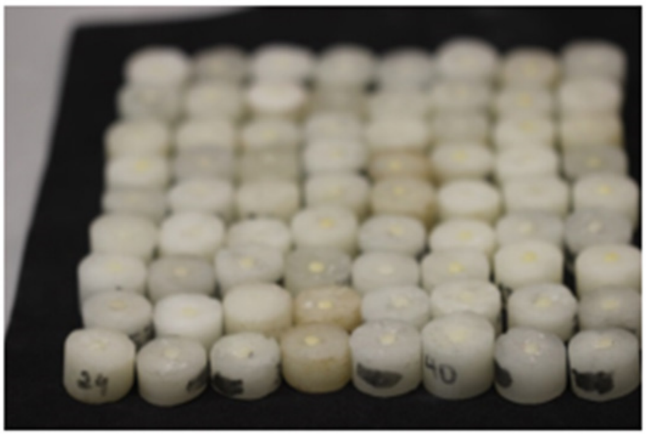


Figure 1: Ceramic Specimens.

Figure 2: Stabilized ceramic specimen in colorless acrylic resin.

Figure 3: Finishing and polishing procedures at a fixed device.

Roughness Evaluation

To read the surface roughness of the samples, we used the Rugosimeter apparatus Surf Test SJ 301 (Mitutoyo Corporation, Japan). Figure 4 shows the Rugosimeter apparatus used. Each sample was subjected to three measurements, generating a reliable average of its roughness. Initially all 100 glazed specimens had their roughness measurements, the values were recorded in a spreadsheet, see Appendix. After the groups were divided and made the finishing and polishing, the surface roughness was measured again, by groups.

Figure 4: Rugosimeter apparatus.

In all measurements, the analyzer tip of Rugosimeter travel a path of 1.25mm perpendicular to the long axis of the samples (contrary to the sense of finishing and polishing) and three parallel lines with each other, according to the criteria of the standard ISO 4287.

Scanning ELECTRON MICROSCOPY ANALYSIS

After all surface roughness measurements, the samples were taken to reading their surface, for better illustration of roughness variations in a scanning electron microscope (SEM).

Data Analysis

Data of the surface roughness were analyzed using SPSS v 17.0. The Shapiro-Wilk test evaluated the distribution of the groups as its normal ($P > 0.05$). Then, ANOVA test assessed whether there are significant differences between the groups. SEM imagens were analyzed qualitatively only.

Results

The average values of surface roughness were found among groups for ceramic Noritake: Control - 0.90 (± 0.21) Group 1-4:33 (± 0.70) Group 2-1.37 (± 0.67), Group 3-1.32 (± 0.038) and Group 4-1.98 (± 0.11). For ceramic IPS e.max: Control- 0.54 (± 0.06), Group 1- 2.28 (± 0.85), Group 2-1.17 (± 0.24), Group 3-1.34 (± 0.67) and Group 4-1.93 (± 0.11).

According to the Table 1, it can be stated that in both ceramics (Noritake and IPS e.max) the results of surface roughness were higher in G1 (finishing with a diamond tip of Komet) compared to the control group (glaze). In groups G2 (polishing with abrasive rubbers Komet) and G3 (polishing with Shofu rubbers) in both ceramics (Noritake and IPS e.max) there were no significant differences compared to from the control group (glaze). In G4 (polishing with Dhpro rubbers) was no statistically significant difference in both ceramics (Noritake and IPS e.max) compared to the control group (glaze) and G2 (polishing with abrasive rubbers Komet) and G3 (polishing with rubber Shofu).

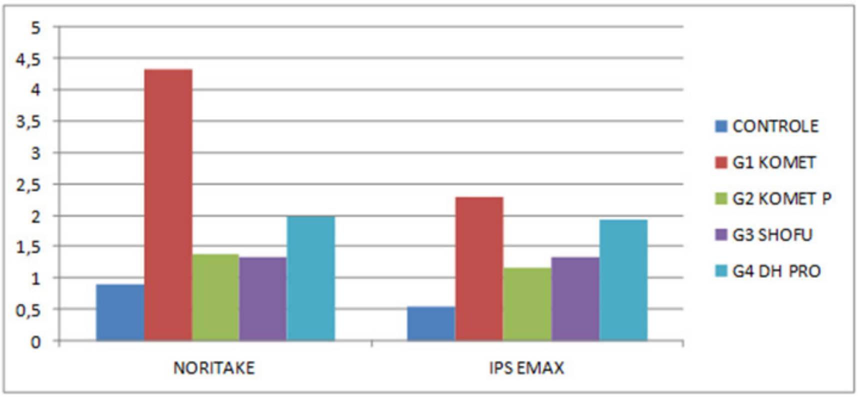
In the comparative analysis between the two types of ceramic, we observed that Noritake ceramic (synthetic ceramic) and the IPS e.max ceramic (glass ceramic) showed no statistically significant differences between them in relation to surface roughness in the Control (glaze), in groups G2 (polishing with abrasive rubbers Komet), G3 (polishing with Shofu rubbers) and G4 (polishing with Dh Pro rubbers). In G1 (finishing with a diamond tip of Komet), there was a statistically significant difference between the two ceramics. Graph 1 shows the significant difference between G1 (finished diamond tip of Komet) in both dental ceramics. It can be observed the closeness of the results of polishing G2 systems (Komet), G3 (Shofu) with the control group. The difference of the results of G2 (Komet), G3 (Shofu) and G4 (Dh Pro) compared to the control is also noticed.

In the scanning electron microscopy images, we can notice that the roughness results are in agreement with these images, showing the difference in texture and roughness in both ceramics (Noritake and IPS e.max), mainly in G1 (finishing with a diamond tip of Komet) in which the surface is quite rough (Figure 5-14).

Table 1: Mean and standard deviation of surface roughness (μm) of glazed ceramics, after finishing and polishing with different polishing systems.

Ceramic	Control	G1- Finishing Komet	G2-Polishing Komet	G3-PolishingCeramisté (Shofu)	G4 -Polishing Dh Pro
Noritake	0.90 ±0.211	4.33 ±0.702	1.37 ±0.671	1,32 ±0,0381	1.98 ± 0.113
IPs Emax	0.54 ± 0.061	2.28 ±0.853	1.17 ±0.241	1.34 ±0.671	1.93 ± 0.113

Different numbers represent statistically significant differences within each row (≤0.05).



Graph 1: Comparative analysis between the two ceramics and polishing groups.

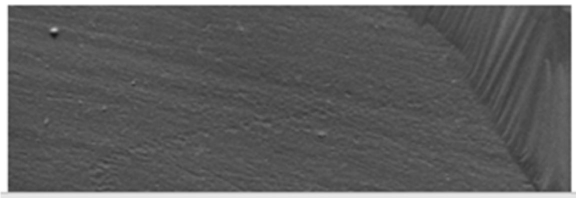


Figure 5: SEM of Control Noritake.

Figure 6: SEM of Control IPS E.max.

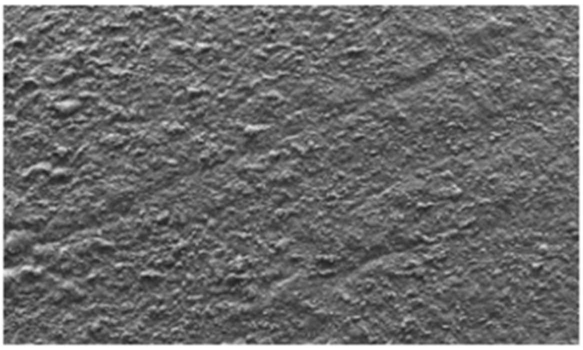


Figure 7: SEM of Finishing Noritake (group1).

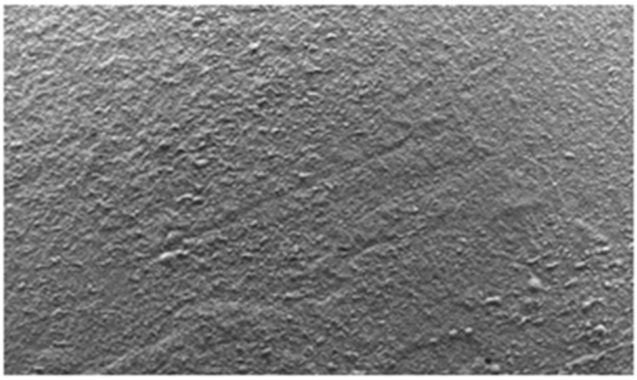


Figure 8: SEM of Finishing IPS E.max (group1).

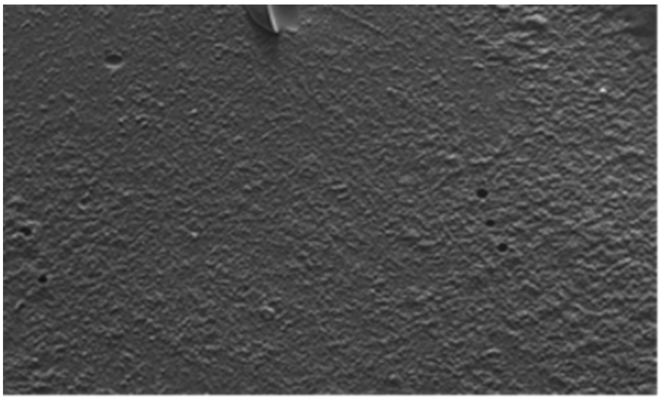


Figure 9: SEM of Polishing Komet Noritake (group2).

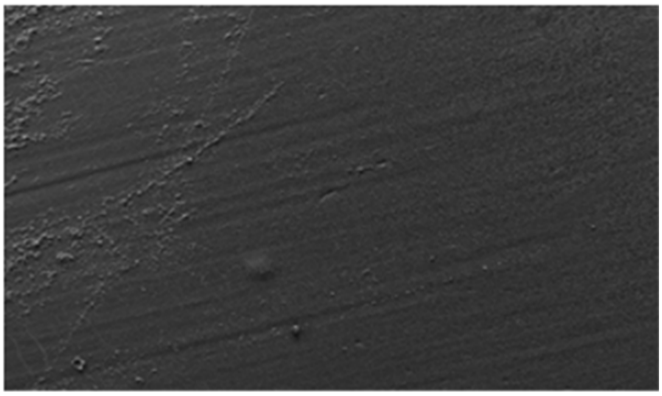


Figure 10: SEM Polishing Komet IPS E.max.

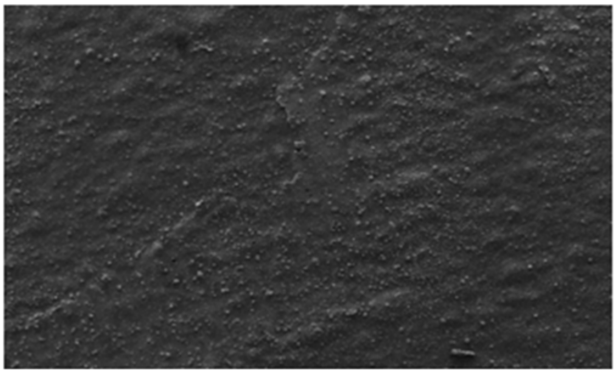


Figure 11: SEM of Polishing Shofu Noritake (group3).

Figure 12: SEM of Polishing Shofu IPS E.max (group3).

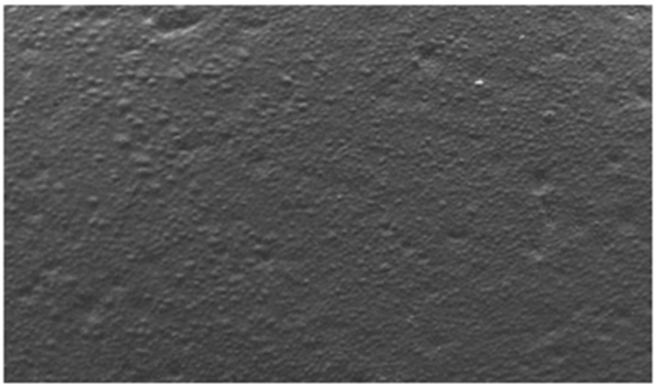


Figure 13: SEM of Polishing DhPro Noritake (group4).

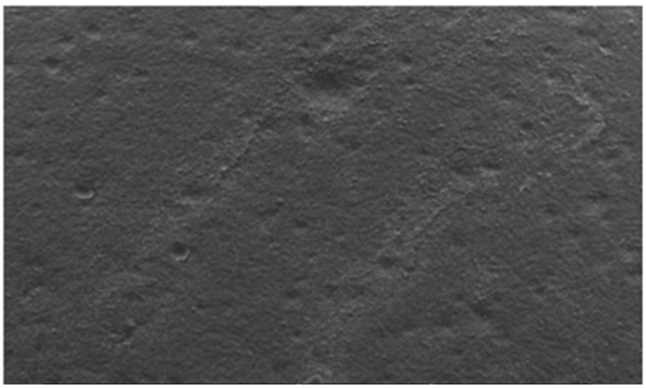


Figure 14: SEM of Polishing DhPro IPS E.max (group4).

Discussion

In many clinical situations of ceramic prosthetic rehabilitation some adjustment of occlusal contact or contour is can be required. In this circumstance, the surfaces are worn by diamond burs that remove the top layer of glaze. Ceramic surface must be polished and smooth, without pores or microcracks, to avoid plaque accumulation, gingival irritation, discoloration of the ceramic surface, fractures and wear of the opposite tooth. The finishing and polishing of the ceramic surface is still a challenge, there are many kinds of techniques and rubber points available for this situation [9].

One advantage of the ceramic restorations is related to the fact that the glaze layer (surface gloss), is impervious to oral fluids. Rupture of the glaze layer produces a rough surface, leading to clinical problems cited above [9]. Because of these reasons mentioned, it is reported the use of a new glazing process or polishing of ceramic restorations as alternatives resulting in a higher surface smoothness [9,10].

In order to make a new glaze is necessary that the ceramic restoration is subjected to another cycle burning kiln. This process can cause some damage to the ceramic structure, as another firing is carried out and that the ceramic becomes more fragile and require more time because it is necessary to send it back to the dental laboratory and schedule a new clinical appointment with the patient. Alternatively, we may use existing ceramic polishing systems in the current dental market. There are several systems and brands for finishing and polishing of ceramic surfaces available, however, there is a lack of consensus about the efficiency of theseis procedures when performed in everyday clinical practice [9].

Thus, the ceramic surfaces should be polished mechanically after the occasional occlusal adjustment, using various instruments and diamond polishing pastes. Therefore, many studies have been conducted to find out the efficiency of different finishing and polishing systems, but a comparative evaluation is not well documented. Several studies have shown that the final surfaces obtained with the polishing process are comparable to the glazed surfaces. On the other hand, other author's showeday that the polishing systems do not have the ability to reach the smoothness similar to those obtained on the samples of glazed surfaces [9].

[11] Scota evaluated, among other ceramics, the ceramics Super Porcelain EX-3 (Noritake, Nagoya, Japan) simulating wear by the used of one diamond bur 4138 (KG Sorensen, Barueri, SP, Brazil) at high speed and with water cooling, applied to the surface of the ceramic to glaze removal. Then, the diamond burs 4138F and 4138FF (thin granule, KG Sorensen, Barueri, SP, Brazil) were used. The polishing system were Komet (Lemgo, Germany) and the other half, EDENTA (St. Gallen, Switzerland). These both systems have 3 granules tips (coarse, medium and fine), which were assembled into a low speed and applied on the surface of the ceramic during 1minute for each abrasive tip. The results showed no statistical difference in the final surface roughness of both polishing systems for the ceramics Super Porcelain EX-3.

The nule hypothesis established in this work was accepted, since some types of rubber tips for polishing of ceramic after occlusal adjustment, has a similar result compared to the glaze. Regarding the limitations of this present laboratorial study, long term clinical trials should be carried out to confirm and ratify these findings [12-28].

Conclusions

Based on the results obtained and within the limitations of this study, we can conclude that:

A. DhPro polishing system had the worst results of recovering the surface roughness on two ceramics (Noritake and IPS e.max)

B. The two ceramics polished with polishing systems Komet and Shofu showed similar results regarding the glazed ceramics

C. After finishing with Kometa diamond burs, there was a significant difference between the ceramic types, IPS e.max showed the smoother surface.

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