Original Article

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 feldsapathic, pressable, CAD/CAM ceramic specimens were fabricated. Surface roughness and color parameters Δ L*, Δa*, and Δ 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

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and Soflex discs were compared for their effectiveness the former appeared to be more superior but not to a significant level. Mechanically altering feldspathic, pressable, and porcelain used in CAD/CAM technology does not cause any change in shade.

Keywords: Computer-aided design/computer-aided manufacturing, feldspathic ceramic, polishing, pressable ceramic, surface texture

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.[1] 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.[2,3] 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.[4] 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.[5] 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.[5,6]

Different products are available in the market which has proven polishing capabilities but certain areas regarding their efficiency still remains to be explored.[7-9] The possible shade changes which accompany the abrasive process and the efficiency of the polishing systems[10] to regain the shade need further exploration and documentation. In an *in vitro* study conducted by Manjuran and Sreelal[11] polishing with porcelain adjustment kit followed by diamond particle-impregnated wax, created surfaces significantly smoother than the glazed feldsapathic 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.[12]

Very few studies[13,14] 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 I.

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.

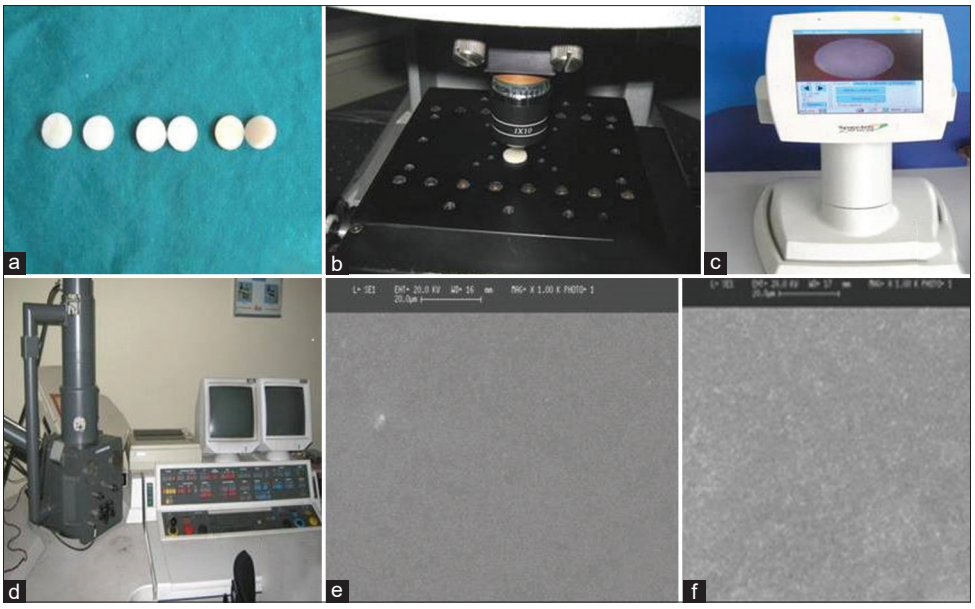

Figure 1: (a) Preparation of study samples; (b) Profilometer; (c) Colorimeter; (d) Scanning electron microscope; (e) Qualitative analysis of glazed computer-aided design/computer-aided manufacturing specimen; (f) Qualitative analysis of polished computer-aided design/computer-aided manufacturing specimen.

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 Δ L*, Δa*, and Δ 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 μ m 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 Δ L*, Δa* and Δ 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

ceramic used in CAD/CAM technique for Group A (3.004 μm and Group B 2.576 μm).

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). Feldsapthic 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 for group A (3.824 μm) as well as B (4.364 μm) and lowest was for group A (2.95 μm) and Group B feldspathic 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 A, 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). Feldsapthic ceramic samples demonstrated a mean roughness value of 1.38 μm.

After polishing in Group B, the highest mean surface roughness value of specimen was found to be highest with ceramic used in CAD/CAM samples which demonstrated a mean roughness value of 1.38 μm and lowest was for feldpathic ceramic (0.704 μm). Samples made using pressable technique demonstrated 1.3 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 Δb and Δa 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 Δ b; whereas in Group B statistically a significant relation was observed between all the ceramics for Δb and Δa 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

Table 1: Surface roughness values (Ra-μm) of three different ceramic specimens which were polished with felt wheel and pearl finish polishing paste (Group A); and Soflex discs (Group B)

Ceramic specimens	Unglazed	Glazed	Difference	Glazed	After abrasion	Difference	After abrasion	After polishing	Difference
Feldspathic									
Group A	2.728	1.546	−1.11	1.546	2.95	1.53	2.95	1.384	−1.71
Group B	2.428	1.692	−0.736	1.692	3.154	1.462	3.154	0.704	−2.45
Pressable									
Group A	4.064	2.41	−1.51	2.41	3.824	1.614	3.824	1.438	−1.924
Group B	3.544	2.704	−0.826	2.704	4.364	1.768	4.364	1.3	−3.064
CAD/CAM									
Group A	3.004	1.326	−1.624	1.326	3.572	2.246	3.572	0.736	−2.836
Group B	2.576	1.298	−1.278	1.298	3.626	2.188	3.626	1.35	−2.318
ANOVA statistical analysis									
F-statistics		0.821			1.905			9.180	
df		29			29			29	
*P**		0.451			0.168			0.208	

**P*>0.05 is insignificant. CAD/CAM: Computer-aided design/computer-aided manufacturing

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.*[16] 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	−2.318
ANOVA statistical analysis for Group A			
F-statistics		2.629	
df		29	
P		0.113*	
ANOVA statistical analysis for Group B			
F-statistics		0.579	
df		29	
P		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 feldsapthic, 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 feldsapthic, 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 3: Intergroup comparisons between different surface treatments for Group A and Group B

Intergroup comparisons	CAD/CAM				Pressable				Feldspathic			
	Group A		Group B		Group A		Group B		Group A		Group B	
	t	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*
Unglazed Glazed	2.329	0.080	5.364	0.006*	3.459	0.026*	1.517	0.204	5.334	0.006*	4.853	0.008*
Glazed Abraded	−4.163	0.014*	−4.973	0.008*	−3.595	0.023*	−2.412	0.073	−4.277	0.013*	−4.570	0.010*
Abraded Polished	5.775	0.004*	5.262	0.006*	4.644	0.010*	4.191	0.014*	9.567	0.001*	7.461	0.002*

**P*-value <0.05 is significant

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±9.40	−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

	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
F-statistics	1.943	7.664	6.917
df	29	29	29
P	0.186	0.007*	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.

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