

An *In vitro* Evaluation to Compare the Surface Roughness of Glazed, Reglazed and Chair Side Polished Surfaces of Dental Porcelain

Abstract

Aim: The aim of this study was to evaluate the effect of glazing, reglazing, and chairside polishing on the surface roughness of dental porcelain. **Materials and Methods:** A total of 50 discs of feldspathic porcelain were fabricated using a metal mold of dimension 10 mm × 2 mm. Based on the surface treatment, the samples were divided into five groups. Group A – Glazed (control), Group B – Abraded and reglazed, Group C – Abraded and polished with porcelain adjustment kit (Shofu Dental Corp. PN 0301 Classic Plastic HP Kit, Shofu Inc., Kyoto, Japan), Group D – Abraded and polished with diamond polishing paste (Shofu Dental Corp. PN 0558 DirectDia, Shofu Inc., Kyoto, Japan), Group E – Abraded and polished with the combination of porcelain adjustment kit followed by diamond polishing paste. The surface roughness (Ra) values (μm) were evaluated by a profilometer (Mitutoyo SurfTest SJ-310, Tokyo, Japan). The data obtained were statistically analyzed using one-way ANOVA and *post hoc* Tukey's test. **Results:** The mean surface roughness (Ra) of Groups A, B, C, D, and E was $0.567 \pm 0.078 \mu\text{m}$, $0.433 \pm 0.059 \mu\text{m}$, $0.882 \pm 0.126 \mu\text{m}$, $2.361 \pm 0.195 \mu\text{m}$, and $0.438 \pm 0.043 \mu\text{m}$, respectively. The samples of Group D (Polished with polishing paste alone) had the highest surface roughness (Ra value). Whereas the samples of Group B and E had similar surface roughness (Ra) value. Differences between Groups A, B, and E were statistically insignificant ($P > 0.05$). **Conclusion:** After adjustment of ceramic restorations in dental clinics, diamond polishing paste, when used after porcelain adjustment kit, could provide the marked finish equal to glazed or reglazed surface.

Keywords: Dental porcelain, glazing, polishing kit, profilometer, surface roughness

Introduction

Dental porcelain is used widely in a variety of restorations in dental clinics because of its esthetic, biological, and mechanical properties.^[1] Glazing is termed as the process where porcelain surfaces are coated with an impervious layer or vitreous substance and have been fused through firing. A glazed ceramic surface is generally considered beneficial because it may increase surface smoothness, fracture resistance and reduces the potential abrasiveness of the ceramic surface by sealing open pores.^[2,3]

Glazed ceramic restorations may require some adjustments for correcting shape and contour. Dentists commonly adjust the porcelain surfaces of the prosthesis at the clinic, by using fine-grained diamond burs. These adjustments will interrupt the glaze layer and make the surface rough.

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The surface roughness of dental restorations may cause some clinical problems such as plaque accumulation, soft-tissue inflammation, increased wear of opposing dentition, increased staining, and decreased flexural strength.^[4-6]

Reglazing or polishing after adjustment procedures is required to improve the esthetic and flexural strength.^[7] Reglazing takes an extra clinical session as it is not a common practice to have a firing oven in dental clinics.^[1] Although reglazing is an important factor in optical appearance, subjecting the ceramic material to another firing cycle during reglazing has the potential for changing the porcelain structure (i.e., devitrification). Thus, reflecting more light than the natural one, hence producing an artificial effect on ceramic restorations.^[8-10] Polished ceramic restorations, when compared to glazed restorations, may have the advantage of reducing the wear on the opposing dentition.^[11]

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Several researchers^[12-15] have investigated and described different polishing techniques of ceramic restorations and supported the use of polishing as an alternative to glazing. Whereas others found that glazed surface has superior smoothness than the polished surfaces.^[1,16,17]

There is considerable controversy regarding the best techniques to obtain the smoothest porcelain surface after chairside clinical adjustments. Therefore, there is a need to do this study so that a conclusion can be made, and a protocol can be set for adjustment of the prosthesis before final cementation. The null hypothesis was that there would be no difference between the surface roughness of glazed and polished ceramic surfaces.

Materials and Methods

In the present study, the commonly used dental porcelain and different polishing system were investigated [Table 1]. A total of 50 disc shape feldspathic porcelain specimens of diameter 10 mm and thickness 2 mm were prepared using a prefabricated mold. Specimen were made by a single investigator who mixed equal preweighed porcelain powder of shade A2 (Vita Master Zahnfabrik-Bad Sackingen-Germany) with measured distilled water over a glass slab. The mixed mass was then loaded into the mold in increments. The absorbent paper was used to remove extra water before adding the next increment. After complete condensation, samples were taken out of the mold by tapping and were placed on a sagger tray and fired in the porcelain furnace according to the manufacturer's instructions.

Following cooling, a layer of dentin (A2) and enamel ceramic of (EN1) shade were applied over the ceramic surface to compensate for any shrinkage. After firing, specimens were finished with medium-grit diamond bur at 10,000 rpm (Shofu medium grit diamond point) to remove any irregularities. A thin layer of overglaze (Vita Zahnfabrik-Bad Sackingen-Germany) was applied in a single stroke over one side of each specimen, and firing was done according to the manufacturer's instructions.

These 50 specimens were then divided into five groups of 10 specimens each [Table 1]. Glazed surfaces in Group A

Table 1: Formation of groups

Group A: Glazed (Vita VMK Master, Vita Master Zahnfabrik - Bad Sackingen - Germany)
Group B: Reglazed (Vita VMK Master, Vita Master Zahnfabrik - Bad Sackingen - Germany)
Group C: Polished with adjustment kit (Classic Plastic HP Kit, PN 0301, Shofu Inc., Kyoto, Japan)
Group D: Polished with diamond polishing paste (PN 0558 DirectDia Polishing Paste, PN L523 Standard Buff Disk and Metal mandrel, Shofu Inc., Kyoto, Japan)
Group E: Polished with porcelain adjustment kit + diamond polishing paste

were considered as the control. The remaining 40 samples were abraded or deglazed using medium grit diamond point with a slow speed handpiece (10,000 rpm). The diamond rotary instrument was applied over the specimen surface producing linear contact and was moved from left to right by the same operator to cover the entire disc surface evenly for 20 s, to simulate clinical chairside adjustments.^[12,17] Thereafter, all the deglazed specimens were cleaned in an ultra-sonic unit with distilled water for 8 min to remove any kind of residues from their surfaces. The specimens were then dried with absorbent paper and surface treated according to their group.

Deglazed surfaces in Group B samples were reglazed. The layer of overglazed (Vita Zahnfabrik-Bad Sackingen, Germany) was applied on the abraded surfaces, and firing was done according to the manufacturer's instructions.

Deglazed surfaces of Group C samples were subjected to chairside polishing with the Porcelain adjustment kit (Shofu Dental Corp. PN 0301 Classic Plastic HP Kit Shofu Inc., Kyoto, Japan). It consisted of a four-step process as follows: (1) Dura-white stones for adjusting, and contouring, and three different polishers of decreasing particle sizes: (2) Ceramiste standard Polishers for pre-polishing, (3) Ultra (yellow band) polishers for polishing, and (4) Ultra II (white band) polishers for super-polishing. Specimens were polished for 10 s, using a micromotor at a speed of 10,000 rpm for each polisher, with a total duration of 40 s.^[12]

In Group D, deglazed surfaces were polished using diamond polishing paste alone (Shofu Dental Corp. PN 0558 DirectDia, Shofu Inc., Kyoto, Japan). The small quantity of polishing paste was applied over the super-snap buff disk (Shofu). Surfaces of the specimen were polished using a low-speed handpiece at 10,000 rpm for 10 s.

Deglazed specimens in Group E were subjected to a combined surface treatment of porcelain adjustment kit followed by Diamond polishing paste as described in Group C and Group D, respectively.

All the specimens were then ultrasonically cleaned in distilled water for 8 min to remove polishing residue and dried with a blast of air and stored in the dust-free container.^[12,13,17,18] One operator performed all the grinding and polishing procedures.

The surface roughness was measured using a profilometer (Mitutoyo SurfTest SJ-310, Tokyo, Japan). Specimens were stabilized in a stainless steel metal mold. A diamond stylus of 5 μm tip radius and 90° stylus angle was moved over the surface of a specimen under constant pressure force of 4 mN. Before measurements, the instrument was calibrated using a standard reference specimen (ISO 1997) and then set to travel at a speed of 0.5 mm/s with a traversing length of 0.25 mm during the testing.

Table 2: Mean and standard deviation of surface roughness (Ra) of different groups (µm)

Groups	Mean	SD	SE	Minimum	Maximum
A (glazed)	0.567	0.078	0.024	0.47	0.74
B (reglazed)	0.433	0.059	0.018	0.36	0.52
C (polished with adjustment kit)	0.882	0.126	0.040	0.70	1.12
D (polished with polishing paste)	2.361	0.195	0.061	2.11	2.69
E (adjustment kit and polishing paste)	0.438	0.043	0.013	0.39	0.54

SD: Standard deviation; SE: Standard error

For each specimen, three measurements were made. First, the stylus was run in a horizontal direction on the specimen’s surface trajectories to evaluate the surface roughness, and then the stylus was run in the vertical direction. After evaluating the surface roughness in two directions, the stylus was then run again in the oblique direction. The arithmetic mean (Ra) of these values determines the overall roughness of a specimen. One-way ANOVA followed by *post hoc* Tukey’s Test honestly significant difference (HSD) was applied to statistically analyze the data obtained from the profilometer.

Results

The mean average surface roughness (Ra) and the standard deviation of all the five groups were shown in Table 2 and Figure 1. Samples of Group B (Reglazed) show smoothest surface $0.433 \pm 0.059 \mu\text{m}$ followed by Group E (Adjustment kit and polishing paste) $0.438 \pm 0.043 \mu\text{m}$, Group A (Glazed) $0.567 \pm 0.078 \mu\text{m}$, Group C (Polished with adjustment kit) $0.882 \pm 0.126 \mu\text{m}$, and Group D (Polished with polishing paste) $2.361 \pm 0.195 \mu\text{m}$. A higher Ra value represents a rougher surface.

A one-way analysis of variance for the surface roughness within the groups showed a statistically significant difference ($P < 0.001$) [Table 3]. Multiple comparisons of all groups by *post hoc* Test-Tukey HSD showed that there was a statistically insignificant difference ($P > 0.05$) between the Groups A, B, and E. Surface polished with polishing paste (Group D) was significantly ($P < 0.001$) rough when compared with other treated surfaces (Groups A, B, C and E) [Table 4].

Discussion

Within the limitations of this study, the null hypothesis of the study was rejected. Hence, the polishing technique significantly affects the surface smoothness of dental ceramics. Many dentists prefer the adjusted porcelain surfaces to be reglazed before cementation, while others prefer chairside polishing of ceramic surfaces, owing to the various limitations of reglazing.

Drawbacks of reglazing as reported in the literature are;

- More plaque retention on the glazed surface as compared to the polished surface,^[5] Glazing as means of strengthening porcelain restoration is controversial^[19-21]
- Reglazed layer gets worn off easily in a short period

Table 3: Statistical comparison of groups using one-way analysis of variance

	Sum of squares	Degree of freedom	Mean square	F	Significance
Between groups	26.699	4	6.675	505.326	0.000
Within groups	0.594	45	0.013		
Total	27.293	49			

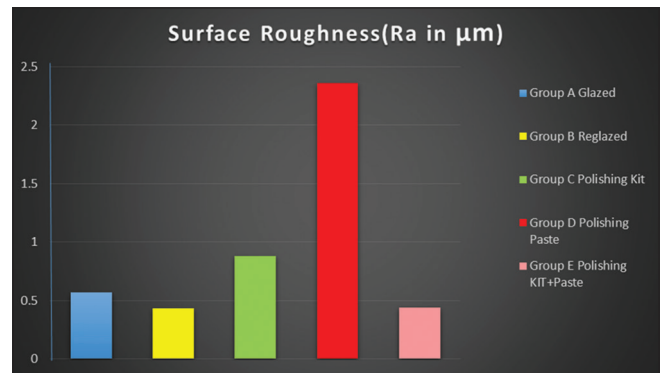


Figure 1: Bar diagram depicting the mean surface roughness (Ra) after various treatment

- More aggressive wear of the opposing teeth by a glazed surface compared to a polished surface^[11]
- Esthetic results also may be improved by polishing rather than by glazing^[8]

In addition, when placing bonded restorations such as porcelain inlays, onlays, and veneers, it is not recommended to adjust or check occlusion before restoration is bonded because of the risk of the fracture. Therefore, the surface of the restoration is often adjusted after the final cementation. Hence, any adjustments done afterward can only be polished intraorally instead of reglazing.

In the current study, the polishing with porcelain adjustment kit alone showed more surface roughness than in glazed and reglazed samples. The same results were seen in the study of Haralur,^[17] that shofu porcelain adjustment kit can decrease the surface roughness of dental porcelain samples. However, adjustment kit alone cannot be the alternative of reglazing. Similar to our study, Sarikaya and Güler^[22] also found that Shofu polishing kit was more effective than the polishing pastes used alone.

There was a statistically insignificant difference in Ra values of the glazed and reglazed groups in this study.

Table 4: Tukey's *post hoc* honestly significant difference comparisons of surface roughness of five groups

Specimen group	Mean difference (I-J)	SE	Significant
Glazed versus reglazed	0.1341	0.0514	0.086
Glazed versus polishing kit	-0.3153*	0.0514	0.000
Glazed versus diamond paste	-1.793*	0.0514	0.000
Glazed versus polishing kit + diamond paste	0.1284	0.0514	0.109
Reglazed versus polishing kit	-0.4494*	0.0514	0.000
Reglazed versus diamond paste	-1.928*	0.0514	0.000
Reglazed versus polishing kit + diamond paste	-0.0057	0.0514	1.000
Polishing kit versus diamond paste	-1.478*	0.0514	0.000
Polishing kit versus polishing kit + diamond paste	0.4437*	0.0514	0.000
Diamond paste versus polishing kit + diamond paste	1.922*	0.0514	0.000

SE: Standard error, *Test of significance-0.000

Although the glazed group shows slightly higher Ra value. Hence, reglazing restores the original surface finish. These findings are in agreement with the study done by Mohammadibassir *et al.*^[23]

The polishing with a combination of dental porcelain adjustment kit (shofu) and polishing paste (Diamond) produce a smoother surface than the polishing kit and paste alone. These findings are in accordance with the result of the study by Al-wahadni,^[4] Saraç *et al.*^[24] and Newitter *et al.*^[25] They reported that the addition of polishing step with diamond paste (2–4 µm) improve the surface smoothness. Similar to the present study Manjuran and Sreelal,^[12] Sethi *et al.*,^[13] Mohammadibassir *et al.*^[23] and Wang *et al.*^[26] also concluded that polishing kit with polishing paste produced surface as smooth or more smooth than glazed or reglazed surfaces, which was concordant with the present study.

Surface roughness (Ra) of glazed ceramic ranges from 0.2 µm to 0.5 µm by various authors in their study.^[1,4,7,15] These variations in the results may be due to several factors, such as type of different ceramic materials, polishing materials, and calibration of the profilometer. From the literature surface roughness (Ra) for ceramic restoration, 0.5 µm may be considered clinically acceptable.

In the current study, surface roughness of samples of Group A (glazed), Group B (reglazed), and Group E (polished with a combination of polishing kit and diamond paste) were within the clinically acceptable limits. However, mean surface roughness (Ra) for samples polished with polishing kit alone (Group C) (Ra 0.88 µm) and polishing paste alone (Group D) (Ra 2.36 µm) produce surface roughness above the clinically acceptable limit.

Wright *et al.*^[15] had proved in their studies that chair-side polishing is equal to or even better than glazing. Only a few studies have shown the opposite results, i.e., glazing is better than chair-side polishing.^[7,27] The reasons for variations of results in different studies may be explained by:

- The number and size of surface pores that are opened due to the grinding of dental porcelain depend on the extent of sintering or condensation of dental porcelain particles.

In all the studies, one sample was used for glazing or reglazing and another sample was used for chair-side polishing. Therefore, one cannot be sure regarding the uniformity of condensation of both the samples

- Surfaces of the specimens were ground with a medium or low grit diamond point, as high grit points widens the pores opened during grinding. These large pores are difficult to close with both reglazing and chairside polishing^[16]
- Different ceramic materials were used for making specimens, multiple operators' variables, different polishing materials, and methods for surface roughness evaluation might cause the variation of results.

Being an *in vitro* study, the size and shape of samples fabricated were not the same as those used clinically. Therefore, it may not be an actual reproduction of what may happen in the oral cavity. The influence of food, saliva, pH, and temperature changes were also not considered. Future studies should be carried out to evaluate the current results are applicable to other ceramic systems or not. The effect of surface treatments on other properties like abrasion resistance, strength, residual stresses, and plaque accumulation can also be done.

Conclusion

Within the limits of this study, it can be concluded that polishing with the combination of a porcelain adjustment kit followed by polishing paste (diamond) produce smoothness similar to the reglazed or glazed surface. Therefore, it can be a good alternative to reglazing after adjustment of ceramic restorations in dental clinics.

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Conflicts of interest

There are no conflicts of interest.

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