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RESEARCH ARTICLE

EFFECTS OF POLISHING TECHNIQUES ON SURFACE ROUGHNESS OF VENEERING CERAMICS FOR ZIRCONIA FRAMEWORKS

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ABSTRACT

The aim of this study was to compare the effect surface finishing and polishing methods on surface roughness of veneering ceramics for zirconia frameworks.35 disc-shaped specimens; (10x2mm) were prepared from each veneering ceramics (IPS e-max Ceram, Noritake-CZR and Vita-VM9) and glazed (Totally 105). Each group were randomly divided into 5 groups and performed the following procedures: G1: Glaze (Control); G2:Silicon wheel+rubber points (Shofu)+diamond polishing paste; G3: Shofu ceramic polishing kit; G4: Edenta ceramic polishing kit; G5: Eve ceramic polishing kit. From G2 up to G5; procedures were applied after the removal of glazed surface with a 25 µm finishing bur (Acurata, Germany). A profilometer (Mahr XR 2.0, GmbH, Gottingen) was used to measure arithmetic mean roughness (RA) of the surfaces. The Shofu and Edenta polishing kits produced a smoother surface than the Eve polishing kit and the other groups. No significant difference was found between G3 and G5 ($p<.05$). Vita-VM9 have the highest surface roughness value ($p<.05$).Within the limitations of this study, glazing and polishing kits have shown lower Ra values than silicon wheel, rubber points and polishing paste group. Clinically adequate smoothness may vary for the crystal contents and structure of ceramic that used.

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INTRODUCTION

In dental restoration, the smoothness of a ceramic surface is essential for the prevention of opposing surface wear; it also reduces discoloration and the inflammation of soft tissues around restorations. As patients can detect irregularities of up to 0.3 µm with the tongue, smooth surfaces are also important for patient comfort (Heintze *et al*., 2006). Although glazed ceramic has been accepted recently as the gold standard material for the achievement of the best polishing characteristics, several ceramic refinishing methods have been proposed and a number of commercial polishing kits are available for this purpose (Kelly *et al*., 1996). The main purposes of these kits are to obtain the smoothest surface and to reduce working time and laboratory cost. Several studies have shown that rough ceramic surfaces resulting from insufficient polishing lead to increased adhesion of bacteria and cannot be cleaned sufficiently by patients (Anami *et al*., 2012; Aykent *et al*., 2010). Rough surfaces may have an abrasive effect on antagonistic and adjacent teeth. Studies using mastication simulators have shown that increased ceramic surface roughness causes significant wear of antagonistic teeth (Preis *et al*., 2013). Moreover, effective polishing prevents discoloration of rough areas and leads to a more natural appearance of ceramic restorations. After intraoral adjustment, rough or irregular ceramic surfaces may concentrate stresses and initiate crack propagation, resulting in premature restoration fracture. Ceramic restorations may be polished using kits, discs, or cleaning prophylaxis pastes. Polishing kits and discs have been shown to achieve surface smoothness more effectively than the use of polishing pastes alone or in combination with discs (Sarikaya and Guler, 2010). In addition to the mechanical polishing of ceramics to improve surface smoothness, the application of glaze is another consideration. One study compared the surface smoothness of various ceramic systems treated with glaze, pastes, rubber, discs, and abrasive paper, and demonstrated that clinically acceptable smoothness could be obtained from glazing and paste applications (Yilmaz and Ozkan, 2010). Several studies have examined whether ceramic polishing kits can help to recreate surfaces similar to original glazed ceramic surfaces before any modification is made (Boaventura *et al*., 2013; Flury *et al*., 2010). The purpose of this study was to investigate the effects of mechanical polishing methods on ceramic surfaces quantitatively (*via* surface roughness analysis) and

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qualitatively (*via* scanning electron microscopy - SEM). The null hypothesis was that the smoothness of ceramic surfaces treated with various commercially available ceramic polishing kits would not differ significantly.

MATERIALS AND METHODS

One low-fusing and two high-fusing veneering ceramics were used for this in vitro study (Table 1). To ensure standardization, one operator prepared all specimens (n = 35 per ceramic type). Ceramic powder and an appropriate amount of the indicated liquid were mixed to form slurry. Modeling fluid specific for each ceramic was used according to the manufacturer's instructions. The fluid was poured into a prepared round, split silicon mold, the mold was vibrated to eliminate air bubbles, and excess moisture was removed with a tissue. Specimens were then placed on a plane tray and fired once in a furnace (Programat EP 5000; Ivoclar Vivadent, Schaan, Liechtenstein), according to the manufacturers' instructions (Table 2). After firing, a glaze specific to each ceramic type was applied.

RESULTS

Quantitative Analysis of Surface Roughness

The means and standard deviations (SDs) of Ra values for the IPS e.max Ceram, Noritake Cerabien ZR (CZR), and VitaVM9 ceramics are shown in Table 3. ANOVA revealed relationships between the ceramic systems and polishing techniques and the ceramic systems themselves for Ra values (p< 0.05; Table 4). Polishing technique affected Ra significantly (p< 0.05).

The lowest and highest Ra values were obtained in G3 (1.34± 0.22 µm) and G5 (2.87±0.45 µm), respectively (Table 3).Differences between surface finishing protocols were significant in all groups except G1 (p<0.05). G1Ra values did not differ among ceramic systems. Mean (±SD) Ra values according to polishing technique and ceramic system are presented in Table 5. Tukey's test showed that Ra values were higher for VitaVM9 than for other ceramic materials when polishing technique was considered. Figure 1 shows Ra values for all ceramic materials and groups.

Table 1. Ceramic materials used in this study

Veneering ceramic	Manufacturer	Composition[a]
Cerabien ZR	Noritake, Nagoya, Japan	Potassium aluminosilicate glass, leucite, etc.
Vita VM9	Vita Zahnfabrik, Bad Säckingen, Germany	Feldspar, alumina, etc.
IPS e.max Ceram	Ivoclar-Vivadent, Schaan, Liechtenstein	Nanofluorapatite, etc.

[a]As reported by manufacturers.

Table 2. Firing parameters used in this study, as given by manufacturers

Veneering ceramic	Pre-drying temperature (°C)	Pre-drying time (min)	Heating rate (°C/min)	Firing temperature (°C)	Holding time (min)
Cerabien ZR	600	10	45	935	1
Vita VM9	500	6	55	910	1
IPS e.max Ceram	403	8	50	750	1

Specimens of each type were divided randomly into the following five treatment groups: glaze(G1; control),silicon wheel+rubber points (ShofuRubber, Kyoto, Japan)+diamond polishing paste (Diamond Excel; FGM, Joinville, SC, Brazil; G2), Shofu ceramic polishing kit (ShofuRubber; G3), Edenta ceramic polishing kit (Edenta Ag Dental Products, Hauptstrasse, Switzerland; G4), and Eve polishing kit (RA 105 Diamond, Eve, Ernst Vetter, GmbH, Germany; G5). For G2–G5, surface finishing was performed after removal of the glazed surface with a 25-µm finishing bur (Acurata, Thurmansbang, Germany). A digital caliper (Digimatic IP67; Mitutoyo GmbH) was used to ensure the consistency of specimen dimensions. A profilometer (XR 2.0; MahrGmbH, Göttingen, Germany) was used to measure the arithmetic mean roughness (Ra) of the surfaces (in micrometers). One randomly selected specimen from each group was cleaned ultrasonically in distilled water for 10 min and air dried for SEM examination (JSM-5410 LV SEM; Tokyo, Japan). Surface features resulting from the finishing procedures were examined. The data were analyzed using SPSS software (version 21; IBM Corporation, Armonk, NY, USA). Descriptive statistics (mean, standard deviation, minimum, and maximum) were calculated. Data were analyzed using two-way analysis of variance (ANOVA), and mean values were compared using Tukey's difference test (α = 0.05).

Table 3. Effects of porcelain material and polishing technique (two-way ANOVA)

Source of variation	SS	df	Mean square	F	Sig
Polishing	12.45	4	4.16	28.35	0.01*
Ceramic	0.6	2	0.5	3.4	0.01*
Ceramic-polishing	3.19	14	1.1	6.21	0.01*

Table 4. Mean values of surface roughness (Ra) and standard deviations after the application of polishing treatments

	Mean (µm)	SD
G1	1.88	0.21
G2	1.98	0.30
G3	1.34	0.22
G4	1.48	0.21
G5	3.37	0.55

Table 5. Mean (± standard deviation) roughness values (µm) for polishing and ceramic systems (Tukey's test, p< 0.05)

Ceramic	Polishing technique
IPS e.max Ceram	1.99 ± 1.1[a]
Cerabien ZR	1.71 ± 0.6[a]
Vita VM9	2.82 ± 1.8[b]
(Mean ± SD)	2.17 ± 1.5

[a,b]The same letters represent groups that are similar statistically.

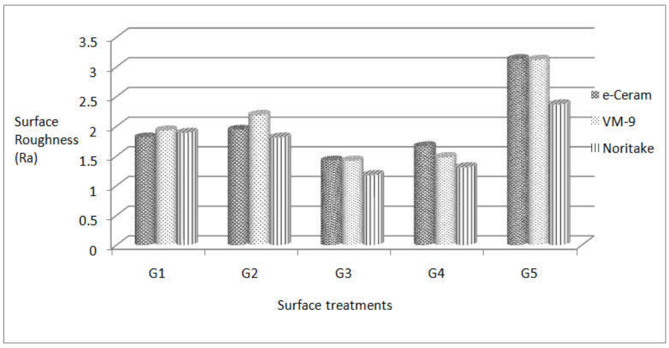

Figure 1. Mean surface roughness values according to ceramic material and polishing treatment

Qualitative SEM Analysis

The smoothest (NoritakeCZR G3) and roughest (VitaVM9 G5) topographic surfaces are depicted in Figures 2 and 3, respectively. The Ra value of the NoritakeCZR G3 specimen was lower than that of the control.

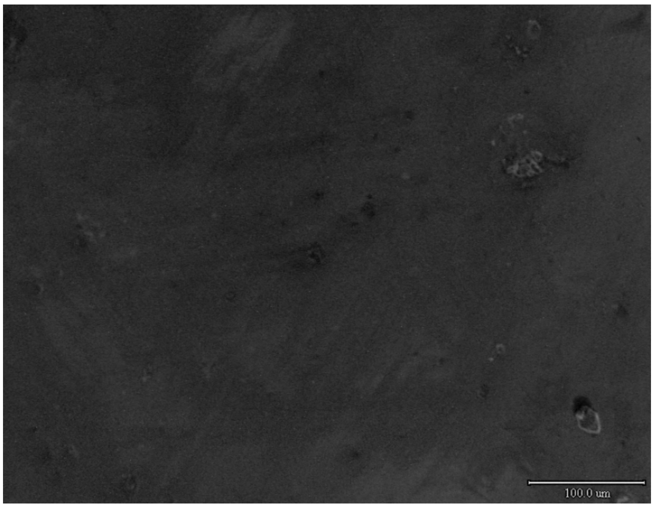

Fig. 1. SEM micrographs of Noritake –CZR surface after polishing with Shofu system. Magnification: at 100x

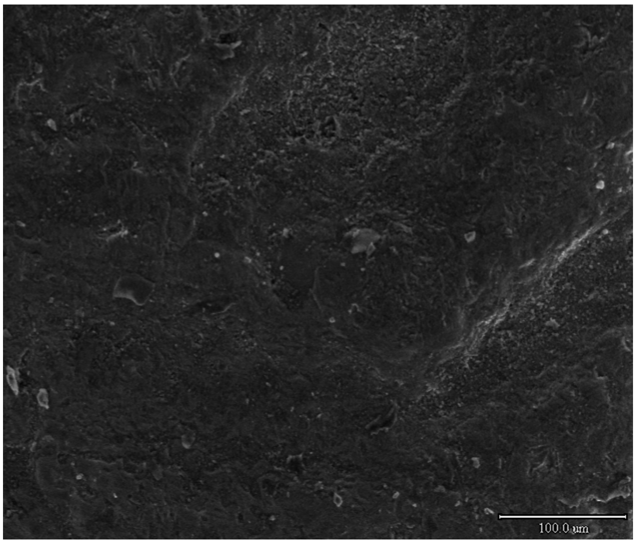

Fig. 2. SEM micrographs of VM9 surface after polishing with Kerr polishing kit. Magnification: at 100x

DISCUSSION

Based on the results of the present study, the null hypothesis was that the smoothness of ceramic surfaces treated with various commercially available ceramic polishing kits would not differ significantly was rejected. Adjustments must be made to ceramic restorations after cementation to ensure the achievement of surface anatomy and texture similar to those of natural teeth, and to achieve proper occlusion (Patterson *et al.*, 1992; Wang *et al*., 2009). These adjustments usually result in ceramic surfaces that are incompatible with oral tissues (Hulterstro¨m and Bergman, 1993), requiring the use of finishing and polishing kits to obtain smooth surfaces (Chu *et al.,* 2000). The achievement of acceptable smoothness makes the material as inert as possible (Patterson *et al.*, 1992) and provides good mechanical strength for the restoration (Jager*et al.,* 2000). Several finishing and polishing methods have been described in the literature (Dalkız *et al.*, 2009; Patterson *et al.*, 1992; Yilmaz and Ozkan, 2010). In this study, we used kits indicated for the intraoral finishing and polishing of dental ceramics that were readily available in the national market and easy to use. In previous studies, the surface characteristics of dental ceramics have been assessed qualitatively and quantitatively. Several methods for the measurement of surface texture have been described, including laser reflectivity, non-contact laser stylus metrology, SEM, compressed air measurement, and atomic force microscopy. SEM, a commonly applied qualitative method, was used in the present study. Raimondo *et al.* (1990) compared the application of six polishing techniques to previously polished and roughened ceramics using SEM, but they conducted no statistical analysis. They found superior results for oven-reglazed specimens on SEM examination and equivalent smoothness of these materials and others on macro-inspection, although Shofu system surfaces were smoother than glazed surfaces (Raimondo *et al.*, 1990). Wright et al. (2004) used SEM to evaluate the smoothness achieved by the application of three polishing kits to an ultra-low-fusing dental ceramic. The three polishing systems provided smoother surfaces than observed in the autoglazed group. Other studies have found that the use of the Shofu kit produces smoothness comparable to that of glazed specimens (Al-Wahadni *et al.*, 2006; Saraç *et al.*, 2006). Similar to these previous reports, the Shofu (G3) and Edenta (G4) polishing systems produced surfaces with lower Ra values than observed in the glazed (G1) group in the present study.

In general, different parameters of surface roughness (e.g., Ra, maximum profile peak height (Rp), maximum profile valley depth (Rv), maximum profile (Rt) height) are measured in the evaluation of topographical features on material surfaces. Rp and Rv represent the height of the highest peak on the reference line and the depth of the deepest valley under the reference line, respectively. Rt is the vertical distance between the highest and lowest points of the profile within the evaluation length. Ra, which describes overall surface roughness, is established by finding an average centerline; all valleys below the centerline are then inverted and measured as peaks. Ra remains the most commonly reported measurement in dental studies (Sasahara *et al.,* 2006*;* Werneck and Neisser, 2008) and it was used in the present study to compare the surface smoothness of dental ceramic materials. Ra may be influenced by ceramic density, porosity, and microstructure (Milleding and Karlsson, 2006). The difference in Ra values between the VitaVM9 ceramic and the IPSe.max Ceram and NoritakeCZR materials observed in the present study may be related to the composition and microstructure of these veneering ceramics. Alumina crystals in the VitaVM9 ceramic may make it tougher, preventing the achievement of a smooth surface. This study has several limitations. We evaluated surface roughness using only the measurement of Ra; the evaluation of other parameters (e.g., Rp, Rv, Rt) may produce more descriptive results (Al-Shammery *et al.*, 2007; Field *et al.,* 2010). In addition, we did not examine whether press-on force and polishing time affected the polishing results. Heintze *et al.* (2006) found that surface roughness decreased after 5 s of polishing, and increased with the application of 4 N force relative to the use of 2 N force. This study has assessed only surface roughness, so further studies are required to assess other properties simultaneously, to confirm the efficacy of chair-side polishing. Ceramic trimming may reduce the strength of a ceramic restoration (al-Wahadni *et al.,* 1998). Although the results of many studies suggest that glazed ceramic provides the smoothest and densest surface, other studies have shown better results with polishing. Ceramic smoothness, mechanical properties, and discoloration, as well as wear of opposing enamel, have been of particular interest in these studies (Haywood *et al.,* 1988). Haywood VB found equal smoothness of veneer ceramics finished with polishing kits and glazing.

Conclusion

The results of this in vitro study indicate that mechanical polishing of IPS e.max Ceram and NoritakeCZR specimens can produce surfaces as smooth as those of glazed specimens, as evidenced by Ra values and SEM appearance. For these two ceramic materials, application of the Shofupolishing system resulted in significantly lower mean Ra values than did the use of the Eve polishing system. Ra values were highest in specimens of all three ceramics treated with silicon wheel+rubber points+diamond polishing paste. Thus, reglazing must be performed to achieve a smooth surface. Due to the difficulty of reaching certain intraoral regions, especially those in the posterior oral cavity, occlusal correction may result in insufficient polishing, and the resulting microcracks may render dental ceramics susceptible to later catastrophic fracture. Thus, careful intraoral polishing with an appropriate kit is necessary following occlusal adjustment of a ceramic restoration after cementation. After abrasion of the glaze layer due to adjustment, the best choice of surface polishing method depends on ceramic type. The results of this study suggest that adequate smoothness may not be attainable for ceramics containing crystalline alumina (i.e., VitaVM9); in such cases, reglazing may be required. For porcelain surfaces, chairside polishing with the Shofu system may be a good alternative to reglazing.

Abbreviations: SEM: Scanning electron microscopy, Ra: Surface roughness.

Competing interests: The authors declare that they have no competing interests.

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REFERENCES

Al-Shammery, H.A., Bubb, N.L., Youngson, C.C., Fasbinder D.J. and Wood, D,J. 2007. The use of confocal microscopy to assess surface roughness of two milled CAD-CAM ceramics following two polishing techniques. Dent Mater., 23:736–741.

Al-Wahadni, A. 2006. An in vitro investigation into the surface roughness of 2 glazed, unglazed, and refinished ceramic materials. Quintessence Int., 37:311–317.

Al-Wahadni, A. and Martin, O.M. 1998.Glazing and finishing dental ceramic: a literature review. *J Can Dent Assoc*., 64(8):580-583.

Anami, L.C., Pereira, C.A., Guerra, E., Assunção e Souza, R.O., Jorge.A.O. and Bottino MA.2012. Morphology and bacterial colonisation of tooth/ceramic restoration interface after different cement excess removal techniques. *J Dent.,* 40:742-749.

Aykent, F., Yondem, I., Ozyesil, A.G., Gunal, S.K., Avunduk, M.C. and Ozkan, S. 2010. Effect of different finishing techniques for restorative materials on surface roughness and bacterial adhesion. *J Prosthet Dent.,*103:221-227.

Boaventura, J.M., Nishida, R., Elossais, A.A., Lima, D.M., Reis, J.M., Campos. E.A,, de Andrade MF. 2013. Effect finishing and polishing procedures on the surface roughness of IPS Empress 2 ceramic. Acta Odontol Scand.; 71:438-443.

Chu, F.C.S., Frankel, N. and Smales, R.J. 2000. Surface roughness and flexural strength of self-glazed, polished, and reglazed in-ceram/ vitadur Alpha ceramic laminates. *Int J Prosthodont*. 13:66–71.

Dalkiz, M., Sipahi, C. and Beydemir B. 2009. Effects of six surface treatment methods on the surface roughness of a lowfusing and an ultralow-fusing feldspathic ceramic material. *J Prosthodont*., 18:217–222.

Field. J., Waterhouse, P. and German, M. 2010. Quantifying and qualifying surface changes on dental hard tissues in vitro. *J Dent.,* 38:182–190.

Flury, S., Lussi, A. and Zimmerli, B. 2010. Performance of different polishing techniques for direct CAD/CAM ceramic restorations. Oper Dent., 35:470-481.

Haywood, V.B., Heymann, H.O, Kusy, R.P, Whitley, J.Q, and Andreaus SB. 1988. Polishing ceramic veneers: an SEM and specular reflectance analysis. *Dent Mater.,* 4(3):116-121.

Heintze, S.O, Zellweger, G., Cavalieri, A andFerracane, J. 2006. Influence of the antagonist material on the wear of different composites using two different wear simulation methods. *Dent Mater*. 22(2):166-175.

Hulterstro¨m A.K. and Bergman M. 1993.Polishing systems for dental ceramics. *Acta Odontol Scand.,* 51:229–234.

Jager, N., Feilzer, A.J., Davidson. C.L. 2000. Theinfluence of surfaceroughness on ceramicstrength. Dent Mater.;16:381-388.

Kelly, J.R., Nishimura, I. and Campbell, S.O. 1996. Ceramics in dentistry: historical roots and current perspectives. *J Prosthet Dent.,* 75(1):18-32.

Milleding, P. and Karlsson, S. 2003. On the surface elemental composition of noncorroded and corroded dental ceramic materials in vitro. *J Mater Sci Mater Med*, 14:557–566.

Patterson, C.J.W., McLundie, A.C., Stirrups, D.R. and Taylor WG.1992. Efficacy of a ceramic refinishing system in restoring surface finish after grinding with fine and extra-fine diamond burs. *J Prosthet Dent*., 68:402–406.

Preis, V., Weiser, F., Handel, G. and Rosentritt, M. 2013. Wear performance of monolithic dental ceramics with different surface treatments. Quintessence Int.;44:393-405.

Raimondo, R.L., Richardson, J.T. andWiedner, B. 1990. Polished versus autoglazed dental ceramic. *J Prosthet Dent.*, 64(5):553-557.

Sarac, D., Sarac, Y.S., Yuzbasioglu, E. and Bal S. 2006. The effects of ceramic polishing systems on the color and surface texture of feldspathic ceramic. *J Prosthet Dent.*, 96:122–128.

Sarikaya, I. andGuler, A.U. 2010. Effects of different polishing techniques on the surface roughness of dental ceramics. J Appl Oral Sci.;18:10-16.

Sasahara, R.M., Ribeiro, F.C., Cesar, P.F. and Yoshimura HN. 2006. Influence of the finishing technique on surface roughness of dental ceramics with different microstructures. Oper Dent.;31:577–583.

Wang, F, Chen, J.H. and Wang, H. 2009. Surface roughness of a novel dental ceramic following different polishing procedures. *Int J Prosthodont*, 22:178–180.

Werneck, R.D. and Neisser, M.P. 2008. Surface roughness of a feldspathic dental ceramic after simulation of occlusal adjustment and polishing. Rev Odont Cieˆnc.;23:166–169.

Wright, M.D., Masri, R., Driscoll, C.F., Romberg, E, Thompson, G.A., Runyan, D.A. 2004. Comparison of three systems for the polishing of ultra-low fusing dental ceramic. *J Prosthet Dent.,* 92(5):486-490.

Yilmaz, K. and Ozkan, P. 2010. Profilometer evaluation of the effect of various polishing methods on the surface roughness in dental ceramics of different structures subjected to repeated firings. Quintessence Int.;41:e125-31.

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