A comparative study on the effect of polishing systems on the color and surface texture of different porcelain systems - feldspathic, pressable, and computer-aided design/computer-aided manufacturing

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Abstract

Aim: To find and compare the qualitative and quantitative change in color and surface texture of feldspathic ceramic, pressable ceramic and ceramic used in computer-aided design/computer-aided manufacturing CAD/CAM after different surface treatments namely glazing, abrading and polishing. To compare the effectiveness of pearl finish polishing paste and Soflex polishing system used in the study.

Setting and Design: In-vitro, comparative study.

Materials and Methods: Disc-shaped feldspathic, pressable, CAD/CAM ceramic specimens were fabricated. Surface roughness and color parameters ∆ L*, ∆a*, and ∆ b* were measured before glazing, after glazing, after abrasion with 02 diamond bur and after polishing with two different polishing systems. Surface roughness was measured qualitatively using scanning electron microscopy and quantitatively using an optical profilometer. The value of color parameters was obtained using a colorimeter. Data were statistically analyzed with ANOVA.

Statistical Analysis Used: SPSS software 20.0 version (IBM, New York, United states of America).

Results: Unglazed feldspathic, pressable and CAD/CAM porcelain specimens showed a mean surface roughness value of 2.73 ± 0.38, 3.54 ± 1.42, and 3 ± 1.74 specimens. After glazing and polishing, the surface roughness values decreased. After abrasion, surface roughness values increased. Polishing did not alter the color along the red green axis and yellow blue axis.

Conclusions: Abraded specimens of feldspathic, pressable and CAD/CAM after polishing using pearl finish polishing paste and Soflex disc became smoother than glazed specimens. When pearl finish polishing paste...
INTRODUCTION

Prosthodontic restorations have achieved near natural perfection once all ceramic restorations were introduced. Ceramic holds a special place in dentistry because it is still considered to produce esthetically the most pleasing result. Ardent research in ceramic technology has improved both the mechanical as well as esthetic properties. However, ceramic is not easily adapted to the clinical requirements. The conventional occlusal adjustment and hand-held modifying techniques are no more befitting to the modern all ceramic restorations. Although these restorations are done with great precision, in a Clinical Research carried out in 2006, it was reported that at cementation 68% of the three unit bridges required occlusal adjustment. Many at times clinicians are forced to employ abrasives techniques on the restorations to achieve glaze like finish on adjusted ceramic surfaces.

Feldspathic, pressable lithium disilicate and ceramic used in computer-aided design/computer-aided manufacturing (CAD/CAM) technology popularly find a place in prosthodontic practice. When ceramic is subjected to abrasion, the glazed restoration supplied by the laboratory gets a very rough surface which is capable of producing further abrasion to the opposing dentition, can also harbor plaque causing biological hazards and possibly lead to esthetic changes. Hence, the abraded restoration has to be sent to the laboratory to be reglazed which can be a source of cross contamination between the clinic and laboratory as the SARS COV2 stays viable on surfaces for several days which may be associated with nosocomial spread of infection. Therefore, to prevent the potential cross contamination associated with reglazing of ceramic restoration an acceptable and efficient chairside technique to modify the abraded surface and to regain an optimum color and surface texture of polished surface is the need of the hour.

Different products are available in the market which has proven polishing capabilities but certain areas regarding their efficiency still remains to be explored. The possible shade changes which accompany the abrasive process and the efficiency of the polishing systems to regain the shade need further exploration and documentation. In an in vitro study conducted by Manjuran and Sreelal polishing with porcelain adjustment kit followed by diamond particle-impregnated wax, created surfaces significantly smoother than the glazed feldspathic porcelain specimens with no significant negative effect on color however the behavior of different ceramics which are developed in the recent past toward abrasion as well as polishing also need to be studied because future of the prosthodontic practice lies in the ability of the dentist to select the appropriate choice of materials for the particular situation, which satisfies the patients need and expectation.

Very few studies have been documented in literature comparing the effect of different polishing agents on surface roughness and color changes of feldspathic, pressable and CAD/CAM ceramic materials in a single study. Hence, the present study was designed and conducted to compare all the three ceramics namely feldspathic, pressable and ceramic used in CAD/CAM technology and also assess their response toward abrasion and polishing using two different commercially available polishing agents.

MATERIALS AND METHODS

The IRB for the current study was obtained from ESIC-PGIMSR and ESIC Medical college and hospital Joka vide letter number 412(DEAN-JOKA)/IEC/2014-15/ Vol 1.

The present study was conducted to compare the effect of different polishing systems on the color and surface roughness of feldspathic porcelain, pressable ceramic, and ceramic used in CAD-CAM technology. Two disc-shaped steel dies having 10 mm diameter with thickness of 0.5 and 2 mm were prepared, to make addition silicone molds, that in turn are used to make inlay wax patterns. 10 specimens each of feldspathic porcelain, heat pressed leucite IPS Empress and ceramic specimens using CAD-CAM technology were prepared [Figure 1a]. All the specimens in each group were subjected to abrasion and checked for surface roughness and color change.
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All the specimens of feldspathic, pressable, and CAD-CAM porcelain obtained before glazing were evaluated quantitatively for surface roughness using optical profilometer [Figure 1b]. Qualitative evaluation of surface roughness was done using scanning electron microscope [Figure 1f]. The porcelain specimens were checked for color before glazing using a colorimeter [Figure 1c] and the ∆ L*, ∆a*, and ∆ b* values were obtained.

The final glaze layer mixture of universal glazing paste with the glaze and stain liquid was applied to the specimens and kept in a furnace which was heated from 403°C to 790°C at the rate of 60°C/min for 1 min and cooled for 6 min. After glazing, all the specimens were again evaluated quantitatively and qualitatively for surface roughness using optical profilometer and scanning electron microscope [Figure 1d], respectively. The color of each glazed porcelain specimens was again evaluated using a Colorimeter.

All the study samples were then abraded using 60–74 µm diamond bur number 02 at 20,000 revolutions per minute in unidirectional motion. The abraded specimens were then analyzed for surface roughness quantitatively and qualitatively; and for color change using colorimeter.

After postabrasive treatment evaluation for color change and surface roughness, the porcelain specimens were divided (n = 5 each) into two Groups A and B. Group A specimens were polished using felt wheel with pearl finish polishing material at the speed of 10,000 revolutions per minute. Group B specimens were polished using Soflex of medium, fine and very fine grit discs at the speed of 10,000 revolutions/min. Then, the polished specimens in both the groups were checked for surface roughness quantitatively and qualitatively [Figure 1d and e], followed by the assessment of color using colorimeter.

The data obtained was subjected to statistical analysis using SPSS software 20.0 version (IBM, New York, United states of America).

RESULTS

Three types of ceramic specimens were divided into two groups each, according to polishing system used. Group A specimens were polished with felt wheel and pearl finish polishing paste; and Group B were polished with Soflex discs. The surface roughness and color data were obtained at four different stages namely.

1. After preparing the samples
2. After the glazing of the samples
3. After abrasion of the samples and
4. After polishing of the samples. In each stage, the Ra value and ∆ L*, ∆a* and ∆ b* were obtained.

Surface roughness

Among all the three materials the highest mean surface roughness value of unglazed specimen was found to be with ceramic samples made using pressable technique for group A (4.064 µm) as well as for Group B (3.544 µm) and lowest was for felspathic ceramic samples which was 2.728 µm for Group A and 2.42 µm for Group B. The
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After glazing the samples, the highest mean surface roughness value of specimen was found to with ceramic samples made using pressable technique for Group A (2.4 µm) as well as Group B (2.704 µm) and lowest was for the ceramic used in CAD/CAM technique in group A (1.326 µm) as well as Group B (1.298). Feldsparitic ceramic samples demonstrated a mean roughness value of 1.54 µm for Group A and 1.692 µm for Group B.

There was a decrease in the surface roughness after glazing with respect to all the three ceramic material however it was not statistically significant ($P = 0.451$) [Table 1].

After abrading the samples, the highest mean surface roughness value of specimen was found to be with ceramic samples made using pressable technique (1.43 µm) and lowest was for the ceramic used in CAD/CAM technique (0.736 µm). Feldsparitic ceramic samples demonstrated a mean roughness value of 1.38 µm.

After polishing in Group A, the highest mean surface roughness value of specimen was found to be with ceramic samples made using pressable technique (1.824 µm) as well as B (4.364 µm) and lowest was for group A (2.95 µm) and Group B feldsparitic ceramic (3.154 µm). Ceramic used in CAD/CAM technique demonstrated a surface roughness after abrasion of 3.572 µm for Group A and 3.626 µm for Group B.

After polishing in Group B, the highest mean surface roughness value of specimen was found to be with ceramic samples made using pressable technique (1.43 µm) and lowest was for the ceramic used in CAD/CAM technique (0.736 µm). Feldsparitic ceramic samples demonstrated a mean roughness value of 1.38 µm.

No significant difference between in the surface roughness of the abraded ceramic specimens after polishing with felt wheel and pearl finish polishing paste ($P = 0.113$) [Table 2].

No significant difference was found in the surface roughness of abraded ceramic specimens after polishing with Soflex discs ($P = 0.576$) [Table 2].

Surface treatments of glazing, abrasion and polishing were also compared for three different ceramics in both the groups using one sample t-test. It was observed that a statistically significant relation was found between all the surface treatments for both the groups of three different types of ceramics ($P < 0.05$) [Table 3].

**Color**

Besides surface roughness, the mean values of all the three parameters of color were also recorded after abrasion of glazed specimens. It was observed that statistically the difference between all the three ceramics was found to be significant with respect to ∆b and ∆a values ($P < 0.05$), [Table 4]. After polishing the abraded specimens with two different systems, the mean values of parameters of color were calculated. ANOVA statistical analysis showed that polishing with Group A, showed statistically significant relation with values of ∆ b; whereas in Group B statistically a significant relation was observed between all the ceramics for ∆b and ∆a values ($P < 0.05$), [Table 5]. The intergroup comparisons between three types of surface treatments (glazing, abrading, and polishing) revealed a statistically insignificant relation, for all the ceramic specimens in both the groups for all the three-color parameters.

**DISCUSSION**

Ceramic restorations are considered to be superior due to their shade matching glossy surface that is impervious...
to oral fluids. Ceramic restorative surfaces are sometimes abraded for occlusal adjustment which results in increased surface roughness, change in color and periodontal damage as well as abrasive wear of opposing dentition.[8]

As an alternative to glazing abraded restorations can regain smooth surface and shade through various finishing and polishing techniques.[15] Hence, it becomes imperative to evaluate the effectiveness of various ceramic polishing systems on the surface texture and color of the conventional and newer ceramic systems.

After abrasion of specimens, the surface roughness values increased in our study. Martin et al.[10] also found similar results, that mechanical alteration of porcelain surface increases the surface roughness as compared to glazed and polished specimens.

Quantitative analysis by surface roughness was accompanied by qualitative analysis by scanning electron microscopy (SEM) for this study. The profilometer and SEM verified that the smoothest porcelain surfaces were obtained after polishing.

Table 2: Intergroup comparison between both groups for surface roughness values of three different ceramic specimens

| Ceramic specimens | After abrasion | After polishing | Difference |
|-------------------|---------------|----------------|------------|
| Feldspathic        |               |                |            |
| Group A           | 2.95          | 1.384          | -1.71      |
| Group B           | 3.154         | 0.704          | -2.45      |
| Pressable         |               |                |            |
| Group A           | 3.824         | 1.438          | -1.924     |
| Group B           | 4.364         | 1.3            | -3.064     |
| CAD/CAM           |               |                |            |
| Group A           | 3.572         | 0.736          | -2.836     |
| Group B           | 3.626         | 1.35           | -2.218     |

ANOVA statistical analysis for Group A

| F-statistics | df | P   |
|--------------|----|-----|
| 2.629        | 29 | 0.113*|

ANOVA statistical analysis for Group B

| F-statistics | df | P   |
|--------------|----|-----|
| 0.579        | 29 | 0.576*|

*P-value < 0.05 is significant. CAD/CAM: Computer-aided design/computer-aided manufacturing

In studies conducted by Scherer et al.,[17] Haywood et al.,[18] Grieve et al.,[19] Klausner et al.[20] Scurria et al.[21] Amaya Pjeras et al.[22] Sarac et al.[23] polishing porcelain mechanically produced a surface that is as smooth as glazed porcelain. However, in our study, we found mechanical polishing of feldspathic, pressable, and CAD/CAM porcelain using pearl finish polishing paste and Soflex discs could produce a surface which was smoother than the glazed specimens.

In our study, pearl finish polishing paste (diamond paste) and Soflex discs were compared for their effectiveness and the former appears to be more superior but not to a significant level. The findings with respect diamond polishing paste were similar to the study conducted by Grieve et al.[19] Camacho et al.[24] where they found diamond polishing paste to be more effective than other techniques when used with an appropriate vehicle.

Our study showed that mechanical polishing of feldspathic, pressable, and CAD/CAM porcelain using pearl finish polishing paste and Soflex discs of medium, fine and very fine grits can produce a color similar to that of glazed porcelain. Similar findings were observed by Vieira et al.,[25] who also proved that cold polishing did not alter the color of feldspathic porcelain. In contrast, a study by Karan et al.[26] observed that currently available polishing systems cannot recreate a surface that is as smooth as the original glaze. Fuzzi et al.[27] reported that the polishing paste offers a slight improvement in the surface brightness and roughness when used after the polishing system. Similarly, Bottino et al.[28] affirmed that the polishing paste must be used after polishing rubbers, promoting better results. It should be highlighted that although surface roughness is the factor associated with ceramic color change, this is not the only cause of staining.[29]

Limitation of the study

1. The glazing and polishing procedures were performed on disc-shaped specimens, which are not identical to real restorations
2. Direct extrapolation of results to the clinics is not possible because of differences in pressure and time.
Table 4: Mean values of color change of all ceramic specimens after abrasion of the glazed specimens

| Material             | Mean±SD | ΔL values | Δa values | Δb values |
|----------------------|---------|-----------|-----------|-----------|
| Feldspathic          | -1.31±1.40 | -0.56±1.13 | -5.21±4.36 |
| Pressable            | -5.68±5.09  | 0.81±1.14  | -0.33±1.29 |
| CAD/CAM              | 0.19±1.68   | -0.03±0.53  | -1.18±1.11 |
| ANOVA statistical analysis |
| F-statistics         | 2.381     | 5.012     | 9.313     |
| df                  | 29        | 29        | 29        |
| P                   | 0.112     | 0.014*    | 0.001*    |

*P<0.05 is significant. SD: Standard deviation, CAD/CAM: Computer-aided design/computer-aided manufacturing

Table 5: Mean values of color change of all ceramic specimens after polishing of abraded specimens using Group A and B

| Material             | Mean±SD | ΔL values | Δa values | Δb values |
|----------------------|---------|-----------|-----------|-----------|
| Group A material     |         |           |           |           |
| Feldspathic          | 6.68±11.04 | 0.62±1.22  | 6.66±3.10 |
| Pressable            | 4.08±4.56  | -0.20±0.89 | 0.56±1.78 |
| CAD/CAM              | -0.40±2.99 | -0.04±0.13 | 1.32±1.34 |
| ANOVA statistical analysis |
| F-statistics         | 1.269     | 1.243     | 11.347    |
| df                  | 29        | 29        | 29        |
| P                   | 0.316     | 0.323     | 0.002*    |
| Group B material     |         |           |           |           |
| Feldspathic          | 5.58±8.37  | 1.06±0.67  | 6.82±5.04 |
| Pressable            | 3.72±4.86  | -0.06±0.59 | 0.50±2.04 |
| CAD/CAM              | -1.32±2.18 | -0.04±0.13 | 0.28±0.59 |
| ANOVA statistical analysis |
| F-statistics         | 1.943     | 7.664     | 6.917     |
| df                  | 29        | 29        | 29        |
| P                   | 0.186     | 0.000*    | 0.010*    |

*P<0.05 is significant. SD: Standard deviation, CAD/CAM: Computer-aided design/computer-aided manufacturing

applied by different practitioners during the polishing procedures.
3. Further studies should be conducted with standardization of methods, to determine the best finishing and polishing technique for each material.

Despite the limitations and variability encountered in this study, it was inferred that polishing porcelain can produce acceptable results.

CONCLUSIONS

Specimens made of feldspathic, pressable CAD/CAM on glazing exhibited a decrease in surface roughness. On abrading the ceramic specimens the surface roughness increased. On polishing the abraded specimens using pearl finish polishing paste and Soflex discs the surface roughness decreased and provided a smoother surface than glazed ones. When pearl finish polishing paste and Soflex discs were compared for their effectiveness the former appears to be more superior but not to a significant level. Mechanically altering feldspathic, pressable, and CAD/CAM porcelain technology does not cause change in shade. Ceramic restorations can be subjected to an abrasive process as and when required and on polishing the shade of the ceramic will be maintained thereby decreasing the number of dental visits of the patient as well as laboratory technician helping to reduce spread of COVID-19 infection.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Krishna JV, Kumar SV, Savadi RC. Evolution of metal-free ceramics. J Indian Prosthodont Soc 2009;9:70-5.
2. Maciel LC, Silva CF, de Jesus RH, Conceiçao LR, Kano SC, Xible AA. Influence of polishing systems on roughness and color change of two dental ceramics. J Adv Prosthodont 2019;11:215-22.
3. Kelly JR, Benetti P. Ceramic materials in dentistry: Historical evolution and current practice. Aust Dent J 2011;56 Suppl 1:84-96.
4. Doremalen NV, Bushmaker T, Morris DH, Holbrook MG, Gamble A. Aerosol Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. N Engl J Med 2020;382:1564-7.
5. Carrabba M, Vichi A, Valtrago G, Pallari S, Paravina R, Ferrari M. Effect of finishing and polishing on the surface roughness and gloss of feldspathic ceramic for chairside CAD/CAM systems. Oper Dent 2017;42:175-84.
6. de Kok P, Pereira GK, Fraga S, de Jager N, Venturini AB, Kleverlaan CJ. The effect of internal roughness and bonding on the fracture resistance and structural reliability of lithium disilicate ceramic. Dent Mater 2017;33:1416-25.
7. Anusavice KJ, Shen C, Rawał HR. Phillips’ Science of Dental Materials, 12th ed. St. Louis: Elsevier/Saunders; 2012. p. 418-73.
8. Rashid H. The effect of surface roughness on ceramics used in dentistry: A review of literature. Eur J Dent 2014;8:571-9.
9. Yuzugullu B, Celik C, Erkut S, Ozcelik TB. The effects of extraoral porcelain polishing sequences on surface roughness and color of feldspathic porcelain. Int J Prosthodont 2009;22:472-5.
10. Yilmaz C, Korkmaz T, Demirkoparılı H, Ergün G, Ozkan Y. Color stability of glazed and polished dental porcelains. J Prosthodont 2008;17:20-4.
11. Manjurana JG, Sreelal T. In vitro study to identify a ceramic polishing protocol effecting smoothness superior to glazed surface. J Indian Prosthodont Soc 2014;14:219-27.
12. Aathirai, All ceramics- when, where & what. J Indian Prosthodont Soc 2018;18(Suppl 2):S89-S90.
13. Cakar G, Pekkan G, Çal E, Eskiştaşçıoğlu G, Özeçan M. Effects of surface-finishing protocols on the roughness, color change, and translucency of different ceramic systems J Prosthet Dent 2014;112:314-21.
14. Maciel LC, Silva CF, de Jesus RH, Conceiçao LR, Kano SC. Xible AAInfluence of polishing systems on roughness and color change of two dental ceramics. J Adv Prosthodont 2019;11:215-22.
15. Owen S, Reaney D, Newsome P. Finishing and polishing porcelain surfaces chairside, International dentistry – Australasian edition 2011;6:668-73.
16. Martin C, Vieira GC. Quantitative analysis of dental porcelain surfaces following different treatments: Correlation between parameters obtained by a surface profiling instrument. Dent Mater J 2002;21:44-52.
17. Scherrer D, Bragger U, Ferrari M, Mocker A, Joda T. In-vitro
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18. Haywood VB, Heymann HO, Kasy RP, Whitley JQ, Andreaus SB. Polishing porcelain veneers: An SEM and specular reflectance analysis. Dent Mater 1988;4:116-21.
19. Grieve AR, Jeffrey IW, Sharma SJ. An evaluation of three methods of polishing porcelain by comparison of surface topography with the original glaze. Restorative Dent 1991;7:34-6.
20. Klausner LH, Cartwright CB, Charbeneau GT. Polished versus autoglazed porcelain surfaces. J Prosthet Dent 1982;47:157-62.
21. Scurria MS, Powers JM. Surface roughness of two polished ceramic materials. J Prosthet Dent 1994;71:174-7.
22. Amayapajares SP, Ritter AV, Resendiz CV, Henson BR, Culp L, Donovan T. Effect of finishing and polishing on the surface roughness of four ceramic materials after occlusal adjustment. J Esthet Restor Dent 2016;28:382-96.
23. Sarac D, Sarac YS, Yuzbasioglu E, Bal S. The effects of porcelain polishing systems on the color and surface texture of feldspathic porcelain. J Prosthet Dent 2006;96:122-8.
24. 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;17:191-4.
25. Vieira GF, De Caroli A, Amorim JC, Matson E. The influence of the surface treatment and saliva on the color of two porcelains. Dent Mater J 2001;20:127-34.
26. Karon S, Toroglu MS. Porcelain refinishing with two different polishing systems after orthodontic rebonding. Angle Orthodontist 2008;78:947-53.
27. Fuzzi M, Zaccheroni Z, Vallania G. Scanning electron microscopy and profilometer evaluation of glazed and polished dental porcelain. Int J Prosthodont 1996;9:452-8.
28. Bottino MC, Valandro LF, Kantorski KZ, Bressiani JC, Bottino MA. Polishing methods of an alumina-reinforced feldspar ceramic. Braz Dent J 2006;17:285-9.
29. Samra AP, Pereira SK, Delgado LC, Borges CP. Color stability evaluation of aesthetic restorative materials. Braz Oral Res 2008;22:205-10.