

The effect of polishing techniques on the surface roughness of a feldspathic porcelain

Efeito de técnicas de polimento sobre a rugosidade superficial de uma porcelana feldspática

Abstract

Purpose: This *in vitro* study compared the effect of four different polishing methods on the surface roughness of a feldspathic dental porcelain.

Methods: Forty disc-shaped specimens were fabricated with a feldspathic porcelain (Super Porcelain EX3), glazed, and randomly divided into 4 experimental groups and 1 control group (n=8/group). For the experimental groups, the glazed layer was ground with a diamond rotary instrument, and the surface was polished with: rubber points (Edenta), steel finishing burs (Meisinger), silicon rubber point (Shofu) + diamond felt wheel (FGM) + diamond paste (Diamond Excel, FGM), or aluminum oxide discs (Sof-Lex, 3M-ESPE) + diamond felt wheel + diamond paste. Surface roughness (Ra) was measured profilometrically. Data were analyzed by analysis of variance and Tukey test ($\alpha=5\%$).

Results: The Ra values were not statistically different among the four polishing groups ($P>0.05$). All polishing groups had significantly higher mean Ra values than the control glazed specimens ($P<0.001$).

Conclusion: Within the limitations of this study, the results indicate that the tested polishing techniques were not able to provide a porcelain surface as smooth as the glazed surface.

Key words: Ceramic; roughness; polishing techniques

Resumo

Objetivo: Este estudo *in vitro* comparou o efeito de quatro métodos de polimento sobre a rugosidade superficial de uma porcelana feldspática.

Metodologia: Quarenta discos de porcelana (Super Porcelain EX3) foram confeccionados, glazeados e divididos aleatoriamente em 4 grupos experimentais e 1 grupo controle (n=8/grupo). Nos grupos experimentais, a camada de glaze foi removida com ponta diamantada e as superfícies desgastadas foram polidas com: pontas de borracha (Edenta), brocas multilaminadas (Meisinger), pontas siliconadas (Shofu) + disco de feltro Diamond (FGM) + pasta diamantada (Diamond Excel, FGM), ou discos de óxido de alumínio (Sof-Lex, 3M-ESPE) + disco de feltro Diamond + pasta diamantada. A rugosidade superficial (Ra) foi medida com um rugosímetro. Os dados analisados por análise de variância e teste de Tukey ($\alpha=5\%$).

Resultados: Os valores Ra não foram estatisticamente diferentes entre os quatro grupos com polimento ($P>0,05$). Todos os grupos experimentais com polimento apresentaram valores de Ra significativamente maiores que os espécimes glazeados do grupo controle ($P<0,001$).

Conclusão: Dentro das limitações do estudo, os resultados indicaram que as técnicas de polimento utilizadas não foram capazes de produzir uma superfície tão lisa quanto a superfície glazeada.

Palavras-chave: Cerâmica; rugosidade; técnicas de polimento

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Introduction

Dental ceramics are able to mimic natural teeth due to their excellent physical properties such as esthetics, biocompatibility, low thermal conductivity, and wear resistance (1-3). Because of these features, dental ceramics have been extensively used in several rehabilitation procedures, including inlays, onlays, crowns, and porcelain veneers (4). In the dental laboratory, porcelain is fired and traditionally subjected to a “glaze” that results in a surface texture and appearance resembling that of a natural tooth surface (1,5). However, the dentist often removes part of the glazed surface after cementation of the ceramic restoration because of the need for occlusal adjustment, correction of inadequate contour, or improvement of esthetics (1,2,6).

The clinical adjustment of ceramic restorations with abrasive rotary instruments creates a rough surface, which may facilitate biofilm accumulation, leading to gingival inflammation and adverse soft tissue reaction (7-9), or may increase the wear of the opposing enamel or other restorative material (10-12). Therefore, this rough surface should be subjected to finishing and polishing procedures to return optimum surface texture, biocompatibility, and esthetics (13). The color of the ceramic restoration is also affected by surface roughness as a smooth surface reflects a greater amount of light than a rough surface (14,15). Previous studies have described different finishing and polishing techniques for several dental ceramics after simulation of chairside adjustment, but the outcomes are contradictory (16-22).

The purpose of this *in vitro* study was to evaluate the effect of different finishing and polishing techniques on the surface roughness (Ra parameter) of a feldspathic dental porcelain widely used in Brazil after removal of the glazed surface.

Methods

Porcelain (Super Porcelain EX3, Noritake Dental Supply Co, Aichi, Japan) discs were fabricated using a stainless steel rectangular mold to standardize the specimen shape and dimensions (5mm-diameter and 2mm-thick). The same amount of porcelain and liquid were used to prepare all specimens, and the excess moisture was removed by using an absorbent paper. The specimens were placed in a porcelain-firing oven (Vita Vacumat 40T, VITA Zahnfabrik, Germany) and fired according to the manufacturer’s instructions. After firing, the specimens were ground with water-cooled sandpapers of decreasing abrasiveness (#280-, #400-, and #600-grit) to remove surface irregularities and standardize roughness. All specimens were subjected to autoglazing according to the manufacturer’s instructions. A total of 40 specimens were fabricated and randomly divided into 5 groups (n=8/group): 1 control group and 4 experimental groups.

For all specimens of the four experimental groups, a diamond bur (3168F, KG Sorensen, São Paulo, Brazil) was used to remove the glaze layer under constant air/water coolant for 10s in a high-speed handpiece (Dabi Atlante, São Paulo, Brazil). The ground porcelain surfaces then received the experimental treatment using one polishing system or a

combination of systems as depicted in Table 1. Polishing was performed by a single trained investigator using a slow-speed handpiece at 15.000rpm for 30s, until the surface was visually shiny, simulating clinical procedures used for finishing and polishing porcelain surfaces. The glazed specimens were used as a control group. All specimens were ultrasonically cleaned (Thornton T740, São Paulo, Brazil) with distilled water and dried with air-blast for 30s before roughness measurements.

Table 1. Description of the porcelain surface treatments.

Group	Finishing/polishing technique
G1 (Control)	Glaze
G2	Rubber points (Edenta AG Dental, Hauptstrasse, Switzerland)
G3	Steel finishing burs (Meisinger, Düsseldorf, Germany)
G4	Silicon rubber point (Shofu Inc., Kyoto, Japan) + Diamond felt wheel (FGM Produtos Odontológicos, Joinville, SC, Brazil) and Diamond paste (Diamond Excel, FGM Produtos Odontológicos, Joinville, SC, Brazil)
G5	Complete sequence of aluminum oxide discs (Sof-Lex, 3M-ESPE, St. Paul, MN, USA) + Diamond felt wheel (FGM Produtos Odontológicos, Joinville, SC, Brazil) and Diamond paste (Diamond Excel, FGM Produtos Odontológicos, Joinville, SC, Brazil)

Surface roughness (Ra parameter in micrometer) was evaluated using a rugosimeter (Mitutoyo-Surf Test 301, Kanagawa, Japan). The diamond stylus (5-mm tip radius) moved across a 600mm-range at 0.100mm/s under a constant load of 3.9mN during testing. This procedure was repeated three times at a different location for each specimen, and the measurements were averaged. Data were analyzed by one-way ANOVA followed by Tukey test, with the level of significance set at 5%.

Results

Table 2 displays the comparison of Ra mean values of the tested groups. Ra was significantly affected by surface treatment ($P<0.001$). The glazed group (control) had the lowest Ra mean and was statistically different from the other groups. No significant difference was found among the polishing groups ($P>0.05$).

Table 2. Surface roughness (Ra mean and standard deviation) (μm) for the control and experimental polishing groups (n=8/group).

Group	Mean*	SD
G1 (Control)	0.61 ^a	0.39
G2	2.76 ^b	0.55
G3	2.38 ^b	0.43
G4	2.60 ^b	0.59
G5	2.45 ^b	0.70

* Means followed by same letters indicate no significant difference (Tukey test, $P>0.05$).

Discussion

This study showed that all tested polishing techniques resulted in similar surface roughness for the Super Porcelain EX3, which suggests that complex procedures with more clinical steps may not reflect in smoother surfaces for this porcelain. Post-cementation adjustment of porcelain restorations is often necessary for occlusal or contour correction, but the resulting rough surface may lead to abrasive wear of the opposing dentition or increase plaque accumulation (8,10,12). Therefore, clinicians and patients would benefit from simple chairside finishing and polishing procedures to smooth the adjusted ceramic surfaces and increase the long-term restoration success.

Although all finishing and polishing systems tested showed similar efficacy, none provided surface roughness similar to the glazed surface. The polished surfaces were four times rougher than the glazed specimens of Super Porcelain EX3. This finding is in agreement with previous reports on the effect of different polishing techniques on the surface roughness of several dental ceramics (2,5,13,20,21). Conversely, other studies have shown that polished ceramics produced surfaces that were as smooth as glazed ceramics, or provided smoother surfaces than glazing (14,16-19,22). Some explanations for these conflicting findings are the

differences of experimental designs, dental ceramics, and polishing methods. Nevertheless, these results suggest that surface roughness may be dependent on the combination of ceramic and polishing technique.

One limitation of this study is that the polishing procedures were performed on disc-shaped specimens, which are not identical to real restorations. Direct extrapolation of results to the clinics also is not possible because of differences of pressure and time applied by different practitioners during the polishing procedures. Moreover, roughness values of the polished groups may have varied if the initial surface grinding was performed by using other rotary instruments. However, the findings of this work reinforce the need of additional studies and standardization of methods to determine the best finishing and polishing technique for each material and the smoothness cut-off limit to predict clinical success.

Conclusions

Within the limitations of this *in vitro* study, it may be concluded that mechanical finishing/polishing procedures were not able to provide a surface as smooth as the glazed surface for the tested feldspathic porcelain (Super Porcelain EX3).

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