British Journal of Applied Science & Technology
11(4): 1-6, 2015, Article no.BJAST.20589
ISSN: 2231-0843

SCIENCEDOMAIN
SCIENCEDOMAIN *international*
www.sciencedomain.org

Can Polishing Systems Restore the Smoothness of Glazed Ceramics?

Nathalie Müller Machado[1], Diego Fabris Ferreira da Silva[1], Gilberto Antonio Borges[2] and Ana Maria Spohr[3*]

[1]*Department of Restorative Dentistry, School of Dentistry, Pontifical Catholic University of Rio Grande do Sul, Brazil.*
[2]*Department of Restorative Dentistry, Uberaba University, Brazil.*
[3]*Department of Dental Materials, Pontifical Catholic University of Rio Grande do Sul, Brazil.*

Authors' contributions

This work was carried out in collaboration between all authors. Author NMM performed the experiments and managed the literature searches. Authors DFFS and GAB contributed substantially to the discussion. Author AMS designed the study, performed the statistical analysis, and wrote the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2015/20589
Editor(s):
(1) Shiu-yin CHO, G/F, MacLehose Dental Centre, 286 Queen's Road East, Wanchai, Hong Kong.
Reviewers:
(1) Maen Mahfouz, Arab American University Jenin, Palestine.
(2) Anonymous, International Islamic University, Malaysia.
Complete Peer review History: http://sciencedomain.org/review-history/11220

Original Research Article

Received 31st July 2015
Accepted 19th August 2015
Published 1st September 2015

ABSTRACT

Aim: The purpose of this study was to analyze the surface roughness of three mechanically polished feldspathic ceramics by using two different polishing systems after simulated occlusal adjustment.

Methodology: Thirty feldspathic ceramic discs were fabricated: 10 with Duceram, 10 with Duceragold, and 10 with Symbio Ceram. All specimens were glazed, and 8 specimens in each group received simulated occlusal adjustment with diamond burs. Half of the 8 specimens was polished using the Edenta system, and the other half was polished using the Komet system. The mean surface roughness was measured before and after surface polishing using the Rugosimeter SL-201. Qualitative analysis of the ceramic surfaces was performed by scanning electron microscopy (SEM) in two glazed specimens and in two polished specimens. The data were submitted to analysis of variance for repeated measures, followed by Tukey's test (α=0.05).

**Corresponding author: E-mail: ana.spohr@pucrs.br;*

Results: The Edenta system produced statistically lower surface roughness than the Komet system for the Duceram and Duceragold ceramics ($p<0.05$). However, for the Symbio Ceram ceramic, there was no significant difference between the Edenta and Komet systems ($p>0.05$). The application of diamond paste significantly decreased the roughness of the ceramic surface compared with the isolated application of the Komet or Edenta system. The SEM images showed that the mechanical polishing did not restore the surface smoothness of the glazed surfaces.
Conclusions: Neither the Edenta nor Komet systems reproduced the surface smoothness of glazed ceramics. The use of diamond paste considerably reduced the surface roughness. The Edenta system provided lower surface roughness than the Komet system.

Keywords: Ceramic; polishing; surface roughness.

1. INTRODUCTION

Dental ceramics have been used as restorative materials for over 150 years. These ceramics can be used for crowns, inlays, onlays, overlays and fixed prostheses of various elements, either with or without metallic alloys. Such ceramics are one of the materials most widely used in restorative dentistry [1].

The feldspathic ceramics are used the most because of their greater capacity to reproduce the characteristics of natural teeth [2]. Because of their low toughness and susceptibility to fracture under relatively low stress, the feldspathic ceramics have been used in association with reinforced ceramics or metals [3]. As a veneer material, it is important to obtain a smooth surface due to aesthetic and biological reasons [4].

The surface smoothness of a ceramic restoration is generally obtained by mechanical polishing associated with glazing. However, there is a common need in clinical practice for occlusal adjustments and small corrections of the inappropriate contour of the restoration after luting. The adjustment of ceramic restorations produces a rough surface, which may facilitate the retention of microbial film [5,6] and the consequent inflammation of the periodontal tissue when this adjustment is performed close to the gingival area. In addition, the surface roughness can decrease the resistance of the ceramic restoration [7-9], and cause wear of the opposing dentition when the roughness is located in the occlusal region [10]. After luting, it is not possible to glaze the ceramic surface again, and it is important to restore the surface smoothness of the ceramics through a mechanical polishing procedure.

Several studies have assessed the ability of various techniques and systems to restore surface smoothness. Some studies have shown that mechanical polishing can restore the ceramic smoothness close to the one of the glazed ceramics [11-13]. However, other studies have shown that the best procedure is glazing [14,15].

There are several polishing systems for ceramics on the market, and it is important to verify the ability of these materials to polish the ceramic surface. Thus, the aim of this study was to measure the surface roughness and analyze the surface topography of three feldspathic ceramics when they were subjected to mechanical polishing with two different systems after simulating occlusal adjustment. This study was conducted under the following hypotheses: a) the polishing systems can restore the smoothness of the glazed ceramics, and b) the polishing systems produce similar surface roughness.

2. MATERIALS AND METHODS

Three feldspathic ceramics were used in the present study: Duceram (Dentsply, York, PA, USA), Symbio Ceram (Dentsply, York, PA, USA) and Duceragold (Dentsply, York, PA, USA). To fabricate the ceramic specimens, a circular metallic matrix (7-mm-diameter, 2-mm-thick) was used. For all three ceramics, the powder was mixed with the sculpting liquid and placed into the matrix, and tissue (Kleenex, Kimberly-Clark, Neenah, WI, USA) was used to absorb excess moisture. For each ceramic, ten specimens were made and then removed from the matrix and placed on a sagger tray. The tray was placed in a ceramic-firing oven (Keramat I; Knebel Dental Products, Porto Alegre, RS, Brazil) and fired according to the manufacturer's recommendations. The specimens were allowed to cool off and were then finished with a medium-grit diamond bur on both sides to remove any irregularities. One side of each specimen was polished with 400-, 600- and 1200-grit silicone carbide abrasive papers and wetted with water using manual pressure and rotary movements for

1 minute for each grit. The specimens were then placed in the ceramic-firing oven to obtain an autoglazed surface. The ceramic specimens were fabricated by an experienced technician.

The initial surface roughness of eight specimens from each ceramic was measured using a roughness tester SL-201 (Mitutoyo Surftest Analyzer, Tokyo, Japan). Three consecutive measurements of the specimens were taken from different regions (one central, one right and one left) with a cut-off of 0.25, and the arithmetic mean roughness (Ra) was obtained. This initial surface roughness corresponded to the glazed surface.

Using a carborundum disk mounted in a low rotation handpiece, a mark was made in the central region of each specimen. This procedure aimed to visually divide the specimens into two halves such that each half would be polished by a different system. To differentiate the two halves, left and right, each specimen was marked on the left side with a diamond bur at the lateral region of the specimen.

To simulate the occlusal adjustment performed clinically in a ceramic restoration, a diamond bur 4138 (KG Sorensen, Barueri, São Paulo, Brazil), connected to a high-speed handpiece with water-cooling, was applied to the ceramic surface for the total removal of the glaze. Then, the diamond burs 4138 F and 4138 FF (KG Sorensen, Barueri, São Paulo, Brazil) were applied for 10 s each, using light pressure. The diamond burs were changed every five specimens.

The Komet polishing system (Komet Dental, Lemgo, Germany) was applied on the left half, and the Edenta polishing system (Edenta, Aubonne, Switzerland) was applied on the right half of the specimens. These polishing systems have three tips with different grits (coarse, medium and fine). Each tip was connected to a low-speed handpiece and applied to the ceramic surface for 1 min each, using moderate pressure. At the end, diamond paste (Kota, São Paulo, SP, Brazil) was applied with a felt wheel mounted in a low-speed handpiece for 30 s, using moderate pressure. The surface roughness was measured again for each half after the following procedures: a) simulating the occlusal adjustment, b) polishing with Edenta or Komet system, and c) polishing with the diamond paste. Three consecutive measurements for each half of the specimens were taken from different regions (one central, one right and one left), and a mean average was obtained.

All procedures for the occlusal adjustment and polishing were performed by a single operator.

For the three feldspathic ceramics, two glazed specimens, two specimens polished with Edenta system, and two specimens polished with Komet system were ultrasonically cleaned in distilled water for 15 min and dried in a dehumidifier with silica gel for 7 days. The specimens were metalized with gold and observed under a scanning electron microscope (SEM) (Phillips XL 30, Philips Electronic Instruments Inc., Mahwah, NJ, USA) at 5,000x magnification for a qualitative analysis of the surface.

The values of surface roughness were processed by the Kolmogorov-Smirnov normality test. Analysis of variance (ANOVA) for repeated measures was used for the values of surface roughness, followed by Tukey's test at a significance level of 5%.

3. RESULTS

Table 1 shows the surface roughness values obtained in this study.

Smaller surface roughness mean values were obtained from the glazed surfaces, whereas greater values were obtained from the three ceramics after the diamond bur was used. Polishing with the Edenta system produced statistically lower surface roughness than did the Komet system for Duceram and Duceragold ($p<0.05$). However, for the Symbio Ceram ceramic, there was no significant difference between the Edenta and Komet systems ($p>0.05$). There was no significant difference between the glazed and polished surfaces with the Edenta system associated with diamond paste for Duceram and Symbio Ceram ($p>0.05$). For all of the ceramics, the application of diamond paste significantly decreased their surface roughness compared with the isolated application of either the Komet or Edenta system.

The SEM images (Fig. 1) show the superficial topography of the glazed surfaces and polished surfaces with the Edenta or Komet system associated with diamond paste. It was observed that mechanical polishing did not restore the surface smoothness of the glazed surfaces.

4. DISCUSSION

The glaze of the ceramic surface can be obtained using two different techniques, namely overglazing (glass overcoating) and autoglazing.

In overglazing, a thin layer of low-fusing glass overcoat is spread over the ceramic surface, followed by firing in a ceramic-oven under a specific temperature to obtain a glassy film on the ceramic surface. In autoglazing, the surface of the ceramic itself is allowed to melt at high temperature to provide the glaze layer [14]. Because the low-fusing glass has a higher content of glass modifiers, the chemical durability of glazed surfaces by this technique is lower than that of the autoglazed surface [16]. The glazing provides a superficial sheen on the ceramic surface and seals the surface cracks, thus favoring the increased strength of the material [17]. In the present study, the specimens were autoglazed after being polished with 400-, 600- and 1200-grit silicone carbide abrasive papers. This procedure was done to standardize the ceramic surfaces before the autoglazing. Regardless of the standardization, it was observed that the surface smoothness of the autoglazed ceramics was different. The higher surface roughness was obtained for Duceram (0.091 µm) and Symbio Ceram (0.095 µm), and the lowest was obtained for Duceragold (0.044 µm). The differences in surface roughness are likely related to the composition of the ceramics. However, all of the ceramics obtained a

Table 1. Mean values of surface roughness (µm) and standard-deviations of the ceramics under different surface treatments

Surface roughness means (µm) and standard-deviations			
Treatment/Ceramic	**Duceram**	**Duceragold**	**Symbio ceram**
Glazed	0.091 (0.044)^{a}	0.044 (0.011)^{a}	0.095 (0.044)^{a}
Diamond bur	0.995 (0.115)^{b}	0.679 (0.098)^{b}	0.620 (0.099)^{b}
Komet system	0.409 (0.121)^{c}	0.398 (0.094)^{c}	0.336 (0.124)^{c}
Edenta system	0.257 (0.058)^{d}	0.228 (0.049)^{d}	0.314 (0.051)^{c}
Komet system + Diamond paste	0.260 (0.145)^{d}	0.191 (0.073)^{e}	0.168 (0.052)^{e}
Edenta system + Diamond paste	0.122 (0.042)^{a}	0.145 (0.083)^{e}	0.118 (0.049)^{a}

** Means followed by distinct letters in a column differ statistically by Tukey's test at a significance level of 5%*

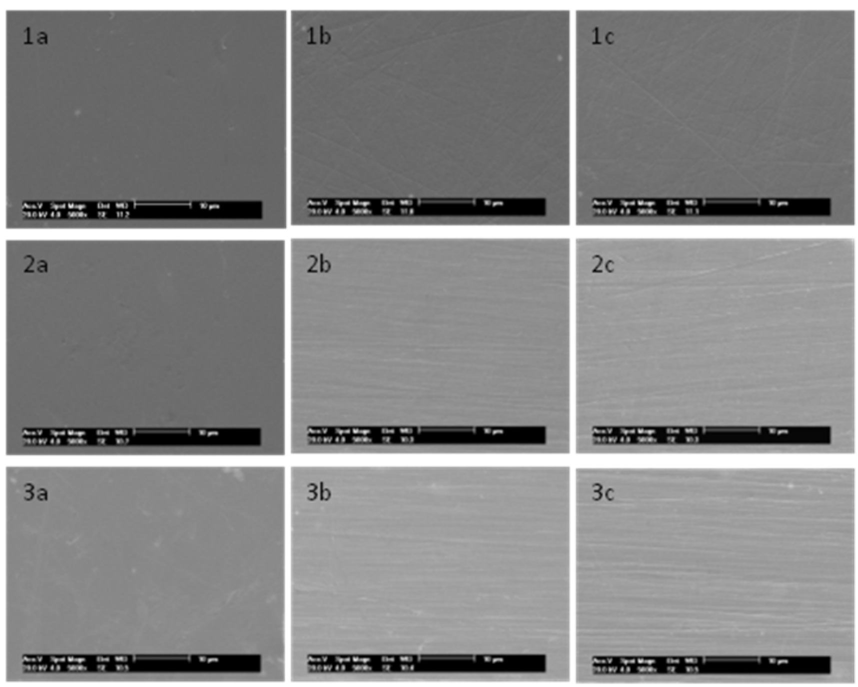

Fig. 1. SEM images (500X): 1- Duceram ceramic; 2- Duceragold ceramic; 3- Symbio Ceram ceramic; a- Glazed; b- Edenta system + diamond paste; c- Komet system + diamond paste. The surface of the glazed surface is smoother than the polished surfaces. Scratches remain for the surfaces polished with the Edenta and Komet systems

clinically acceptable surface roughness that was no higher than 0.2 µm. According to Bollen et al. [5], a surface roughness above 0.2 µm favors microbial film retention.

In this study, the occlusal adjustment simulation was performed with a 4138 diamond bur, followed by 4138 F and 4138 FF diamond burs. For the polishing procedure, materials with abrasive particles were used in order of decreasing size to remove the scratches produced by the diamond burs. Thus, increasingly fine scratches are formed on the material surface to the point of being imperceptible by the human eye [16]. In the present study, either the Komet or Edenta polishing system was applied with their three tips of different grits (coarse, medium and fine). According to the results, the first hypothesis was rejected because no polishing system, without diamond paste application, managed to restore the smoothness of the autoglazed surface, which shows that mechanical polishing was not sufficient to remove the scratches caused by the diamond burs. Without diamond paste, the surface roughness was above 0.2 µm, which facilitates microbial film retention. However, a lower surface roughness was obtained for all ceramics after polishing with diamond paste. The same result was obtained in other studies, which showed that the inclusion of a diamond polishing paste step is recommended to improve surface smoothness [18,19]. Therefore, some studies have suggested that even with the use of diamond paste, the surface roughness of mechanically polished surface is rougher than the autoglazed surface [14,15]. However, other studies have shown that mechanically polished surfaces had surface roughness comparable to glazed surfaces [13,20]. The difference in these results is likely related to the different materials and polishing techniques applied and to the different ceramics used.

For Duceram and Symbio Ceram, there was no significant difference in roughness between the glazed surface and the polished surface when using the Edenta system associated with the diamond paste. However, the roughness of the glazed surface was statistically lower than the Duceragold polished with either of the systems with the diamond paste. The best choice of surface treatment after removal of the glaze can also depend on the microstructure of the ceramic composition. The leucite content of the materials appears to play an important role because ceramics with a lower leucite content tend to have a lower surface roughness than do those that have a higher leucite content after mechanical polishing [21]. This may explain the contradictions found in the results of previous studies.

The second hypothesis of the study was also rejected because the values of the surface roughness polished with the Edenta system was statistically lower than those polished with the Komet system. The Edenta system was more effective than the Komet system for the three ceramics. Although there was no significant difference between the polishing systems for the Symbio Ceram ceramic, the surface roughness value was lower for the Edenta system. Furthermore, it was observed that the abrasive tips of the Edenta system had increased durability and that one kit was sufficient to polish all of the specimens. However, the abrasive tips of the Komet system were worn down sooner; thus, three kits were required to polish all of the specimens. Therefore, the greater effectiveness of the Edenta system was likely related to the composition of its tips, which could have a higher percentage of diamond abrasive particles, thereby increasing the abrasion capacity on the ceramic surface, and a lower percentage of binder, thus reducing the wear of the tips.

5. CONCLUSIONS

- The Edenta and Komet polishing systems did not reproduce the surface smoothness of the glazed ceramic.
- The use of diamond paste considerably reduced the surface roughness.
- The Edenta system provided lower surface roughness than the Komet system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kelly JR, Benetti P. Ceramic materials in dentistry: Historical evolution and current practice. Aust Dent. J. 2011;56(1);84-96.
2. McLaren EA, LeSage B. Feldspathic veneers: What are their indications? Compend Contin Educ Dent. 2011; 32(3):44-9.
3. Quinn JB, Quinn GD, Sundar V. Fracture toughness of veneering ceramics for fused

to metal (PFM) and zirconia dental restorative materials. J Res Natl Inst Stand Technol. 2010;115(5):343-52.
4. Silva TM, Salvia AC, Carvalho RF, Pagani C, Rocha DM, Silva EG. Polishing for glass ceramics: Which protocol? J Prosthodont Res. 2014;58(3):160-70.
5. Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature. Dent Mater. 1997; 13(4):258-69.
6. Queiroz JR, Fissmer SF, Koga-Ito CY, Salvia ACRD, Massi M, Sobrinho AS, et al. Effect of diamond-like carbon thin film coated acrylic resin on Candida albicans biofilm formation. J Prosthodont. 2013; 22(6):451-5.
7. Jager N, Feilzer AJ, Davidson CL. The influence of surface roughness on porcelain strength. Dent Mater. 2000; 16(6):381-8.
8. Fleming GJP, El-Lakwah SFA, Harris JJ, Marquis PM. The influence of interfacial surface roughness on bilayered ceramic specimen performance. Dent Mater. 2004; 20(2):142-9.
9. Ahamad R, Morgano SM, Wu BM, Russel AG. An evaluation of the effects of handpiece speed, abrasive characteristics, and polishing load on the flexural strength of polished ceramics. J Prosthet Dent. 2005;94(5):421-9.
10. Jagger DC, Harrison A. An in vitro investigation into the wear effects of unglazed, glazed, and polished porcelain on human enamel. J Prosthet Dent. 1994; 72(3):320-3.
11. Al Wahadni A, Martin DM. Glazing and finishing dental porcelain: A literature review. J Can Dent Assoc. 1998;64(8):580-3.
12. Bottino MC, Valandro LF, Kantorski KZ, Bressiani JC, Bottino MA. Polishing methods of an alumina- reinforced feldspar ceramic. Braz Dent J. 2006;17(4):285-9.
13. Sarac D, Sarac S, Yuzbasioglu E, Bal S. The effects of porcelain polishing systems on the color and surface texture of feldspathic porcelain. J Prosthet Dent. 2006;96(2):122-8.
14. Aksoy G, Polat H, Polat M, Coskun G. Effect of various treatment and glazing (coating) techniques on the roughness and wettability of ceramic dental restorative surfaces. Colloids Surf B Biointerfaces. 2006; 53(2):254-9.
15. Vieira AC, Oliveira MC, Lima EM, Rambob I, Leite M. Evaluation of the surface roughness in dental ceramics submitted to different finishing and polishing methods. J Indian Prosthodont. 2013;13(3):290-5.
16. Anusavice, KJ. Phillips´ science of dental materials. 10 ed. Philadelphia: W.B. Saunders Co. 1996;33-48.
17. Baharav H, Laufer BZ, Pilo R, Cardash HS. Effect of glaze thickness on the fracture toughness and hardness of alumina-reinforced porcelain. J Prosthet Dent. 1999;81(5):515-9.
18. Camacho GB, Vinha D, Panzeri H, Nonaka T, Gonçalves M. Surface roughness of a dental ceramic after polishing with different vehicles and diamond pastes. Braz Dent J. 2006;17(3):191-4.
19. Steiner R, Beier US, Heiss-Kisielewsky I, Engelmeier R, Dumfahrt H, Dhima M. Adjusting dental ceramics: An *in vitro* evaluation of the ability of various ceramic polishing kits to mimic glazed dental ceramic surface. J Prosthet Dent. 2015; 113(6):616-22.
20. Manjuran NG, Sreelal T. An in vitro study to identify a ceramic polishing protocol effecting smoothness superior to glazed surface. J Indian Prosthodont Soc. 2014;14:219-27.
21. Sasahara RMC, Ribeiro FC, Cesar PF, Yoshimura HN. Influence of the finishing technique on surface roughness of dental porcelains with different microstructures. Oper Dent. 2006;31(5):577-83.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/11220