Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2016;5:2:67-75.

# Effect of Different Chair Side Polishing Systems on Color and Surface Texture of Feldspathic Porcelain: In Vitro Study

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## ABSTRACT

**Aims**: Compare the effect of different chair side porcelain polishing systems and polishing paste on the surface texture and color changes of a feldspathic porcelain

**Methods and Material**: 70 glazed porcelain specimen of 10mm diameter and 2mm thickness divided into seven groups of 10 specimens. The glazed surface in first group served as control. The remaining 60 specimens underwent deglazing. The deglazed surface in the second group was retained as such and did not undergo polishing. The deglazed surfaces of experimental groups were underwent polishing with different systems. From each group, one specimen was set aside for scanning electron microscopy (SEM).

**Results**: Polishing with diamond bur and buff, created surface smoother as near to glazed surface with no significant negative effect on color.

**Conclusions**: Use of diamond polishing bur with polishing buff (DB+B) created surfaces as smooth as glazed specimens and color changes at clinically acceptable level.

**Keywords:** Feldspathic porcelain, ceramic polishing, reglazing, Porcelain adjustment kit, DFS polishing system, polishing paste.

## INTRODUCTION

With the advances in dental materials and new techniques in restorative dentistry, the demand for esthetic restorations has increased tremendously. Dental porcelain has been used extensively as a restorative material in a variety of dental restorations, including all-ceramic restorations like inlays, onlays, veneers, metal-ceramic crowns, all ceramic crowns and fixed partial dentures, because of its esthetic properties, durability, low thermal conductivity, wear resistance and biocompatibility.[1] Dental porcelain is a type of ceramic that is mainly composed of feldspar, quartz, and kaolin. This material is fired at very high temperatures, and the subsequent glazing of the porcelain provides an aesthetic and hygienic surface that is suitable for crowns and other restorations.[2] The aim of glazing is to seal the open pores in the surface of fired porcelain. Dental glazes are composed of colorless glass powder, applied to the fired crown surface, so as to produce a glossy surface.

Surface roughness (Ra) refers to the finer irregularities of the surface texture that usually result from the action of the production process or material condition and is measured in micrometers

**Received:** Sept. 11, 2015: **Accepted:** Nov. 1, 2015
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(µm).[3] Surface modifications are essential for correcting occlusal interferences and faulty contours, finishing the margins of ceramic restorations, and improving the esthetic appearance and surface smoothness of porcelain restorations. In the clinical set up it is not possible to reglaze the restorations due to practical constraints. In such situations, the surface tends to become the rough and ceramic surfaces abrade opposing teeth and/or restorations.[4,5] Rough porcelain surfaces also significantly reduce the strength of ceramic restorations and make them prone to fracture.[6] The roughness of intraoral hard surfaces is a major cause for adhesion and retention of oral microorganisms. This will lead to excessive plaque accumulation, gingival irritation, increased surface staining and poor or suboptimal esthetics of the restored teeth and thereby increasing the risk of dental caries and periodontal disease.[7,8] In such situations, roughness must be smoothened to render the surface acceptable to the patient and make it less likely to abrade opposing tooth structure or restorative materials.[9,10] The effective finishing and polishing of dental restorations not only result in optimal aesthetics and longevity of restored teeth, but also provide for acceptable oral health of soft-tissues and marginal integrity of the restorative interface.[11]

The adjusting, contouring and finishing procedures for ceramic restorations play a critical role in achieving both proper function and optimal esthetics. Thus it has become imperative to consider the various available ceramic finishing systems to recreate the lost smoothness of the abraded surfaces to obtain optimal biocompatibility. A number of mechanical polishing techniques are described in the literature and have been compared with the gold standard given by the original glaze. Some authors initially demonstrated the superior smoothness of glazed porcelain.[12,13] Others, however, favor mechanical polishing and concluded that intraoral polishing of porcelain can equal or surpass the smoothness of glazed porcelain.[14] Today, it is recognized that improved esthetic results are obtained by polishing.[15,16]

The present in vitro study was designed to qualitatively and quantitatively evaluate and compare the effect of two ceramic polishing systems and diamond polishing paste on the surface texture and color changes of ceramic surface.

## MATERIALS AND METHODS

Stainless steel die was fabricated to made specimen of 10mm in diameter and 2mm thick. Molten modeling wax was filled into the die. After cooling, wax specimen was removed from the die and converted into heat cure acrylic resin (Luciton). The vinyl polysiloxane molds was prepared with use of acrylic specimen.

## FABRICATION OF SPECIMEN

A total number of 70 specimens of porcelain were made. The porcelain powder and liquid were mixed in fixed ratio (Volume ratio of 4:1) and poured into the siloxane mould. The mixture was compress with stainless steel spatula to avoid void formation. The extra moisture was absorbed with tissue paper (Ekdant Enterprise, india). After removal from mold, the specimens were placed in porcelain firing oven. The program was set at 900-920$^{c}$ for 15 min at voltage of 220-240 V.

The Specimens were finished using a fine-grit diamond rotary cutting instrument and over glaze was applied to the specimens according to the manufacturer's instructions. After application of the over glaze, the specimens were placed into the porcelain-firing oven. The program set at 450-900$^{c}$ for 9min at 220-240 V. Seventy specimens were prepared using this procedure

The specimens were divided into 7 groups of 10 specimens. The glazed surface in the first group served as control (C) and was not subjected to deglazing or polishing. The remaining 60 specimen were deglazed using medium grit diamond rotary instruments with slow-speed approximately 10,000 rpm, with water irrigation to remove irregularity. The bur was applied over the specimen surface producing linear contact and moved from left to right in entire disc surface evenly for 60 seconds. The deglazed surface in the second group (D) was retained as such and did not undergo polishing. The remaining 50 deglazed surface were polished using a single polishing system or combination of systems, as shown in table 1 and 2, using speed of 10,000 rpm. Polishing

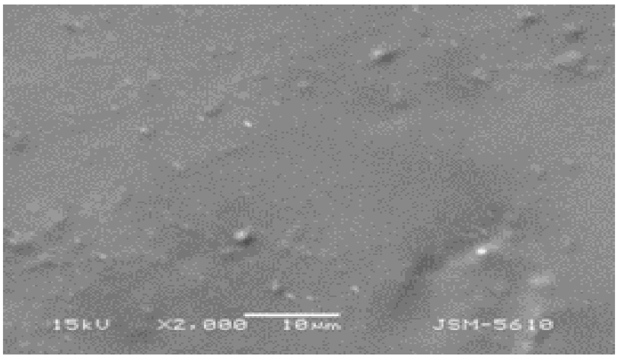



Fig 1: SEM of glazed surface.

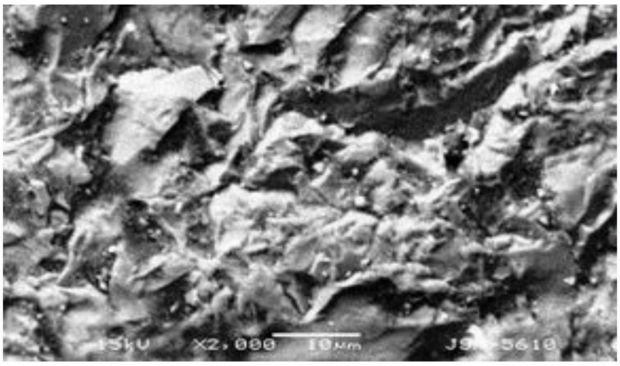


Fig 2: SEM of deglazed surface.

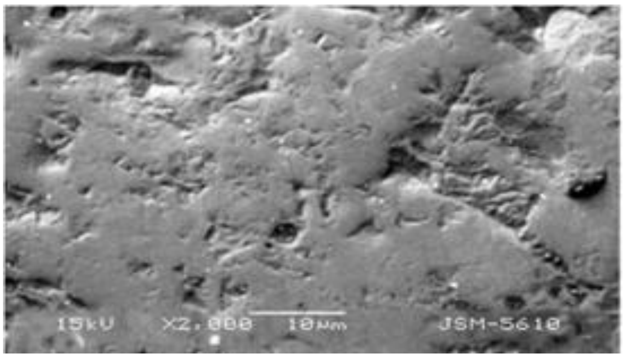



Fig 3: SEM of specimen polished with diamond bur.

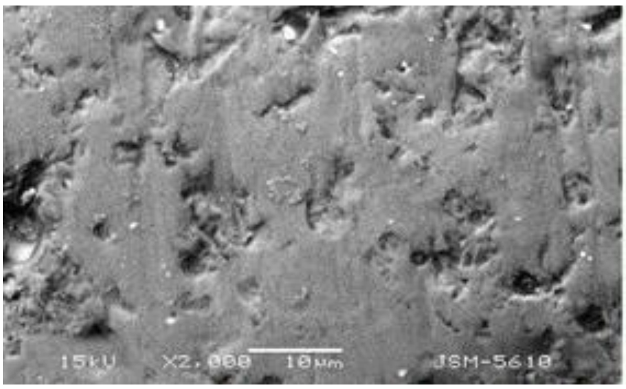



Fig 4: SEM of specimen polished with adjustment kit.

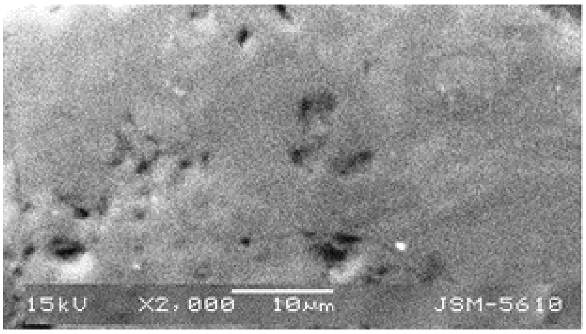



Fig 5: SEM of specimen polished with diamond bur and buff.

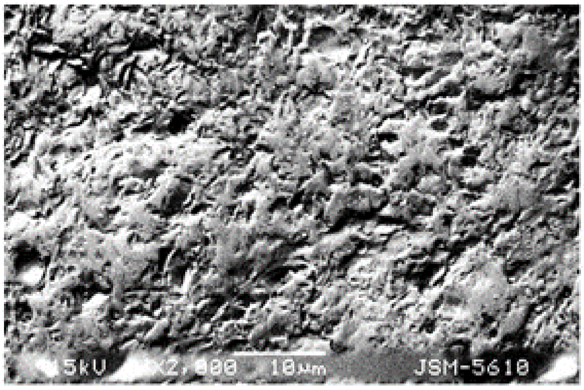


Fig 6: SEM of specimen polished with wheel and paste.

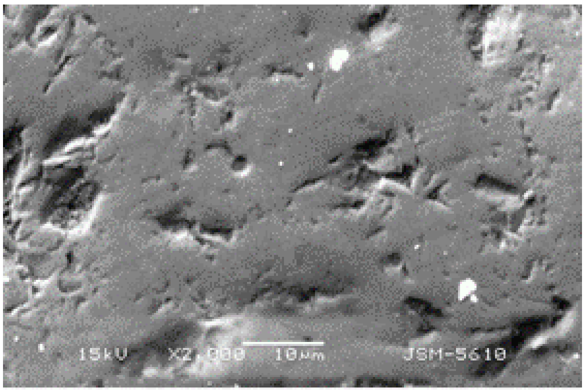



Fig 7: SEM of specimen polished with adjustment kit and polishing paste.

was performed by the same person in the same sitting. The deglazed surface of third group (DB) were polished using polishing bur. The fourth group (AKT) were polished using an adjustment kit (Porcelain adjustment kit, Shofu Dental Corp., California) for 40 sec. It consist white stone and three different polishers of decreasing particles sizes were used, one at time for 10 sec, with total of 40 sec. The fifth group (DB + B) was polished with fine grit diamond sintered polishing bur (DFS, Germany) and oil impregnated polishing buff (DFS, Germany). The deglazed surfaces was initially polished with bur for 40 sec and then with polishing buff for 40 sec. The deglazed surface of six group (W + B) were initially polished with polishing wheel for 40 sec and then with polishing buff for 40 sec. The seven group (AKT + PP), polished with adjustment kit as described for 40 sec and diamond impregnated polishing paste for 40 sec.

Table 1: Materials used in Study.

| Material | Products | Manufacturer |
|---|---|---|
| Polishing Kit | DFS | DFS polishing system Germany |
| Adjustment kit | Porcelain adjustment kit | Shofu Dental Corp., California |
| Polishing paste | Universal polishing paste | Ivoclare |

Table 2: Polishing methods employed.

| No | Study group | Polishing system/s | No. of specimens | Polishing time |
|---|---|---|---|---|
| 1 | C | Nil (Glazed surface) | 10 | |
| 2 | D | Nil (Deglazed surface) | 10 | |
| 3 | DB | Diamond polishing bur | 10 | 40 sec. |
| 4 | AKT | Porcelain adjustment kit | 10 | 40 sec. |
| 5 | DB + B | Polishing bur + Polishing buff | 10 | 40 + 40 sec. |
| 6 | W + B | Polishing wheel + Polishing buff | 10 | 40 + 40 sec. |
| 7 | AKT + P | Porcelain adjustment kit + Polishing paste | 10 | 40 + 40 sec. |

All specimens were clean in running water and dried with a blast of air for 30 sec before measurements. Color measurements were made using a colorimeter (Minolta CR-321 ChromaMeter; Minolta, Osaka, Japan) according to the CIE L*a*b* color system recommended by the Commission International de l'Eclairage or International Commission on Illumination (CIE) in 1976. The CIE L*a*b* color system is an approximately uniform color scale organized in a cube form. The L* value is a measure of lightness, the maximum for L* is 100 which represents a perfect reflecting diffuser. The minimum for L* is zero, which represents black. The a* value is a measure of redness (positive +a*) or greenness (negative –a*), and the b* value denotes yellowness (positive +b*) or blueness (negative –b*). These coordinates, obtained with a spectrophotometer, provides a numerical description of the color position in a three-dimensional color space.

The ΔL*,Δa*,and Δb* indicate how much a standard and sample differ from each other in L*, a*, b* values, respectively. The total color difference is denoted as ΔE. It mathematically expresses the amount of difference between the CIE L*a*b* coordinates of different specimens or the same specimen at different instances. The human eye cannot perceive color difference (ΔE) values less than 1. ΔE values between 1 and 3.3 represent a perceptible and clinically acceptable range. ΔE values of 3.3 and higher are reported to be unacceptable under clinical conditions and 3.3 has been used as the upper limit in sever several studies concerning the perceptibility of color differences. To position the tip of the colorimeter in the same location on each specimen, a nylon mould was prepared. The colorimeter was calibrated according to the manufacture's instruction. The quantitative ΔE values between the specimens of group C and the experimental groups were calculated with the following formula

$$\Delta E = [(L^*_E - L^*_C)^2 + (a^*_E - a^*_C)^2 + (b^*_E - b^*_C)^2]^{1/2}$$

Where; $(L^*_E - L^*_C)$, $(a^*_E - a^*_C)$, and $(b^*_E - b^*_C)$ are the differences in L*, a*, b* values respectively; E represents the experimental specimens, and C represents the control specimens. To evaluate the effects of polishing systems on the ceramic surfaces at a microscopic level, one specimen surface from each of the seven groups was analyzed under Scanning Electron Microscope (Jeol JSM- 5610 LV, Japan). The SEM photomicrographs were taken with 500x, 1000x and 2000x magnification for visual inspection. The data obtained from test parameter of the study, namely Ra and color differences (ΔE) were expressed as mean and standard deviation. One way ANOVA was performed as parametric test to compare different treatments. Tukey's HSD was employed as post hoc analysis to evaluate individual multivariate comparisons. For all statistical evaluation, a two tailed probability of value, <0.05 was considered significant.

## RESULTS

The mean color difference values (ΔE), their standard deviations and results of one way ANOVA of test and control specimens are given in Table 3.

[p< 0.0001 to 0.001: Extremely significant; p<0.001 to 0.01: Very significant; p< 0.01 to 0.05: Significant; p≥0.05: Not significant]

The value obtained from color difference is statistically significant. The deglazed specimens had an average ΔE value of 3.22, which is nearly perceivable by naked eye. The color difference values were lower in the group polished with (i) the dental bur and polishing buff (DB+B) ΔE 1.09, (ii) adjustment kit and polishing paste (AKT+P) ΔE 1.11, (iii) adjustment kit alone (AKT) ΔE1.15, (iv) wheel and polishing buff (W+B) ΔE 1.16; E value were relatively higher with the use of (v) diamond bur alone (DB) ΔE 1.42. The mean Ra values, their standard deviations and results of one way ANOVA of test and control specimens are given in Table 4.

Table 3: Analysis of variance in color changes (ΔE) in µm comparing experimental groups with the control and deglazed groups.

| (I) GROUP | (J) GROUP | Mean Difference (I-J) | Std. Error | P Value | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| Deglazed (D) | Control | 2.16 | 0.365 | <0.001 | 1.049 | 3.277 |
| Deglazed (D) | Diamond Bur (DB) | 1.80 | 0.365 | <0.001 | 0.688 | 2.916 |
| Deglazed (D) | Adjustment Kit (AKT) | 2.06 | 0.365 | <0.001 | 0.95 | 3.178 |
| Deglazed (D) | Diamond Bur + Buff (DB+B) | 2.13 | 0.365 | <0.001 | 1.012 | 3.24 |
| Deglazed (D) | Wheel + Buff (W+B) | 2.06 | 0.365 | <0.001 | 0.941 | 3.169 |
| Deglazed (D) | Adjustment Kit + Paste (AKT+P) | 2.11 | 0.365 | <0.001 | 0.995 | 3.223 |
| Diamond bur (DB) | Control (C) | 0.36 | 0.365 | 0.955 | -0.75 | 1.475 |
| Adjustment kit (AKT) | Control | 0.10 | 0.365 | 1.000 | -1.02 | 1.213 |
| Diamond bur +Buff (DB+B) | Control | 0.04 | 0.365 | 1.000 | -1.08 | 1.151 |
| Wheel + Buff ( W+B ) | Control | 0.11 | 0.365 | 1.000 | -1.01 | 1.222 |
| Adjustment kit + Paste ( AKT+P ) | Control | 0.05 | 0.365 | 1.000 | -1.06 | 1.168 |

Table 4: Analysis of variance of surface roughness (Ra) in µm comparing experimental groups with the control and deglazed groups.

| (I) GROUP | (J) GROUP | Mean Difference (I-J) | Std. Error | P Value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Control (C) | Deglazed (D) | -0.64 | 0.094 | <0.0001 | -0.93 | -0.36 |
| Control (C) | Diamond bur (DB) | -0.08 | 0.094 | 0.981 | -0.36 | 0.21 |
| Control (C) | Adjustment Kit (AKT) | -0.06 | 0.094 | 0.995 | -0.35 | 0.23 |
| Control (C) | Diamond bur+ Buff (DB+B) | -0.02 | 0.094 | 1.000 | -0.30 | 0.27 |
| Control (C) | Wheel + Buff (W+B) | -0.27 | 0.094 | 0.072 | -0.56 | 0.01 |
| Control (C) | Adjustment kit+Paste (AKT+P) | -0.04 | 0.094 | 1.000 | -0.32 | 0.25 |
| Deglazed (D) | Diamond bur (DB) | 0.57 | 0.094 | <0.0001 | 0.28 | 0.85 |
| Deglazed (D) | Adjustment Kit (AKT) | 0.58 | 0.094 | <0.0001 | 0.30 | 0.87 |
| Deglazed (D) | Diamond bur+ Buff (DB+B) | 0.63 | 0.094 | <0.0001 | 0.34 | 0.91 |
| Deglazed (D) | Wheel + Buff (W+B) | 0.37 | 0.094 | 0.004 | 0.08 | 0.66 |
| Deglazed (D) | Adjustment kit+Paste (AKT+P) | 0.61 | 0.094 | <0.0001 | 0.32 | 0.89 |

Analysis of variance in surface roughness (Ra) between the control (C) group and the deglazed (D) group has shown the difference of 0.64 and is shown to be statistically significant. The comparison of surface roughness between the control group and the experimental group using diamond bur (DB) is 0.08, using adjustment kit (AKT) is 0.06, whereas, using diamond polishing bur + buff (DB+B) is 0.02, using wheel + buff (W+B) is 0.27, while using adjustment kit + paste (AKT+P) is 0.04, these results shows no statistical significance

SEM photomicrographs (500x, 1000x and 2000x magnification) of specimens demonstrated the surface texture. Examination of these images revealed surface appearance paralleling the mean surface roughness of study groups. The SEM photomicrograph of deglazed surface appears roughest of all. The descending order of degree of irregularity and visual appearance of roughness was as follows: D, W+B, DB, AKT, AKT+P, DB+B. The surface polished with combination of bur and polishing buff (DB+B) is the smoothest of all test specimens as per SEM analysis.

## DISCUSSION

In today's health and image-conscious society, cosmetic or aesthetic dentistry is becoming much more of a 'must have.[17] It is our prime concern as a dentist to meet patient's realistic esthetics expectations. One such way of attaining the expected results is by using chair side polishing systems which improves the color and surface texture of the prosthesis.

The glazed surface of ceramic restoration becomes roughened during adjustment procedure for correcting occlusal interferences and inadequate contour. The rough porcelain surface is prone to adhesion and retention of oral microorganisms causing excessive plaque accumulation, gingival irritation, increased surface staining and poor esthetics of the restored teeth and thereby increasing the risk of dental caries and periodontal disease.[4, 18] Hence, it has been recommended by many authors that the roughened surface must be either reglazed or polished to produce the smoothest surface possible.

The increasing availability of newer chair side polishing systems has evoked a keen interest in the studies comparing effect of polishing to glazed surface. A few studies found polishing by combinations of systems producing surface as smooth as glazed surface.[1]

In the present study, the efficiency of 3 different polishing systems (Shofu porcelain adjustment kit, DFS polishing system and Diamond polishing paste) and their combinations were compared on the feldspathic porcelain specimens. These systems were selected as being quick, efficient polishing systems, and not labor-intensive to use.

Obregon et al[19] investigated the effect of opaque and porcelain texture on the color of metal ceramic restorations using a spectrophotometer. The authors found that porcelain surface texture, whether rough or smooth, did not make a difference in hue. However, the glossy type of surface found in the opaque layer shifted the color from yellow toward yellow-red. This study demonstrated that a dull opaque layer has a lower chroma, and a glossy porcelain surface has higher value compared to a rough surface.

In the present study, significant differences were found between the polishing techniques in terms of color difference, and the mean color difference (ΔE) values ranged from 1.03 to 3.36. The color differences were found to be greater than 1 ΔE unit, which can be easily perceived by the human eye. Although, the polishing techniques affected the color differences significantly, the ΔE values showed that the color differences were at the acceptable level.

The results of color difference (ΔE) obtained from present study, comparing the experimental groups with the deglazed surface is statistically significant but shows statistically insignificant result with the control group i.e. all the polishing systems have color changes values in clinically acceptable range. The higher mean color changes (ΔE) were obtained with diamond bur (DB) or wheel and buff (W+B) and lower values were obtained with the use of the diamond bur and buff (DB+B).

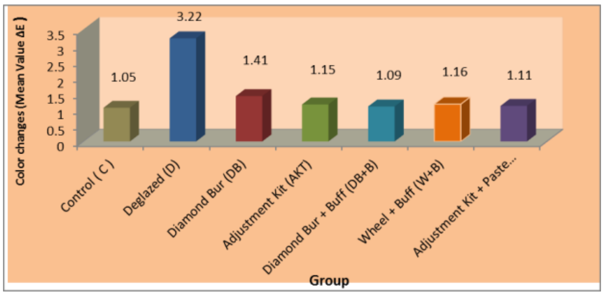
In 2004, Wright et al[20] used three different polishing systems on ultra low fusing porcelain. They used Axis dental, Jelenko and Brasseler polishing kit and polished until the surface appeared shiny to the naked eye using 1 of 3 porcelain polishing kits and achieved surface smoother than glazed porcelain surface. But they did not mention the time duration of polishing the deglazed porcelain surface.

In 2006, Sarac et al[1] concluded that the most efficient individual polishing system among those studied by them was porcelain adjustment kit. Porcelain adjustment kit is a combination of four components (adjusting, prepolishing, polishing and superpolishing). Further, they noted that other polishing systems, including diamond paste when used after adjustment kit, could provide only slight improvement and such an improvement was not statistically significant.

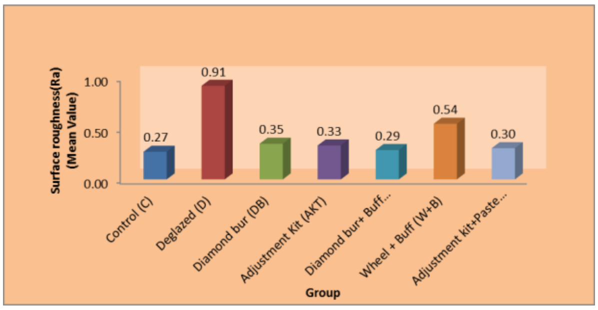
When the results of this study were analyzed, there is statistical significance result obtained by comparing experimental groups with the deglazed surface, but shows statistically insignificant difference with the control group, suggesting that there is marked decreased in the surface roughness using any of the polishing method. The surface of a group polished with the diamond bur and buff (DB+B) and the adjustment kit preceding a polishing paste (AKT+P) showed almost similar surface roughness compared to the control group. Also, specimens from these groups depicted in SEM photomicrographs demonstrated a smooth appearance with few pores. This finding is in agreement with previous reports investigating the effects of different polishing systems on the surface roughness of ceramics.[21]

One of the limitations of this in vitro study is that only 1 type of porcelain was evaluated. Different results might have been obtained with different polishing materials and techniques.

Some of the other limitation of present study and areas requiring further research need elaboration. Different firing protocols with varying temperature setting and duration, multiple firings, varying quantity of liquid mixed with unit amount of porcelain powder etc can alter the porosity of the ceramic discs and restorations and hence their roughness when glazed layer is removed. A study on experimental groups consisting of actual ceramic prosthesis will be more informative. An analytic study on the abrasive particles of different polishing systems with particular reference to their hardness, size and chemical composition, is beyond the scope of the present study.




Graph 1: Analysis of variance (one way ANOVA) of color changes (ΔE), comparing different groups.




Graph 2: Analysis of variance (one way ANOVA) of surface roughness (Ra) in um, comparing different groups.

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## CONCLUSIONS

Within the limitation of this in vitro study, the following conclusions were drawn.

1. The significant differences were found in the surface roughness of the feldspathic ceramic specimens subjected to the different polishing techniques evaluated. The use of diamond polishing bur with polishing buff (DB+B) created surfaces as smooth as glazed specimens.
2. There is statistically significant difference in value of color changes (ΔE) obtained between the experimental groups and deglazed group but shows non statistical significant result with control group. Although, the ΔE value of experimental group were at clinically acceptable level (i.e. ΔE< 3.3).
3. The lowest value of surface roughness (Ra) and color changes (ΔE) were obtained for the diamond polishing bur and polishing buff (DB+B) specimens, although the values are statistically insignificant, it achieved the best result, which is confirmed by Scanning electron microscope (SEM) (P<0.001).

An implication of the present study in the clinical practice is that the adjusted areas of porcelain restorations may be polished with polishing bur followed by polishing buff to achieve smoothness comparable to reglazing.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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